COMPONENTS OF SYSTEM FOR IDENTIFICATION AND ASSESSMENT OF OCCUPATIONAL RISKS IN AGRICULTURAL ENTERPRISES

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Abstract. The relevance and problems of implementing elements of the occupational risk management system in the agricultural sector of Ukraine, in particular at agricultural enterprises, are substantiated and outlined. It is shown that the features of occupational safety and health in agricultural production affect the structure of the occupational risk management system. The disadvantage of the occupational hazard monitoring system, which is currently partially implemented in Ukraine, is its focus on obtaining only statistical data on individual indicators of industrial injuries (occupational morbidity), so its structure is not optimal and justified enough. This study uses a systematic approach based on the methodology for analyzing statistical indicators of industrial injuries. This allowed us to substantiate the structure and relationships of the developed occupational risk management system in agriculture. The changes in organizational, technical and psychophysiological causes of industrial injuries during 2017-2021 were analyzed in relative values. The elements of the subsystem for identifying potential hazards are systematized in the form of a structural diagram, the type of which reflects the features of the subsystem's functioning at an agricultural enterprise. Possible types of emergency situations in mechanized processes in agriculture, their causes and consequences are analyzed, including the unsatisfactory technical condition of agricultural machinery due to damage to parts and structural elements. It is shown that statistical data from flaw detection control obtained in the system for identifying potential hazards can be used in models for creating hazardous situations. Among the basic and intermediate events of these models, it is necessary to specify statistical indicators (probability) of organizational, technical, and psychophysiological causes of occupational injuries.

Keywords: industrial accidents, occupational risk, risk assessment, safety, agricultural engineering.

Introduction

In 2021, a policy document "EU strategic framework on health and safety at work 2021-2027" was adopted [1]. Attention to these issues is due to the introduction of new technologies and work processes, which significantly change the types of work performed and the level of technical equipment of workplaces; the share of distant (remote) forms of employment and work organization increased [2]. New occupational risks have emerged, i.e. threats to the safety and health of workers that need to be assessed and reduced [3; 4]. In particular, it is necessary to scientifically substantiate and systematize the elements of the workplace risk management system [5]. This problem is also relevant for the agricultural industry.

The occupational risk assessment system requires continuous monitoring of occupational hazards based on monitoring of working conditions and analysis of systematically collected data on existing or potential hazards [6; 7]. It should be noted that in Ukraine, the creation of small and medium-sized enterprises in agriculture, the inconsistency of the legislative occupational safety framework with the new conditions for organizing labor in the agro-industrial complex, as well as the high level of informal employment and undeclared work in rural areas have created significant obstacles to the implementation of an effective system for preventing industrial accidents and occupational diseases [8; 9].

Currently, the system for monitoring industrial hazards and occupational risks in Ukraine is aimed mainly at obtaining statistical data on individual occupational safety indicators, which does not allow us to consider it sufficiently optimal and justified [10]. At agricultural enterprises, occupational safety monitoring is mainly limited to the certification of workplaces according to the working conditions. The approaches to implementing a system for monitoring hazards and occupational risks at industrial enterprises presented in the literature do not take into account the numerous features of the conditions of work in agriculture.

The purpose of the article is to develop, substantiate and systematize the elements (structure, components, etc.) of the system for monitoring hazards and risks at the workplaces of an agricultural enterprise.

Materials and methods

A certain basis for developing an occupational risk management system in a sector (subsector) of the economy or at an enterprise can be an analysis of the statistical causes of occupational injuries (this information is published annually by the State Labor Service of Ukraine). This study uses a systemic approach based on the methodology of analyzing statistical indicators of occupational injuries, which allows us to substantiate the structure and relationships of the system for preventing industrial hazards (occupational risks).

This article analyzed statistical data on the causes of fatal occupational injuries for the period from 2017 to 2021 [10]. The choice of such a research period is due to the fact that in 2022, Russia's full-scale invasion of Ukraine began, which led to significant changes in the statistics of occupational injuries. The COVID-19 epidemic has caused certain, but less significant, changes in the structure of causes of occupational injuries.

The statistical data on the state of occupational injuries analyzed in this work were taken from the annual information of the State Labor Service of Ukraine, published on the website in the section "Injuries. Statistics. Causes". Nine main causes of occupational injuries were considered and grouped into three groups:

Organizational (1. Unsatisfactory organization of preparation for safe work performance. 2. Violation of established requirements during the performance of work. 3. Violations regarding the use of personal protective equipment);

Technical (4. Means of production, equipment, vehicles, buildings, etc. - dangers during direct performance of work. 5. Violations in project (design) documentation, technological process (at the preparatory stage) regarding the safety of work performance. 6. Non-observance (failure to ensure) of safety standards of the production environment).

Psychophysiological (7. Illegal factors. 8. Personal physical factors. 9. External factors of influence).

It should be noted that the statistical structure of reporting on industrial accidents and occupational diseases in Ukraine is somewhat different than in the countries of the European Union (EU). In many EU countries, the consequences of occupational diseases are also considered within the framework of statistics on fatal occupational accidents [11]. According to this approach, fatal occupational injuries account for only about 2%, while oncological and cardiovascular occupational diseases account for 52% and 24%, respectively (the remaining 22% are classified as other causes).

Results and discussion

Table 1 presents the results of calculating the share of individual causes of occupational injuries for the studied period 2017-2021. As it can be seen from the statistics for 2020 and 2021, for these years the total percentage in Table 1 does not equal 100% due to the fact that the analyzed statistics did not take into account the new group "social reasons", which appeared as a result of the COVID epidemic.

Table 1

Kinetics of the share (in percent) of causes of fatal occupational injuries in Ukraine for the period 2017-2021

Groups of causes of injury	Years					Results of statistical calculations		
	2017	2018	2019	2020	2021	Average value	Incline	Dispersion
Organizational	76.23	74.08	73.46	73.54	73.832	74.23	-0.5336	1.31
Technical	14.21	14.18	13.51	10.05	12.95	12.98	-0.665	2.95
Psychophysiological	9.56	11.74	13.03	12.96	11.4	11.74	0.49	2.01
Total	100	100	100	96.55	98.182	–	–	–

As a result of statistical analysis, it was found that the ratio of organizational, technical and psychophysiological causes of fatal industrial injuries during the studied period changed insignificantly (the dispersion values are quite small), kinetic diagrams that can be constructed according to the data in

Table 2 will be close to horizontal (their incline is -0.5336; -0.665 and 0.49, respectively). The ratio of the shares of individual causes of injuries can be considered practically unchanged.

It should be noted that the statistical study was conducted on national data on fatal occupational injuries, since in Ukraine this information is more objective compared to data on general occupational injuries. For individual sectors of the economy, the statistical sample of data is significantly smaller, so the study was not conducted for them. For the agricultural sector, when conducting such studies, it is necessary to calculate data scatter intervals with a certain error.

The statement about the invariance of the ratio of shares of individual causes of injuries can be extended to the analysis of the causes of general industrial injuries. It should be noted that the dispersion of statistical data in Table 1 regarding individual causes of occupational injuries is large, so in the following analysis it is advisable to use data regarding groups of causes of occupational injuries.

Organizational causes of occupational injuries significantly outweigh technical and psychophysiological causes, but in the case of mechanized work in agriculture, prevention of technical causes is important. Fig. 1 shows in the form of a block diagram possible types of emergency situations in mechanized processes in agriculture, their causes and consequences. Among the causes of emergency situations with agricultural machinery, unsatisfactory technical condition is often caused by damage to parts and structural elements [12]. The types, causes and consequences of dangerous situations in Fig. 1 relate mainly to the operating conditions of agricultural machinery, and it should be taken into account that technical aspects are often related to organizational and psychophysiological ones.

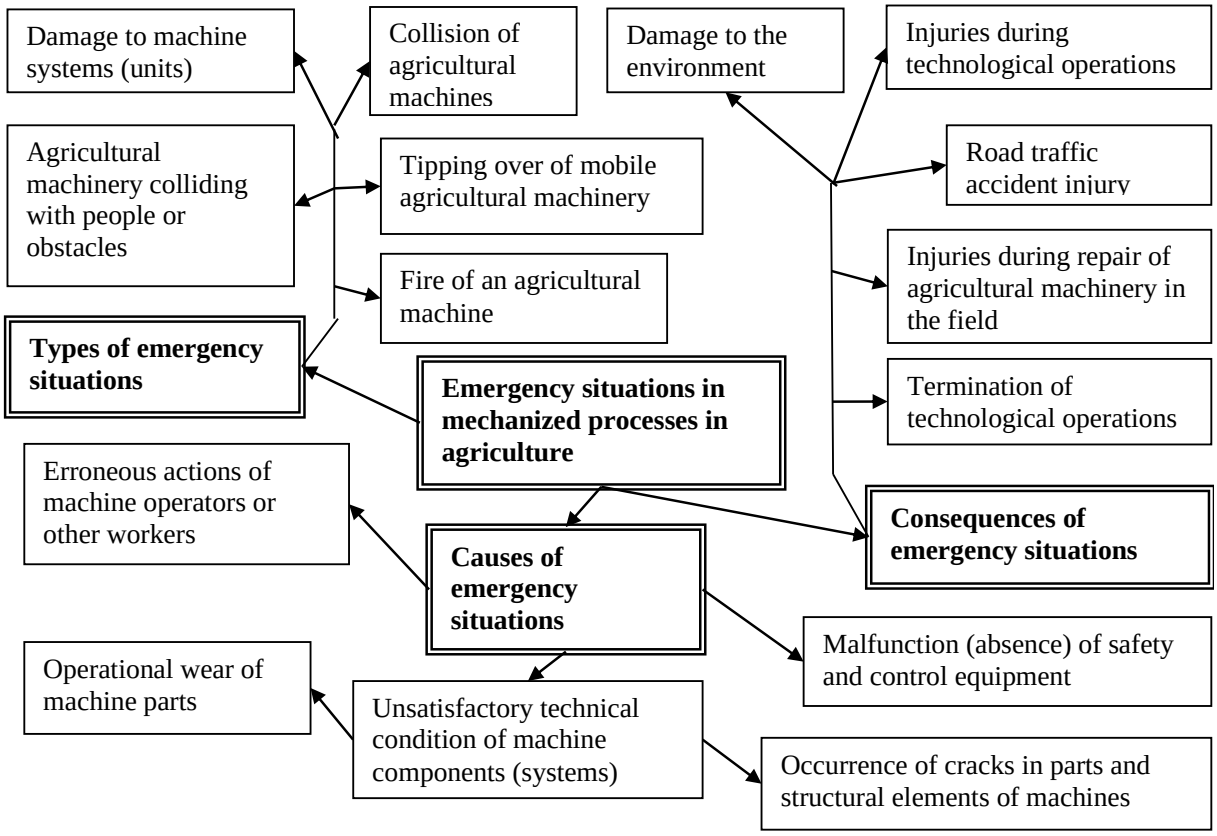

Fig. 1. **Causes and consequences of emergencies on mechanized processes in agriculture**

In the occupational risk management system, it is advisable to distinguish the subsystem for identifying potential hazards (SIPH). The elements of SIPH in the case of performing mechanized work at an agricultural enterprise can be characterized in the form of a flowchart in Fig. 2. This flowchart indirectly reflects the causes of occupational injuries listed in the article [10].

An important element of SIPH is the detection of operational defects of critical dimensions in mobile agricultural machinery that is in long-term operation. The information obtained during the inspection (diagnosis, defect detection) of machine parts and assemblies allows assessing their current technical condition and predicting the remaining resource [13].

The kinetics of the intensity of the initiation of operational cracks in the array of parts of mobile agricultural machinery is not monotonic and is characterized by a maximum in the range of about 11-13 years of operation [12]. This service life can be used as a criterion for discontinuing the operation of mobile agricultural machinery, conducting defectoscopic inspection of parts, and replacing defective parts. With such a long period of operation of agricultural machines and tractors, there is a high probability of sudden failure of agricultural machinery components and the creation of emergency situations [13].

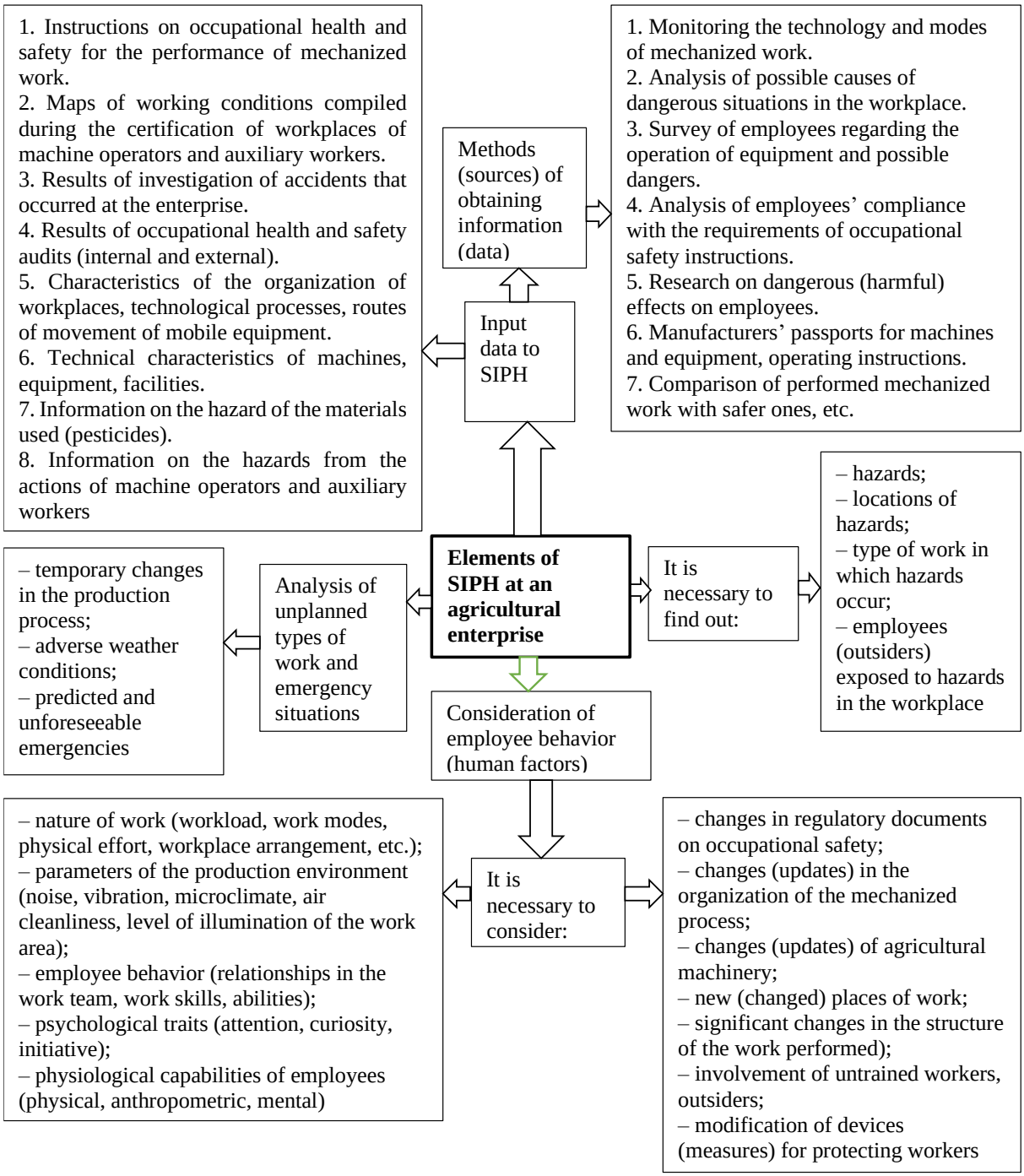

Fig. 2. **Elements of SIPH at an agricultural enterprise**

The SIPH information is used to assess occupational risks at the enterprise [14]. For example, statistical data from flaw detection inspection of an array of parts of mobile agricultural machinery can be used in hazard analysis models in the form of structural diagrams (trees), which combine the relationships between basic and intermediate events that form the main event with a certain risk of injury

to workers or the occurrence of emergencies [15]. Among such events, in addition to the individual causes of industrial accidents indicated in the article [10] and Fig. 1, it is advisable to consider erroneous actions of machine operators; accumulated during operation of a critical number of defects, which leads to equipment failures; adverse external influences of the production environment on the safety of mechanized processes.

As an example of the use of logical simulation models in this work, the probability of an injury-hazardous situation due to the occurrence and accumulation of an array of operational cracks in the parts of the tractor's running system and steering system was calculated.

The *SAPHIRE* computer program was used to analyze the logical simulation model of the occurrence of a traumatic situation and determine the risk of injury to employees [15; 16]. The list of probabilities of basic events corresponding to the average statistical indicators of industrial injuries in mechanized agricultural processes in Ukraine included the relative number of cracks in the total array of studied tractor parts for two periods of tractor operation. Changes in production risk indicators for a certain element of the logical simulation model of a dangerous situation show that the risk of injury to workers due to the accumulation of operational damage in critical parts and assemblies of the tractor increases several times after reaching a critical density of operational cracks in the parts of the tractor running system and steering system (Table 2).

Table 2

Risk indicators for a logic-simulation model of a dangerous situation during the movement of wheeled tractors with operational cracks in the parts of the running system and steering system

Dangerous factor	Duration of operation of the tractor, years	Calculated risk indicator	Change in the risk indicator in the presence of danger (how many times)
Presence of cracks in tractor system parts	6	$2.998 \cdot 10^{-3}$	–
	13	$6.739 \cdot 10^{-3}$	2.25

The identification of potential hazards and assessment of occupational risks in the workplace should be documented in the form of an occupational risk management system, which should present the main elements of the system in their interaction and protocols (in accordance with OHSAS 18001) that allow planning and implementing algorithms for identifying hazards and assessing occupational risks in an agricultural enterprise.

Conclusions

1. Analysis of literary sources showed that the elements of the occupational risk assessment system need to be systematized and substantiated. In particular, the system of monitoring industrial hazards and dangers in Ukraine is aimed at obtaining only statistical data on individual indicators of industrial injuries (occupational morbidity) and is not optimal enough.
2. The statistical analysis of the causes of fatal occupational injuries showed that the ratio of organizational, technical and psychophysiological causes changed (75% - 13% - 12%) slightly over the studied period, which allows us to determine the most optimal directions of occupational safety work, particularly in agriculture.
3. It is proposed to consider the occupational risk management system in the form of three subsystems: 1) identification of potential hazards; 2) assessment of occupational risks; 3) development and implementation of preventive occupational safety and health measures. The elements of the subsystem for identifying potential hazards are systematized in the form of a structural diagram, the type of which reflects the features of the functioning of this subsystem at an agricultural enterprise.
4. It is indicated how to assess the occupational risk (probability of injury) of machine operators; it is advisable to use data from statistical analysis of the causes of industrial injuries and information on the critical accumulation of an array of operational defects in the parts of mobile agricultural machinery. In particular, for the duration of operation of wheeled tractors for more than 13 years, the density of operational defects in the array of responsible parts of the running system and steering system becomes critical, which leads to emergency situations. The developed methodological approach can be used to create an occupational risk classifier for mechanized work in agriculture.

Author contributions

Conceptualization, O.V.; methodology, O.V. and O.E.; validation, O.V. and M.M; formal analysis, O.V. and O.E.; investigation, O.V., O.E., T.Z. and M.M.; data curation, M.M.; writing-original draft preparation, O.V.; writing-review and editing, O.V. and T.Z.; visualization, O.V., M.M.; project administration, T.Z.; funding acquisition, O.E. All authors have read and agreed to the published version of the manuscript.

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