from liquid friction through the limit to dry and ends with an emergency failure due to the heel digging out from the plunger jamming.

2. Reducing the number of emergency failures caused by jamming of the plunger in the block sleeve is possible due to structural changes to the block sleeve, which will reduce the action of forces in the contact zone of the plunger with the sleeve during its skewing due to damping of vibration loads and absorption of shock loads.

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SELECTION OF OPTIMIZATION CRITERIA AND FACTORS AFFECTING THE CLEANING PROCESS OF REPAIR OBJECTS

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Problem Statement. Cleaning technology is one of the key factors determining the technical level of repair and maintenance production. Removal of contaminants is a prerequisite for high-quality servicing of machinery, productive disassembly without damaging dismantled parts, accurate defect detection and inspection, as well as obtaining reliable coatings during galvanic, polymer, surfacing, and other restoration operations. Inefficient cleaning technologies and equipment also negatively affect sanitary and hygienic working conditions and worker productivity. In particular, the quality of component cleaning directly influences the service life of repaired machines.

The use of modern synthetic cleaning solutions leads to dissolution, adsorption, emulsification, dispersion of contaminants, and other processes. Control over the cleaning process can be achieved through operating parameters such as temperature, mechanical energy, volume, specific consumption and intensity of cleaning solutions, process duration, and its stages. This study investigates the selection of optimization criteria and factors influencing the cleaning process of repair objects.

Primary Research Materials. The primary objective of the study is to obtain an experimental mathematical model of the immersion cleaning process. The developed model will provide practical recommendations for immersion cleaning of assemblies and enable regulation of process parameters to achieve maximum cleaning efficiency.

Before planning the experiment, it is necessary to select an optimization criterion, i.e., the parameter by which the cleaning process is evaluated and which links all factors into a mathematical model. The optimization criterion must have a clear physical meaning and quantitative measure. Ideally, it should serve as a comprehensive and exhaustive characteristic of the study.

Possible optimization criteria for the cleaning process include:

- cleaning quality (surface cleanliness of external and internal surfaces rated 6-7 points),
- minimal energy consumption of all types,
- minimal cleaning time,
- minimal environmental impact of cleaning processes,
- safe sanitary and hygienic working conditions.

Since the primary purpose of cleaning is contaminant removal, the most significant optimization criterion for substantiating and calculating optimal parameters of immersion cleaning is cleaning quality.

The task is to construct a mathematical model that maximizes or minimizes the optimization criterion through appropriate selection of

influencing factors.

After choosing the optimization criterion, it is necessary to identify all possible factors affecting its value. Factors must be non-correlated and independent. Non-correlation implies the ability to vary any factor level regardless of the levels of other factors.

The selection of key factors influencing the cleaning process was based on prior literature review and analysis. In total, fourteen factors directly affect immersion cleaning [1]:

1) composition of cleaning agents,
2) solution temperature,
3) chemical activity of cleaning agents,
4) concentration of cleaning agents,
5) frequency of low-frequency oscillations,
6) amplitude of low-frequency oscillations,
7) average velocity of object movement during high-frequency oscillations,
8) frequency of high-frequency oscillations,
9) cleaning agent velocity,
10) contaminant concentration in the cleaning solution,
11) dimensions of the working zone of cleaning equipment,
12) cleaning duration,
13) efficiency of filtering elements,
14) number of containers.

All these factors directly influence the process and must therefore be considered in detail.

When selecting factor variation levels, maximum and minimum permissible values were taken into account, ensuring proper functioning of cleaning equipment.

The chosen optimization criterion – cleaning quality [2] – depends on many factors, the most important being solution temperature, concentration and chemical activity of cleaning agents, parameters of object movement in liquid, and contaminant concentration in the solution.

Based on prior studies and scientific analysis, eight factors were selected for further investigation: composition of cleaning agents, solution temperature, concentration of cleaning agents, frequency of low-frequency oscillations, amplitude of low-frequency oscillations, average velocity of object, movement during high-frequency oscillations, frequency of high-frequency oscillations, cleaning duration, efficiency of filtering elements.

It can be assumed that these factors most strongly influence cleaning quality.

The calculation of the concordance coefficient ($W = 0.92$) demonstrated a high level of agreement among experts.

Identifying the smallest number of most influential factors simplifies further description and study of the factor space with minimal labor and resource costs, while maintaining sufficient reliability of results.

Subsequent ranking of factors allowed the selection of four most significant ones from the fourteen influencing immersion cleaning [3]:

1) solution temperature,
2) frequency of low-frequency oscillations,
3) amplitude of low-frequency oscillations,
4) average velocity of object movement during high-frequency oscillations.

Conclusions. The study identified the factors most affecting the cleaning quality of machine components during repair. This enables determination of optimal parameter values for solution temperature, low-frequency oscillation frequency, low-frequency oscillation amplitude, and average velocity of object movement during high-frequency oscillations.

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METHODOLOGY FOR DETERMINING THE NATURE AND DYNAMICS OF WEAR OF PLUNGER PAIR PARTS

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Problem Statement. The work is part of a series of articles devoted to increasing the durability of plunger pairs of axial piston pumps. The purpose of the research is to increase the durability of mobile machines and improve the operational characteristics of axial piston pumps by minimizing power losses based on modeling of tribological processes in plunger pairs [1 – 3].