



Slovak international scientific journal

№99, 2025

Slovak international scientific journal

The journal has a certificate of registration at the International Centre in Paris – ISSN 5782-5319.

The frequency of publication – 12 times per year.

Reception of articles in the journal – on the daily basis.

The output of journal is monthly scheduled.

Languages: all articles are published in the language of writing by the author.

The format of the journal is A4, coated paper, matte laminated cover.

Articles published in the journal have the status of international publication.

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BOTANY

QUANTITATIVE OCCURRENCE OF EUROPEAN MISTLETOE (*VISCUM ALBUM* L. SUBSP. *ALBUM*) IN POPLAR STANDS IN THE AREA OF NESSEBAR (SOUTHERN BLACK SEA COAST)

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DOI: [10.5281/zenodo.17118935](https://doi.org/10.5281/zenodo.17118935)

Abstract

European mistletoe (*Viscum album* L. subsp. *album*) is increasingly abundant in coastal and urban habitats of Europe, but quantitative data from dune-associated plantations remain limited. In this study, artificial poplar stands within approximately 12 km² around Nessebar (Bulgaria) were surveyed. For each tree, diameter at breast height (DBH) and number of mistletoe clusters were recorded. A total of 3,047 mistletoe individuals were counted, ranging from 1 to 39 clusters per tree. The mean abundance was 2.6 clusters per tree overall and 5.2 per infested tree. *Populus × canadensis* dominated the stands (95.8% of poplars) and was the only infested species, with 50.2% of individuals carrying mistletoe. Infestation frequency and intensity increased with host size, showing moderate positive correlations with DBH (Pearson $r = 0.47$; Spearman $\rho = 0.52$). A regression model explained 22% of the variation, suggesting that other factors such as dispersal and microclimate also play a role. The population displayed an aggregated pattern, with most trees uninfested or lightly colonized, while a minority carried heavy parasite loads. These results provide a quantitative baseline for assessing mistletoe dynamics in vulnerable dune-linked plantations.

Keywords: Plants, hosts, semiparasitism, dunes, *Populus*.

Introduction

The genus *Viscum* comprises approximately 100 obligate hemiparasitic plant species distributed mainly in Africa, Asia, and Europe [13]. Among them, the European mistletoe (*Viscum album* L.) is gaining increasing importance in both natural and urbanized habitats across Europe. The species has been recorded on more than 384 host species, which accounts for its broad geographical and ecological range [14]. In Bulgaria, *V. album* is represented by three subspecies: *ssp. album*, *ssp. abietis*, and *ssp. austriacum*, the first of which parasitizes broadleaved trees and poses a serious threat to their health condition [2].

Studies in Europe focusing on the quantitative characteristics of *V. album* populations and their host trees are relatively scarce and most often address the health condition of infested trees. The study in Łódź, Poland [8] recorded 2,147 mistletoe-infested trees across 28 host taxa, with a strong preference for alien, planted species such as *Acer saccharinum*, *Populus × canadensis*, and *Robinia pseudoacacia*. Infection prevalence was higher in taller trees and in the city center, suggesting that mistletoe dispersal and survival are influenced by tree size and urban environmental conditions, particularly nitrogen input. In a survey of 956 urban trees in Kharkiv (Ukraine) by [11], mistletoe-infested trees showed a significantly worse health index (2.98 ± 0.08) compared to non-infested trees ($2.43 \pm$

0.03), with the difference being statistically significant ($\lambda = 3.14$; $P > 0.999$). A positive correlation was found between mistletoe abundance and tree age ($\rho = 0.36$), as well as between infestation severity and tree health index ($\rho = 0.23$). In a study of 200 trees in Cannock Chase (UK), a strong positive correlation was found between mistletoe density and crown defoliation, with heavily infested trees losing over 70% of foliage. *Tilia cordata* proved significantly more vulnerable than *Acer pseudoplatanus*, while low soil moisture and high light availability further exacerbated mistletoe-induced damage [15].

The coastal dune complexes of the Bulgarian Black Sea coast represent vulnerable and dynamic systems, including types such as embryo dunes, mobile dunes, and fixed dunes [6], often covered with *Populus*, *Salix*, *Robinia*, and other host tree species. This structural and biotic base makes dunes both potentially vulnerable and relevant for the study of *V. album ssp. album*. Several studies in Bulgaria identify poplars as the main vector for the spread of European mistletoe, especially along the Black Sea coast, where in some areas its populations reach significant sizes [1, 2, 4, 5].

The aim of the present study is to analyze the quantitative parameters of the population, distribution, and impact of European mistletoe (*V. album* L. *ssp. album*) in poplar stands in the region of Nessebar.

Materials and methods

Object of study

The study focuses on artificial poplar plantations in the area of the Nessebar dune complexes. The survey area covers approximately 12 km² and includes parts of compartments 561, 562, and 563 as defined in the current Forest Management Plan (2019–2028) for the State

Hunting Ground Nessebar, Regional Forest Directorate–Burgas, where poplar (*Populus* sp.) and black locust (*Robinia pseudoacacia* L.) plantations predominate (Fig. 1). The prevailing age of the poplars in these stands is 20–40 years, with occasional older individuals present.

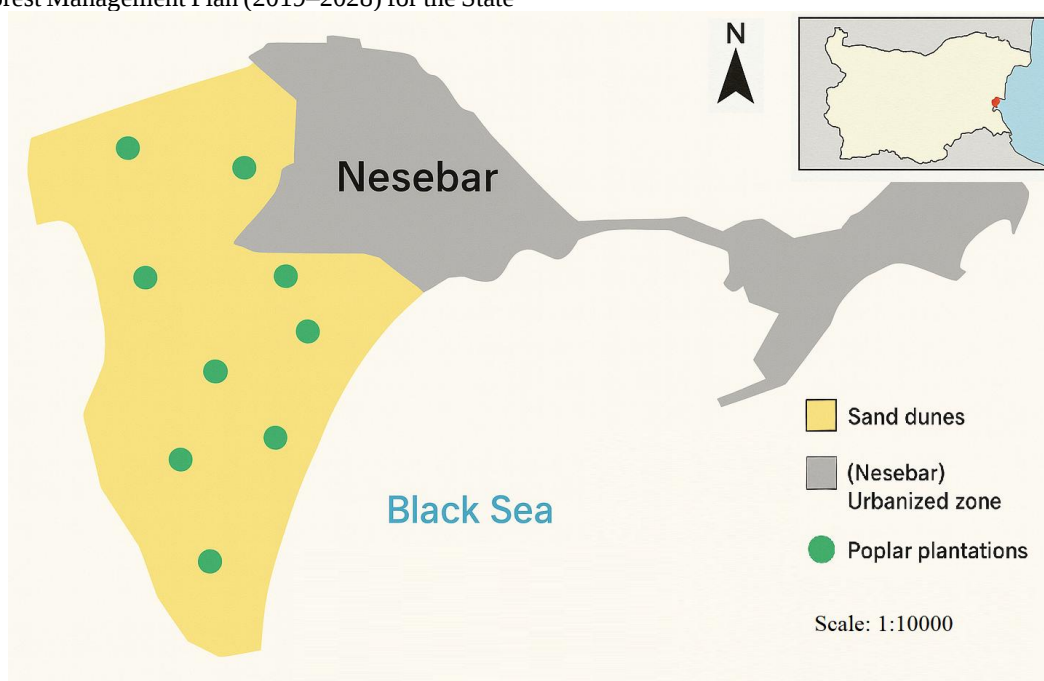


Fig. 1. Map of distribution of the prevailing artificial plantations of poplars (green marks) in the study area (based on data from the current Forest Management Plan (2019–2028) of the State Hunting Ground Nessebar, Regional Forest Directorate Burgas)

The climate of the area is strongly influenced by the Black Sea and the Mediterranean, and is characterized by high humidity, relatively high mean air temperatures, and a greater number of sunny days. The soils are Arenosols with their typical loamy-sand to sand texture, high contents of quartz sand and carbonates, and a slightly alkaline to alkaline reaction [2]

Methodological approach

A census of all individuals of the genus *Populus* was conducted within the study area, and the number and species of trees infected with European mistletoe (*V. album* ssp. *album*) were determined. In this study, the name Canadian poplar (*Populus* × *canadensis* Moench) is treated as a synonym of Euro-American poplar (*Populus* × *euramericana* Guinier) following [10]. Information on the taxonomy and biological characteristics of Euro-American poplar cultivars follows [3]. For each tree, the following variables were recorded:

1. **Tree diameter at breast height (DBH, cm)** – measured at 1.3 m above ground with a diameter tape.
2. **Number of mistletoe individuals (clusters) per tree** – counted visually for the entire crown of each tree.

Based on these measurements, several population characteristics were derived:

- **Population size and prevalence** – total number of mistletoe clusters recorded in the sample, absolute number of infected vs. non-infected trees, and the proportion (%) of infected individuals.

- **Population density** – mean number of mistletoe clusters per tree (all trees) and mean number per infected tree only.

- **Distribution of infestation** – frequency distribution of mistletoe clusters per tree (histogram) to illustrate the spread of infestation intensities across the population.

- **Structural (size-class analysis)** – grouping of host trees into diameter classes of 10 cm intervals (e.g., 0–10, 10–20, 20–30 cm, etc.). For each class, the number of trees, number of infected trees, percentage of infection, and mean mistletoe load were calculated. This approach allows assessment of how infestation varies with host size. Such grouping methods are commonly used in ecology to study population structure and dynamics [9].

- **Correlation and regression analysis** – relationships between tree diameter and mistletoe abundance were tested using:

- Pearson's correlation coefficient (linear association).
- Spearman's rank correlation coefficient (monotonic association).
- Simple linear regression, modelling the number of mistletoe clusters per tree as a function of tree diameter. The coefficient of determination (R^2) was used to evaluate the explanatory power of diameter.

- **Population structure** – boxplots and class-based comparisons were used to assess the variation in infestation intensity among trees of different diameter

classes, highlighting the heterogeneity within the host population.

For the statistical processing of the data, descriptive statistics were applied – means, medians, modes, minimum and maximum values, as well as relative proportions of infected trees. Such indicators are standard in studies of biological and ecological populations [16]. To evaluate the relationship between tree diameter (DBH) and the number of mistletoe (*Viscum album*) clusters, Pearson's correlation coefficient (for linear association) and Spearman's rank correlation coefficient (for monotonic association) were calculated. These methods are widely applied in ecological data analysis when assessing the strength and direction of relationships between quantitative or ordinal variables [12]. For a more detailed modelling of the relationship, a simple linear regression was fitted, considering the number of mistletoe clusters per tree as the dependent variable and tree diameter as the independent variable. The explanatory power of diameter on mistletoe abundance was evaluated using the coefficient of determination (R^2), which is a standard approach in biostatistics [7]. For structural analysis, trees were grouped into diameter classes (10 cm intervals). For each class, the infection frequency (percentage of infected trees), mean number of mistletoe clusters per infected tree, and the total number of clusters were calculated. This methodology provides a comprehensive characterisation of

mistletoe population parameters, combining descriptive statistics with structural and relational analyses. It allows for both quantification of infestation levels and evaluation of the factors influencing the spread of *Viscum album*.

Results

The population of European mistletoe parasitizing poplars in the studied area consists of **3,047 individuals**. The number of mistletoe clusters per tree ranges from **1 to 39**. The mean abundance across all host trees is **2.6 clusters per tree**, which, given the bio-ecological characteristics of the species, may be considered as the population density. When only infested trees are considered, the mean number rises to **5.2 clusters per tree**. The median number of clusters per tree is **10**, while the mode (the most frequent value) is **0**. The spatial extent of the mistletoe population coincides with the study area of **12 km²**.

The diameter of host trees ranged from **10 to 76 cm**, with a mean of **24.1 cm** and a median of **21 cm**. The proportion of trees infested with mistletoe was as follows: **49.8% uninfested**, **34.0% with 1–5 clusters**, and **6.6% with more than 10 clusters**. Among all representatives of the genus *Populus* in the area, **95.8% belong to *Populus × canadensis* Moench** (cultivars '*Regenerata*' and '*Bachelieri*') (Fig. 2).



Fig. 2. Canadian poplar plantations in sample plots with medium to high levels of European mistletoe infestation (photo P. Glogov)

The distribution of the remaining *Populus* species is as follows: 3.9% white poplar (*Populus alba* L.); 0.3% Lombardy poplar *Populus pyramidalis* Rozier (syn. *Populus nigra* f. *italica*, *Populus nigra* subsp. *pyramidalis* Čelak). From the distribution of species by

the percentage of individuals infested with mistletoe (Table 1), it is evident that infestation was recorded only in Canadian poplar.

Table 1.

Quantitative distribution of *Viscum album* individuals among host tree species

Tree species	Total number of trees	Percentage of trees infested by mistletoe (%)	Total number of mistletoe individuals (clusters)
<i>Populus × canadensis</i>	1158	50,2	3047
<i>Populus alba</i>	47	0	0
<i>Populus pyramidalis</i>	4	0	0

Half of the trees in the stands were infected with mistletoe, with the number of clusters varying considerably (from 1 to 39) (Table 2). With increasing diameter, both the proportion of infested trees and the mean number of mistletoes increased – for example, in the 10–20 cm class about 38% were infested, whereas in

the 40–50 cm class the proportion reached 77%. This is a characteristic feature of *Viscum album* populations: infection accumulates with the age and size of trees. Despite this clear trend, the regression model indicates that additional factors (spatial distribution, bird dispersers, microclimate) also influence the variation.

Table 2.

Quantitative distribution of mistletoe clusters in relation to host tree diameter classes

Diameter class	Number of host trees	Number of infested host trees	Share (%) of infested host trees	Mean number of clusters per all host trees	Mean number of clusters per infested host trees	Total number of clusters
0–10 cm	1	1	100.0	2.0	2.0	2
10–20 cm	426	161	37.8	0.86	2.27	366
20–30 cm	453	233	51.4	2.59	5.04	1174
30–40 cm	207	132	63.8	4.67	7.32	966
40–50 cm	64	49	76.6	7.36	9.61	471
50–60 cm	7	6	85.7	9.71	11.33	68
60–70 cm	1	0	0.0	0.0	–	0

The histogram of mistletoe abundance per tree reveals (Fig 3) that the largest proportion of host trees carry between 0 and 5 mistletoe clusters. With increasing infestation levels, the frequency of trees gradually declines, indicating that higher numbers of clusters per tree are progressively less common. Nevertheless, a few extreme cases were recorded, with individual trees hosting more than 30 clusters, demonstrating that heavy

infestation, although rare, does occur. Overall, the population of *Viscum album* displays a mosaic distribution: the majority of trees are either uninfested or only lightly infested, whereas a relatively small proportion is heavily colonized. This pattern is typical for parasitic plants, where spread and establishment are largely governed by stochastic processes such as seed dispersal by birds.

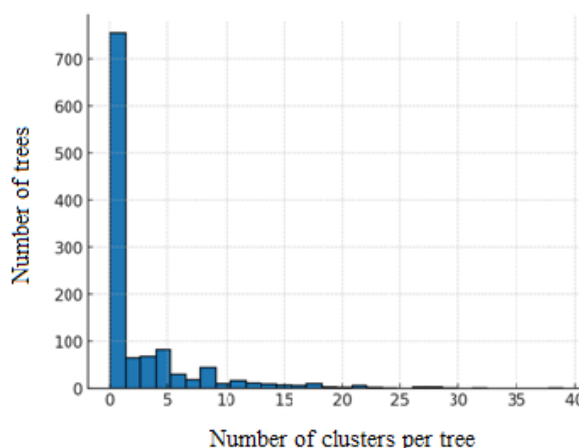


Fig. 3. Histogram showing the distribution of mistletoe clusters across host trees

The relationship between tree diameter and mistletoe abundance (Fig 4) shows a clear positive trend: as diameter increases, the number of mistletoe clusters also tends to rise. Although the data points are scattered, the overall upward slope of the regression line is evident. Larger trees may host several dozen clusters, while smaller individuals rarely carry more than a few. This pattern highlights tree size as a key factor influ-

encing infestation intensity. Both the likelihood of mistletoe presence and the number of clusters increase with tree age and size. Nevertheless, the coefficient of determination ($R^2 = 0.22$) indicates that tree diameter alone explains only part of the variation, suggesting that additional factors such as stand location, bird disperser activity, and microclimatic conditions also play important roles.

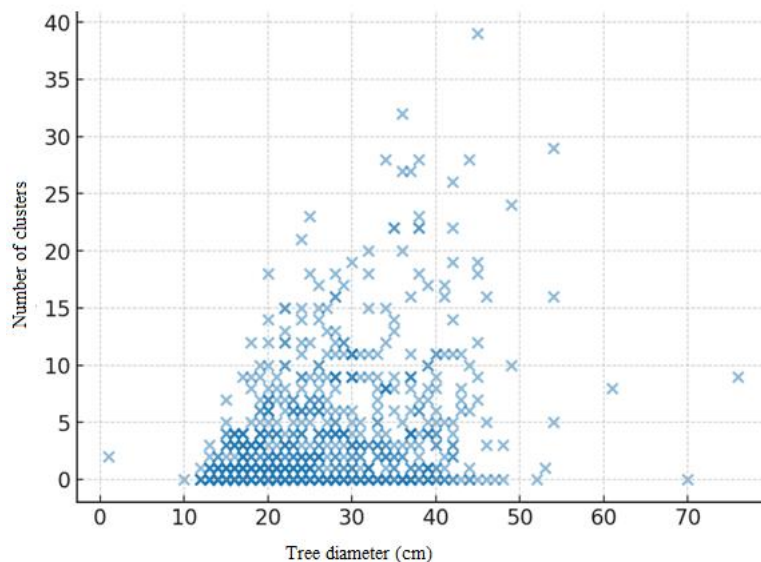


Fig. 4. Relationship between host tree diameter and the quantitative occurrence of *Viscum album*

The distribution of mistletoe abundance across diameter classes (Fig. 5) demonstrates a clear size-related pattern. In each successive class, both the median number of clusters and the degree of variation increase with tree diameter. Small trees (diameter 10–20 cm) show consistently low and relatively uniform infestation levels, whereas in the 40–50 cm class and above, the variability becomes much greater. Among the larger diam-

eter classes, extreme values (“outliers”) are also present, with some individual trees carrying disproportionately high numbers of clusters.

These findings suggest that mistletoe accumulation over time results in increasing variability within the population. Older trees include both moderately and heavily infested individuals, indicating differences in susceptibility among hosts, as well as the likely influence of local site conditions and spatial factors.

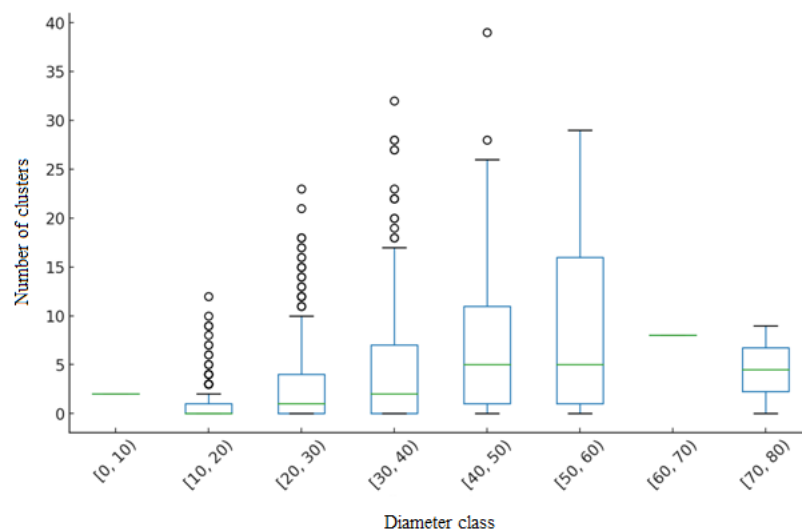


Fig. 5. Boxplot showing the distribution of mistletoe clusters by host tree diameter classes

The statistical analysis of the relationship between tree diameter and mistletoe infestation was carried out using three complementary approaches. **Pearson’s correlation coefficient ($r = 0.47$)** indicates the strength of a linear relationship between tree diameter at breast height (DBH) and the number of mistletoe clusters. The obtained value ($r = 0.47$) reflects a moderately positive association, meaning that larger trees tend to host more mistletoe. However, since the coefficient is not close to 1, the relationship is far from perfect and additional factors clearly contribute to the variation. **Spearman’s**

rank correlation ($\rho = 0.52$) captures monotonic rather than strictly linear relationships. The slightly higher value compared to Pearson’s coefficient suggests that the general tendency—larger trees carrying more mistletoe—is more robust when examined in terms of ranked values. In practice, smaller trees usually bear few or no clusters, whereas larger trees more frequently support higher numbers of mistletoe. A simple linear regression quantified the relationship between DBH (independent variable) and the number of mistletoe clusters (dependent variable). The model ($y = 0.13$,

DBH – 0.49) indicates that each additional centimeter of tree diameter is associated with an average increase of 0.13 clusters. While this increment appears small, it scales considerably: for example, a tree 70 cm larger in diameter than another is expected to carry approximately nine more clusters.

Discussion

The present study provides a comprehensive quantitative characterization of *Viscum album* subsp. *album* populations in coastal poplar stands of the Nessebar region. The total number of recorded mistletoe individuals exceeded 3,000, distributed across more than half of the surveyed trees. Such a high proportion of infestation demonstrates the strong capacity of mistletoe to establish and spread in artificially created stands dominated by *Populus × canadensis*. The mean population density of 2.6 clusters per tree (5.2 clusters per infested tree) indicates that mistletoe is not evenly distributed, but rather occurs in concentrated foci of infestation, consistent with the mosaic patterns typically reported for hemiparasitic plants.

The frequency analysis confirmed that the majority of trees were either uninfested or carried only a few clusters, while a smaller fraction of the population sustained high levels of infestation, with extreme cases exceeding 30 clusters per tree. This strongly skewed distribution reflects the role of stochastic factors such as seed deposition by birds, combined with local site conditions, in shaping population structure.

The increased infestation rate of *Populus × canadensis* by European mistletoe confirms the findings of [2], who reported that non-native poplar species in the study region are more frequently attacked by this hemiparasite. This can be attributed both to the widespread cultivation of hybrid poplars and to the removal of many mature individuals of *Populus alba* at the end of the 20th and the beginning of the 21st century, which had previously served as an important vector for mistletoe spread among native poplars in the area. A favorable factor for the development of poplar plantations is the slightly alkaline soil reaction combined with the light mechanical composition of the soils. At the same time, increased carbonate content in certain areas, as well as soil compaction leading to reduced aeration, may contribute to the deterioration of the overall condition of the stands or of individual trees. The absence of mistletoe on Lombardy poplar is consistent with the generally rare infestations of this species reported elsewhere [8]. The established direct relationship between tree diameter (age), the number of mistletoe individuals of host trees has also been observed in other tree species [15]. No significant difference in the level of infestation (number of mistletoe individuals) was found between the two *Populus × canadensis* cultivars, 'Regenerata' and 'Bachelieri', during the study.

Conclusions

The quantitative assessment revealed that mistletoe is a widespread and abundant parasite in the poplar stands of Nessebar, with more than 50% of trees infested and a total population exceeding 3,000 individuals within 12 km². Infestation is highly aggregated: most trees remain uninfested or lightly colonized, while a smaller fraction hosts heavy parasite loads. Such a

distribution is characteristic of hemiparasitic plants and reflects the combined influence of bird-mediated dispersal and site-specific conditions.

The almost exclusive dependence on *Populus × canadensis* as a host highlights both the ecological vulnerability of plantations dominated by this hybrid and the role of species composition in shaping parasite populations.

At this stage, no difference in the degree of mistletoe infestation has been established between the two cultivars 'Regenerata' and 'Bachelieri'. A positive relationship between stem diameter and the number of *V. album* individuals was confirmed. Further research is needed to assess the potential significance of variations in soil pH, carbonate content, and soil texture, and their relationship with the quantitative occurrence of mistletoe in the plantations.

Overall, the study demonstrates that quantitative parameters—population size, density, and frequency distribution—are essential for understanding the population ecology of *V. album* and for developing effective monitoring and management approaches in vulnerable dune habitats.

Acknowledgements

The authors express their gratitude to the staff of the State Hunting Ground Nessebar, Regional Forest Directorate Burgas, for their assistance and support during the course of this study.

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ECOLOGICAL AND BIOLOGICAL CHARACTERISTICS OF PATHOGENS OF WINTER HYBRID RYE MYCOSES IN THE FOREST-STEPPE OF UKRAINE**Melnyk M.,***PhD candidate**Department of Plant Production Technologies***Stoliar S.***Candidate of Agricultural Sciences, Associate Professor**Head of the Department of Crop Production Technologies**ORCID ID: 0000-0001-5925-2008**Polissia National University, Zhytomyr, Ukraine**DOI: [10.5281/zenodo.17118942](https://doi.org/10.5281/zenodo.17118942)***Abstract**

The article highlights the results of a study of the ecological and biological characteristics of pathogens of winter hybrid rye mycoses in the forest-steppe zone of Ukraine. It has been established that the dominant diseases are brown leaf and stem rust, leaf septoria, powdery mildew, and a complex of root rot. Snow mold, fusarium head blight, and smut are less widespread, but in years with high humidity, they can significantly reduce grain yield and quality. It has been shown that the development of pathogens is determined by a combination of their biological properties, varietal characteristics of hybrids, and climatic factors. The results obtained provide a scientific basis for improving the integrated crop protection system aimed at reducing the infection load and ensuring stable yield formation.

Keywords: winter rye hybrid, mycoses, rust, septoria, powdery mildew, root rot, fusarium, smut.

Introduction. In recent years, hybrid winter wheat has been gaining ground in Ukraine's crop structure thanks to its high winter hardiness, undemanding soil and climate requirements, and growing demand for grain for food, feed, and bioenergy purposes. Hybrid forms demonstrate a significant heterosis effect – increased yield, uniformity and quality of grain, as well as stability under various growing conditions. At the same time, the intensification of technologies, densification of crops, and shifting of sowing dates, combined

with climatic fluctuations in the forest-steppe zone of Ukraine, create conditions for an increase in the incidence of fungal diseases (mycoses) in crops [1, 2]. This necessitates a thorough study of the ecological and biological characteristics of mycosis pathogens in the context of hybrid rye, which may differ in plant phenology and response to the infectious background from varietal populations (Fig. 1).



Figure 1. Phytocenosis of hybrid winter rye in the forest-steppe zone of Ukraine, 2025 (original photo)

Features of hybrid rye: higher stem density, modified leaf architecture, accelerated initial growth, and other phenodynamics that can modify the microclimate of crops (leaf surface moisture, wetting duration, aeration), which directly affects the intensity of primary and secondary infection by pathogens. At the same time, the

system of maintaining hybridity (using cytoplasmic male sterility or genetically determined fertility control) indirectly affects the structure of genetic resistance to diseases and the possible variability of plant responses to different pathogen pathotypes. In view of this, it is extremely important to generalize and deepen

knowledge about the biology of pathogens in specific ecological niches of the Forest-Steppe, their infectious potential, development cycles, overwintering and spread routes, as well as the factors that determine their harmfulness [3, 4, 5].

Thus, the relevance of this article is determined by the need for a comprehensive analysis of the ecological and biological characteristics of the pathogens of winter hybrid rye mycoses in the Forest-Steppe zone of Ukraine for the scientific justification of an integrated crop protection system, improvement of monitoring and forecasting of disease development, optimization of technological solutions, and minimization of losses in yield and grain quality.

The aim of the study is to identify the composition of dominant pathogens, describe their life cycles and critical periods of infection in the Forest-Steppe, establish the ecological determinants of disease intensity, and assess the role of biological and agrotechnical factors in the formation of the infectious background of hybrid crops.

Material and Methods. The aim of the research was to identify common diseases of winter rye and determine the species composition of their pathogens in the agroecosystems of the Forest-Steppe for further improvement of the comprehensive system of crop protection against pathogens.

In order to assess the impact of pathogens on the productivity of winter rye at the Levor Farm (Berdychevsky District, Zhytomyr Region), a long-term study was launched in 2024. It involves studying the characteristics of plant growth and development, adaptive properties, competitiveness, as well as the formation of yield and grain quality in modern varieties and hybrids of rye under organic and traditional production conditions.

Monitoring of the development of fungal disease pathogens was carried out at agricultural enterprises of various forms of ownership in the Zhytomyr, Kyiv, and Vinnytsia regions.

Disease monitoring in crops was carried out in accordance with generally accepted methods of phytopathological research [14], which included: systematic visual inspections of crops at key stages of organogenesis (sprouting, tillering, stem elongation, heading, grain filling); records on permanent plots (5×10 m) and selection of plant samples for further laboratory analysis; determination of disease development according to recording scales.

The climate of the Ukrainian forest-steppe is characterized by a temperate continental regime with mild but unstable winters, frequent thaws and periods without snow, sufficient but unevenly distributed moisture (especially in spring and summer), as well as significant fluctuations in temperature and precipitation. Such conditions significantly affect the epidemiology of key rye mycoses: prolonged exposure of plants to wet snow cover or overwintering with temperature changes promotes the development of snow mold (*Microdochium nivale*), while warm and humid springs intensify the development of powdery mildew (*Blumeria graminis* f. sp. secalis), rust diseases (*Puccinia* spp.), leaf spots (*Drechslera* spp., *Septoria/Stagonospora* spp.), while

wet periods during the flowering and filling phases create conditions for fusarium wilt (*Fusarium* spp.) with the associated risks of grain contamination with mycotoxins. The soils of the experimental plots are typical chernozems.

The results obtained were subjected to mathematical and statistical processing using methods of variance and correlation analysis. The reliability of differences was assessed using Student's criterion ($p \leq 0.05$).

Results. The most dangerous fungal diseases for winter rye include: rust (leaf and stem) as powerful defoliants and reducers of photosynthetic activity; powdery mildew as an early spring and spring-summer factor of assimilation surface suppression; leaf spots of various etiologies as a chronic factor of premature aging; snow mold as a critical risk of overwintering and thinning of crops; root and ear fusariosis as a cause of lodging, reduction in 1000-grain weight, and toxicological risks. For each group of pathogens, it is important to identify the optimum temperature and humidity, sources of inoculum (seeds, plant debris, soil, wild cereals), infection mechanisms (through stomata, mechanical damage, direct penetration), survival strategies (chlamydospores, sclerotia, urediniospores, etc.) and factors determining the dynamics of epiphytotics.

The situation is complicated by changes in the phytosanitary status of phytocenoses under the influence of climate change: the lengthening of the growing season, the increase in the frequency of warm and wet springs, and more frequent extreme weather events (from prolonged droughts to torrential rains) contribute to shifts in the phenology of pathogens, the emergence of new races and pathotypes, and changes in the proportion of individual diseases in the overall phytosanitary pressure.

Despite numerous studies of cereal mycoses, this issue has not been sufficiently studied for hybrid rye in the forest-steppe zone of Ukraine.

Based on a review of the literature and our field and laboratory (phytological examination of crop seeds) studies conducted in 2024–2025, it was established that hybrid winter rye is affected by a number of disease pathogens, the most dominant of which are fungi.

It should be noted that diseases whose pathogens affect rye plants in the early stages of development include root rot, in particular common fusarium, ophiobolus, and cercosporium; in early spring – snow mold and sclerotinia; in the period from germination to milk ripeness of the grain – powdery mildew, septoria; in the phenophase of tubing–milk-waxy ripeness of the grain – brown, stem, and yellow rust; during the flowering period–milky-waxy ripeness of grain – fusarium head blight, alternaria, helminthosporiosis, loose and smut, olive mold, black spot and basal bacteriosis [8].

Our research data show that the most common diseases in winter rye hybrid crops in the Forest-Steppe zone are brown leaf rust, leaf septoria, powdery mildew, and root rot. Snow mold, fusarium head blight, and smut have developed insignificantly in crop agroecosystems. One of the most harmful diseases of winter rye is brown leaf rust (*Puccinia recondite* Dietel & Holw.) (Fig. 2). Compared to other mycoses, its pathogen is

able to adapt to various external conditions and form aggressive races characterized by high resistance of spores to high temperatures and relative air humidity.



Figure 2. *Puccinia recondite* Dietel & Holw.

This disease appears earlier than others and quickly reaches an advanced stage. The pathogen's urediniomycelium is frost-resistant and can overwinter on winter crops and wild grasses that have been infected since autumn. Brown rust appears on the leaves and sheaths, initially in the form of reddish-brown pustules (uredopustules), and later as black pustules with a

glossy sheen (telopustules). They are usually located on the upper side of the leaves, less often on the lower side, and never merge into a solid spot, which distinguishes them from stem rust. Chlorotic and necrotic spots may form around the uredospores [6, 8, 9].

Linear or stem rust (*Puccinia graminis* Pers. f. sp. *secalis* Erikss. Et Henn.) is no less harmful (Fig. 3).



Figure 3. *Puccinia graminis* Pers. f. sp. *secalis* Erikss. Et Henn.

It affects leaves, sheaths, stems, awns, and spikelet scales, on which rusty-brown powdery pads initially form, merging into elongated lines of urediniopustules. At the end of the growing season, black convex telia appear in the places where uredinia form and next to them, which also merge into continuous lines. More than 300 physiological races have been identified in the stem rust pathogen.

The sources of infection are affected cereal residues (teliospores), affected crops of winter rye and other cultivated and wild cereals (urediogybnytsia in

living plant tissue). The harmfulness of the disease lies in the disruption of the water balance when the disease is severely developed. Yield losses can reach 60–70%. [8, 10]

Among leaf spots, the most common disease of hybrid winter rye is septoria, which can affect plants throughout the growing season, but causes the most damage during the stem elongation-ear emergence phase (*Septoria tritici* Desm.) or ear emergence-flowering phase (*Stagonospora nodorum* (Berk.) E. Castell. & Germano) (Fig. 4).



Figure 4. *Septoria tritici* Desm.

On leaves, the disease manifests itself in the form of irregularly shaped spots of various colors (light, light brown, yellow, brown) that grow and merge, causing the leaves to gradually lose their green color and dry out. Later, the affected parts become lighter in color, and small black pycnidia appear in the center of these spots. The nodes on the stem are affected, as are the scales on the green ear. It should be noted that the development of the disease intensifies when plants are injured, stressed, burned, etc. The harmfulness of septoria lies in the reduction of the assimilation surface of the leaves, their premature drying, early infection reduces

the number of grains in the ear, stem brittleness, underdevelopment of the ear, premature ripening of the grain, and a decrease in grain quality, which leads to crop losses of more than 40%. Intensive infection and development of the disease are facilitated by prolonged wet and warm windy weather, dense crops, excessive doses of nitrogen fertilizers, infected post-harvest residues, etc. [8, 11]

Annual crop losses are also observed from the infection of winter rye crops with powdery mildew (*Blumeria graminis* (DC.) f. sp. *Tritici* Speer.) [8] (Fig. 5).



Figure 5. *Blumeria graminis* (DC.) f. sp. *Tritici* Speer.

The disease develops intensively starting from the second half of May to early June. The pathogen affects leaves, leaf sheaths, and stems, and in years of severe disease development, it affects spikelets and awns. It manifests itself as a white cobweb-like coating. Gradually, the coating turns gray and brown. Sources of infection are plant debris, wild grasses, and winter crop seedlings.

During the epiphytotic development of powdery mildew, the entire leaf surface is affected, which dies prematurely, disrupting plant nutrition and, as a result, reducing plant productivity by up to 50%, which causes significant crop losses [12].

In the forest-steppe zone of Ukraine, winter hybrid rye is most often affected by common (*Bipolaris sorokiniana* (Sacc.) Shoemaker), fusarium (caused by fungi

of the genus *Fusarium* Link.), *cercospora* (*Cercospora herpotrichoides* Fron.) and *ophiobolous* (*Ophiobolus graminis* Sacc.) root rot (Fig. 6).



Figure 6. Root rot of winter hybrid rye

Common to all types of root rot pathogens is their connection to the soil, widespread distribution, ability to switch from saprophytic to parasitic nutrition, and lack of clear specialization in host plant infection [13].

Root rot develops throughout the growing season: in autumn during the sprouting-tillering phase, in spring after wintering during the tillering phase, flowering, or at the beginning of milk ripeness and when the grain ripens. It affects the root system, underground internodes, the base, and lower internodes of the stem. The main symptoms are browning and deformation of seedlings, the formation of brown stripes and spots on the leaves, the death of productive stems, white ears, empty ears, underdeveloped ears, and shriveled grains. In some years, in crop rotations with a high saturation of grain crops, grain losses from plant damage by root rot pathogens can exceed 30%.

It should be noted that, along with the most common diseases of winter rye in crop agroecosystems, there were others whose development did not exceed economic thresholds of harmfulness: snow mold, fusarium head blight, and smut.

The causative agent of snow mold is the fungus *Fusarium nivale* (Fr.) Ces. [8, 12]. The disease manifests itself in the spring, as soon as the snow melts, in the form of a cobweb-like gray or whitish coating with a pink tint. The disease is also known as winter rye blight, accompanied by partial or complete plant death. Crop damage by mold fungi occurs as a result of early snowfall on unfrozen soil, heavy snow cover, and temperatures close to zero under the snow, especially during late spring snowmelt.

It should be noted that worldwide, fusarium head blight is one of the most dangerous diseases of cereals. The causative agents of the disease are imperfect fungi of the genus *Fusarium* Link [8, 11]. The disease develops intensively under conditions of high humidity and low air temperatures in the second half of the growing season. At first, the ear acquires a pale pink hue, and then a coating of the same color forms on the scales, which gradually covers almost the entire surface of the ear. Fusarium head blight is easy to diagnose, since a healthy ear retains its green color, while an infected one

turns white. In wet and warm weather, small dark blue perithecia appear on the affected spikelets.

Along with crop losses caused by a decrease in field germination of seeds, a decrease in the number of grains in the ear, and a decrease in the weight of a thousand grains, fusarium can impair the baking or brewing qualities of the grain and also form dangerous mycotoxins in the harvested crop.

Ergot has also been found in rye crops. The causative agent of the disease is the sac fungus *Claviceps purpurea* Tub. [6, 8]. In infected flowers, the fungus mycelium grows, fills the ovary, and gradually turns into a black horn – a sclerotium ranging in size from 1 to 3 cm. Subsequently, fairly large purple sclerotia appear on the ear, forming instead of the grain and protruding beyond the spikelet scales. Ergot reduces the rye yield, and flour obtained from grain with an ergot content of more than 0.5% is unsuitable for baking bread and feeding livestock. The main source of infection of crops is sclerotia that overwinter in the soil and are contained in the seed material. Wild cereals contribute to the spread of ergot.

Thus, fungal diseases are dominant in hybrid winter rye agroecosystems. Their intensive development is due to the biological characteristics of the pathogens, varietal characteristics, and hydrothermal conditions of the surrounding natural environment during the vegetation period of plants. Therefore, to limit the development and harmfulness of pathogens, it is necessary to research and improve effective elements of a comprehensive crop protection system

Conclusion. As a result of field and laboratory studies conducted in the Forest-Steppe zone of Ukraine, it has been established that fungal diseases play a leading role in reducing productivity in winter rye hybrid agroecosystems. The most common among them are leaf and stem rust, septoria, powdery mildew, and a complex of root rot. These pathogens exhibit high ecological plasticity, are capable of forming numerous races, and adapt to changing hydrothermal conditions.

Snow mold, fusarium head blight, and ergot are less prevalent, but in years with high humidity and prolonged thaws, they can cause significant crop losses

and deterioration in quality. Contamination of grain with mycotoxins when crops are affected by fusarium is particularly dangerous.

The development and harmfulness of mycoses are determined by a combination of the biological properties of pathogens, the morpho-biological characteristics of rye hybrids, and the influence of hydrothermal factors. The identified patterns indicate the need to improve the integrated crop protection system based on a combination of breeding, genetic, agrotechnical, biological, and chemical measures, which will reduce the infection load, minimize the risks of epiphytotics, and ensure stable yield and grain quality.

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COMPUTER SCIENCES

DATA PROCESSING ALGORITHMS IN INFOCOMMUNICATION SYSTEMS

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DOI: [10.5281/zenodo.17118950](https://doi.org/10.5281/zenodo.17118950)

Abstract

The paper analyzes the features of effective methods for processing and transmitting data over infocommunication networks and the possibilities of improving the quality of data by using modern algorithms and restrictions on the basic duration of the code element used as the basis for constructing timer signal structures. The possibilities of increasing the channel performance by reducing the energy distance between timer signal structures, where the information parameter is time, are investigated. The disadvantages of classical coding methods with redundant codes are determined and the algorithms for generating signal structures of traditional noise-immune positional codes are analyzed. At the same time, positional coding is inferior in such important data transmission parameters as information capacity and entropy. In addition, the results of calculating the quality indicators of data transmission are significantly affected by the language used in the transmitted text information or the volume of the analyzed text, and it is proposed to use a certain/adapted type of coding for the transmitted data. A comparative analysis and assessment of the influence of the studied parameters on the quality of data transmission are carried out. Practical confirmation of the correctness of the results obtained is achieved by simulating a virtual transmission system with different coding principles on a software model.

Keywords: data processing algorithms, Nyquist element, information segment, signal code construction, Hamming code, positional code, information element, noise immunity.

I. INTRODUCTION

The main problem of further development of infocommunication systems is creation and provision of differential services (QoS - Quality of Service) with the corresponding quality of service (SLA - Service Level Agreement). At the same time, the main tasks of the differential service quality assurance system are to increase the speed of information transfer and maintain high reliability of information reception. The solution of such problems is achieved by increasing the efficiency of the transmission system and using error-correcting coding [1]. To increase the efficiency of the transmission system, it is proposed to use multi-level timer signals, which allow to significantly increase the speed of information transfer [2-3], and the increase in the fidelity of information reception is achieved by using error-correcting coding in information transmission systems [4-6]. Thus, the use of these two methods allows to build effective infocommunication systems.

The disadvantages of traditional approaches to building telephone networks are low efficiency and the ability to transport all types of information using passive optical networks. At the same time, providing access to transport networks is a key issue for most telecommunications operators. One of the main problems is the task of effectively using the transmission medium capacity and increasing spectral efficiency in the process of developing modern telecommunications networks. This problem is solved using overlay networks

based on multiple access with code and time division of channels, which uses CDMA and TDMA technologies and makes it possible to theoretically use the allocated frequency band twice as efficiently [3].

In the known works, the main attention is paid to positional coding based on noise-resistant (redundant) codes and the use of multi-level timer signal structures allows to increase the information transfer rate in comparison with positional coding. However, no comparisons have been made between positional and timer coding based on the entropy assessment of code words and the information capacity of the Nyquist element [6]. Certain works [3-8] are devoted to the development of efficient algorithms for the formation of noise-resistant codes and methods for their decoding. An analysis of these works, as well as research in the field of data transmission and reception, have shown that high noise immunity of signal reception is achieved with a large length of code combinations. Based on the conducted research, algorithms for constructing efficient timer code structures [6-8] were proposed, which were used in the development of timer code structures of long codes having a certain code rate, as well as the maximum possible code distance between the nearest code combinations and, with an increase in the length of the code structure, the proportion of correctable errors. According to classical theory, such codes allow achieving high fidelity of message reception by increasing the code length without increasing the transmitter output

power. The structure of the error-correcting code must be regular for the implementation of the algorithms for encoding messages and decoding the received code structures. The regularity of the code structure implies that the algorithm for generating code structures corresponding to the information sequences of symbols arriving at the encoder input corresponds to certain mathematical rules and must be simple enough.

It is known [6-8] that for modern transmission systems, information is contained in the information parameter on a fixed interval of the Nyquist element. The throughput is increased by increasing the number of states of the information parameter on this interval: the number of different amplitudes, phases, and oscillation frequencies. In turn, the peculiarity of positional encoding is that the number of symbols transmitted over the channel, presented in binary form in the form of information segments with durations multiple of the Nyquist element, corresponds to the number of consecutively transmitted ones or zeros in the number [6-8].

II. Principles of construction and implementation of algorithms of positional codes for processing digital data

2.1. Basic principles of construction of positional codes

Positional coding is understood as [8] the representation of the number N through the weight coefficients of the number system corresponding to the alphabet of the channel " a ":

$$N = d_n a^n + \dots + d_2 a^2 + d_1 a^1 + d_0 a^0, \quad (1)$$

$$d = 0; 1; \dots (a - 1).$$

where a – is the number of states of the information parameter.

It can be noted that with an increase in the code distance " d " the number of digits in the representation of the same number (1) decreases.

The amount of information in positional code words (H) is determined by the number of information elements in them. If the code is simple [8], i.e. all N_m code words are used, then

$$H = \log_2 N_m = \log_2 a^n = n \log_2 a. \quad (2)$$

From expression (1) it follows that if $a > 2$, then with positional coding each element contains more than one bit of information. Existing communication systems use redundant codes in which each combination contains m information elements and r additional (redundant) elements [7]:

$$n = m + r.$$

For example, in a code with an even number of units, only $(n - 1)$ elements are informational, and in a 9-element Hamming code there are 5 information elements and 4 check elements [5], therefore, the entropy of each code word $H_0 = 5$, and the information capacity of one element $I_H = 5/9 = 0.555 \dots$

It should be noted that each code word in positional coding is transmitted by the channel with coefficients x_i , the signal duration of each of which is equal to the duration of the Nyquist element [4]

$$t_0 = (1/\Delta F) \cdot t,$$

where ΔF – is the frequency band of the signal spectrum.

In works [8-11], the conditions for data transmission over channels with a base are analyzed:

$$B = t_0 \times \Delta F = 1 \div 2,$$

where t_0 – is the duration of the transient process at the output of the channel with the band ΔF ;

$\Delta F \rightarrow := \frac{1}{\Delta F}$ – which is called the Nyquist element itself. The band ΔF is understood as the real band ΔF_p divided by 1.3 (a decrease of 30% is associated with the nonlinearity of the amplitude and phase-frequency characteristics).

Individual elements a_i of the decomposition (1) are transmitted to the data transmission channel as signal segments of duration t_0 with different amplitudes, frequencies or initial phases. At the moment of changing the coefficient in the representation (1), modulation (change) of the information parameter occurs.

It is known [7,8] that the main disadvantages of the positional coding method are the minimum energy distance between code words and the impossibility of adjusting this parameter, therefore, increasing the number of implementations in a given time interval.

2.2. Implementation of positional coding algorithms for digital data processing

Let us consider the practical application of algorithms of the positional method of digital data processing for the transmission of two symbolic ensembles of text information of a given alphabet during encoding. The calculations were performed using the software environment for solving engineering problems Scilab [10]. As is known, the amount of information in positional encoding is determined by expression (2). So, for example, to transmit 32 symbols of the alphabet according to (2), 5 code elements are required ($\log_2 32 = 5$), and to transmit two symbolic ensembles ($N_p = 32 \cdot 32 = 1024$), $\log_2 1024 = 10$ elements in the code word are required (similarly, to transmit 3-symbol ensembles, the length of the code words will be equal to $3 \log_2 32 = 15$ elements). Thus, we can conclude that when transmitting information of $0 - Z$ symbols of the alphabet by one code word, there is a linear dependence of the number of elements of the group combination on the multiplicity of Z symbolic ensembles. It should be noted that with different methods that provide the formation of (32^Z) different combinations, the total number of elements n in the code word is equal to

$$n_\Sigma = Z \cdot \log_2 32.$$

Let the number of realizations be $N_{p1} = 23$ and $N_{p2} = 31$. To form 1024 code words, one can use one code word with the number of elements $n_1 = 10$ or two code words with 5 elements $n_1 = n_2 = 5$, or two code words with $n_1 = 2$ and $n_2 = 8$ with subsets of the numbers of realizations $N_{p1} = 2^2$ and $N_{p8} = 2^8$, which will provide the total number of realizations ($4 \cdot 256 = 1024$). With $n_1 = 3$ and $n_2 = 7$, the subsets will be $2^3 = 8$; $2^7 = 128$; ($n_{\Sigma} = 3 + 7 = 10$) with the same number of realizations ($8 \cdot 128 = 1024$) [11]. As was indicated, in positional coding the distance between adjacent modulation moments is a multiple of the duration of the Nyquist element itself, which limits the power of the realized set on the interval of n elements. The elements of the code word n are determined by the number of different states of the coded source N_K [4]:

$$n = E^+ \log_2 N_K,$$

where E^+ – is the symbol of an integer greater than $\log_2 N_K$ and then from (1) and (2) it follows that the maximum number N for binary signals does not exceed 2^n .

In correcting (redundant, not necessarily linear) codes, the maximum number of additional r elements is determined by the boundary, i.e. the Varshamov-Gilbert limit value [2]:

$$2^{n-m} = 2^r \geq \sum_{i=0}^{d_0-2} C_n^i - 1,$$

where d_0 – is the required code distance.

Table I shows the numbers of redundant elements r , for $m \in 1 \div 15$, $d_1 = 3$ and $d_2 = 5$.

Table I

Number of check elements for $d \in \text{const}$ data

d_0/m	2	3	4	5	6	12	13	14	15
3	3	3	3	3	4	5	5	5	5
5	7	8	8	9	9	14	15	15	15

As follows from Table I, with a code distance of $d = 5$ and $m \geq 1$ implementation intervals, the number of redundant elements during positional coding of a large amount of information increases significantly, which makes such a code ineffective.

III. Principles of construction and implementation of algorithms of timer signal structures for processing digital data

3.1. Basic principles of constructing timer signal structures

When forming timer code structures [12], in contrast to the positional encoding method, when information about the transmitted discharge is determined by the type of signal on a single (Nyquist) interval, the information

is embedded in the number of information segments " i " located on the interval $T_{sk} = mt_0$, their locations on the interval T_{sk} and the duration of each ($\tau_{si} \geq t_0 + z\Delta$, ($k \in 1; 2; \dots z$ is an integer)). The value of Δ determines the step of changing the durations of the segments, ensuring a given probability of erroneous determination of the duration of the segments " τ_{si} " on reception (for a standard channel $\Delta = \frac{t_0}{7} = 0.143 \cdot t_0$ (Table II)).

As an example, Table II shows the quality of transmission of code words by a standard data transmission channel using positional coding (PC) and coding due to the duration of individual signals " τ_{si} " of code structures (timer signal structures - TSS).

Table II

Comparative parameters of position and timer coding

Positional coding (PC)				Timer signal structures (TSS), for $s = 7$ ($\Delta = 0.143t_0$)			
N	N_{tr}	N_{er}	P_{er}	n	N_{tr}	N_{er}	P_{er}
10	10^6	700	7×10^{-4}	9	10^6	104	$1,04 \times 10^{-4}$
20	10^6	770	$7,7 \times 10^{-4}$	17	10^6	1150	$11,5 \times 10^{-4}$
40	10^6	1500	15×10^{-3}	33	10^6	1620	$1,6 \times 10^{-3}$

The following notations are used in Table II: N_{tr} – is the number of transmitted code words; N_{er} – is the number of errors in received code words; P_{er} – is the length of the code word of the Nyquist element itself.

It follows from the Table II that the energy distance between the communication channels (CC) for TSS is determined by the energy, which is 7 times less than for PC ($s = 7$), (the error probabilities for close durations of the CC differ insignificantly).

The duration of each of the signal segments of the signal structure is not less than the Nyquist interval [12-13]:

$$\tau_{si} = t_0 + z\Delta,$$

where $z\Delta \in 0 \div z_0$ are integers.

A part of a single element of a single element $t_0 > \Delta = \frac{t_0}{s}$ is determined by the parameters of interference in the channel and the permissible probability of erroneous reception of the signal structure ($s \in 2, 4, \dots, s_0$).

The application of t_0 in (3) ensures the establishment of a transient process at the channel output when transmitting all "i" segments of each signal structure, and $z\Delta$ carries information about the code word.

3.2. Implementation of algorithms of timer signal structures for digital data processing

It is known [12-15] that the power (the number of realizations of the TSS, (N_p)) on the interval m of the most Nyquist elements can be determined by the expression:

$$N_p = C_{ms-i(s-1)}^i.$$

After expanding expression (4) we obtain:

$$N_p = \frac{(ms-i(s-1))!}{i!(ms-is)!}.$$

The number of realizations N_p (powers) of timer signal structures calculated by algorithm (5), under certain specified conditions are presented in Table III.

Table III

The number of realizations of the tsK and the amount of information in the Nyquist

S/m	4	5	6	7	8	9	10
	$2^4 = 16$	$2^5 = 32$	$2^6 = 64$	$2^7 = 128$	$2^8 = 256$	$2^9 = 512$	$2^{10} = 1024$
2	10/0,83	35/1,026	84/1,065	165/1,052	286/1,02	455/0,98	680/0,941
4	35/1,282	165/1,473	455/1,472	969/1,417	1771/1,349	2925/1,279	4495/1,213
6	84/1,598	455/1,766	1330/1,730	2925/1,645	5456/1,552	9139/1,462	14190/1,379
8	165/1,842	969/1,984	2925/1,919	6545/1,811	12341/1,699	20825/1,594	32509/1,499
10	286/2,039	1771/2,158	5456/2,068	12341/1,941	23426/1,814	39711/1,697	62196/1,592

In Table III, the numerator shows the number of realizations of the TSS for $i = 3, m \in 4 \div 10$, for $s = 2; 4; 6; 8; 10$, and the denominator is the amount of information contained in one element:

$$I_H = \frac{\log_2 N_p}{m}.$$

It follows from Table III:

- in a binary channel, without changing the alphabet, due to a sharp increase in the number of repetitions $N_p \gg 2^m$, more than two bits of information $I_H = \log_2 2 = 1$) can be transmitted on one Nyquist element (with positional coding);
- with an increase in m at $s = \text{const}$, the information capacity of the Nyquist element itself increases to $m_{\max}$ (after $m_{\max}$ it decreases);
- the maximum amount of information per element is transmitted with a signal structure length $T_{sk} = 5t_0$;
- when changing the channel alphabet, the number of realizations when changing the channel alphabet i , therefore, I_H will increase significantly;
- for example, if $a = 5$, the number of realizations will increase by $[(5/2)]^3 = 15.625$ times. Then for $m = 8, i = 3$ and $s = 7$ (Table III) the number of releases will be $(8436 \cdot 15.625) = 133375$, that is, one Nyquist element will contain ($I_H = \log_2 133375$) more than 17 bits of information.

IV. Principles of construction and implementation of Hamming code algorithms for processing digital data.

Basic principles of Hamming code formation.

Hamming code that allows to correct errors of multiplicity and should have a minimum code distance $d_M = 2t_{HO}$. The number of elements of the code combination is determined by the inequality [5]:

$$2^m = \frac{2n}{1+n}. \quad (7)$$

This code is constructed in such a way that the number of redundant elements and the number of checks $(n - m)$ correspond to r the check sums of "5" information elements [4-5].

Each of the sums as an addend includes the following information elements:

$$\begin{aligned} S_1 &= a_1 + a_3 + a_5 + a_7 + a_9; \\ S_2 &= a_2 + a_3 + a_6 + a_7; \\ S_3 &= a_4 + a_5 + a_6 + a_7; \\ S_4 &= a_8 + a_9. \end{aligned} \quad (8)$$

Equation (8) involves 9 elements, the numbers of which in binary and decimal codes correspond to Table IV:

Table IV

Binary equivalents of decimal numbers

Decimal code	1	2	3	4	5	6	7	8	9	10
Binary code	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010

It follows from the table that the sequence of using element numbers a_i in equations (8):

- the first sum includes numbers that have "1" in binary form in the first position from the left;
- the second sum includes elements that have "1" in the second position from the left, etc.

We present these patterns in the form of a table. In Table V, the numbers of code elements participating in certain sums in equation (8) are shown by the "+" sign:

Table V

Correspondence of elements to positions in equation (10)

№	1	2	3	4	5	6	7	8	9
1	+		+		+		+		+
2		+	+			+	+		
3				+	+	+	+		
4								+	+

Thus, the above analytical studies and calculations also apply to the case of using a nine-element Hamming code with the corresponding assumptions. Theoretical calculations have shown that the dynamics of change in the main quality parameters of transmission is preserved, the difference being in minor digital values.

V. Conclusion

The material presented in the article is based on a set of fundamental approaches to the formation of redundant codes and algorithms for the formation of timer signal structures based on traditional noise-immune positional codes and, therefore, can be used for successful analysis and synthesis of data transmission systems. Such signal structures allow synthesizing ensembles with a large information content compared to positional coding and, with a limitation on the length of the code word, the time of use of the infocommunication network device is reduced; by changing the number of information segments in the code words of timer codes with a constant value of the implementation interval, it is possible to increase the information transfer rate. When using the algorithm for forming timer signal structures, the resulting gain in the number of implementations can be used to create redundancy in order to ensure a given probability of erroneous reception. A higher implementation of timer signals in a given time interval, depending on the information feature of the most accurate element in the binary channel, can be used to create uniform transmissions of code symbols with an uneven first alphabet. In positional codes, with an increase in the number of information elements, the redundancy coefficient smoothly decreases and the noise immunity of the code decreases. In addition, the results of calculations of the qualitative indicators of data transmission are significantly influenced by the language used in the transmitted text information or the volume of the analyzed text, and it is proposed to use a specific/adapted type of encoding of the transmitted data.

This work was supported by the Azerbaijan Science Foundation – Grant № AEF-BQM-BRFTF-4/2024-5(53)-06/02/1-M-02.

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AI INTEGRATION IN BUSINESS PROCESS MANAGEMENT

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This paper presents issues related to implementing Artificial Intelligence (AI) technology in business process management. The general concept of AI, its key technical characteristics, and functional capabilities that facilitate company activity optimization and automation are discussed.

Based on analysis of various companies' experiences already utilizing AI in business management practices, the multifaceted effect of technology implementation emerged, including operational cost reduction, productivity growth, customer satisfaction improvement, and competitive advantage acquisition in the market.

The article highlights areas where AI application yields high effectiveness and identifies management processes requiring its integration. The findings demonstrate that AI is a strategic business transformation tool that increases competitive advantage in rapidly changing economic environments.

Keywords: artificial intelligence, risk assessment, forecasting, optimization, Digital Transformation.

Introduction. Due to dynamic characteristics of business processes, maintaining competitiveness and diversification requires rapidly adaptable, flexible, and technologically sound management systems. AI has become one of the most significant directions in business process optimization and innovative solution creation. Contemporary technologies are characterized by high levels of scientific-technical progress, observable in all spheres of human life, significantly facilitated by digital transformation. Such revolutionary changes became possible based on 20th-century scientific achievements. AI implementation not only increases operational efficiency but changes decision-making logic, data analytics quality, and customer relationship strategies.

Current processes demonstrate that AI emergence brought revolutionary changes and achieved significant results in almost every field. AI increased efficiency and productivity through automation of repetitive and routine tasks, enabling managers to focus more on strategic and creative activities rather than daily routines.

Methodology. The study employed comparative analysis methods based on experiences from various international and local companies. Data was obtained from public reports, scientific articles, conference materials, and interviews. Evaluation criteria included implementation process complexity, achieved results (efficiency growth, cost reduction, revenue increase), technological adaptation level, personnel involvement, and corporate culture impact.

Discussion. Optimization AI optimizes budgeting, resource allocation, and risk management processes, thereby improving operational efficiency. Furthermore, it is confirmed that GenAI facilitates innovations in strategic planning, automates complex reporting tasks, and offers creative approaches to problem-solving.

Research emphasizes AI technologies' significant role in improving decision-making processes, achieving strategic goals, and increasing organizational overall performance. Integration of AI tools within these

frameworks not only improves operational efficiency but provides organizations with strategic advantages in increasingly data-oriented and competitive business environments.

Optimization AI is one of the most significant tools of contemporary technologies, radically changing business process management and existing resource utilization efficiency. It uses machine learning algorithms for solving complex problems and making optimal decisions, simultaneously analyzing large volumes of data and finding optimal solutions considering multiple variables and constraints [1-6].

In today's digital transformation landscape, optimizing business processes increasingly relies on the convergence of robotic process automation (RPA) and generative artificial intelligence (GenAI). This synthesis marks a fundamental shift from automating traditional tasks to intelligent addition, where organizations benefit not only from operational efficiency, but also from strategic adaptability and innovation. While traditional RPA is designed to manage rule-based and repetitive activities, its integration with artificial intelligence expands its capabilities to intelligent automation that can handle complex and dynamic scenarios. Enhanced with machine learning algorithms, RPA bots will be able to continuously learn from historical data and improve decision-making processes over time. Incorporating natural language processing enables these systems to interpret and analyze unstructured text data such as email and business documents in a near-human way. In addition, computer vision and optical character recognition technologies enable RPA to process images, interpret visual elements, and automatically extract structured information from various document formats. Such capabilities form the basis for advanced applications in business practices, including customer service automation, where sentiment analysis provides contextually relevant responses, as well as document processing and recruitment optimization, where large

volumes of information can be categorized, verified and aligned to organizational needs in an efficient and reliable manner [7-9].

Generative AI further improves the management of business processes by shifting the focus to intelligent addition through automation. Unlike traditional automation, which mostly reduces manual effort, generative AI promotes innovation, creativity and adaptability in organizations. Recent studies show its rapid adoption, showing workplace adoption rising from 22 percent in 2023 to 75 percent in 2024, highlighting its transformative potential across industries. Generative AI significantly contributes to strategic planning by generating scenario-based analyses and suggesting creative problem-solving alternatives, thus expanding the decision-making horizons of management teams. It also supports the automation of complex reporting tasks through natural language generation, improving both efficiency and accuracy. In addition, generative AI enhances decision support functions by analyzing multiple interrelated variables simultaneously and providing data-driven recommendations that inform strategic and operational decisions.

This growing convergence of RPA and generative artificial intelligence reflects the shift from automating simple tasks to more advanced, adaptive and intelligent business solutions. However, while these technologies provide the necessary infrastructure to process unstructured information and improve decision making, effective long-term business optimization also requires powerful forecasting mechanisms that can predict future trends and guide strategic planning. Advanced prediction models such as long-short-term memory (LSTM) networks are used to address this need.

For process optimization, we utilized the LSTM (Long Short-Term Memory) optimization model, representing an integrated technological solution combining time series forecasting with optimization algorithms. Its purpose is high-accuracy forecasting based on historical data and using these forecasts for optimizing business processes, financial resources, and operational plans.

The model implementation involved loading historical data including sales, expenses, production indicators, or customer behavior statistics. Data is cleaned, normalized, and formatted appropriately for the LSTM network.

The forecasting stage involves LSTM neural network learning temporal dependencies in data and generating future period forecasts. The model learning process includes three main components: Input Gate, Forget Gate, Output Gate.

Results.

The results of this study confirm that the integration of artificial intelligence (AI) into the management of business processes provides significant operational, financial and strategic benefits. Evidence from an LSTM-based optimization model shows that AI not only reduces operating costs, but also increases net profit and profit margin. These improvements provide SMBs with significant competitive advantages by increasing forecasting accuracy, improving data analytics efficiency, automating routine and repetitive tasks, personalizing customer service, facilitating faster and more accurate strategic decision-making, enhancing risk and compliance management, and enabling real-time monitoring and anomaly detection.

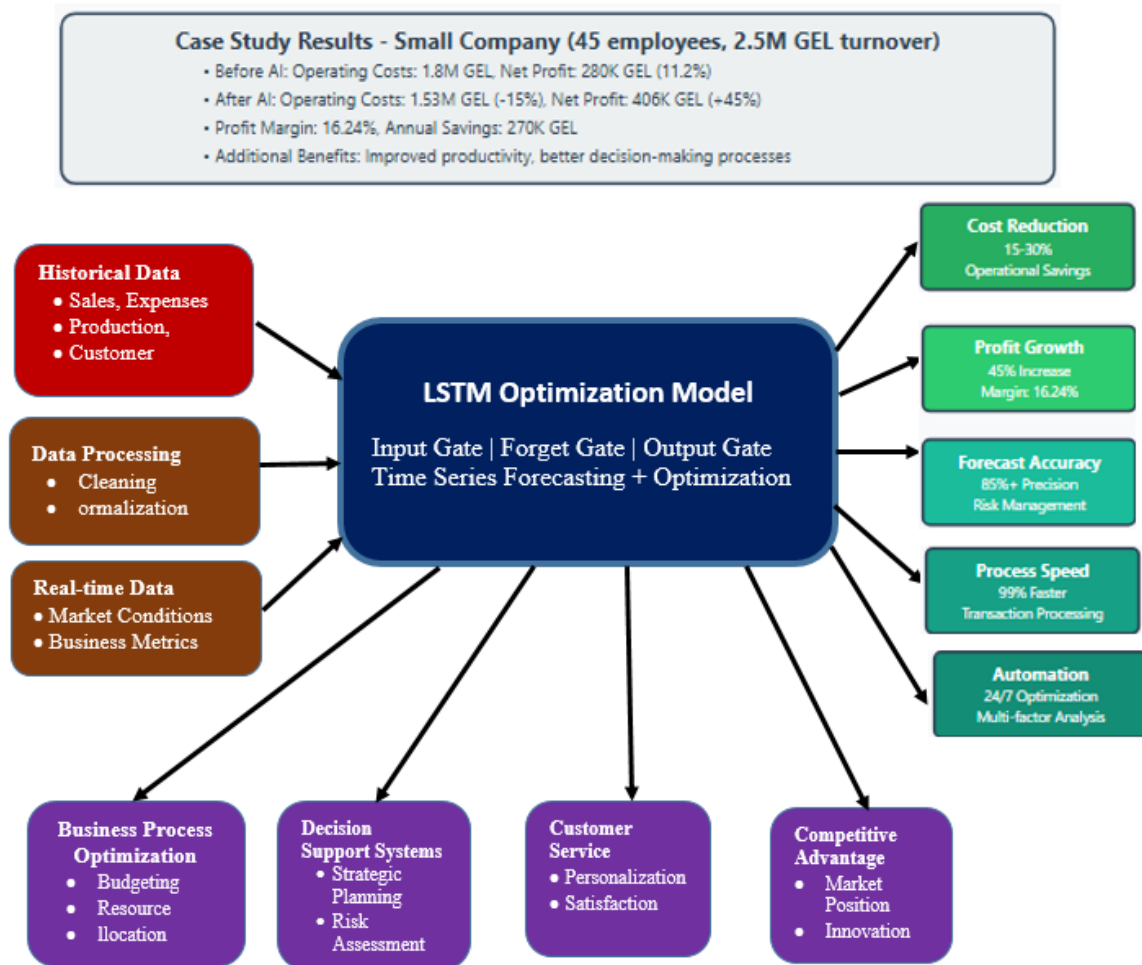
The study also indicates that up to 47% of employees are currently using or planning to use generative artificial intelligence to support or automate their tasks, helping to significantly reduce operating costs while maintaining service quality, increasing profit margins through optimized resource allocation, and strengthening competitive positioning in rapidly changing markets.

Financial return on investment (ROI) figures reported in global studies highlight the strong profitability of AI implementation. On average, companies get \$3.50 out of every \$1 invested in AI, while the top 5% of organizations report \$8.00 out of every \$1 invested. These figures highlight the significant variation in the effectiveness of AI implementation in different organizational contexts. In 2024, nearly three-quarters of companies said their most advanced AI initiatives—especially generative AI projects—met or exceeded ROI expectations. However, enterprise-wide initiatives generated an average ROI of only 5.9% versus a 10% capital investment requirement, highlighting the critical importance of strategic implementation approaches.

According to McKinsey research, generative artificial intelligence has the potential to contribute between \$2.6 trillion and \$4.4 trillion in annual productivity growth across the 63 use cases analyzed—an impact comparable to the entire GDP of the United Kingdom. Moreover, the long-term potential of AI applications in the corporate context is expected to reach \$4.4 trillion in incremental productivity gains. These results highlight the dual nature of AI implementation: although its economic potential is enormous, the practical results depend significantly on the degree of strategic integration.

To illustrate how artificial intelligence technologies, and in particular, predictive models contribute to the optimization of business processes, the schematic diagram below presents the integration of artificial intelligence in business process management.

AI Integration in Business Process Management - Schematic Diagram



The diagram schematically represents the working principle of the LSTM model and its impact on business processes. Research emphasizes that AI implementation success depends not only on technology but on organizational factors: personnel involvement, corporate culture adaptation, and technological infrastructure readiness. This aligns with research published in Scopus materials emphasizing the importance of integrating technological achievements with human resources.

Conclusion

The obtained results show that artificial intelligence is not only a technological innovation, but also an important catalyst for the transformation of business process management, which gives organizations competitive advantages in rapidly changing market conditions. Artificial intelligence in management is no longer an innovative technology of science fiction, but a strategic tool that allows businesses to make global management decisions with a high level of efficiency in complex business production conditions characterized by a high level of uncertainty and significant competition.

The integration of various AI algorithms—from LSTM networks for predictive analytics and RPA to NLP for intelligent automation—creates a comprehensive ecosystem that changes the way businesses operate. The synergy between process management and artificial intelligence generates significant productivity gains, with well-managed processes providing the

high-quality data needed to effectively train AI systems.

Today, investments in AI are a guarantee of future success not only for businesses, but also for entire countries. Organizations that successfully integrate technological innovation with human expertise, supported by strong change management strategies, will emerge as leaders in the AI-driven economy of 2025 and beyond.

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EXPERIMENTAL PHYSICS

ДОСЛІДЖЕННЯ ЗМІНИ ВОЛОГОСТІ ВУГІЛЛЯ ПРИ РІЗНІЙ ШВИДКОСТІ ПОВІТРЯНОГО ПОТОКУ

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STUDY OF CHANGES IN COAL MOISTURE CONTENT AT DIFFERENT AIR FLOW RATES

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DOI: [10.5281/zenodo.17118962](https://doi.org/10.5281/zenodo.17118962)

Анотація

Пилове забруднення повітря в робочих зонах є дуже небезпечним явищем, що суттєво впливає на стан здоров'я працівників. Джерелом пилоутворення є різні технологічні процеси на підприємствах, складування вугілля в штабелях, винесення мінерального пилу від хвостосховищ тощо. Особливо важливим аспектом є зменшення інтенсивності пилоутворення на промислових майданчиках. Для цього дуже поширеним є використання подачі води на поверхню пилоутворення. Але з часом вологість змоченої поверхні зменшується, тому важливо визначати час, коли необхідною є наступна подача. В статті наведено результати лабораторних досліджень по визначенню динаміки зменшення вологості вугілля при різній швидкості повітряного потоку. На базі отриманих результатів експерименту побудовано емпіричну модель для визначення часу, коли потрібно повторити зрошування поверхні пилоутворення. Наведено чисельну модель для оцінювання концентрації водяного пару біля поверхні пилоутворення.

Abstract

Dust pollution in work areas is a very dangerous phenomenon that significantly affects the health of employees. The source of dust generation is various technological processes at enterprises, coal stacking, mineral dust from tailing pits, etc. A particularly important aspect is to reduce the intensity of dust formation at industrial sites. For this purpose, it is very common to use water supply to the surface of dust formation. However, over time, the humidity of the wetted surface decreases, so it is important to determine the time when the next supply is needed. The article presents the results of laboratory studies to determine the dynamics of coal moisture reduction at different air flow rates. On the basis of the obtained experimental results, an empirical model was built to determine the time when it is necessary to repeat the irrigation of the dust formation surface. A numerical model for estimating the concentration of water vapor near the surface of dust formation is presented.

Ключові слова: пилове забруднення, робоча зона, фізичний експеримент, емпірична модель, чисельне моделювання.

Keywords: dust pollution, working area, laboratory experiment, empirical model, mathematical modeling.

Вступ

Пилове забруднення повітря робочих зон на промислових майданчиках залишається дуже небезпечним явищем на різних промислових підприємствах [1, 4, 9, 10]. Дуже інтенсивне пилове забруднення повітря має місце біля штабелів вугілля, хвостосховищ, місць, де здійснюється складування відходів різних підприємств. Винесення пилу призводить до довгострокового та інтенсивного забруднення повітря в робочих зонах. Тут можна виділити два процеси пилового забруднення повітря в робочих зонах – первинне забруднення, коли пил потрапляє в робочу зону внаслідок переносу повітряним потоком від джерела пилоутворення, та вторинне забруднення – коли має місце забруднення повітря в робочих зонах внаслідок динамічного впливу на пил, що осів на поверхню землі промислового майданчику (підлогу робочої зони). Формування пилових хмар та їх рух може викликати пилове забруднення повітря на значній відстані від джерел пилоутворення. Тобто, під вплив джерела пилоутворення потрапляють робочі зони, де мають місце інші технологічні процеси. Тому значна кіль-

кість наукових досліджень присвячена дослідженню процесів пилоутворення та розповсюдження пилу в повітрі. В рамках даного наукового напрямку широко використовуються лабораторні методи дослідження, емпіричні моделі, аналітичні моделі та CFD моделі для аналізу процесів забруднення повітря в робочих зонах [1-3, 5-8]. Розглядаючи проблему пилового забруднення робочих зон, слід виділити таку важливу задачу, як боротьба з пилоутворенням. Наукові дослідження в даному напрямку залишаються актуальними та потребують подальших розробок.

Мета

Експериментальне визначення інтенсивності випаровування води зі зволоженої поверхні вугілля при різній швидкості повітряного потоку; розробка чисельних моделей для прогнозування концентрації водяного пару біля зволоженої поверхні вугілля.

Методика

Подача води на поверхню сипучих матеріалів (вугілля, мінеральний пил тощо) є методом боротьби з пилоутворенням, який дуже широко використовується в світі (рис. 1).



Рис. 1. Зволоження поверхні штабелю вугілля [11]

Але після закінчення процесу зволоження поверхні сипучого матеріалу починається випаровування води, що призводить до зменшення вологості поверхневого шару матеріалу та з часом, при певній вологості, знову почнеться процес пилоутворення. Тому дуже важливо визначати час, коли потрібно знову повторити процес зрошування поверхні.

Далі розглядається рішення задачі по визначенню часу, коли потрібно починати новий цикл

зрошування у зв'язку з випаровуванням води з поверхні вугілля.

Дослідження проводилися лабораторним шляхом. Для проведення експериментальних досліджень використовувалось вугілля з Павлоградського району Дніпропетровської області. Фото дослідної установки показано на рис. 2.

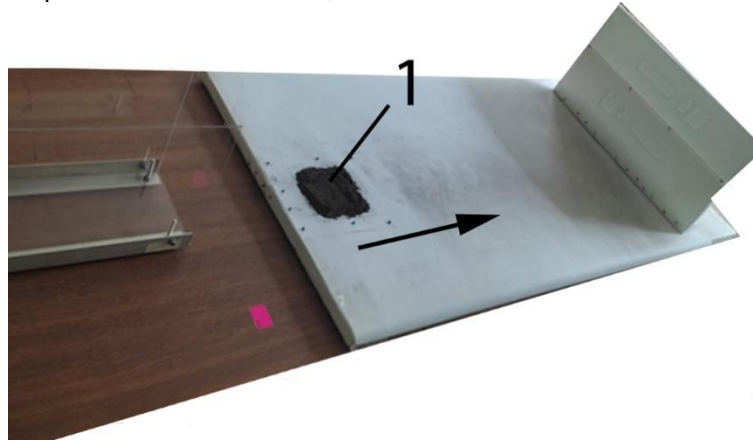


Рис. 2. Дослідна установка: 1 – область пилоутворення (вугільний пил)

Вугільний пил розташовувався в межах прямокутника (майданчик). Температура повітря 20 °С. Перед проведенням досліджень по визначенню зміни вологості вугільного пилу при обдуві моделі майданчика зразок вугільного пилу знаходився у сушильній шафі (шафа сушильна, модель 2В-151) при температурі +40 °С протягом 1 год. Після цього зразок вугілля було зважено. Далі в зразок додавалась вода в кількості, необхідній для отримання потрібного значення вологості зразка. Вологість зразка визначалася так:

$$P = \frac{M_{вл} - M_c}{M_c} 100\% \quad (1)$$

де Р – вологість, %; М_с – маса сухого зразка; М_{вл} – маса вологого зразка.

Далі зразок розташовувався на експериментальному майданчику (рис. 2) та здійснювався обдув

його протягом 2 хв. Потім зразок зважувався, визначалась остаточна вологість та експеримент з даним зразком продовжувався далі. Експеримент проводився для різної швидкості повітряного потоку. Швидкість повітряного потоку вимірювалась за допомогою анемометра НТ-9830. При проведенні експерименту здійснювалась відеозйомка.

Так як вимірювання здійснювалися при турбулентному режимі, то анемометр показував певний діапазон швидкості повітряного потоку. При обробці даних, для побудови графічної залежності розраховувалось середнє значення швидкості повітряного потоку. Початкова вологість зразка вугілля була 10 %.

Після обробки даних вимірювань була побудована графічна залежність зміни вологості зразка вугілля з часом при різній швидкості повітряного потоку (рис. 3).

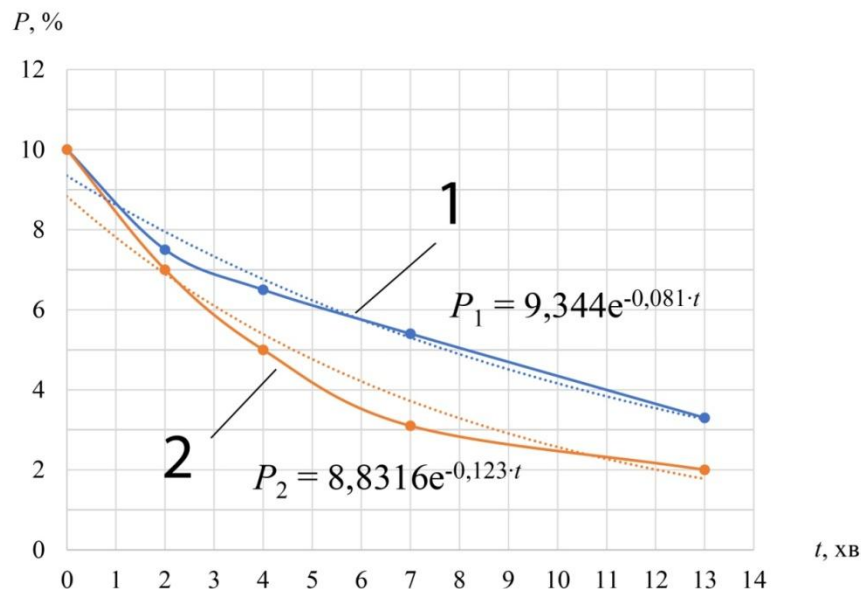


Рис. 3. Зміна вологості вугілля з часом:

1 – швидкість повітряного потоку 4,6 м/с; 2 – швидкість повітряного потоку 7,1 м/с

Аналіз даних на рис. 3 показує таку закономірність: зниження вологості йде швидко протягом перших 7-8 хв; за цей проміжок часу вологість зменшується в 2 рази, якщо швидкість повітряного потоку 4,6 м/с, та в 3 рази, якщо швидкість повітряного потоку 7,1 м/с.

Експериментальні дані (рис. 3) дозволяють встановити таку закономірність: йде інтенсивне зменшення вологості вугілля протягом перших 8 хв. Також можна бачити, що на цьому проміжку часу для $V=4,6$ м/с швидкість «падіння вологості» менша, ніж для швидкості повітряного потоку $V=7,1$ м/с:

$$\text{grad}P = \frac{5\% - 10\%}{8} = -0,625 \text{ для } V = 4,6 \text{ м/с};$$

$$\text{grad}P = \frac{2,9\% - 10\%}{8} = -0,887 \text{ для } V = 7,1 \text{ м/с}$$

Обробка експериментальних даних дає можливість отримати такі емпіричні моделі для експрес оцінювання зміни вологості вугілля з часом при різних швидкості повітряного потоку:

$$P_{4,6} = 9,344 \cdot e^{-0.081t}, \quad (2)$$

$$P_{7,1} = 8,831 \cdot e^{-0.123t}. \quad (3)$$

Візуальний аналіз експерименту та аналіз відеозйомки експерименту дозволив визначити таку закономірність пилоутворення:

- при вологості порядку 5 % починається рух часток пилу біля поверхні вугілля, якщо швидкість повітряного потоку порядку 7,1 м/с;

- при вологості порядку 3 % починається активне винесення часток вугільного пилу повітряним потоком, якщо швидкість повітряного потоку порядку 7,1 м/с;

- при вологості порядку 3 % починається рух часток пилу біля поверхні вугілля якщо швидкість повітряного потоку порядку 4,6 м/с;

- при вологості порядку 2 % починається активне винесення часток вугільного пилу повітряним потоком, якщо швидкість повітряного потоку порядку 4,6 м/с;

Різниця в значенні вологості: 2 % (швидкість повітряного потоку 4,6 м/с) та 3 % (швидкість повітряного потоку 7,1 м/с) при якій починається активне винесення часток вугільного пилу, можна пояснити тим, що при малій швидкості повітря кінетичної енергії потоку не вистачає для «відриву» часток пилу від поверхні вугілля.

Таким чином, при використанні в якості боротьби з пилоутворення зволоження водою поверхні вугілля, слід контролювати вологість цієї поверхні, і в разі, коли вологість поверхні вугілля буде порядку 2-3% слід повторити змочування вугілля.

Використовуючи отримані дані – емпіричні моделі (2) та (3), та здійснюючи певне «округлення» чисел в цих моделях, а саме:

$$9.344 \approx 9, \quad 8.831 \approx 9, \quad 0.081 \approx 0.1, \\ 0.123 \approx 0.1,$$

можна отримати емпіричну модель, що поєднує дві моделі (2) та (3):

$$P = 9 \cdot e^{-0.1t} \quad (4)$$

Таким чином, за допомогою моделі (4) можна визначати час, коли вологість вугілля зменшиться та досягне критичної межі $P=3\%$. При такій вологості починається процес пилоутворення, тому слід повторити змочування поверхні вугілля.

На наступному етапі була розроблена чисельна модель для оцінювання концентрації водяної пари біля поверхні, на яку подається вода для зменшення пилоутворення. Моделююче рівняння має вигляд:

$$\frac{\partial C}{\partial t} + \frac{\partial uC}{\partial x} + \frac{\partial vC}{\partial y} = \text{div}(\mu \cdot \text{grad}C) + \sum_{i=1}^N Q_i(t)\delta(x-x_i)\delta(y-y_i), \quad (5)$$

де C – значення концентрації водяної пари в атмосферному повітрі; u, v – компоненти вектору швидкості повітряного потоку; x_i, y_i – декартові координати i -ого точкового джерела емісії пилу; t – час; μ_x, μ_y – коефіцієнти турбулентної дифузії; $\delta(x-x_i)\delta(y-y_i)$ – дельта-функція Дірака, за допомогою якої в моделі задається місце виходу водяної пари від поверхні вугілля. Інтенсивність випаровування води з поверхні, що піддається зрошуванню, дорівнює Q .

Значення параметра Q визначається на базі емпіричної моделі (Мацак В. Г.):

$$Q = (5,83 + 4,1V)P_n \sqrt{M},$$

де V – швидкість повітряного потоку; P_n – тиск насичених парів; M – молекулярна маса води.

Крайові умови для рівняння масопереносу (5) розглянуті в [1, 2].

Побудова чисельної моделі масопереносу заснована на розщепленні рівняння (5) наступним чином:

$$\frac{\partial C}{\partial t} + \frac{\partial uC}{\partial x} + \frac{\partial vC}{\partial y} = 0, \quad (6)$$

$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x} \left(\mu_x \frac{\partial C}{\partial x} \right) + \frac{\partial}{\partial y} \left(\mu_y \frac{\partial C}{\partial y} \right), \quad (7)$$

$$\frac{\partial C}{\partial t} = Q_i \delta(x-x_i) \delta(y-y_i). \quad (8)$$

Принцип побудови кінцево-різницевої схеми чисельного інтегрування рівняння переносу (6) розглянемо на прикладі аналогу рівняння (6) – на рівнянні переносу:

$$\frac{\partial C}{\partial t} + a \frac{\partial C}{\partial x} = 0, \quad (9)$$

де $a > 0$.

Представимо функцію $C(x, t)$, значення якої необхідно визначити на новому часовому кроці t^{n+1} , так (М. М. Беляєв, В. К. Хрущ):

$$C(x, t^{n+1}) = C(x, t^n) + VC(x, t),$$

де $C(x, t^n)$ – відоме значення функції C на часовому кроці t^n ; $VC(x, t)$ – невідомий приріст функції C .

Тоді, рівняння переносу (9) можна записати у вигляді:

$$\frac{\partial VC}{\partial t} + a \frac{\partial VC}{\partial x} = -a \frac{\partial C^n}{\partial x}. \quad (10)$$

В різницевому вигляді (10) можна записати так:

$$\frac{VC_i^{n+1} - VC_i^n}{\Delta t} + a \frac{VC_i^{n+1} - VC_{i-1}^{n+1}}{h_x} \beta = -a \frac{C_{i+1}^n - C_{i-1}^n}{2h_x}. \quad (11)$$

Як можна бачити з (11), для апроксимації конвективної похідної VC використовується схема «проти потоку», а для апроксимації конвективної похідної для функції C – центральна апроксимація. Ця кінцево-різницева схема є абсолютно стійкою. При практичній реалізації даної різницевої схеми приймається $\beta=0,5$.

Після визначення величини VC_i^{n+1} з рівняння (11), визначається значення шуканої функції C на новому часовому кроці:

$$C_i^{n+1} = C_i^n + VC_i^{n+1}.$$

Таким же шляхом побудовано чисельну модель для інтегрування двовимірного рівняння масопереносу.

Для чисельного інтегрування рівняння (7) використовується схема А. А. Самарського. Для чисельного інтегрування рівняння (8) використовується метод Ейлера.

Для програмування побудованої чисельної моделі використовувався FORTRAN.

Висновки

1. Наведено результати фізичного експерименту по дослідженню динаміки зміни вологості вугілля при різних швидкості повітряного потоку.

2. Отримано емпіричну модель, що дає можливість визначати зміну вологості вугілля при різних швидкості повітряного потоку.

3. Побудована емпірична модель може бути використана для експрес оцінювання вологості вугілля для розробки регламенту зрошування пилоутворюючої поверхні.

4. Побудовано чисельну модель масопереносу для визначення концентраційного поля водяної пари при зрошуванні пилоутворюючої поверхні.

5. Подальший розвиток даного напрямку буде проводитися шляхом розробки тривимірних моделей масопереносу при пилоутворенні.

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MATERIALS SCIENCE AND MECHANICS OF MACHINES

ИССЛЕДОВАНИЕ ВЛИЯНИЯ РЕЖИМА ТЕРМОЦИКЛИРОВАНИЯ НА СТРУКТУРУ И СВОЙСТВА КОМПОЗИЦИОННОГО МАТЕРИАЛА НА ОСНОВЕ БАЗАЛЬТОВОГО ВОЛОКНА

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г. Минск*

STUDY OF INFLUENCE OF THERMAL CYCLING MODE ON STRUCTURE AND PROPERTIES OF COMPOSITE MATERIAL BASED ON BASALT FIBER

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DOI: [10.5281/zenodo.17118972](https://doi.org/10.5281/zenodo.17118972)

Аннотация

Исследовано влияние выбора режима термоциклирования на структуру и свойства композиционного материала на основе базальтового волокна без добавления и с добавлением высокодисперсного SiO_2 . Показано, что пористость и проницаемость в композиционном материале в диапазонах $800\text{ }^{\circ}\text{C} - 1050\text{ }^{\circ}\text{C}$ и $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$ остаются практически постоянными и составляют 75,6% и 76,2 %, $41,6 \cdot 10^{-12}\text{ м}^2$ и $41,8 \cdot 10^{-12}\text{ м}^2$; на основе базальтового волокна с добавлением SiO_2 в диапазоне термоциклирования $500\text{ }^{\circ}\text{C} - 770\text{ }^{\circ}\text{C}$ уменьшаются в среднем в 1,2 раза с 77,1 % до 62,4 % и с $54,9 \cdot 10^{-12}\text{ м}^2$ до $46,5 \cdot 10^{-12}\text{ м}^2$ относительно диапазона $500\text{ }^{\circ}\text{C} - 750\text{ }^{\circ}\text{C}$. Добавление к базальтовому волокну высокодисперсного SiO_2 модифицирует поверхность волокна и увеличивает предел прочности на сжатие до 15 МПа. Предел прочности на сжатие композиционного материала на основе базальтового волокна после термоциклирования в диапазоне температур $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$ составляет 8 МПа.

Abstract

The effect of thermal cycling mode selection on the structure and properties of the basalt fiber composite without addition and with addition of finely dispersed SiO_2 was investigated. It is shown that porosity and permeability in the composite material in the ranges of $800\text{ }^{\circ}\text{C} - 1050\text{ }^{\circ}\text{C}$ and $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$ remain practically constant and amount to 75.6% and 76.2%, $41.6 \cdot 10^{-12}\text{ m}^2$ and $41,8 \cdot 10^{-12}\text{ m}^2$; based on basalt fibre with addition of SiO_2 in the range of $500\text{ }^{\circ}\text{C} - 770\text{ }^{\circ}\text{C}$ - decrease on average 1.2 times from 77.1% to 62.4% and from $54.9 \cdot 10^{-12}\text{ m}^2$ to $46.5 \cdot 10^{-12}\text{ m}^2$ relative to the range of $500\text{ }^{\circ}\text{C} - 750\text{ }^{\circ}\text{C}$. The addition of highly dispersed SiO_2 to the basalt fiber modifies the surface of the fiber and increases the compressive strength to 15 MPa. Compression strength of composite material based on basalt fibre after thermal cycling in temperature range $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$ is 8 MPa.

Ключевые слова: композиционный материал, базальт, структура, свойства, пористость, проницаемость, термоциклирование.

Keywords: composite material, basalt, structure, properties, porosity, permeability, thermal cycling.

Введение

Уровень современной техники требует все более широкого применения различных средств и способов, улучшающих качество пористых материалов. Необходимо создавать такие материалы, которые способны противостоять гидравлическим или пневматическим ударам, неизбежно возникающим при резком изменении давления в режиме регенерации обратной промывкой или продувкой. Для расширения области применения пористых керамических композиционных материалов (КМ) стоит задача существенного повышения проницаемости при сохранении достаточной прочности [1 – 3]. Керамика на основе дисперсных волокон характеризуется малым удельным весом в сочетании с повышенной прочностью, теплопроводностью,

устойчивостью относительно тепловых ударов. Создание КМ на основе базальтовых волокон к указанным выше преимуществам добавит и увеличение коэффициента проницаемости. Однако, ассортимент волокон, пригодных для создания технологически прочной керамики, ограничен свойствами исходного материала. При производстве базальтовых волокон в качестве сырья используются горные породы, химический состав которых близок по составу к алюмосиликатным порошкам и содержит (по массе): 45 – 55 % SiO_2 ; 10 – 20 % Al_2O_3 и до 20 % $\text{FeO} + \text{Fe}_2\text{O}_3$ и MgO . Как было ранее доказано, спекание подобной композиции происходит с участием жидкой фазы [2 – 4].

Основным направлением, позволяющим значительно улучшить характеристики и, следова-

тельно, повысить конкурентоспособность керамических изделий, является создание композиционных материалов с разнофазной структурой. Исследование закономерностей формирования структуры и физико-механических свойств КМ на основе базальтовых волокон и разработка научно-практических рекомендаций по получению заданных свойств композиций на основе базальтовых волокон путем сравнительного анализа их структурно-фазового состояния, полученного при различных технологических режимах, является актуальной задачей. Разработка научно-практических рекомендаций по получению заданных свойств КМ на основе базальтовых волокон путем сравнительного анализа их структурно-фазового состояния является научной новизной работы.[5 – 7].

Целью работы является исследование влияния выбора режима термоциклирования на структуру и свойства композиций на основе базальтового волокна.

Методы и принципы исследования.

Исследования выполнялись в Испытательном Центре Института порошковой металлургии имени академика О.В. Романа Национальной Академии наук Беларуси.

Объектами исследования влияния выбора режима термоциклирования на структуру и свойства являлись образцы КМ на основе базальтового волокна без добавления и с добавлением высокодисперсного SiO_2 , спрессованные при давлении 4 МПа. Добавление высокодисперсного SiO_2 осуществлялось для повышения прочности и устойчивости к разрушению КМ за счет модифицирования поверхности волокна, т.к. одним из основных его недостатков является *низкая адгезия* с матрицей КМ.

Составы КМ, диапазоны термоциклирования и время выдержки при термоциклировании представлены в табл. 1.

Таблица 1

Составы КМ на основе базальтового волокна и диапазон термоциклирования

Состав КМ, мас. %	Давление прессования, МПа	Диапазоны термоциклирования, °C	Количество циклов/время выдержки, мин
Базальтовое волокно – 88, пластификатор – 12	4	800 – 1050	3/15
		800 – 1080	
Базальтовое волокно – 63, SiO_2 – 25, пластификатор – 12	4	500 – 750	3/15
		500 – 770	

Режимы термоциклирования в виде графиков приведены на рис. 1, 2.

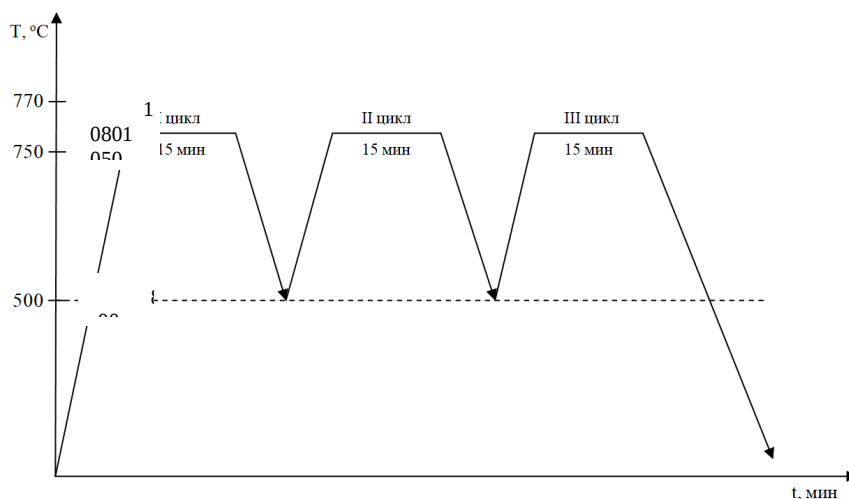


Рис.1. Режим термоциклирования в виде графика в температурных диапазонах 800 °C – 1050 °C и 800 °C – 1080 °C для КМ на основе 88 % базальтового волокна с 12 % пластификатора

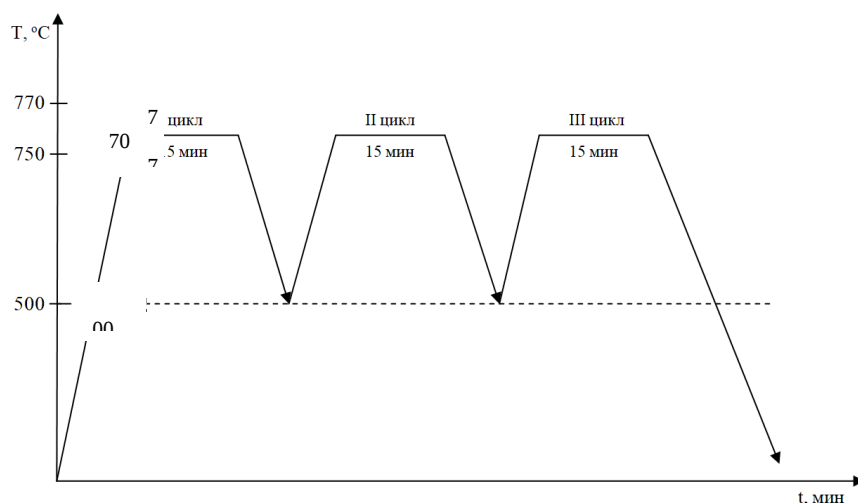


Рис. 2. Режим термоциклирования в виде графика в температурных диапазонах 500 °C – 750 °C и 500 °C – 770 °C для КМ на основе 63 % базальтового волокна с 25 % высокодисперсного SiO_2 и 12 % пластификатора

Термоциклирование проводилось с целью повышения прочности композиций за счет формирования фазового состава, сохранения части аморфного состояния волокна и порового пространства, снятия микронапряжений. Температурные интервалы термоциклирования в диапазонах 800 °C – 1050 °C и 800 °C – 1080 °C для КМ на основе базальтового волокна выбирались на основании ранее полученных результатов. Было установлено, что в данных диапазонах температур происходит формирование фазы железно-магниевого шпинели (Mg,Fe) $_3\text{O}_4$. При этом также начинают кристаллизоваться фазы, характерные для кристаллического базальта: авгит $\text{Ca(Mg,Fe)Si}_2\text{O}_6$, анортит $\text{CaAl}_2\text{Si}_2\text{O}_8$ и прочие минералы. Важно отметить, что интенсивное окисление Fe^{2+} до Fe^{3+} ускоряет процесс кристаллизации базальтового волокна при повышенных температурах. Термоциклирование увеличивает количество кристаллической фазы, повышая прочность. Охлаждение при термоциклах до 800 °C не позволяет полностью заполнить поровое пространство жидкой фазой [5, 6]. Температурные диапазоны термоциклирования 500 °C – 750 °C и 500 °C – 770 °C для базальтового волокна с добавлением высокодисперсного SiO_2 выбирались, исходя из термограмм на основе алюмосиликатов с модифицирующими добавками высокодисперсного SiO_2 . В данном диапазоне температур происходит образование жидкой эвтектической фазы силлиманита

($\text{Al}_2\text{O}_5\text{Si}$), которая участвует в образовании контактов при спекании композитов [6, 7]. Термоциклирование увеличивает ее количество, повышая прочность. Охлаждение при термоциклах до 500 °C не позволяет заполнить поровое пространство жидкой фазой и сохраняет аморфность [7].

Морфологический анализ поверхности КМ осуществлялся на сканирующем электронном микроскопе высокого разрешения «Mira» фирмы «Tescan» (Чехия). Определение степени аморфности выполнялось методом рентгеноструктурного анализа на рентгеновском дифрактометре Ultima IV (Rigaku) в $\text{CuK}\alpha$ -излучении. Испытание на сжатие проводилось на универсальной испытательной машине «Tinius Olsen H150K-U» (Англия) с погрешность измерения 1 %. Пористость и проницаемость определялись на автоматизированном порометре капиллярных потоков Porolux 500 по исследованию порошковых материалов газодинамическим методом, общая пористость – методом гидростатического взвешивания.

Результаты исследования

Морфология поверхности КМ на основе 88 % базальтового волокна с 12 % пластификатора после прессования при давлении 4 МПа и проведения трех термоциклов в диапазонах температур 800 °C – 1050 °C и 800 °C – 1080 °C приведена на рис. 3.

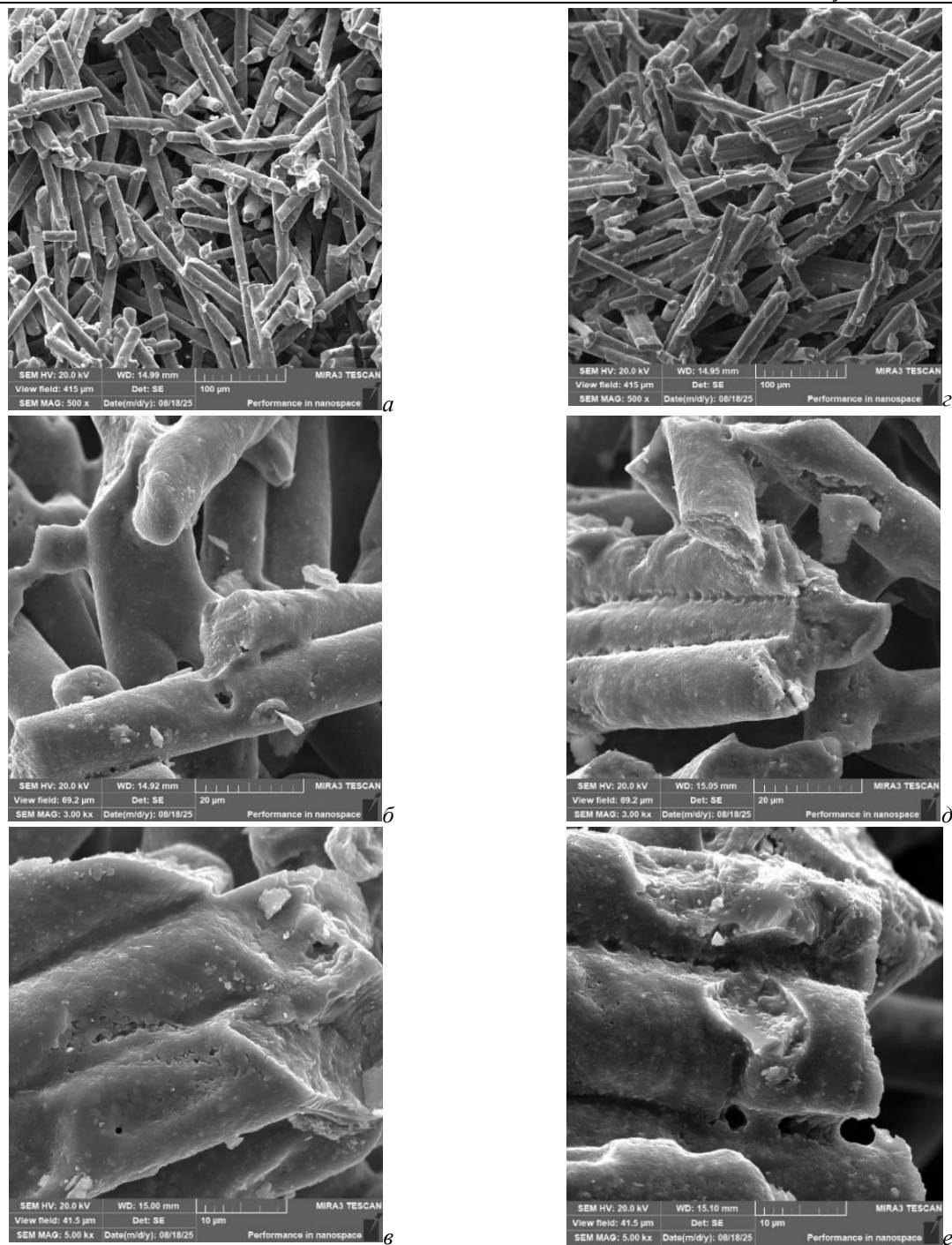


Рис. 3.

Морфология поверхности КМ на основе 88 % базальтового волокна с 12 % пластификатора после прессования при давлении 4 МПа и трех термоциклов: а – в – 800 °С – 1050 °С; з – е – 800 °С – 1080 °С

Морфология поверхности КМ на основе 63 % базальтового волокна, модифицированного добавкой 25 % высокодисперсного SiO₂ и 12 % пластификатора после прессования при давлении 4 МПа и проведения трех термоциклов в диапазонах 500 °С – 750 °С и 500 °С – 770 °С приведена на рис.4.

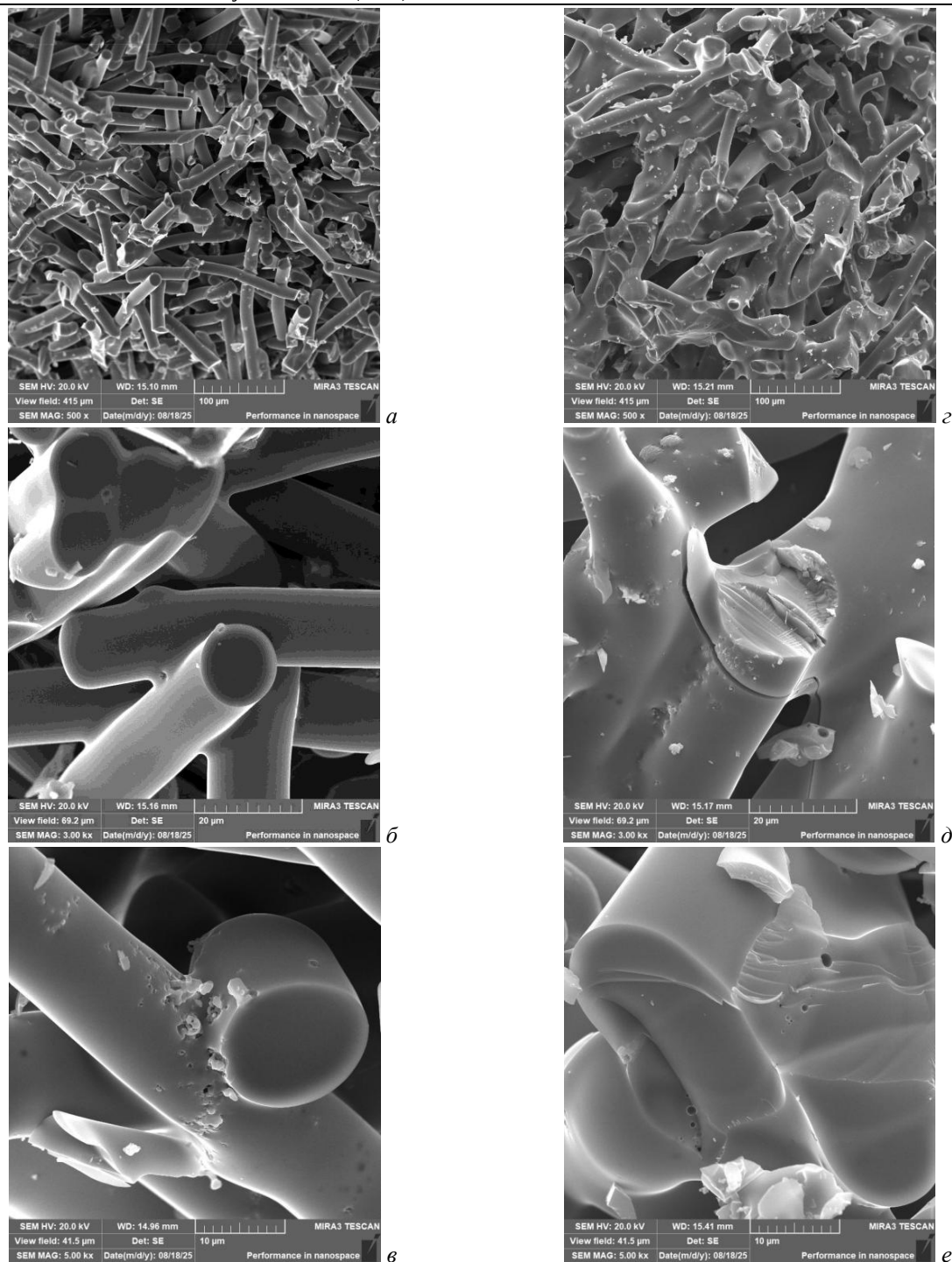


Рис. 4. Морфология поверхности КМ на основе 63 % базальтового волокна с 25 % высокодисперсного SiO_2 и 12 % пластификатора после прессования при давлении 4 МПа и трех термоциклов: а – в – 500 °C – 750 °C; з – е – 500 °C – 770 °C

Морфологический анализ поверхности КМ показал, что проведение трех термоциклов в диапазонах температур 800 °C – 1050 °C и 800 °C – 1080 °C не нарушает поровое пространство КМ (рис. 3). Наблюдается жидкофазное спекание КМ с образованием на поверхности базальтового волокна эвтектических фаз, участвующих в контактообразовании и повышающих прочность. Поры остаются открытыми, незаполненными жидкой фазой. При нагреве до 1080 °C происходит более интенсивное контактообразование между волокнами по сравнению с нагревом до 1050 °C. Поверхность волокон становится кристаллической, т. е. теряет «гладкость», аморфность (рис. 5 а, б).

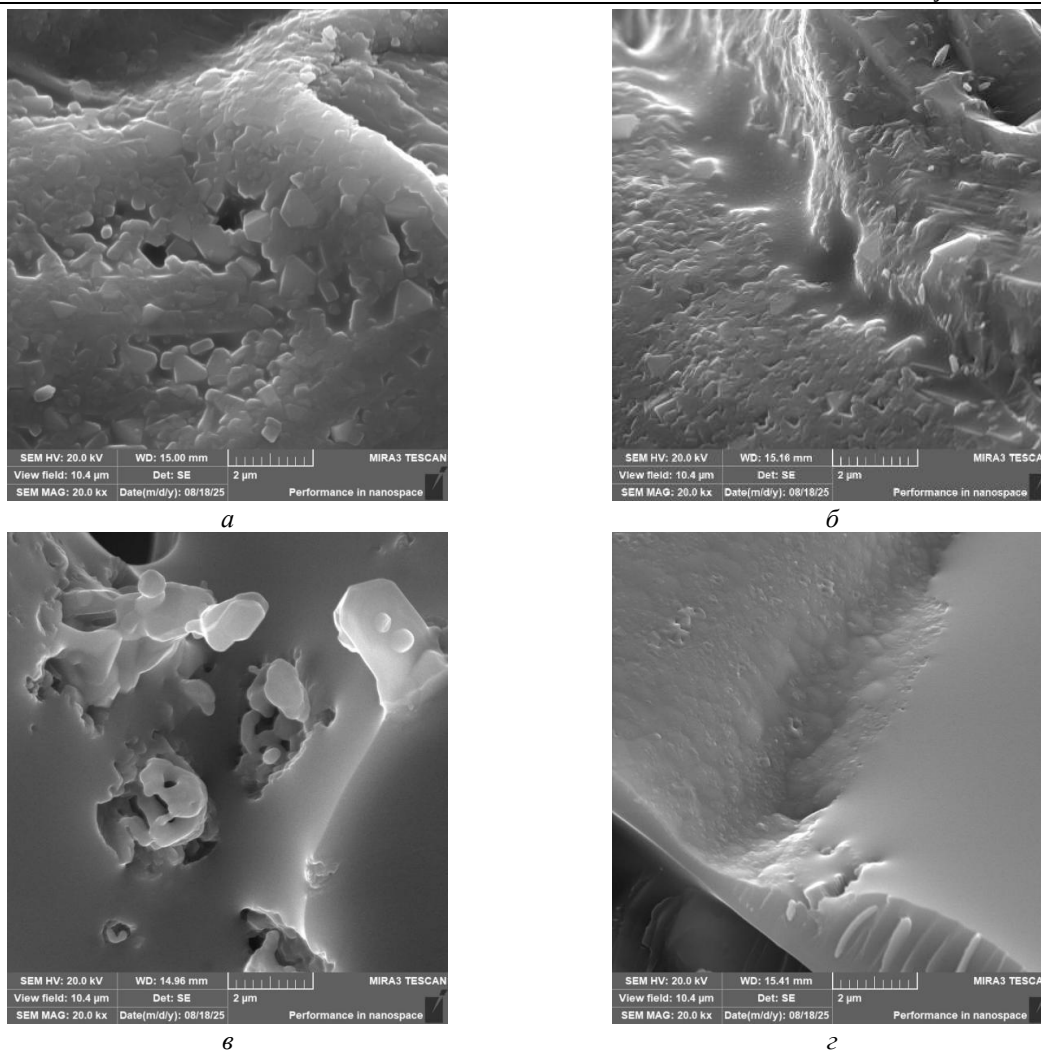
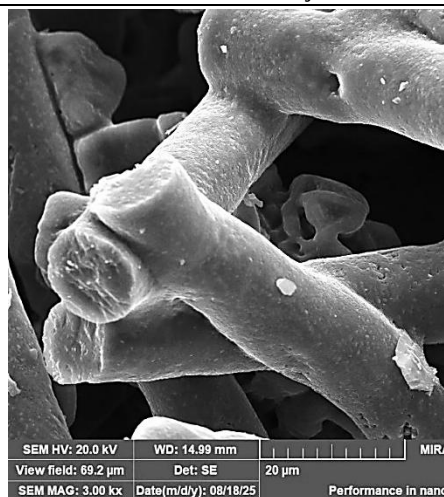
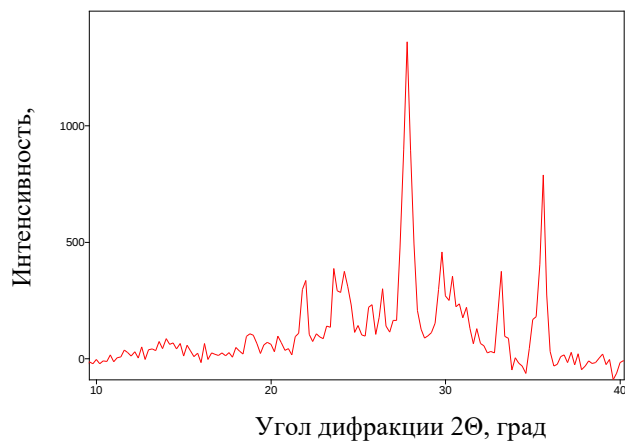


Рис. 5. Контактообразование между волокнами базальта (а, б) и волокнами базальта с высокодисперсным SiO_2 (в, г) после трех термоциклов: а – $800^\circ\text{C} - 1050^\circ\text{C}$; б – $800^\circ\text{C} - 1080^\circ\text{C}$; в – $500^\circ\text{C} - 750^\circ\text{C}$; г – $500^\circ\text{C} - 770^\circ\text{C}$;

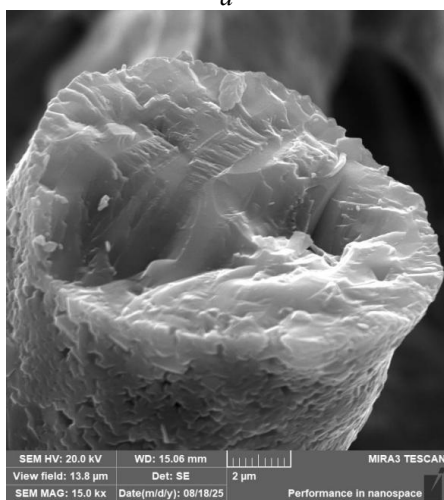
Проведение трех термоциклов в диапазонах $500^\circ\text{C} - 750^\circ\text{C}$ и $500^\circ\text{C} - 770^\circ\text{C}$ в КМ на основе базальтового волокна с высокодисперсным SiO_2 практически не нарушает поровое пространство КМ (рис. 4). При нагреве до 770°C происходит небольшое уменьшение размера пор, за счет образования большего количества жидкофазной эвтектической фазы силлиманита ($\text{Al}_2\text{O}_3\text{Si}$) по сравнению с нагревом до 750°C и более интенсивное контактообразование. Поверхность волокон остается гладкой (рис. 5 в, г). Структура и рентгенограмма КМ на основе базальтового волокна после трех термоциклов в диапазонах $800^\circ\text{C} - 1050^\circ\text{C}$ и $800^\circ\text{C} - 1080^\circ\text{C}$ представлены на рис. 6.



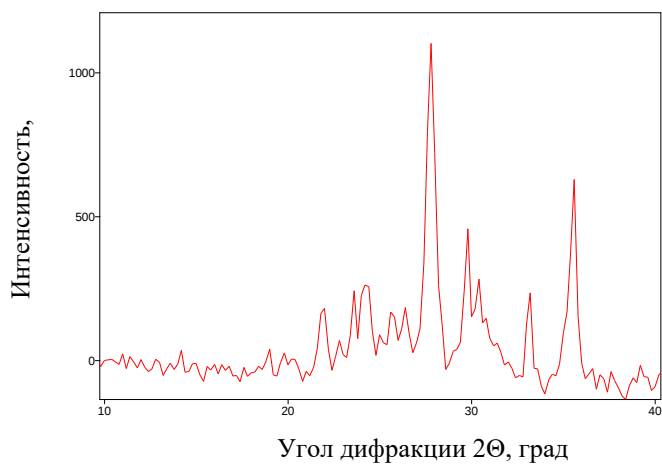
a



б



в



г

Рис. 6. Структура и рентгенограммы КМ на основе базальтового волокна после трех термоциклов: а, б – $800\text{ }^{\circ}\text{C} - 1050\text{ }^{\circ}\text{C}$; в, г – $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$

Определено, что проведение трех термоциклов в диапазоне $800\text{ }^{\circ}\text{C} - 1050\text{ }^{\circ}\text{C}$ приводит к снижению аморфности до 10 %, в диапазоне $800\text{ }^{\circ}\text{C} - 1080\text{ }^{\circ}\text{C}$ до 3 %, рис. 6. Структура и рентгенограммы КМ на основе базальта с высокодисперсным SiO_2 после трех термоциклов в диапазонах температур $500\text{ }^{\circ}\text{C} - 750\text{ }^{\circ}\text{C}$ и $500\text{ }^{\circ}\text{C} - 770\text{ }^{\circ}\text{C}$ приведены на рис. 7.

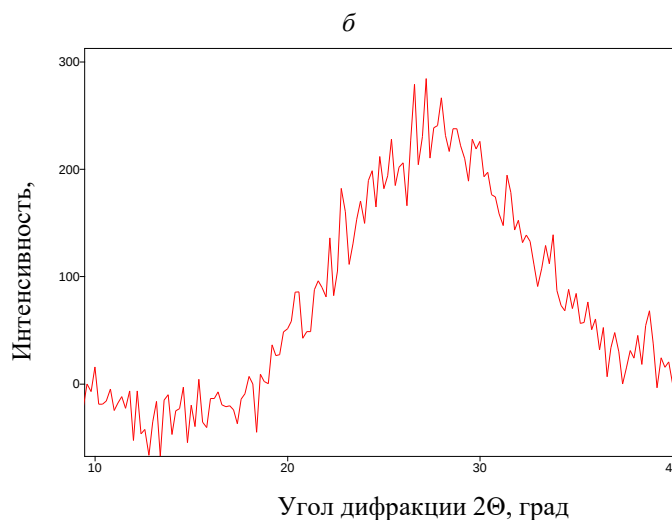
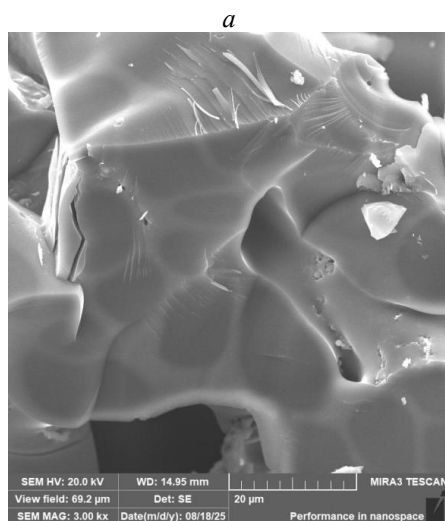
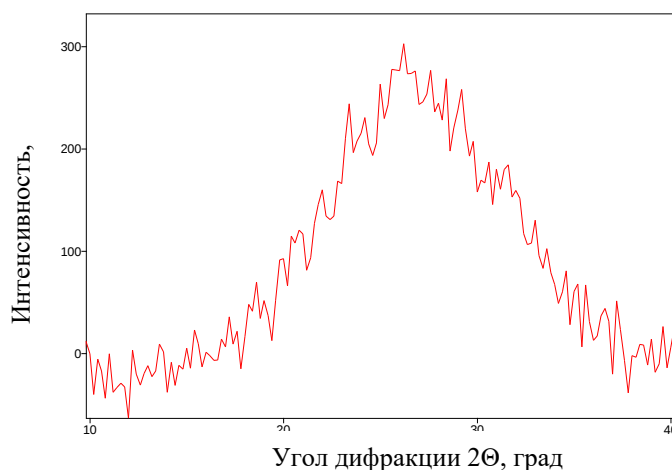
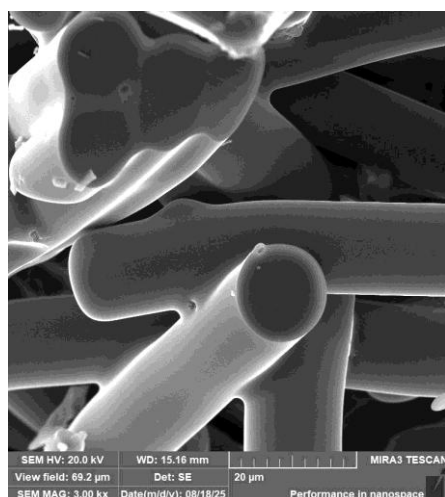


Рис. 7. Структура и рентгенограммы КМ на основе базальта с высокодисперсным SiO_2 после трех термоциклов: а, б – 500 °С – 750 °С; в, г – 500 °С – 770 °С

Исследовано, что проведение трех термоциклов в диапазонах 500 °С – 750 °С и 500 °С – 770 °С в КМ на основе базальта с высокодисперсным SiO_2 показало, что добавление высокодисперсного SiO_2 модифицирует волокно, блокируя его кристаллизацию. В образцах наблюдается 100 % аморфность.

Максимальный, средний размер пор, общая пористость, газовая проницаемость представлены в табл. 2.

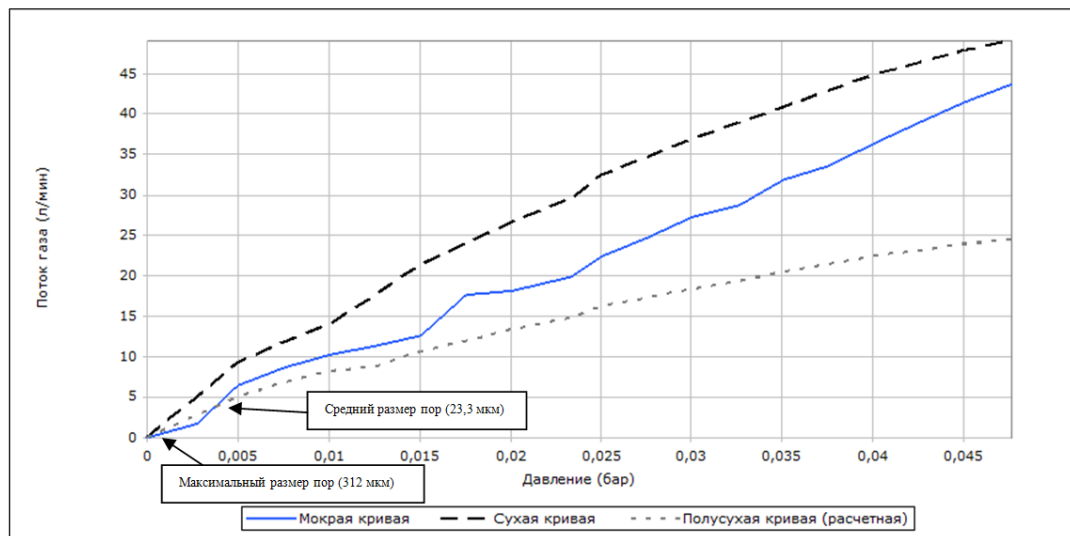
Таблица 2

Максимальный, средний размер пор, общая пористость, газовая проницаемость

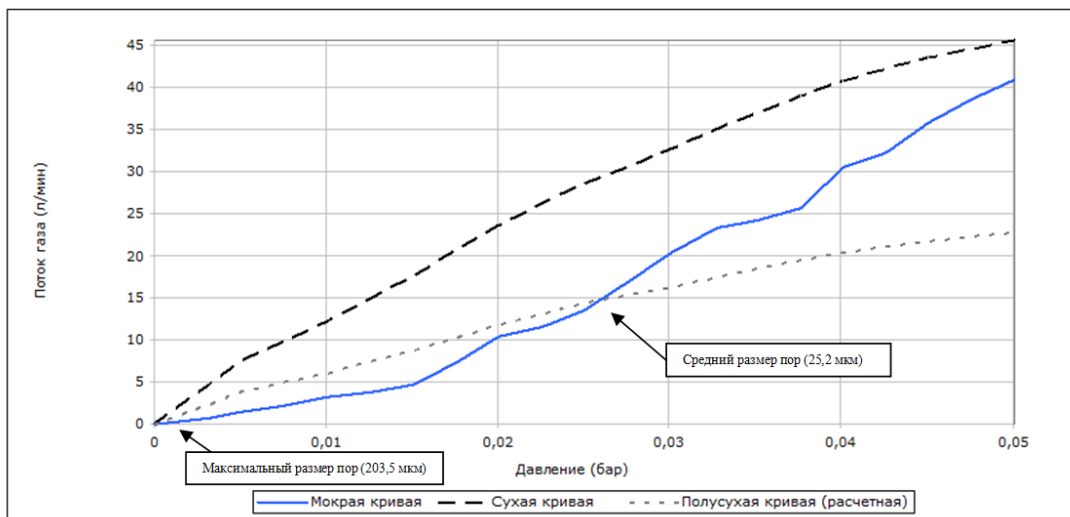
Наименование КМ	Диапазон термоциклирования, °С	Размер пор, мкм		Газовая проницаемость при 0,1 бар, 10^{-12} м^2	Пористость %
		Максимальный	Средний (расчетный)		
Базальтовое волокно	800-1050	312,0	23,3	41,6	76,2
Базальтовое волокно	800-1080	203,5	25,2	41,8	75,6
Базальтовое волокно с SiO_2	500-750	377,0	67,1	54,9	77,1
Базальтовое волокно с SiO_2	500-770	239,0	45,1	46,5	62,4

Порометрический анализ показал, что пористость и проницаемость в КМ на основе базальтового волокна в диапазонах 800 °С – 1050 °С и 800 °С – 1080 °С остается практически постоянной и составляет 75,6

% и 76,2 %; $41,6 \cdot 10^{-12} \text{ м}^2$ и $41,8 \cdot 10^{-12} \text{ м}^2$. В КМ на основе базальтового волокна с добавлением SiO_2 в диапазоне термоциклирования $500^\circ\text{C} - 770^\circ\text{C}$ происходит уменьшение в среднем в 1,2 раза с 77,1 % до 62,4 % общей пористости и проницаемости с $54,9 \cdot 10^{-12} \text{ м}^2$ до $46,5 \cdot 10^{-12} \text{ м}^2$ относительно диапазона $500^\circ\text{C} - 750^\circ\text{C}$. Порометрические кривые определения размера пор в КМ на основе базальтового волокна и с добавкой к волокну SiO_2 после трех термоциклов приведены на рис. 8, 9.

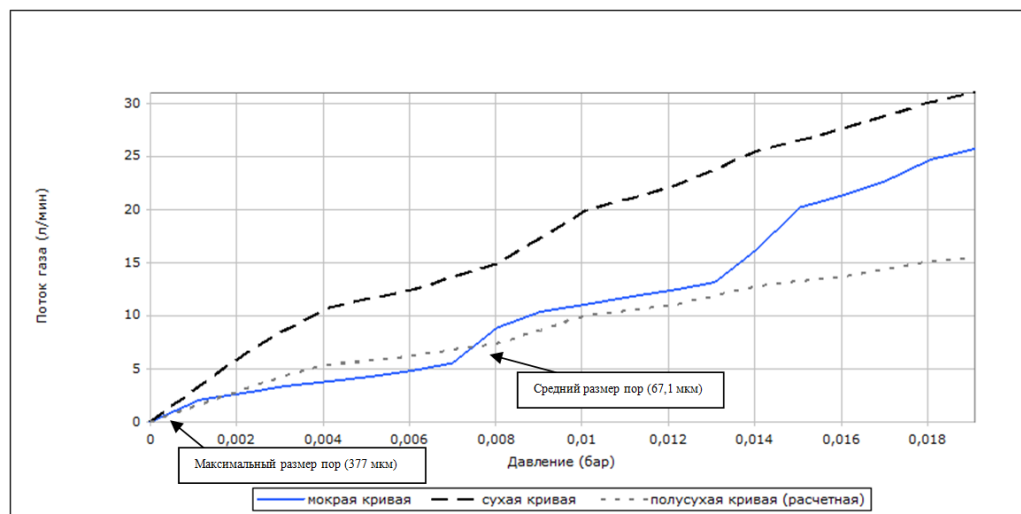


а

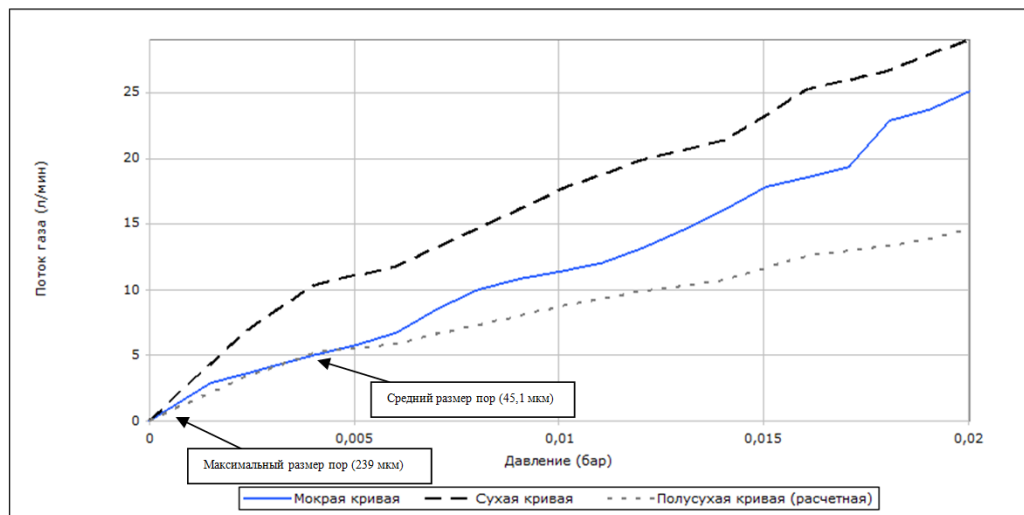


б

Рис. 8. Порометрические кривые определения размера пор в КМ на основе базальтового волокна после трех термоциклов: а – $800^\circ\text{C} - 1050^\circ\text{C}$; б – $800^\circ\text{C} - 1080^\circ\text{C}$



а



б

Рис. 9. Порометрические кривые определения размера пор в КМ на основе базальтового волокна с добавкой SiO_2 после трех термоциклов: а – $500^\circ\text{C} - 750^\circ\text{C}$; б – $500^\circ\text{C} - 770^\circ\text{C}$

Общий вид КМ и диаграммы сжатия образцов, спрессованных при давлении 4 МПа и термоциклированных в диапазонах $800^\circ\text{C} - 1050^\circ\text{C}$ и $800^\circ\text{C} - 1080^\circ\text{C}$ и диапазонах $500^\circ\text{C} - 750^\circ\text{C}$ и $500^\circ\text{C} - 770^\circ\text{C}$ представлены на рис. 10.



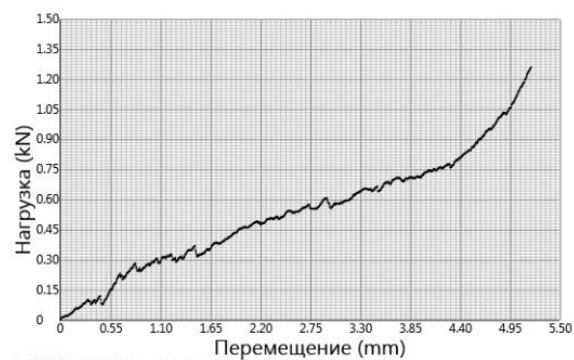
а



б



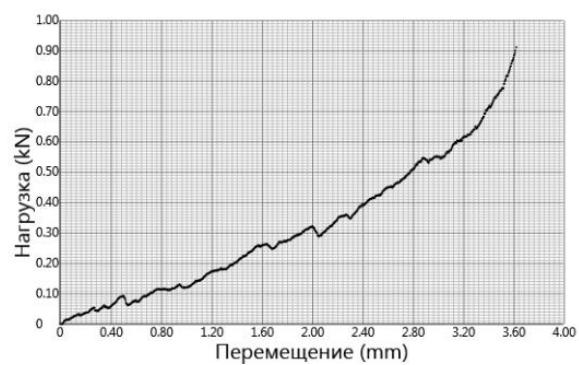
в



г



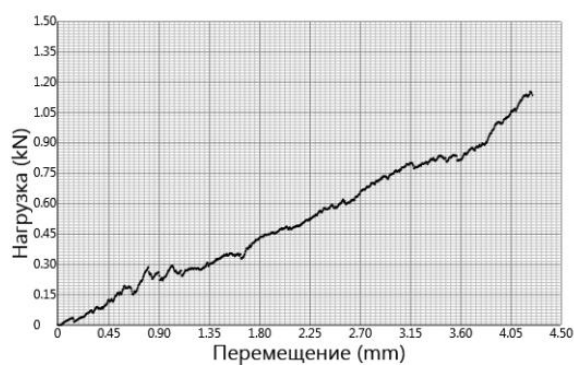
д



е



ж



и

Рис. 10. Общий вид и диаграммы сжатия КМ на основе базальтового волокна после трех термоциклов: а, б – 800 °С – 1050 °С; в, г – 800 °С – 1080 °С; д, е – 500 °С – 750 °С; ж, и – 500 °С – 770 °С; а – г – базальтовое волокно; д – и – базальтовое волокно с добавкой SiO₂

Результаты испытания на сжатие КМ после термоциклирования представлены в табл. 3.

Результаты испытания КМ на сжатие после термоциклирования

Наименование КМ	Диапазон термоциклирования, °С	Предел прочности на сжатие, МПа
Базальтовое волокно	800 – 1050	2,5
	800 – 1080	8,0
Базальтовое волокно с SiO ₂	500 – 750	7,0
	500 – 770	15,0

Определено, что диаграммы сжатия имеют «пилообразный» характер, что свидетельствует об осыпании частиц с поверхности образца при нагружении и образовании слабых связей между компонентами композиции. Предел прочности на сжатие КМ на основе базальтового волокна после термоциклирования в диапазоне температур 800 °С – 1080 °С составляет 8 МПа. Добавление к базальтовому волокну высокодисперсного SiO₂ модифицирует поверхность волокна и увеличивает предел прочности на сжатие до 15 МПа.

Заключение

Морфологический анализ поверхности КМ показал, что проведение трех термоциклов в диапазонах температур 800 °С – 1050 °С и 800 °С – 1080 °С не нарушает поровое пространство КМ. Наблюдается жидкофазное спекание КМ с образованием на поверхности базальтового волокна эвтектических фаз, участвующих в контактообразовании и повышающих прочность. Поры остаются открытыми, незаполненными жидкой фазой. При нагреве до 1080 °С происходит более интенсивное контактообразование между волокнами по сравнению с нагревом до 1050 °С. Поверхность волокон становится кристаллической, теряется «гладкость» – аморфность.

Исследовано, что проведение трех термоциклов в диапазонах 500 °С – 750 °С и 500 °С – 770 °С в КМ на основе базальтового волокна с высокодисперсным SiO₂ практически не нарушает поровое пространство КМ. При нагреве до 770 °С происходит небольшое уменьшение размера пор, за счет образования большего количества жидкофазной эвтектической фазы силлиманита (Al₂O₅Si) по сравнению с нагревом до 750 °С и более интенсивное контактообразование. Поверхность волокон остается гладкой.

Определено, что проведение трех термоциклов в диапазоне 800 °С – 1050 °С приводит к снижению аморфности до 10 %, в диапазоне 800 °С – 1080 °С – до 3 %. Проведение трех термоциклов в диапазонах 500 °С – 750 °С и 500 °С – 770 °С в КМ на основе базальта с высокодисперсным SiO₂ показало, что добавление высокодисперсного SiO₂ модифицирует волокно, блокируя его кристаллизацию. В образцах наблюдается 100 % аморфность.

Изучено, что пористость и проницаемость в КМ на основе базальтового волокна в диапазонах 800 °С – 1050 °С и 800 °С – 1080 °С остается практически постоянной и составляет 75,6% и 76,2 %; $41,6 \cdot 10^{-12} \text{ м}^2$ и $41,8 \cdot 10^{-12} \text{ м}^2$. В КМ на основе базальтового волокна с добавлением SiO₂ в диапазоне термоциклирования 500 °С – 770 °С происходит уменьшение в среднем в 1,2 раза с 77,1 % до 62,4 % общей пористости и проницаемости с $54,9 \cdot 10^{-12} \text{ м}^2$

до $46,5 \cdot 10^{-12} \text{ м}^2$ относительно диапазона 500 °С – 750 °С.

Определено, что добавление к базальтовому волокну высокодисперсного SiO₂ модифицирует поверхность волокна и увеличивает предел прочности на сжатие до 15 МПа. Предел прочности на сжатие КМ на основе базальтового волокна после термоциклирования в диапазоне температур 800 °С – 1080 °С составляет 8 МПа.

Проведенные научные исследования структуры и микромеханических свойств пористых КМ на основе базальтовых волокон, полученных по различным технологическим режимам, позволят оптимизировать режимы формирования данных материалов и создавать высокопроницаемые композиционные материалы с модифицированной поверхностью пор и структурой межчастичных контактов для очистки воздуха.

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PEDAGOGY

ТУЯК ЫРЧЫНЫН “ИСФАЙРАМ” АТТУУ ЧЫГАРМАСЫ МЕКТЕП ОКУУЧУЛАРЫН ЭСТЕТИКАЛЫК ЖАНА ЭКОЛОГИЯЛЫК ТАРБИЯЛООНУН ТААСИРДҮҮ КАРАЖАТЫ КАТАРЫ

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THE WORK OF TUYAK YRCHY ON THE THEME “ISFAYRAM” AS AN EFFECTIVE MEANS OF AESTHETIC AND ENVIRONMENTAL EDUCATION OF SCHOOLCHILDREN

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DOI: [10.5281/zenodo.17118975](https://doi.org/10.5281/zenodo.17118975)

Аннотация

Кыргызстандын түштүк-батыш чөлкөмүндө орун алган Пум, Кароол аттуу айылдарын аралап өткөн, чокусу асман тиреген бийик тоолорунун арасынан башат алган Исфайрам дарыясынын, анын жээктерин бойлото жайгашкан байманалуу элдин ырыскысына жаралган ыйык табияттын бир табери катары мүнөздөлөт.

Дарыянын акак сымал, мөлтүр тунук суусу, тээ эзелтен бери таштан-ташка урунуп, шарпылдап аккан өзгөчө уккулуктуу авазы, тигиле караганда көз жоосун алган күмүш сындуу нурлары Туяк ырчынын төкмөлүк өнөрүнүн курчушуна, шык-талантынын ачылышына түрткү, дем берген өңдөнөт. Акындын ыр саптарына сереп сала келген кезде мына ушундай түшүнүк жаралбай койбойт.

Исфайрам дайрасынын көркөмдүгүн, кооздугун, сулуулугун, калктын жашоо-тиричилигиндеги ээлеген ордун акын өзүнө мүнөздүү болгон жогорку сүрөткерлик менен таасирдүү баяндагандыгы байкалат.

Abstract

This research article examines the Isfairam River, which originates from the highest peaks of the mountain range and flows through the villages of Pum, Karool, located in the south-western region of the Kyrgyz Republic. Being a unique natural phenomenon, the river not only plays an important role in ensuring the livelihoods of the population on both its banks, but also serves as a source of aesthetic inspiration. The purity and transparency of water, the melody and timbre of its flow, comparable to silvery rays, are reflected in the artistic perception and creative understanding of the local cultural tradition, including in the works of outstanding Kyrgyz akyns, such as Tuyak yrchy. All these magical properties of Isfairam influenced, stimulated and motivated the improvement of Tuyak's skills, the skilful and virtuoso performance of his poems as a poet-improviser.

When familiarizing oneself with the content of his poetic lines, the above-mentioned thoughts and feelings cannot but appear.

The beauty and charm of the river, its place in the life of the people and in the arrangement of their way of life are sung and conveyed by Tuyak in his characteristic manner and in a special style, in a highly artistic language, which, of course, is extremely impressive.

Түйүндүү сөздөр: Туяк, Исфайрам дарыясы, Пум айылы, Кароол айылы, төкмө ырчы, жаратылыштын белеги, элдик эс тутум.

Keywords: Tuyak, Isfairam river, village Pum, village Karool, improvisational poet, gift of nature, memory of the people.

Akyn - singer-composer, poet-improviser, poet and singer among the Turkic-speaking peoples

Tuyak Ernazar uulu (1856-1912) – a well-known Kyrgyz folk singer, komuz player, and poet-thinker

... нуска сөзүң кап болсун.
Санат ырың сан болсун!
Санжыра сөзүң саз болсун.

Арстанбек Буйлаш уулу

Киришүү. Күнөстүү Кыргызстан, тилекке жараша, дарыя, өзөн сууларга бай өлкө. Алар көк асман тиреген бийик тоолордон башат алып, капчыгайлар аркылуу буркан-шаркан түшүп, күргүштөп агат. Ар бир дарыя, чоңбу же кичинеби, айтор, өзүнчө керемет, сырдуу; аны телмире караган кишинин көңүл көөдөнүн эргитип, суктантып, өзгөчөлүүлүгү менен кандайдыр кайталангыс туюм-сезимдерге кабылтат, таасирлентет. Туяк ырчынын төкмөлүк өнөрүнүн күчү менен Исфайрам тууралуу жана аны жээктей, өзөн бойлото жашаган, өмүр кечирген калктын турмуш-тиричилик жүргүзүүсүндө дарыянын ээлеген орду жана мааниси жөнүндө түшүнүк алабыз.

Изилдөөнүн методдору: теманын алкагында тиешелүү мазмунду ылгоо, окуп-үйрөнүү, талдоо, синтез, индукция, дедукция, абстракция, салыштыруу, конкреттештирүү, жалпылоо, текстти интерпретациялоо жана башка илимий таануу методдору колдонулду.

Негизги мазмун. Исфайрам элге дөөлөт, оомат, ырыскы алып келген, улуу жаратылыш берешендик менен тартуулаган дарыя экендигин, акын төмөндөгү саптар аркылуу сыпаттайт:

*Исфайрамды көрбөгөн,
Бейиш эмне билбеген [1, 12-б.].*

Ал эми:

*Алтын аккан ичинде,
Алаамат бар күчүндө.
Шыпаа болгон ар кандай
Айыкпаган бечелге.
Кимди болсо эмдеген,*

Кучак жайып кел деген [1, 12-б.] – ыр саптарында, мындай мелт-калт чайпала, буркан-шаркан түшүп аккан дайрада эң кымбат, баалуу металл – алтын сөзсүз болуш керек өңдүү жоромолдон тышкары, кыйыр мааниде, анын өзгөчөлүүлүгүн, кайталангыстыгын, касиеттүүлүгүн мүнөздөө да, ошондой эле аскасы көк асман мелжиген тоолордон агылып чыккан мөлтүр таза, тунук сууну ичкен бейтап өз оорусуна шыпаа таппай койбостугун белгилөөдө.

Октурулуп, шарпылдап аккан бул дайра ага кылдат назар салган адамга, ошончолук күч, кубат, дем бергенсйт деген элес калтырат.

Сөздүктө: **бечел** – 2. өт. Чабал, начар. О, карылык, бечел болдум, сөөгүм бар, өзүм жок (Байтемиров) [2, 223-б.].

Исфайрам эчен-эчендеген замандарды, доорлорду артка калтырып, анын айлана-төгөрөгүндө телмирген табияттын, жашаган тургундардын, элдердин санжырасын, тарых-таржымалын “ичине камтып, дээрине сиңирип”, анын табышмактуу, миң сырдуу добушу бизге кудум мына ошол өткөндөрдөн баян куруп жаткан өңдүү элес-сезимдерди жаратат.

Бул дайранын касиет даарыган суусунан жер эне азыктанып, жайыл дасторконубуздун берекесин ашырганы, көрккө бөлөгөнү, адамдын көөдөнүндө ток пейилдүүлүк жаратканы, элдин ырыскысына айланганы төмөндөгү саптарда мүнөздөлөт:

*Алма, өрүк, шабдаалы,
Жүзүм болгон Исфайрам.
Дасторконго төгүлгөн
Күзүң болгон Исфайрам.
Сүлкүлдөгөн сулуунун
Бою болгон Исфайрам [1, 13-б.].*

Асман өңүндөй көпкөк тунук аккан мындай дайраны мекенибиздеги көркөм, көрүнүктүү, берекелүү саналган аймактар Өзгөн менен Алайдан көрбөдүм делет. Бул да болсо Туяк ырчынын даана, таамай салыштыруусу.

“Авазыңды эшитип, кызыл тилим сайрасын” - деген саптарда, акын жогорку сүрөткерлик менен сенин кулакка жагымдуу дабышыңды уккан сайын менин токтоно албай безеленип сайрагым келет, мындайча айтканда менин акындык өнөрүмдүн курчушуна себеп, “шыпаа” болдуң деген ой чабыты ташталууда.

Андан ары:

*Шул тоолорду жамынып,
Сендей болуп агылып,
Өмүр өтсө канаке,*

Дабышыңдай жаңырып [1, 14-б.] аттуу саптарда, жашаган өмүрүм сендей болсо деген тилегин билдиргени, төкмөлүк өнөрүм мени кадырлаган, урматтаган элдердин оозунда айтылып, кулагында жаңырып турса, алгылыктуу, үлгүлүү жагым алардын эсинде сакталат деген өңдүү каалоо үмүтү жаткансыйт.

Жогоруда баяндалган мазмундун негизинде төмөнкү тыянактарга келүү мүмкүн.

Корутунду:

- Туяк ырчынын шык, талантынын ойгонушуна жана өнүгүшүнө Исфайрам дарыясынын тийгизген олуттуу таасирин айкындoo мүмкүн;

- дарыя аны жээктей бойлото жайгашкан элдерге, тиричилигин жүргүзгөн калктарга улуу жаратылыш тартуулаган касиеттүү жана ыйык белеги катары сыпатталат;

- Исфайрамдын бууракандап аккан шарпылдаган өзгөчөлүү дабышы ырчынын элдерге таасирдүүлүгүн арттырып, ыр саптарынын мазмунун байытып, төкмөлүк өнөрүнө дем, кубат, кайрат бергенин сүрөттөгөн сезимдерге кабылтат;

- дарыя суусунун акын сыпаттаган тунуктугу, кооздугу, көз жоосун алган көркөмдүгү, анын жээктеринде тиричилик жүргүзгөн калкка жана жаш муунга жашоосунда суудай таза, жыйнактуу, сарамжал болууга үндөгөн, башкача айтканда экологиялык тарбиянын орчундуу милдеттерин чечүүгө багытталган каражат катары маанилүү материал болуп бере алат.

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PHILOLOGY

THE DIFFERENT USES OF ARTICLES IN ENGLISH

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DOI: [10.5281/zenodo.17118980](https://doi.org/10.5281/zenodo.17118980)

Abstract

The purpose of this paper is to discuss to a number of determiners from the point of view of their semantic content and how they are employed at the level of the text. It is well known that Japanese is an articleless language. Such an explanation would help us emphasize the structure of the Noun Phrase in English, in which definiteness is mainly represented by articles so that we can find similar functions in Japanese and conclude that there are heterogenous items in articleless languages that help convey the definite interpretation. As a matter of fact, I will present a classification of definite and indefinite articles, together with their semantic referentiality at the level of the text, and then I will take into consideration other categories like demonstratives, which contain deictic information and which help rendering the definite interpretation valid in English, as well as in Japanese

Keywords: Classifiers, Japanese, Number, Plurality, Definiteness, Countability, Noun Phrases

1.2. Uses of the Articles

In terms of difference, the dichotomy *definite/indefinite* article can be illustrated through the functions they represent at the level of discourse and syntax together with their employment within the sentence. According to Huddleston&Pullum (2002), the semantic differentiation between focality and non-focality for elements in a discourse is represented by the indefinite article and is generally employed as a numeral. Definite articles have generic (32a), epiphoric (32b), and anaphoric (32c) values within clauses in English, together with specific structures (32d) (proper names, nominalized adjectives)

(32) (a). *The rooster* is a singing bird.

(b). *The window* of the hut was shut.

(c). I didn't refer to *the woman*.

(d). *The Carpathians, The Black Sea; The illiterate* etc.

Another criterion which differentiates syntactically between definite/indefinite articles is that the indefinite article is incompatible with certain modifying constituents of the English NP. Among these are *superlatives*, and determiners *only, same, first* and *next*.

1.2.1. The Indefinite Article

Singular indefinite noun phrases have several basic uses (Jacobs, 1995: 109): (33)

a. A specific entity with which the addressee is not familiar yet and the Noun Phrase does not uniquely identify it is referred to as the *specific indefinite employment of articles*

1. *Tom cut an old tree with yellow flowers.*

2. *A famous businessman helped his employees.*

b. A class of entities is usually denominated as the generic indefinite use of articles:

3. *Tom searched for a four-bedroom flat.*

4. *A fast helicopter is sought after by the Intelligence.*

c. A special case of the generic indefinite article provides a classification and is dealt with as the generic predicate noun phrase:

5. *Ginger was a tabby cat.*

6. *Bucharest is a heavily populated city.*

1.2.2. The Definite Article

English employs the definite article *the* almost in an universal manner with most NPs –singular or plural, countable or uncount (proper nouns are an exception). Speakers usually employ it when an entity identifiable by the addressee is indicated by the Noun Phrase. According to Jacobs (1995:110) there are a number of criteria by means of which an entity becomes identifiable, and, as a matter of fact, turns into a definite NP:

a. The contextual reference is a corollary of the immediate identifiable circumstance.

b. Entity or event is unique and has only a singular occurrence, at least in our known universe, e.g., *the moon, the Earth*.

c. For a number of reasons the entity is peculiar to a certain Universe:

- in the context of science, one can talk about *the mitochondria, the neutron*, etc.

- in the context of a anatomy, one can talk about *the heart, the arm*, etc.

- in the context of a school, one can talk about *the professor, the student*, etc.

- in the context of a written body of work (books, compositions etc.), one can talk about *the beginning, the middle, and the end*.

- in the context of 3D shaped objects in immediate location, one can talk about *the rear, the front, the left-hand side, the interior, the exterior*.

d. Anaphoricity which introduces an already known entity: *An elegant gentleman appeared on the scene. The jury offered him the Oscar.*

e. Superlatives describe a number of entities as unique through the employment of modifiers: *longest, most courageous, least important*, or through quantifiers designating uniqueness, such as *only* and *sole* in the *only computer* and *the sole purpose*.

f. A number of semantic determiners describe the entity as present at the time of the utterance or in proximity, e.g., *the red glove, the guy over the park*.

g. A Noun Phrase consisting of a noun designated with a specific reference and is determined by a relative, as in *the anger that he felt*.

The grammatical system of English allows the definite and indefinite article to be mutually exclusive, even though they complete each other. Their semantic roles are complementary in a clause. In (35a) anaphoricity plays a role in specifying the noun, while in (35b) the noun is not mandatory to be specified.

(35) (a) *He's the chosen.*

(b) *He's a chosen.*

The notion of definiteness encompasses a larger domain and is not restricted only to articles since its range of variation in relation to definite expressions includes other related grammatical phenomena: demonstratives, possessives, personal pronouns. Some of these are definite determiners, differing from *the* in that they combine definiteness with some other semantic content which can account by itself for the definite interpretation. We should follow Lyons' (2003) classification which suggests the existence of *simple definites/indefinites* to describe Noun Phrases with *the* or *a* (to which he ascribes the feature [+Def] or [-Def]), and complex definites/indefinites in which [+Def] is present as a consequence of, or otherwise in combination with another feature.

1.2.3. The Demonstratives

Kaplan (1989) ascribes demonstratives two roles. First, reference is highly involved in that the canonical employment of demonstratives is connected to the context (Roberts's (2002) and has extralinguistic dimension. Second, they own '*prepositional content*'. Researchers like Wolter (2003) pointed out there is not much difference between NPs and the behaviour of demonstratives. The most prominent classes of demonstratives are deictic (36a), anaphoric (36b) and explicit demonstratives (Wolter's paradigm) (36c):

(36) (a) (Pointing at Clark) That guy is intelligent.

(b) A cat_i lives upstairs. That cat_i starts meowing when owner leaves.

(c) [That hero]_i[who killed the dragon]_i[will inherit half the kingdom.]

(Wolter, 2003:2)

Emotive demonstratives are characterized by the requirement of salience since they behave like anaphors in that the entity must have already been discussed. According to Lakoff (1974) '*emotional solidarity*' with interlocutors is in their semantic content.

(37) *That* Gray Gandalf is a wise gentleman!

Some argue that demonstratives are distinguished from the definite article in that they contain a deictic element like in (37). Authors endeavored to find a selective criterion in their structure. J. Lyons (1975, 1977) and Sommerstein (1972) assume that there is a spatial implicature that distinguishes '*this*' and '*that*' from '*the*'. Anderson and Keenan (1985:67) agree on this perspective and argue that a demonstrative system with a singular item would not look much different from the employment of definite articles.

Demonstratives *this/these* and *that/those* can function as a complete NP or as a determiner in slot (c) (Heim, 1982:45). No substantial difference in meaning

can sometimes be observed when demonstratives are employed as determiners and may be substituted by the definite article.

The interpretation of definiteness in the form of demonstratives does not rely on the criterion of inclusiveness, even though most authors argue that demonstratives are generally definite in nature. What might set them apart is the actual referent might be in semantic contrast with other potential referents, since the demonstrative reference is clear or implied. (Hawkins: 1978). Identifiability is the common link between demonstratives and definite articles and the reference becomes clearly implied as in '*Give me that spell*'.

Demonstratives roll around two kinds of anaphoric function – substitution anaphora and textual anaphora, both of which are intricately explained by a number of researchers like Dixon (2003:38).

A.Substitution Anaphora: A full NP is substituted by the anaphoric NP, and the anaphoric constituent repeats it in place. More precisely, a demonstrative in slot (c), with substitution anaphoric function, might usually be replaced with the definite article:

(38) (a) He wins more money, but *that/this salary* is not sufficient.

(b) She gave birth on Monday and (on) *that morning* they argued heavily.

B.Textual Anaphora: it introduces a proposition mostly in the form of a clause or even a lengthy piece of discourse and is referred to by a NP with a demonstrative. Examples:

(39) (a) He argues excessively and *for that* (reason) Anna hates him.

(b) He doesn't exercise and *this* (behaviour) threatens Mary.

In the textual anaphoric case, the definite article may not be replaced with a demonstrative. Something larger in extent than an NP is required to be specified by a deictic determiner. Deixis comes as the main criterion linking definite articles with demonstratives (*This/(the) robe comes in handy. Whom did you sell that/(the) falt to?*).

A semantic value not peculiar to the definite article, but to the demonstrative *that* is as an intensifier with adjective or adverb (Jespersen, 1933:50) The appropriate contextual reference introduces emotional semantic content as a derogatory overtone:

(40) I hate *that* Smith John, the all knowing magician.

1.3. Conclusions of This Section

The main methods to express definiteness in English are through the employment of definite and indefinite articles and through the usage of demonstratives along with possessives. Unlike Japanese, English has the advantage that both Number is expressed through the employment of plural marker -s while Gender is not overtly expressed just like in Japanese. Definiteness can be dealt with in terms of uniqueness and familiarity as logic forms that derive from contextual reference. We bring into discussion the importance of context for English, even though it is not a necessary topic due to the presence of articles, because in Japanese the definite interpretation of a NP resides mostly on anaphoricity

and cataphoricity of the contextual reference within different clauses. This does not mean that Japanese resorts only to ambiguous processes like contextual reference, as we will see in the next chapters.

The difference between definite and indefinite interpretations for English NPs brings into discussion one of the major characteristics of English nouns, namely that they are inherently non-definite, unlike Japanese, which has been shown, through null-NPs to possess inherently definite nouns, even though the demonstration is still highly debatable in the literature. The previous observation is supported by the fact that the indefinite character of a noun in English is overtly marked, that is, through the employment of an indefinite article, which means that nouns must represent a different nature in terms of definiteness, other than that of the dichotomy definite/indefinite and that is the tertiary non-definite nature.

One argument comes from the idea that nouns in English cannot be grammatical in their lexicon status, more specifically, they cannot occur in sentences in their non-definite nature. What distinguishes *the* from *a/an* is uniqueness –the existence of an entity meeting the descriptive content of the NP. While the use of an

indefinite description in a simple, sentence merely asserts the existence of an entity, the use of a definite description asserts in addition its uniqueness in that regard. Familiarity, on the other hand, comes hand in hand with the uniqueness criterion in that it presents the entity described as part of the universe of the observer, unlike uniqueness which presents the object as part of the general universe. Unlike definiteness, which is a syntactic notion that can be demonstrated through diagrams, uniqueness and familiarity are essentially semantic and point out to the content of a noun.

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DEFINITENESS IN JAPANESE WITH PARTICLES WA/GA

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DOI: [10.5281/zenodo.17118987](https://doi.org/10.5281/zenodo.17118987)**Abstract**

The purpose of this paper is to understand that Noun Phrases in Japanese can acquire definite interpretation even in the absence of definite or indefinite articles, since the morphosyntactic structure of them allows for such specification. Even though the discussion is extremely broad, we will resume in this paragraphs to the problem of the nominal markers *wa/ga* in order to show that these two particles are a parallel mechanism that conveys definiteness in Japanese. It acts like a topicalisation marker since the semantic content that is determined by these particles becomes focused and they bring about the details about the noun they determine.

Keywords: Topicalisation, Syntax, Japanese, Particles, Definiteness, Deep-Structure, Noun Phrase, Linguistics.

Returning to definite NPs, noun phrases that refer to a particular part of a set <Specified Part> are centered on noun phrases called “pronominally used” common noun phrases (Kinsui, 1986: 479). Examples of these are noun phrases that express deictic demonstratives in the form of deictics *soko*, *koko*, *sono* etc. These demonstratives are definite and they act like adjectives for nouns in Japanese. Even though they lack number, many authors argue in their favor since such pronouns add a plus of semantic content to the noun they determine. As the Japanese language does not contain articles, definite and indefinite noun phrases must be determined through their meaning. Examples where indefinite noun phrases function as the topic in “*topics of property/situation*” are given in Section 2. However, these are special cases that are close to definite noun phrases. In Section 3, the observation that the topic can be represented by indefinite noun phrases in “*topics of existence*” is presented together with all the classifications below.

2.1. About Topic Markers Wa/Ga

Topic markers are commonly represented in Japanese by the postpositional particle *wa*. In the statement *A wa B*, *wa* creates the focus-topic relationship of “*about a, saying b*,” but the characteristics of its meaning and sentence structuring are subject to various issues and debates. Moreover, the difference between it and the subject-predicate relationship *A ga B* has also sparked many discussions, and many ask if *ga* is a *postpositional particle* as well.

This section is concerned with the restriction relating to noun phrases that function as topics. It is commonly understood that noun phrases that function as topics must be definite noun phrases (in other words, noun phrases for which the hearer can identify the referent). Li and Thompson (1976), who researched subjects and topics from a typological perspective, noted that “*one of the primary characteristics of topics is that they must be definite*,” and Japanese makes no exception from this general linguistic principle.

The existence or nonexistence of a referent for the topic-noun phrase has been under large debate by authors who question topic-statement relationship in Japanese, and the conclusion is that indefinite Japanese NPs can represent the topic in these types of sentences.

This paper is largely derived from Chapter 5 of Shoin (2006). The author classifies topics in Japanese as a by-partite system: “*topics of existence*” and “*topics of property/situation*”. The first class of elements include: attributes of existential property as in (41a) and predicates expressing states or events as in (41b). This classification is almost identical with that found in English but the key distinction is that predicates are not always existential and can be found in the form of *aru/iru* instead of *desu*.

41. a. *Chikyū- wa marui.*

*Earth- TOP**Round*

The earth is round.

b. *Tarō- wa onaka- ga suite- iru.*

Taro- TOPstomach- NOM empty

Taro is hungry.

c. *Yamada-san- wakinōkaette- kita.*

Yamada-san- TOPyesterdaycame back

Yamada-san came back yesterday.

These formulas revolve around the properties that characterize a certain entity and the kind of situations it is found in. On the other hand, “*topics of existence*” around the empirical or ideatic existence of an entity or its semantic universe:

42 *Konoatari- niyūbinkyoku wa arimasu ka?*

around here- LOCpost office- TOPexist- POL- Q

Is there a post office around here?

Since topicality includes a dual dimension which includes two entities in the form of *about X*, *we say Y*, which are mostly equivalent, they are taken as identical. However, we capitalize on the conclusions of Shoin (2006) that “*topics of property/situation*” are limited to definite noun phrases while “*topics of existence*” may include indefinite noun phrases. However, we notice the importance of a syntactic perspective on the problem of definiteness in Japanese, otherwise the arguments brought would be insufficient for our thesis. This section will show the ambiguity in differentiating between *definite noun phrases* and *indefinite noun phrases* in order to prepare the next section where we argue in favor of a syntactic view on definiteness in Japanese.

As the Japanese language does not contain articles, definite and indefinite noun phrases must be de-

terminated through their meaning. Examples where indefinite noun phrases function as the topic in “topics of property/situation” are given in the paragraphs below. However, these are special cases that are close to definite noun phrases. In the following sections, the observation that *indefinite noun phrases* are closely related to “topics of existence” and work as definite articles is presented along with the different semantic variant realizations of this issue.

We will also bring into discussion the relationship of “topics of existence” to “topics of property/situation” and to the employment of *wa* in heterogenous manners, distinct from that of topicality. There are linguistic forms distinct from *wa* for expressing topics, and examples of particles such as *nara*, *-tte* and *-toiu-no-wa* are also included in this paper.

The semantic content of such structures is heterogenous from *wa*, which, although explained in the book of Shoin (2006), are not dealt with in this paper. Not before long we will discuss about the general classification of *ga* in “topic use” and “contrastive use”, while the author only subscribes the topic marker *wa* with only a topic perspective:

43. Chikyū- *wa* marui.

earth- TOPearth- TOP

The earth is round.

44. a. Contrastive use:

Sukoshi- watabeta- *ga*, takusan- watabe- nakatta.

Presented as topic

Presented non-contrastively	Topic Use	Not presented as topic
Presented contrastively	Contrastive topic use	Simple presentational use
		Contrastive use

Topic Noun Phrases in Japanese are identifiable. This is the syntactic restriction that applies to such NPs and turns them into *definite noun phrases*. In examples (46a) and (46b), the topic noun phrases are *ano onna* (*that woman*), where the demonstrative is determined in a NP, and *otoko* (*man*), a generic noun phrase. Identifiability restriction is satisfied. However, in examples (46c) and (46d), *tairyō- no okane* (*a huge amount of money*) and *hito* (*person*) do not specify a designed determiner “money” or “person.” The independent sentence is not allowed and sound unnatural since it flaunts the identifiability restriction.

46. a. Ano onna- wadoko- eiku- no?

that person- TOPwhere- togo

Where is that woman going?

b. Otoka- *wa* tsuyoi.

snow- TOPwhite

Snow is white.

c. Tairyō- nookane- wasoko- nisute- rarete- iru.

1 huge amount- GENtrash- TOPthere- LOCthrow out- PASS

A huge amount of money is thrown out there.

d. Kaijō- nihito- waōzeitsumekaketeita.

hall- LOCpeople- TOP many crowded

Many people crowded the hall.

However, there are exceptions, where some topic sentences with unidentifiable noun phrases (“*indefinite noun phrases*”) become the topic are present:

a little- CNTRate- buta lot- CNTReat- NEG- PAST
I ate a little but I didn’t eat a lot.

b. Contrastive topic use:

Yamada-wamajimeda- *ga*, Tanaka-*wa* fumajime da.

Yamada- CNTR TOPserious - butTanaka- CNTR TOPnot serious

Yamada is serious but Tanaka is not serious.

Shoin (2006:25)

The simple presentational interpretation of *wa* is often encountered and does not represent topicality of a contrastive behavior, but plays the semantic role of describing an element that precedes the topic marker *wa* as a pure structural entity.

45. Kōnattaijō- *wa* akirameru- shika nai.

this happened now that- SIMP PRESENTgive up- no choice but

Now that this has happened, the only thing to do is to give up.

In the sentence *X wa Y*, this classification is linked together by entailment, where by stating the phrase *X wa*, the universe to be described is introduced so that a predicate of the form *Y desu* describes its logical notes, almost like the criterion of *uniqueness*. To make the previous classification more affordable, we bring forth a table dividing the “*presented as topic*” criterion into cases that are about “*existence*” and cases about “*property/situation*.”

Not presented as topic

47. Wārudokappunokaisai chūōku- nohitotachiwa terebinikugizuke- datta

World Cup- GENheld- duringmany- GENperson- PL- TOP television- DATriveted- COP- PAST

Many people were riveted to the TV during the World Cup.

48. Okyakusamanonaka- nioishasamawairasshaimasuka?

customer- HON- GENin- LOCdoctor- HON- TOPthere- HON- POL- Q

Is there a doctor among the customers?

In examples such as (47) and (48), while the identifiability restriction is not followed, the conditions differ. In the former, the topic noun phrase restriction is slightly looser than actually being identifiable. In the latter, the character of the topic differs from typical topics. While the topics of (46a), (46b) and (46c) deal with property/situation, the topic of (46d) revolves around the existence or nonexistence of *X*. Some authors argue that the identifiability restriction doesn’t apply to existential *wa*. In the following paragraphs, we will take into consideration more thoroughly the definite noun phrase and its structure focusing on understanding existential topic markers like in the previous illustrations. Moreover, the nature of topics of existence and their relationship with subjects in a sentence must also be taken into consideration.

The identifiability restriction for topic noun phrases is expressed as follows in prior research and

offers the condition for a semantic interpretation of definiteness in Japanese. Even though some accounts might differ, they all refer to focus and uniqueness:

- (49) The hearer will not comprehend the semantic content of a piece of information even if an explanation was added to it. Thus, for an established entity “X,” the hearer semantically points to “X” as a singular item, and must determine the whole set of notes for ‘X’. (Shibatani, 1978: 213)

- (50) The topical *wa* is employed for Noun Phrases where the speaker assumes that the hearer is familiar with new information. It is usually referred to as a “known definite noun phrase,” meaning that from the speaker’s point of view, the hearer knows what is being talked about. (Inoue, 1983: 32)

- (51) The conversation flow is important in rendering a Noun Phrase as atopic since it allows to identify the target being referred to along with the situation it is spoken in, common sense (Masuoka and Takubo, 1992:145)

There are questions related to how topic markers function in Japanese at the syntactic level, in the form of “a noun phrase the semantic content of which the hearer must identify,” or ‘how do we know when the universe of a noun is known to the interlocutor or not. They all relate to one mission, in other words, the problem of how *definite noun phrases* can be defined and this must be investigated thoroughly, since it is highly peculiar to Japanese. First of all, one must endeavor to find a way and characterize what defines definite and indefinite articles and what sets them apart. This paper will define and classify definite/indefinite based, for the most part, on Horiguchi’s (1995: 29-33) classification.

- (52) a. Definite noun phrases (identifiable NPs) are a group of semantic elements where the hearer is believed by the speaker to have the target of elements clearly defined and consists of the following noun phrases:
- (i) Syntagms involving a certain individual <Specified Individual>
 - (ii) Syntagms interpreting a particular set as a whole <Whole Set>
 - (iii) NPs which include a certain part of a certain set <Specified Part>
- b. Indefinite noun phrases (unidentifiable noun phrases) are noun phrases where hearer is believed by the speaker to not have the target of elements clearly defined for the hearer and consist of the following noun phrases:
- (iv) A set from a Noun Phrase with undefined elements <Unspecified Set>
 - (v) A part of a set is designated by the Noun Phrase <Unspecified Part>

Noun phrases that refer to particular individuals, or the (i) <Specified Individual> category, are demonstrative noun phrases or proper noun phrases that refer

to single individuals, such as *kono onna* (this woman), *anata* (you), or *chikyū* (Earth). Noun phrases that refer to a set as a whole, (ii) <Whole Set>, draw a syntactic line to the following examples:

- (53) Torawa atama- ni yora- nu mono.
person- TOP head- DAT depend- NEG thing
 Tigers are not what they seem from their head.
- (54) Kono ie- no teriyaki- ga ichiban oishii.
this house GEN teriyaki- NOM the most delicious
 This house’s teriyaki is the most delicious.
- (55) Soko- ni tsudotteiru shosetsukatachi- o minna- de torikakonda.
there- LOC gather writer- PL- ACC together approach
 All of them approached the writers gathered there.

Tora (tiger), *kono ie-no teriyaki* (this house’s teriyaki), and *soko-ni tsudotte-iru shosetsuka-tachi* (authors gathered there) include the set of entities as a whole. Noun Phrases are included in (53) or (54), as a generic category, while the rest obviously are not generic; for example, (55) is a non-generic phrase, but since it includes the reference to a certain set as a whole, it shares the same characteristic. Further, both instances can account for the same referent. For instance *tora* (tiger) is a <Specified Individual> but *kono ie no teriyaki* (this house’s teriyaki) is a case of unique referent where a singular item of the <Whole Set> is identified.

Apart from definite descriptions, we can argue that indefinite linearization also occur in Japanese. Noun phrases which includes categories with elements that remain non-defined <Unspecified Set>, for one, include undefined nouns such as (56):

- (56) Donnaonna- ga sukino ka
what kind woman- NOM like
 What kind of woman do you like?
- These words are regarded as indeterminates and they are marked for singularity in Japanese, and, as a matter of fact, should be considered markers of definiteness in Japanese, together with plural suffixes and nominalizations, since they syntactically add new information.

2.2. Conclusions of This Section

The semantic interpretation of definiteness in Japanese can be related to the notions of uniqueness and familiarity we often encounter in English. However, the problem is much diversified and the opinions divergent. All the examples presented in this section are the direct result of the assumption that topic phrases in Japanese must be analyzed as definite, but, in the case of existence topics, there are some exceptions as demonstrated above, and we consider these exceptions as clear tokens of the frailty of presenting definiteness in Japanese as a pure semantic process.

We presented three definitions pertaining to Shibatani (1978: 213), Inoue (1983: 32), Masuoka & Takubo (1992:145) regarding the semantic interpretation of definiteness in Japanese, but in our opinion, they are all insufficient in that they either present parts of the problem or stake or they contain syntactic elements

like in the case of Inoue, who brings into discussion the presence of the topical particle *wa*. Shibatani also brings into discussion psychological criteria by moving the focus on the hearer itself, while Masuoka&Takubo relate to the common contextual reference the core of which can be summarized to anaphoricity or cataphoricity. It must be noted, however, that, as shown in the examples regarding dictionary definitions, the particle *wa* can also be ambiguous between definite or indefinite readings because, as presented in the case of English, the focus is totally different, while verbs are different, but in Japanese topical *wa* is always employed not taking into consideration the status of the sentence, be it declarative or informational etc.

Some authors like Niwa (2013) observe themselves the limits of a semantic interpretation of definiteness by quoting authors like Haroguchi (1995), but their analysis continues in the line of semantics, citing these limits as mere exceptions, and not as hints pointing out that such a semantic overview cannot be acceptable at all. Kinsui (1986) treats the problem of definiteness by bringing into discussion a third category, namely that of generics, but he does not take into consideration that such an approach is quite limited, because, unlike English which is an article language, Japanese does not have articles so all nouns

can be accounted for as generic. Sakihara (1996) makes the matter the issue even more intricate because he talks about bare nouns and that these lexemes have the functions of definite and indefinite articles and their interpretation relies on the information that the speaker brings, but this is merely a case of contextual reference and insufficiently determined notions, because, we cannot talk about bare nouns in a language without articles.

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DOI: [10.5281/zenodo.17118996](https://doi.org/10.5281/zenodo.17118996)**Abstract**

The purpose of this article to bring into discussion the features of Noun Phrases in Japanese since definiteness is ultimately influenced by the morphosyntactic and morphologic phenomenology at a deep level. As we know, features are generally of three categories, privative, binary and attributive, with the latter containing more than one feature. Here we will resort only to emphasize a few characteristics of the system. Features have gained increasing importance within theories of syntax and morphology in Japanese. This was obtained in two different manners. As theories try to capture ever more subtle distinctions, the features involved become more fine-grained and the noun phrases allow for more possible combinations.

Keywords: Determiners Japanese, Particles, Lexicality, Topic Definiteness, Ono, Shibatani.

4. The Features System of Noun Phrases in Japanese

In this chapter we will analyze the structure and features of the NP which is remarkable in that it shows a large cross linguistic variation, since these characteristics contribute to the rendition of definiteness as a valid concept for both English and Japanese. As a matter of fact, the widespread and complex multiple faceted body of theories allows us to draw important conclusions with regard to the interpretation of definiteness with semantic and morphosyntactic arguments. This chapter aims to describe definiteness by taking into consideration the features and structure of the lower noun phrase. The semantics, morphology, syntax and phonology interact with each other by means of a featural system in order to turn the process of definiteness into a syntactically driven phenomenon that acts on its own.

This section is a summarized investigation into the behaviour of the features that exist, at least in Japanese, in the lower branches of the nominal projection, namely at the lexical level. The term feature is employed along the chapter to encode a minimal distinction between linguistic units that individually represent a certain relevant property for definiteness. For example, if we look closer at privative features, we can imagine words share the same linguistic behaviour with exception for one property that cannot be further divided and which becomes eloquent.

Definite or indefinite features are structured in a two-fold classification: (i) what is the internal structure of a feature and (ii) how can larger structures can be obtained by adjoining features? Our purposal in this section is to assume that definiteness is syntactically determined at a deeper level and a bundle of features represent the tractioning wheels behind the linguistic mechanism. We evidently only resume discussing what we can achieve as simplest possible in this thesis (with privative and binary features) without deepening the discussion further with increased complexity (e.g. Lexical Functional Grammar), evaluating them on the ground of the already discussed system of Borer's minimalist program.

4.1. Features in Japanese

Features in Japanese have been primarily described by Unoue (1978) who tried to borrow early transformational rules that applied directly to English morphemes

(such as those proposed by Postal (1966) to capture determiner-noun agreement) and frame them on the peculiarities of Japanese. According to him, a NP starts out as in Unoue (1978:49)

1. [NP[Bareun]]
[Noun[Stemalumn]][PARTICLE][Nominative/Dative]]

The above structure arises as a result of Japanese not having overt means for Gender and Number expressions. Nonetheless, particles are employed to modify a noun. For example, an obligatory transformational rule applies to mark the nominal suffix *-er* to the determiner in (2) and (3) when nominalization occurs in theses structure:

2. Hon o yomu shigoto no hito.
N. book Part. Acc. Vb. Read N. work Part. Nom N. person

A person whose activity is to read. (a student)

3. Ryori o suru shigoto no onna.
N. meal Part. Acc. Vb. do N. work Part. Nom N. person

A woman whose activity is to cook. (housewife)

This nominalizing process is highly characteristic to Japanese and it compensates for the lack of Gender and Number markers that English exhibits. Unoue (1978:54) then offers the following structure in order to argue for the syntactic grammaticality of the aforementioned examples:

4.
[NP[Determinerun[PART.[ACCUSATIVE]]][Verb[Stemalumn][Noun[PART.[NOMINATIVE]]]
HEAD Noun]]]

Following Chomsky (1965), who made a number of transformational rules more abstract, replacing the morphemes with abstract featural content, Shibuya (1982) proposes another system of features for Japanese in which he describes the categories of Number and Gender along with Case as intrinsic features of Noun Phrases in Japanese. For this fact, nouns *'present both Gender and Number co-indexed in the syntactic structure of a Noun by means of paratactic mapping'* (Shibuya, 1982:31):

5. Shakai de takusan no tenin ga taisetsu na koto o hanashimashita

N. *conference* Part.DAT. N. *Gathering* Part. NOM.
N. *Clerk* Part. TOP Adj. *Important* N. *Thing* Part.

Many clerks tackled with important issues at the conference.

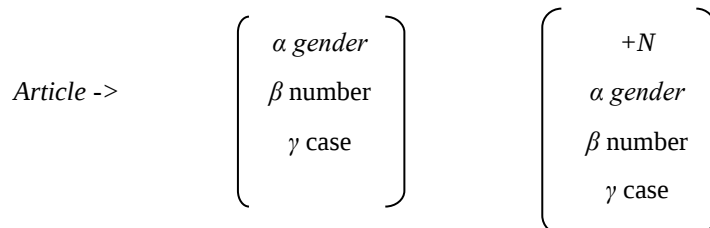
Onna mo otoko mo arimashita.

N. *women* Part. N. *men* Part. Vb. PAST *b*

There were both women and men. Shibuya 1982:58

According to the author, even though in (95) there are no overt grammatical items for Gender and Number marking or to express definiteness, the paratactic mapping introduced by Shibuya as a specialized process in Japanese helps drawing closer the grammatical specificity of Japanese to the English paradigm. In other

6.



From this point, features have gained increasing importance within theories of syntax and morphology in Japanese. This was obtained in two different manners. As theories try to capture ever more subtle distinctions, the features involved become more fine-grained. For example, some authors like Tokutsuba (1988) argue that features in Japanese must also be derived based on semantic grounds since *the vast majority of language begins with perception* (p.91).

His theory includes the analysis of so-called organisational elements in Japanese grammar by means of a semantic system of features (e.g. *cat* should not be described as [+animate] [-human] as in English, but rather *four legged vertebrate which meows*), the taxonomic reinforcement of clauses (semantic elements impose the structure of a clause and its properties), the proposal for a larger domain of features in Japanese etc. According to him, the left periphery of the clause *becomes ever more decomposed due to the different features and functional projections* which Tokutsuba (1988:14) demonstrates can act independently of each other:

7. Sensei wa heya ni doubutsu o irete wa ikenai to iimashita.

N. *teacher* Part.Nom N. *room* Part.Dat. N. *animal* Part.Acc. Vb. *Enter* Part.Nom. Vb.Neg *come* Vb. Teacher said that animals are not allowed in the room.

While the traditional English analysis of features in the previous example would usually assign binary characteristics to nouns, Tokutsuba's (1988:17) analysis proposes a larger array of properties that must be brought into discussion:

8. Sensei: [+animate] [+human] [teacher] [Japanese] [University]

Doubutsu: [+animate] [-human] [dog] [cat] [hamster] [parrot]

Heya: [-animate] [+concrete] [+utility] [Education] [University]

Tokutsuba takes into account the order of words in Japanese as a linguistic token which also assigns features to nouns and even verbs. He coins the notion of

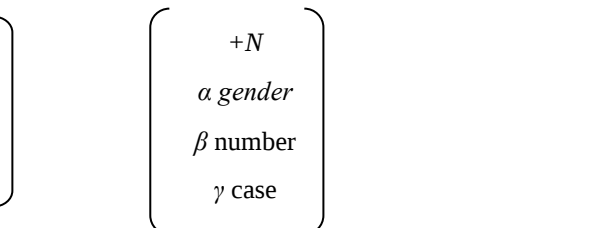
words, both Gender and Number are overtly emphasized in Japanese through:

- Pluralizing nominalization: *taksuan no tenin* (many clerks)

- Contextual Indexation of Gender: *onna mo otoko mo* (both women and men)

- Number Referential Mapping: *onna mo otoko mo* (plural nouns from *takusan*)

Shibuya (1982) pleads for a more comprehensive feature system in Japanese Noun Phrases, since he argued for the syntactic relevance of Gender and Number against Yamada (1978), while, at the same time, discovering novel means of expression for these categories in Japanese:



It draws a hierarchy within the structure of the clause, meaning that, based on word order, lexemes have a greater wield on scope between each other judging the place they occupy in a sentence (with 0 being the highest scope of a noun). Even implied nouns receive scope like *sensei* in (9) (Tokutsuba, 1988:18)

9. Sensei: [Scope: 0] [+authority]

Doubutsu: [Scope: 2] [+argument]

4.1.1. Conclusions of This Section

In order to comprehend the interpretation of definiteness in Japanese it is highly important to analyze the structure of features for Japanese because, as pointed out before, most authors agree that nouns in Japanese are inherently definite. While it is a bold statement, we cannot fully agree with such an idea, mostly because NPs lack Number or Gender and articles, so the problem of definiteness cannot be solved by simply claiming the argument of null-NPs as sufficient and satisfactory. For this reason, I provided the analysis of Tokutsuba (1988) who endeavors to part ways with the tradition formalist analysis and bring into discussion semantic content in order to characterize Japanese nouns.

The thorough account for the lack of Gender and Number on Japanese nouns and the conservation, at the same time, of the possibility of expressing definiteness, led us to show that this problem was tackled before in a professional manner by Shibuya (1982), who emphasizes three methods for the formation of Number and Gender in Japanese, namely by pluralizing nominalization (*takusan no tenin* - many clerks), contextual indexation of Gender (*onna mo otoko mo* - both women and men), and number referential mapping (*onno mo otoko mo* - plurality of nouns derived from the adverb *takusan*) even though there are no overt grammatical items for Gender and Number marking or to express definiteness, the paratactic mapping introduced by Shibuya as a specialized process in Japanese helps drawing closer the grammatical specificity of Japanese regarding definiteness.

However, the above mechanism was not sufficient, so I decided to bring into discussion the semantic analysis of features which depart from the English tradition by bringing into discussion environmental content, pragmatic and empirical features. For this reason, it is fairly acceptable to conclude that nouns in Japanese are as complex as their English counterpart and allow for the expression of definiteness in a manner different from its counterparts in Europe, but not exclusive. I emphasized that, even though some linguists agree that Japanese NPs are inherently definite, this is not always the case, since some nouns are analyzed as [+animate] like in *sensei* (teacher), while others are analyzed as [-animate] like in *heya* (room), meaning that a simple formalist analysis would simply render obsolete our efforts to understand definiteness in Japanese by claiming that all nouns are inherently definite, even though there

is no Number or Gender and such state of things would suggest against this statement.

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CLASSIFIERS AND PREPOSITIONAL PHRASES IN ENGLISH

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DOI: [10.5281/zenodo.17119002](https://doi.org/10.5281/zenodo.17119002)**Abstract**

The purpose of this article is to bring into discussion the structure of classifiers and of prepositional phrases in English, in order to offer a parallel to Japanese similar constructions. As we know, the linguistic system of English employs definite and indefinite articles in order to express definiteness, but classifiers are also present mostly in the form of prepositional phrases. Unlike Japanese, where the nouns are intrinsically non-definite, nouns in English are either definite or indefinite. The only equivalent is in the form of mass nouns, which cannot be differentiated as a whole. For this reason, English makes use of classifiers so that these substances can be differentiated in the form of part of a sequence. However, the structure of classifiers is not the same as in Japanese, since here they are mostly prepositional phrases, while in Japanese they form a closed class of elements.

Keywords: Classifiers, Japanese, Prepositional Phrases, Lexicality, Articles, Definiteness, Topicality.

14.0. Classifiers in English - A Summarized Review

Although not a classifier language, English exhibits an open class of words that are functionally similar to classifiers: *a HEAD of lettuce. a HERD of cattle, a BOX of candy*. For some words the collocational and lexical features must be represented directly in the lexicon. For example, *pride* would be listed as the collective classifier for *lion*. Classifiers are not semantically rigid, however, as it is evident in the extended listings from lexicons (*a HERD of linguists* and *a FLOCK of linguists*). In many cases, the lexicon fully integrates the semantic content of the classifier in the lexical employment of the word per-se. Novel occurrences of words in classifier NP constructions (*a HOARD of statues*) involve pragmatic interpretation criteria which are triggered by the ordinary specification of conventional classifiers in lexicons. The appendix on the syntax of classifiers in English emphasizes that all the syntactic tests which purport to make measure phrases distinguishable in partitives, pseudo-partitives, and complement PPs show the employment of classifiers to be syntactically determined phenomena, and not hazardous theories.

Among the constructions in English which have the surface linear structure ((Del) N of (Del) N) there is a significant subgroup, that of classifiers made up of partitives, pseudo-partitives, and measure phrases. We can exemplify these groups in terms of syntagms that abide by the following structures:

- 471. a bunch of carrots
- hundreds of animals
- two pounds of flour
- a number of individuals
- a herd of bovines

English is considered to be a classifierless language, since classifier languages, as described by Greenberg (1972), Allan (1977), Denny (1976,1979), Adams and Conklin (1973), and others, have a closed small and paradigmatically contrasting data of lexemes, which are mandatory, at least in some contexts. In English, classifiers are often employed when individuating masses, their occurrence is not always obligatory. Thus it is acceptable:

- 472. Waiter, bring me wine, please.

Moreover, mass nouns are freely used as count nouns, and any implicit classifier would be determined by the pragmatics of the situation.

- 473 a. Waiter, can you please bring 2 coffees (cups of coffee)

- b. Five coffees are evidently high in caffeine. (kinds of coffee)

- c. Can you bring down the coffees up there? (cans, packages of coffee)

Since English does not have a closed set of classifiers, (but instead an open and productive class), we must look at the rather complex interaction of syntactic, semantic, collocational, and pragmatic factors that apply to words which could be used as classifiers, both as conventional classifiers and as novel ones. The syntactic form of classifier expressions in English is:

(Det) N, (of) (Det) NA

In most cases *of* cannot be replaced by another preposition, nor can it be paraphrased as a compound which reverses the order of the two nouns. *A cup of jewels*, or, in other words, *'the amount of jewels that a cup maintains*, is not semantically identical with syntagms like *cup with jewels. cup for jewels, or jewel cup*. There are instances where the prepositional phrase can be postposed or preposed, as in (474a,b):

- 474. a. A dozen was wasted of those paintballs by professional shooters.

- b. Of the carrots that I was talking about, two sacks were used.

There are a number of interesting syntactic problems involved in classifier expressions, such as which noun is the head, whether *of* should be generated in deep structure, whether *of* and the following noun phrase constitute a prepositional phrase, and whether different deep structures distinguish *a bunch of the carrots* from *a bunch of carrots*. The latter is interesting to analyze because it would show whether classifiers in English contribute to the definite interpretation of Noun Phrases or not, but this issue can simply be brought into discussion by emphasizing that they always determine pluralized nouns which are argued to be definite by most researchers. From these examples another important observation is that the classifier, a noun itself,

can bear a definite or an indefinite article, so it means that at the syntactic structure, it behaves like a common noun, unlike Japanese, where they form a closed class of elements.

Allan's taxonomy of classifiers for English categorizes the classifiers according to a number of criteria, but their number is way smaller than in Asian languages and this illustrates the range of constructions they express (Allan, 1977). The author provides seven categories for English classifiers, but it is neither disjoint or exhaustive.

475.

(a) Unit counters: *a part of equipment, three heads of bovines.*

(b) Fractional classifiers: *2 quarters of the pie.*

(c) Number set classifiers: *many thousands of men, dozens of cats.*

(d) Collective classifiers: *Three clumps of herbs, a herd of wolves.*

(e) Varietal classifiers: *Two species of cauliflower, all types of anemones.*

(f) Measure classifiers: *Two pounds of potatoes, a box of candy, one liter of juice*

(g) Arrangement classifiers: *Two columns of flowers, four stacks of magazines.*

There is another group of classifiers, which some authors bring into discussion, although their existence *per se* is a matter of discussion. These include expressions like *a monster of a man, a slip of a woman, and a horror of a life*. They are typically named 'metaphorical comparison' classifiers, since their interpretation seems to involve a comparison between the two nouns, and the innovative characteristic is the noun interpreted metaphorically. In terms of their properties, classifiers are usually analyzed by means of binary features. I give a few examples below, taken from Lehrer (1985)

476.

a. Kind : + N + count

varietal classifier of [N PI • 'a class of things' •

plural refers to number agreement between N, and N,

a kind of book; several kinds of books

b. Crowd : +N , +count + Verb Classifier use follows from the meaning.

'large number of people gathered together'

c. List : +N

an arrangement of written or printed items, often of a specified + count category'

Some classifiers are deeply cojoined with particular nouns, and conversely, certain nouns are empirically determined by a number of classifiers. Venery terms especially fall into this group. 'In English there is a unique association between the collective classifier *pride* and the noun *lions* and similarly between *gaggle* and *geese*' (Allan, 1977). A similar situation arises in Japanese, where classifiers are closed classes of elements that are grouped on several criteria and are highly specific regarding the category of noun they determine. In this respect they depart from their English counterpart, which are much little in number and which do not function as mandatory constituents of Number:

477. a herd of deer, cattle, horses, goats
a pack of hyenas, dogs, tigers, coyotes
a flock of geese, sheep, a pride of lions
a school of dolphins, a pod of seals

It has often been underlined that classifier languages like Japanese or Chinese, often employ *shape* as a foundation for categorizing (Denny: 1976,1979), Adams and Concklin (1973), and that this criterion represents a striking peculiarity of phenomena which children make use of when acquiring their language. Evidently enough, *bottom* and *shaft* have a semantic clue of shape in their structure. This pattern is repeated by a large number of other English classifiers. We can bring into discussion unit classifiers: *cube, pinch, ball, slice, loaf, sheet*, while arrangement classifiers follow: *field, column, row, heap, stack*. These classifiers are characterized by a relatively free distribution and can determine mostly nouns which adopt a certain shape: *rod, wad, thread, dough, ball, sheet, yarn* of etc.

478. *To season the soup correctly, add a pinch of pepper, a grind of salt, a dash of bay, a sprinkle of love, a shake of mint, and a toss of finely scraped onions.*

One important argument comes from the conventionalized classifier *slice*, which has become a noun through the process of categorization. It is a classifier of shape and shows that there is a determined process that permeates the phenomena of classifiers in English, since it is originally a verb. Lexically, we employ it to denote a source of a three-dimensional substance divided so that its description relatively includes the adjectives *thin, broad, and flat* and it usually results from the process of cutting. The process is productive with deverbal classifiers, allowing novel combinations in original NPs:

14.1. Conclusions of This Section

Classifiers are a unique class of elements that behave separately in Japanese than in English and their structure must be understood in the latter so as to underline their peculiarity and the role they play in Japanese. For this reason, the previous section works as a foil towards the chapter that analyzes classifiers as means of rendering the definite interpretation of Noun Phrases grammatical in Japanese. Had this not been our goal, the present section would bear a little interest, because classifiers in English hold nothing special in comparison to other common nouns and they do not contribute to the semantic or syntactic structure of these nouns with much new information.

One important consequence of studying classifiers in English is the observation that they are lexical items, unlike Japanese, where they are analyzed as functional lexemes. They are common nouns that can be both definite or indefinite and always determine a pluralized Noun Phrase to which they attach as a Quantifier Phrase. Moreover, they are syntactically analyzed in terms of their nominality and countability, even though, as examples presented above would suggest, they could also accept the binary dichotomy definite/indefinite. One similarity with Asian languages is that in English classifiers are roughly classified in terms of their shape or as deverbal nominals, which follows the trend in Chinese or Japanese, for example, where they usually

serve as criteria for the classification of nouns in different classes of elements based on a peculiar characteristic like shape, form, dimension, type of animals, instruments etc. However, their number is much smaller so one cannot conclude that they serve the same purpose like their counterpart do.

Classifiers in English are employed to quantify mass or collective nouns, or bare plurals that cannot be singularized by suffixation or by any syntactic means available in English and they form a Noun Phrase together with the noun they determine, maintaining their status as Quantifier Phrases. In order to emphasize that the employment of classifiers in English is not hazardous, we also brought into discussion the Prepositional Phrase Extraposition to underline there are syntactic phenomena at stake that influence their structure and this could be seen in the examples where syntactic diagrams were provided before, but there are yet other

tests like number agreement between the subject head noun and the finite verb, tag questions, preposition stranding etc. they do not contribute at all to the definite interpretation of the noun.

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DOI: [10.5281/zenodo.17119011](https://doi.org/10.5281/zenodo.17119011)**Abstract**

The purpose of this paper is to discuss the existence of plural morphemes in Japanese, a language where nouns are not marked for Gender or Number whatsoever. Nonetheless, there seems to be a restricted number of morphemes like *-tachi* or *-gata* which are adjoined lexically to a Noun Phrase in order to render it plural. As a matter of fact, I chose to analyze these morphemes with the sole purpose to understand whether they help convey numerosity in Japanese in a similar manner as the plural morpheme *-s* does in English. One important aspect of the problem is that we can further show that these two plural morphemes help convey definiteness in Japanese, since they bear with themselves a plus of semantic content, which otherwise it would be deemed non-existent.

Keywords: Pluralization, Japanese, Morphemes, *-tachi*, *-gata* Countability, Noun Phrases, Definiteness.

12.3.-Tachi the Equivalent of Plural Morphemes in Japanese?

Japanese is another example of a classifier language that has plural marking. In this language, the plural marker *-tachi* allows either a plural reading or an associative reading. However, the two readings are more freely available in Japanese than in Chinese or Korean for example. The relevant distribution of *-tachi* involves movement. This is taken as evidence to suggest that the different interpretations of *-tachi* occupy different positions, Num and D respectively (Ueda and Haraguchi 2008, Ochi 2008), unlike English *-s*, that is argued to occupy Num only to render the plural reading valid.

English *-s* allows only a plural reading with common nouns, and either a plural reading or an associative reading with proper nouns. In Japanese, however, both proper nouns and common nouns allow either a plural or an associative reading (Nakanishi and Tomioka 2004, Nakanishi and Ritter 2009). With a proper noun, *Hanako-tachi*, , can mean either '*Hanako and others*' (associative) or '*a group of people all named Hanako*' (plural). For common nouns, the usual reading is one of plurality; however, this is not necessarily the case (Nakanishi and Tomioka 2004). For example, *kodomo-tachi* 'child-TACHI' could denote a group that does not uniformly consist of children, but may include others who are associated with the children. This is shown most clearly with examples such as (14) (Nakanishi and Tomioka 2004:128):

1. Koen-de utat-tei-ta onnanoko-tachi-no
nakani-wa otokonoko-moni, san-nin mazatteita
N.park-at sing-PROG-PAST girl-TACHI-GEN
among-TOP boy-also a.few-CL were.included
'Among (the) girls who were singing in the park,
a few boys were included.'

In order for (427) to be interpretable, it must be the case that *onnanoko-tachi* 'girl-TACHI' allows the possibility of individuals who are not girls in its denotation; thus, *-tachi* must allow an associative reading with plurals as well. Thus, *-tachi* has two available readings, like English *-s*, although the latter occupies Num on both readings. The two differ in that it is possible to have more than one *-tachi* morpheme suffixed to a noun, either proper or common, as in (2ab), while with

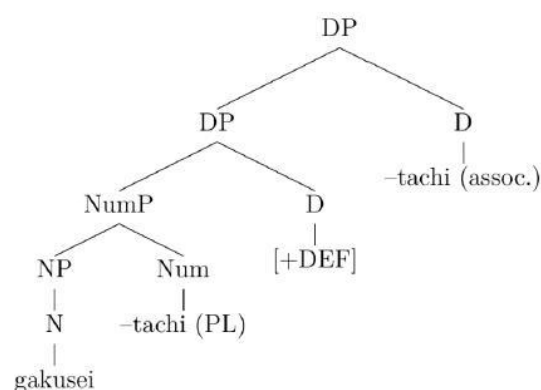
Chinese *-s* this is impossible: (Ueda Haraguchi 2008:237):

2. a. *gakusei-tachi-tachi*
b. *Taroo-tachi-tachi*
student-TACHI-TACHI
Tarou-TACHI-TACHI
'the students and their associates'
'Taroo and his associates and their associates'

In (2), the two examples have slightly different readings: in (2a) the first *-tachi* has a plural reading and the second has an associative reading, while in (2b) both have associative readings. Ueda and Haraguchi note that these are the only possible interpretations of a double-*tachi* construction; it is impossible for them both to have plural readings, or to get an associative reading from the first and a plural reading from the second.

Assuming that multiple NumPs cannot occur, Ueda and Haraguchi propose that the plural *-tachi* is a Num head, which takes an NP complement, thus allowing no recursion. On the other hand, assuming that a DP can be recursive, it is proposed that *-tachi* as an associative morpheme is a D head that takes a DP complement, thus allowing either recursion of a second associative morpheme or the presence of a lower plural morpheme. Under this view, *-tachi* occupies different head positions:

3.



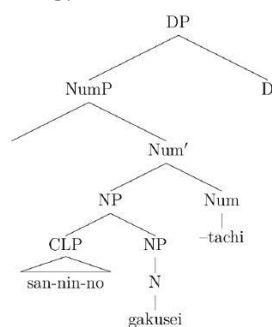
Given this structural analysis of *-tachi*, let us consider the co-occurrence of plural *-tachi* and classifiers. The plural marker *-tachi* can co-occur with classifier phrases (CLP) with common nouns, regardless of

whether the CLP precedes or follows the head noun (Ochi 2012:52). In other words, the plural marker is allowed in both the prenominal order where CLP precedes the head noun, in which case they are accompanied by *-no*, marking the phrase as a genitive modifier, and the postnominal order (4b) where CLP follows the head noun.

4. a. Boku wa san nin no gakusei tachi o maneita.
I TOP three CL GEN student TACHI ACC invited
 'I invited (the) three students for a meal.
 b. Boku wa gakusei tachi san nin o maneita.
I TOP student TACHI three CL ACC invited
 'I invited (the) three students for a meal.

In the prenominal order (4a), CLP has been proposed to be a modifier adjoined to NP (as argued for on the basis of N' ellipsis in Saito, Lin, and Murasugi 2006), which is widely assumed in the Japanese literature (e.g., Ueda and Haraguchi 2008, Huang and Ochi 2011, 2012, Ochi 2012). The adjunct analysis of a CLP will be illustrated later. Under this view, *-tachi* is the head of a higher NumP, and it is still adjacent to the head noun, which capture the word order shown in (5). That is, *-tachi* and a classifier occupy different head positions, and thus, the co-occurrence of classifiers and *-tachi* is fully expected.

5.



(adapted from Ueda and Haraguchi 2008: 235)

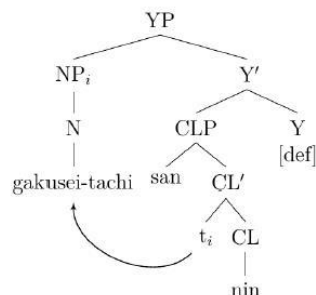
As for the postnominal order as in (4b), according to Tsuyago (2019) a modifier analysis of CLP along the lines of (5) must be rejected, since modifiers invariably precede the head noun in Japanese nominal phrases; Japanese is a strongly head-final language, with heads following both complements and modifiers. Therefore, in the postnominal order CL is widely claimed to be a head that takes NP as its complement (e.g., Murasugi 1991, Kawashima 1998, Watanabe 2006), and the numeral as its specifier (e.g., Watanabe 2006, Huang and Ochi 2011, Ochi 2012), as illustrated in (5). In (4), *-tachi* resides within NP and moves to the specifier of a functional head above the CLP as originally proposed in Watanabe (2006), and further elaborated in Huang and Ochi (2011), Ochi (2012).

The different syntactic analyses do not suggest that the subject at stake is highly debatable or hazardous, but rather complex and that it intrinsically exists in order to explain the mechanisms behind plural suffixes in Japanese. Our endeavor is to show that they express definiteness and that there is a theoretic foundation for their behavior in rendering the nouns they determine definite or indefinite.

According to Huang and Ochi (2011), a functional head such as YP that encodes definiteness/ specificity

is projected above an NP marked with *-tachi*, as shown in (6):

6.



(Ochi 2012: 58)

The NP-*tachi* moves to the specifier of YP for accessibility to a higher head such as *v* for the purpose of case: without moving into an edge of the phrase, it cannot be probed by *v*. As a result of this movement, NP-*tachi* is interpreted as definite. Like Chinese *-men*, *-tachi* is viewed as inducing definiteness (Kurafuji 2004, Ochi 2012), as the contrast in the interpretation between (7a) and (7b) suggests. The sentence in (7b) is not felicitous if the speaker has no particular group of children in mind (Ochi 2012:13)

7. a. Boku-wa kodomo-o sagashiteiru.

I-TOP child-ACC look.for

'I am looking for some/the child(ren).'

- b. Boku-wa kodomo-tachi-o sagashiteiru.

I-TOP child-TACHI-ACC look.for

'I am looking for some specific group of children.'

The existing analyses on Japanese nominal structure suggest that a classifier and the plural marker *-tachi*, regardless of the pre- or postnominal order of the CLP, are not in syntactic complementary distribution: they do not occupy the same syntactic position, and the observed co-occurrence follows from this. In this respect, it means that there are syntactic restrictions at stake with regard to the employment of plural suffixes in Japanese, an observation that aids our demonstration to emphasize that definiteness in Japanese common nouns triggered by plural suffixes is not hazardous, but clearly marked at the semantic and syntactic level. As shown above, the main syntactic operation at stake is movement and turns a common non-definite noun into a pluralized one.

12.3.1. Conclusions to this Section

Even though Number is not overtly expressed in Japanese, this section underlined the possibility of emphasizing plurality with the help of various syntactical schemes like in the case of plural markers (*-tachi*). The comparison with the English plural marker *-s* represents a striking similarity, the reason why we conclude that Number is manifested in Japanese, as well as definiteness, but the methods differ slightly.

We proved earlier that classifiers are an intricate part of Number in Japanese and they act as markers of definiteness. Is the plural marker *-tachi* hazardous or not? The existing analyses on Japanese nominal structure suggest that a classifier and the plural marker *-tachi*, regardless of the pre- or postnominal order of the CLP, are not in syntactic complementary distribution: they do not occupy the same syntactic position, and the

observed co-occurrence follows from this. In this respect, it means that there are syntactic restrictions at stake with regard to the employment of plural suffixes in Japanese, an observation that aids our demonstration to emphasize that definiteness in Japanese common nouns triggered by plural suffixes is not hazardous, but clearly marked at the semantic and syntactic level. As shown above, the main syntactic operation at stake is movement and turns a common non-definite noun into a pluralized one.

Plurality is specified in Num in both English and Japanese. Where the two languages differ is the category on which plurality is realized on the surface. In English, plurality surfaces as -s on N. In Japanese, plurality is realized as *-tachi* on N or D. That is, *-tachi* can be attached to D as well as to N. This accounts for the existence of the associative interpretation in Japanese, one argument in favor of *`tachi`* as a viable plural marker.

English -s allows only a plural reading with common nouns, and either a plural reading or an associative reading with proper nouns. In Japanese, however, both proper nouns and common nouns allow either a plural or an associative reading (Nakanishi and Tomioka

2004, Nakanishi and Ritter 2009). In the case of a proper noun, *Hanako-tachi*, for example, can mean either '*Hanako and others*' (associative) or '*a group of people all named Hanako*' (plural). For common nouns, the usual reading is one of plurality; however, this is not necessarily the case (Nakanishi and Tomioka 2004). The associative reading of the plural marker *-tachi* in Japanese accounts for the colorful peculiarity of this language and argues in favor of novel means to express definiteness, other than those found in European languages.

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THE CRITERION OF MOVEMENT IN JAPANESE NPs

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DOI: [10.5281/zenodo.17119019](https://doi.org/10.5281/zenodo.17119019)**Abstract**

The purpose of this paper is to prove that the process of definiteness in Japanese is not a hazardous one, but it is deeply motivated by syntactic phenomenology. As a matter of fact, we will show that there are certain restrictions at stake which argue in favor of our thesis, and these restrictions are further backed up by syntactic phenomena that determine the projections. One such phenomenon is the criterion of movement, which can be observed in the case of post-nominal phrases. One domain of research will be the pre-nominal NC which we will show it allows ellipsis, much in the opinion of Watanabe (2006). This demonstration will help us with our thesis in that it supports the point of view that definiteness can occur in articleless languages like Japanese, which exhibits a large plethora of linguistically heterogeneous methods for the expression of definite or indefinite Noun Phrase.

Keywords: Classifiers, Japanese, Number, Plurality, Definiteness, Countability, Noun Phrases, Borer, Determiners.

11.2. The Criterion of Movement

One important syntactic phenomenon, apart from restriction, is that of movement which can be observed in the case of post nominal phrases. As Takahashi (2008) demonstrates, it is in principle possible to elide the NP complement of the post-nominal NC.

1. Bushu-wa [jibun-ni kansuru hon] 2-satsu-o yonda.

Bush-Top self-Dat related book 2-CL-Acc read

Obama-wa 3-satsu-o yonda.

Obama-Top 3-CL-Acc read

'Bush read two books about himself. Obama read three.'

He then provides another example to confirm that there is a syntactic process at stake with regard to the definite or indefinite interpretation of the Noun Phrase. More specifically, as shown below, the floating NC is fine in this type of context while the post-nominal NC is not, arguing in favor of his presumption:

2. a. Tomoko-wa 30-sai made-ni kodomo-o 2-ri um-itai to omotteiru.

Tomoko-Top 30-year old by-Dat child-Acc 2-CL bear-want that think

'Tomoko feels that she wants to give birth to 2 children by the age of 30.'

b. *Tomoko-wa 30-sai made-ni kodomo 2-ri-o um-itai to omotteiru.

Tomoko-Top 30-year old by-Dat child 2-CL-Acc bear-want that think

'Tomoko feels that she wants to give birth to 2 children by the age of 30.'

Now we are ready to test the prediction of the above hypothesis. The following example has the floating NC in the first clause, which does not have a specific reading, and the second clause is intended to be derived from the post-nominal NC with the NP complement of the CL elided (Huang, 2014:10)

3. Tomoko-wa 30-sai made-ni kodomo-o 2-ri um-itai to omotteiru.

Tomoko-Top 30-year old by-Dat child-Acc 2-CL bear-want that think

'Tomoko feels that she wants to give birth to 2 children by the age of 30.'

*Hanako-wa 25-sai made-ni 3-nin-o um-itai to omotteiru.

Hanako-Top 25-year old by-Dat 3-CL-Acc bear-want that think

'Hanako feels that she wants to give birth to 3 children by the age of 25.'

In these two examples we see that, unlike (396), the elision of a complement is not allowed formally, which means, in the opinion of the author, that the interpretation of a definite NP is linked to movement. Nominal-internal ellipsis is yet another domain in which the pre-nominal and post-nominal NC behave differently. Turning to Japanese, observe first that the pre-nominal NC nominal in Japanese does not allow ellipsis, as pointed out by Saito&all. (2

4. *Taroo-wa [san-satuohon]-o katta ga, Hanako-wa [go-satu-no hon]-o katta.

Taro-Top three-CL-Gen book-Acc bought though Hanako-Top five-CL-Gen book-Acc bought

'Taro bought three books, but Hanako bought five.'

On the other hand, as we already saw in (396), the post-nominal NC nominal does allow NP ellipsis (see Takahashi 2008), which is confirmed by the fact that the example allows both strict and sloppy readings. This difference naturally follows from our non-uniform view of the adnominal NC. Assuming that the pre-nominal NC always occurs inside the NP, the lowest nominal projection, it follows that there is no maximal projection within

the nominal domain to the exclusion of the pre-nominal NC, which is why examples like

(26) are bad. Watanabe (2010) argues that the pre-nominal NC does in fact allow ellipsis, contrary to Saito et al.'s claim. Watanabe claims that examples like the following may come from the pre-nominal NC source (as well as from the floating one):

5. a. Taroo-wa [san-satu-no hon]-o katta ga, Hanako-wa go-satu katta.

Taro-Top three-CL-Gen book-Acc bought though Hanako-Top five-CL bought

'Taro bought three books, but Hanako bought five.'

b. Hanako-wa [go-satu ~~han~~]-o katta.

But there is evidence that examples like (399a) are derived from the floating NC

construction, and not from the pre-nominal NC construction. As Nakanishi (2012) points out, the floating NC typically has a distributive reading, which becomes salient when a predicate like *koros-* 'kill' is used (*Five men killed Taro*)

6. a. go-nin-no otoko-ga Taro-o koroshita. b. otoko go-nin-ga Taro-o koroshita.

five-CL-Gen man-Nom Taro-Acc killed

man five-CL-Nom Taro-Acc killed

c. *otoko-ga go-nin Taro-o koroshita.

man-Nom five-CL Taro-Acc killed

With this point in mind, let us reconsider (399). If (399b) can be derived from the pre-nominal NC construction (as well as from the floating NC), as Watanabe claims, then

the following example should be acceptable, contrary to the fact.

7. kyonen *san-nin-no* otoko-ga jiroo-o koroshita.

last year three-CL-Gen man-Nom Jiro-Acc killed this year five-CL Taro-Acc killed

'Last year three men killed Jiro.

*Kotoshi *go-nin* taroo-o koroshita.

this year five-CL Taro-Acc killed

This year, five men killed Taro.'

This shows that (399b) is derived only from the floating NC source. Witness the

following paradigm as a confirmation of this conclusion.

8. a. kotoshi go-nin-no otoko-ga taroo-o koroshita.
this year five-CL-Gen man-Nom Taro-Acc killed
(pre-nominal NC)

b. kotoshi otoko go-nin-ga taroo-o koroshita.
this year man five-CL-Nom Taro-Acc killed
(post-nominal NC)

c. *kotoshi otoko-ga go-nin taroo-o koroshita.
this year man-Nom five-CL Taro-Acc killed
(floating NC)

Our conclusion that examples like (399) involve a pre-nominal NC in the first clause and a floating NC in the second indicates that the parallelism constraint on ellipsis is not sensitive to the distinction between the pre-nominal NC and the floating NC. This point is important as we will explore in the next section the hypothesis that the floating NC involves movement of NP out of a larger nominal domain while the pre-nominal NC does not. Now let us reconsider (24) in this light.

By the same reasoning, the NP complement of the classifier head in the second clause should not be forced to move by parallelism considerations. The unacceptability of (24) therefore militates against the PF-driven nature of NP-movement involved in deriving the post-nominal NC. That is, the movement to spec of XP is not triggered by a PF requirement of Num-CL adjacency, but for a separate, formal reason.

11.2.1. Conclusions of This Section

We have shown that the position of the Nominal Phrase within Japanese bears influence on the dichotomy between definite and indefinite readings for nouns. There are three possible position for classifiers in Japanese, namely pre-nominal, floating and post-nominal, with the latter bearing, most often than not, a specific interpretation. In all three cases the link between the noun and the classifier+numeral construction is inalienable and they usually form a compound NP the specificity of which resides on syntactic grounds. Even though it would pose serious risks to suppose that the contextual reference is not playing its role in these situations, we tried to emphasize that in all of three cases the semantic interpretation of the clauses has syntactic phenomena residing at its core, most notably, that of restriction and movement.

Another important conclusion of this section is also underlined in the previous paragraphs and it deals with the nature of the specific noun in Japanese. As stated before, according to Huang (2014) the definite interpretation is strongly linked to movement in Japanese and we brought into discussion some examples that emphasize his idea. In other words, the complement of the Noun Phrase within the Classifier Phrase cannot be elided without movement as shown in (24), arguing in favor of our syntactically driven thesis for the nature of definiteness in Japanese. There are also restrictions at stake, the most important of which are related to the existential locational verb (Kishimoto, 2000) meaning that when it expresses a possessive relation, the object cannot be specific or presuppositional. His observation is important to our thesis because it underlines that there are important syntactic processes behind the definite or indefinite readings of a noun in Japanese.

The ellision of nouns in order to render the classifier and numeral constructions singular in predicative contexts brings into discussion the grammaticality of these Classifier Phrases which can exist on their own without the implication of a noun. This happens in examples like 27(b) and is somehow illustrated in 22 and 24 as well, but bearing other consequences, namely that of the influence of anaphoricity and contextual references for the definite or indefinite interpretation of post-nominal constructions with classifiers and numerals. By discussing the importance of positions in Japanese regarding specificity we brought into discussion another syntactic character of classifiers, namely that which describes them as topic sensitive lexemes.

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№99, 2025
Slovak international scientific journal

The journal has a certificate of registration at the International Centre in Paris – ISSN 5782-5319.

The frequency of publication – 12 times per year.

Reception of articles in the journal – on the daily basis.

The output of journal is monthly scheduled.

Languages: all articles are published in the language of writing by the author.

The format of the journal is A4, coated paper, matte laminated cover.

Articles published in the journal have the status of international publication.

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