Digital technologies for processing equipment reliability management when providing its service

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Abstract. The system for managing the operational reliability of oil production equipment using digital technologies can be based on the identified inter-element interaction and the interaction scheme of the elements of the human-machine system. As a result of experimental studies, the following parameters were established: distribution of failures by groups of complexity; characteristics of failures from the point of view of the theory of reliability by groups of complexity, distribution of time to eliminate failures by groups of complexity. Investigation of the causes of wear of assemblies and parts of oil-extracting equipment, as well as taking into account the factors of reduced performance that affect wear, will prevent equipment failure, increase the technical readiness factor, and reduce the cost of repair and equipment downtime. The scheme of reliability management at oil-extracting enterprises is proposed.

1. Introduction
Determination of the influence of technical factors on the economy in the agro-industrial complex, affecting the prices of the state, municipal contract for the products of the oil processing industry, is the most important issue on which the provision of food security and an increase in the efficiency of budgetary expenditures depend [1]. For this reason, the development of smart manufacturing technologies, i.e. equipping processing plants for processing oilseeds with built-in digital technologies that will allow technological lines to "communicate with each other" with the least human participation, creating methods and algorithms for collecting information in order to predict and optimize the technological process is an urgent scientific task in accordance with modern standards [2] and the development of man-machine systems [3]. The relevance of the topic is also that credit incentives for the processing industry of the agro-industrial complex are increasing, the implementation of the task of austerity of budgetary funds [4], the development of methods for identifying equipment failures in processing industries using the ANP analytical network processes [5].

In this regard, solving the problem of rational management of the operational reliability of equipment in the oil processing industry for processing oilseeds for the purpose of extracting vegetable oil (oil extraction) using the experience of using information technology [6], will allow digital control
systems for technological equipment and its maintenance (so called "smart manufacturing"), which will provide the fourth industrial "industrial revolution", called "Industry 4.0". which stimulates innovation of the fourth technological order in the development of rural areas [7].

The introduction of the principles of "smart production" will allow technological equipment to communicate with each other and its environment, with suppliers of raw materials for production, with logistics systems - for selling products. This will lead to the fact that production systems will become capable of self-optimization, i.e. make adjustments to production processes, adjust productivity, reduce production costs, etc. [4].

In order to develop a system for managing the operational reliability of equipment for oil production using information technology, it is first necessary to assess production according to certain criteria: first of all, the production and technological base of the enterprise should be evaluated. The object of research is the technological process of processing oilseeds with the aim of extracting vegetable oil (oil extraction) using information technologies. The subject of research is the regularities of maintenance and management of the reliability of a technological system for processing oilseeds for the purpose of extracting vegetable oil (oil extraction) using information technologies.

2. Materials and methods
The systematic approach is used in studies of the reliability of technological equipment for oil production due to the fact that the technological equipment operates as part of a complex system.

Since the technological equipment of oil-extracting enterprises is operated in a complex system, technical service (TS) must be considered as a complex system of parametric and functional failures. Both types of failures lead to disruption of the technological system, which means it is necessary to timely prevent and eliminate them [6].

The study used: a systematic approach, methods of probability theory, theory of reliability, monographic and experimental research methods, since the system under consideration in accordance with the standard [2] refers to technological, the achievement of the goal of its functioning has a stochastic nature due to the action of random factors. The main method for studying such systems is mathematical modeling and assessment of the adequacy of the results and generalization. One of the necessary conditions for enterprises should be considered the introduction of the elements of digital production management system (DPMS). An integral part of the DPMS can be considered a reliability management system in the operation of equipment at oil production enterprises. To ensure reliability during the operation of oil production equipment, it is necessary to consider the issues of a systematic approach, it is due to the operating conditions of the equipment both at large oil production enterprises (OEZ) and at small enterprises [8]. We also took into account the experience of modeling and optimization of complex technological systems [9], which can be used in the modernization of maintenance equipment for processing agricultural raw materials [10]. The experience of maintenance planning was also taken into account [11]. We used a methodology similar to the one described in the article to study the wear of equipment parts for steel processing [12], as well as the experience of managing the technical condition using digital technologies [13], taking into account the problems established in known studies [4]. We studied the experience of using the experience in research in innovative branches of science to control the performance of equipment [14].

3. Results and discussion
The subsystem for the operation of oil-extracting equipment is directly connected and interacts with the socio-economic system. Consequently, the oil extraction equipment operates in a subsystem.

The subsystem for ensuring reliability is characterized by a large number of technical and technological parameters. Consequently, in the study of the reliability subsystem, a systematic approach is applicable, since the subsystem "OPERATOR-EQUIPMENT-ENVIRONMENT" is at the lower level (by analogy with Man-Machine-Environment) [3]. Environmental parameters change as a result of equipment operation due to factors such as dust, vibration, evaporation, high temperature,
odors, etc., and we can consider the external environment as the environment for the operator (Fig. 1).

**Figure 1.** Scheme of interaction between operator, equipment, external environment

The interaction of elements (units and parts of equipment for oil production lines) with their environment "... the environment is characterized by corrosion, oxidation, frictional wear, aging of polymer and composite materials" [12]. The interaction is reduced by painting and the application of protective coatings (galvanizing, copper plating, etc.), hardening of surfaces with the help of more durable and resistant materials (composite, alloy steels). Based on the study of failures during the operation of technological equipment, their inter-element influence was revealed (Fig. 2).

**Figure 2.** Hierarchy and structure of the organization of production at the oil processing plant and maintenance of its equipment as a man-machine system

The interrelationships are based on the interaction of vector sets of parameters that characterize the elements of the system [4-6]. The expediency of the aggregate method of eliminating failures was established, which is consistent with the foreign results of the application of this method for the mission of maintaining system reliability and reducing equipment wear [15].

Using the decomposition method, we identified subsystems and their interrelationships that directly affect the reliability and reliability of the system (Table 1).
Table 1. Interaction of elements and their characteristics

| №   | Elements | Characterization of the influence of elements                                    |
|-----|----------|---------------------------------------------------------------------------------|
| 1.  | Eq at Op | Vibration, sound, heat radiation and display influence                           |
| 2.  | En at Op | Visual perception, sound, temperature effects, the influence of odors, suspensions, vapors |
| 3.  | TP at Op | Visual and organoleptic, sound and thermal effects, stray electric currents       |
| 4.  | Eq at En | Environmental pollution with technical fluids, air suspensions, vapors, electromagnetic fields, vibrations, thermal radiation, etc. |
| 5.  | Op at En | Almost all types of influences that compensate for the influence of the external environment by means of electric lighting, ventilation, aspiration, heating, etc. |
| 6.  | TP at En | They are a combination of the effects of technological equipment, weakened measures for labor protection and production safety. |
| 7.  | En at TP | Deterioration of the technological process with a decrease in the temperature and properties of the processed raw materials, high humidity and weediness of oilseeds, a decrease in oil content and an increase in acidity. |
| 8.  | Op at TP | Operator actions through equipment.                                             |
| 9.  | Eq at TP | Various types of technological failures, downtime due to technical reasons due to failures |
| 10. | TP at Eq | Impacts due to the operating mode of the technological process                   |
| 11. | Op at Eq | Control action, process control, compensation for deviations from the mode.       |
| 12. | En at Eq | Corrosion, oxidation, aging, wear of working bodies when interacting with technological material. |

Based on the scheme of interaction of the system elements, the results of production tests of equipment for processing agricultural raw materials were processed: in this case, sunflower seeds (Fig. 3).

Figure 3. Scheme of direct interaction of system elements

Processing the results of oil production line failures arising from technological equipment made it possible to distribute the failures into groups of complexity: the first group of failures prevailed (Fig. 4), the elimination of which was not a problem, since the operations to eliminate them are performed rather promptly (Fig. 5).
Our next task, which was successfully solved, was to classify the equipment failures of the oil production line by complexity groups and by the names of the equipment of the oil production enterprise. The research results are summarized in the table (Table 2).

**Table 2. Analysis of oil production line equipment failures by complexity groups**

| Difficulty group | Name of equipment, unit (refusals) |
|------------------|-----------------------------------|
| **1st group**    | - separator BSH-200 - body depressurization; - fan case VTsP 7-40 - leakage; - sieve body of sieve line NVH - sieve wear; - roller machine VS-4 - wear of drive belts. |
| **2nd group**    | - stone chipper RZ-BKT-100 - wear of the pipes, jamming of the control valve, breakage of the vibrator shaft drive belts; - cyclone UTs-38 - valve wear; - noriya NZ-20/25 - bending of the head shaft and wear of the belt with breakage of buckets; - dry-air separator BSX200 - deformation of the casing of the intake and feed box, wear of the valves of the aspiration chamber, wear of sieves and frames, wear of the brake shoe and cleaning petals; - seed crushing machine HPX-4-01 - wear of the deck and whips, as well as breakage of the drive mechanism belts; - roller mill VTs-4 - cracks in the bed, breakage of doors, wear of the grooves and labyrinth seals of the rolls, jamming of the inter-roll regulation mechanism, weakening of the pressure springs of the upper roll of the feeding mechanism, |
Research on equipment failures of varying complexity has shown that “wear of parts and assemblies of machines and equipment occurs during operation and depends to a greater extent on the operating mode, as well as factors affecting the operating modes. This will prevent equipment failure and increase the technical availability, as a result, reduce the cost of repairs and equipment downtime”, which is consistent with the research data on the reliability of equipment used in agriculture [8, 9, 10, 15]. Consequently, the engineering staff of the enterprise needs to direct certain efforts to create a modern system for managing the reliability of equipment for oil production. We have proposed such a system for managing the reliability of the OPSMK (Fig. 5).
4. Conclusion
When researching the reliability of technological equipment for oil production during operation, it is advisable to use a systematic approach, since the technological equipment is operated as part of a complex system.

The system for managing the operational reliability of oil production equipment using digital technologies can be based on the identified inter-element interaction and the scheme of interaction of the elements of the CHM system. The technological process of oil extraction is divided into logically interconnected stages of production, which make it possible to identify the process by mathematical methods of the theory of reliability.

As a result of experimental studies, the following parameters were established: distribution of failures by groups of complexity - the largest number of failures, 80%, are failures of 2 groups of complexity; characteristics of failures from the point of view of the theory of reliability by groups of complexity, the distribution of time to eliminate failures by groups of complexity - 60% is the time to eliminate failures of 3 groups of complexity. A reliability management scheme (RMS) is proposed for oil production enterprises.
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