ANALYTICAL APPROACH AND MODEL FOR THE FORMATION OF REQUIREMENTS FOR THE DEVELOPMENT OF THE TECHNICAL SYSTEM OF INDUSTRIAL ENTERPRISES

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Abstract. This paper propose an approach based on the methodology, including model and tools for the implementation of specific activities that lead to a longer service life of the equipment and increasing the efficiency of its exploitation. This is an approach and a model for the formation of the technical requirements for updating and development of production equipment of industrial enterprises. For this purpose is proposed and tools for assessment of technical condition, including physical deterioration, obsolescence innovation, including the possibility for an extension of the service life.

Keywords: physical deterioration, obsolescence, residual service life

1. Methodology for the formation of the technical requirements

The modern industrial development began to impose such restrictions on available situated in a long lifetimes technology equipment; it can no longer meet all requirements, forming its effective use. Replace it with new, however, is not always cost-effective, more so in most cases it is physically preserved and can continue to work. The solution to the problem requires seeking and use of approaches and methods with which to extend the remaining useful life of the machines and to establish such production flexibility that they can be effectively used.

This imposes the analytical study of the problem to determine the physical condition of the equipment at the moment, which includes: determining the types of impacts on the physical condition of the equipment or amendment of parameters under the influence of external and internal factors. Outside are structural factors that determine the novelty of construction, whether they are old or new, more innovative designs, etc. Internal are the factors that are associated with the production, or so-called factors of production with which establishes how is organized the prevention, maintenance, repair and other activities related to the operation of the equipment. Determining the level of innovation aging of equipment requires comparing the technical indicators and criteria with these of innovative designs and technology.

The methods used are related to the actual physical deterioration of equipment (partial depreciation - partially modified parameters) or complete depreciation (limit modified parameters) including correctable (overhaul) and irreparably (scrapped), and also occurring deviations in productivity and quality of treatment of the individual processing units and etc. The ultimate aim of determining the degree of physical wear and obsolescence innovation is to determine remaining useful life of equipment or the residual life. The alternative solutions to eliminate their harmful impact on the lifetime and extension of residual life are given in Figure 1.

2. Model for the formation of the requirements for the development of the technical system

2.1. Defining of the physical wear and obsolescence innovation

The model includes both analytical study of plant and equipment and the assessment of their technical suitability for the job. The study is based on variations in equipment such and assessed criteria: physical deterioration, obsolescence and innovation.

2.1.1. Physical deterioration

The following equation is used to determine the physical deterioration:

$$U_f = U_0 + Z \tag{1}$$

where:

U_f - the actual altering parameters;
U_0 - theoretic magnitude of the parameters;
Z - amendment of the parameters under the influence of external and internal factors.

To determine the parameters for the assessment of variations in operating of machinery and equipment as an initial, partial and marginal, the following formula is used:

$$U(t) = f_0(t) + \sum_{i=1}^{n} V_i \cdot f_i(t) \qquad (2)$$

where:

$U(t)$ - actual altering parameters of the state of the elements as a random variable (function);

$f_0(t)$ - mathematical expectation of the random magnitude (function);

V_i - i-ratio of elemental decomposition;

$f_i(t)$ - coordinates of the i-function.

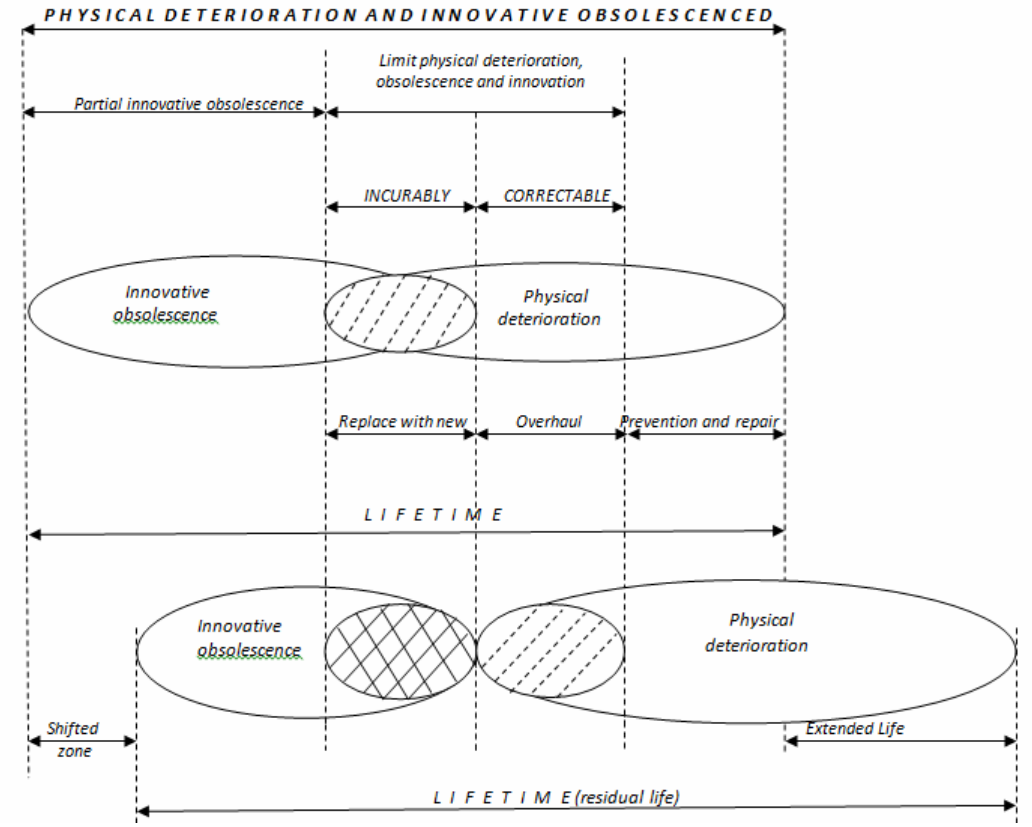

Figure 1. Extending lifetime of repair and modernization

2.1.2. Innovative obsolescence

The obsolescence innovation is calculated as follows:

$$M_3 = W \cdot \left(1 - \frac{K_1}{K_2}\right), \qquad (3)$$

where:

M_3 - total value of innovation obsolescence including the impact of technical and economic factors;

W - Initial value of the old product;

$K_1 = Cn / Cc$ - the ratio of the value of the new item to the value of the old;

K_2 - the impact of innovative solutions expressed by the performance of the designed and implemented in the production new, more modern, more productive and better technical and economic indicators, plant and equipment compared with produced before them.

2.2. Determination of the remaining useful life of the machinery and equipment

Specified is remaining useful life of equipment as a percentage of the theoretical life of the machinery and equipment based on an initial specified service life of machinery and equipment. Used is the following functional dependence:

$$E_f = f\left(K_{f0} - \left(K_{f1} + K_{f2} + \cdots + K_{fn}\right)^n\right), \qquad (4)$$

where:

K_{f0} - specified service life in the introduction of machinery and equipment in operation;

$\left(K_{f0} - \left(K_{f1} + K_{f2} + \cdots + K_{fn}\right)^n\right)$ - reduction of the lifetime of the 1st to n-th year under the influence of various factors including and exploitation.

Calculations are made using the following formula:

$$E_f = F_{ef} - F_{fe} + F_{frm}, \quad (5)$$

where:

E_f - residual service life;

F_{ef} - technically defined service life;

F_{fe} - the reduced life with time at which the machinery and equipment were in operation;

F_{frm} - extended operating life with repair and modernization.

2.3. Results of application of the model

Using this approach and model be carried out technical analysis of the industrial-five companies with similar business move - namely engaging in production and repair of miscellaneous equipment, electrical machinery, manufacture of machinery, equipment and metal structures and production of spare parts, assemblies, parts and steel castings for the machines designed for the needs of businesses throughout the country and abroad.

The enterprises have retained their technical status of uniqueness in terms of activity, plant and equipment, purpose and users of manufactured products and manufacturing services.

In determining the physical deterioration have taken into account the following factors influencing of climate the following parameters: the structure of the elements, aging of machines, speed of change in the parameters of the elements tolerance of the parameters under certain operating conditions, frequency of repair and others. The physical deterioration is expressed by the indicator K_f. It moved in a range of 0.27% - 98% for the machinery and equipment as the average for the five companies. Moreover, a significant part of the machinery and equipment have a large percentage of variation of parameters and require of going and capital repaired. Figure 2 shows the degree of variation of the parameters of the machines.

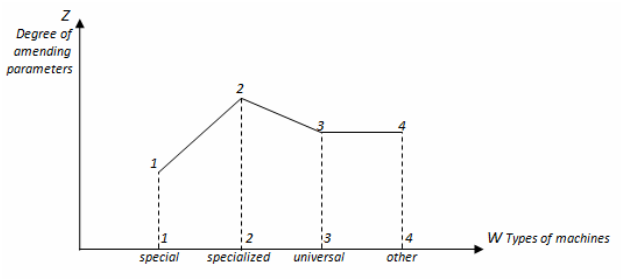

Figure 2. Rate of change of the parameters

For different species and groups of machines as a percentage of their number it is: special machines - from 15% to 20% of the specialized tools and more - from 1% to 25% of drilling, boring, milling and other - 20% to 25%, of the lathes 20% to 28%, by forging - the pressing - from 25% to 40%, by foundry from a 30% to 40%, about 20% more on average. In the facilities percent of their number in need of going and capital repaired, and some of replacement is in the range of 20% to 36%. For the motor fleet percentage is an average of 60% for repair and replacement.

The level of physical deterioration is given in Figure 3.

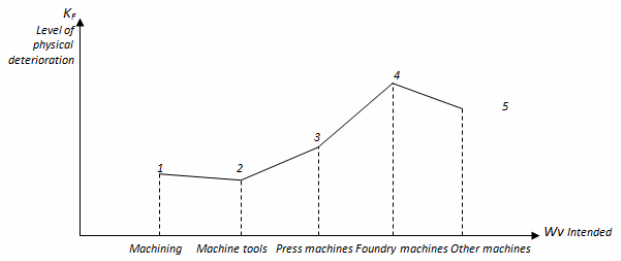

Figure 3. Level of physical deterioration

The studied machines and equipment are initially partially, and some of them and limit altering parameters due to the high rate of physical deterioration, as a consequence of their long service life, and by their repeated repairs. The obsolescence innovation is also great, predestined to conventional type, both of production and machines and their design features for such activities. The greater and the proportion of the machinery and equipment that have correctable physical wear and tear and need going and capital repaired.

The innovative obsolescence of the machinery and equipment is expressed by the indicator K_{iv}. Although conventional type structures, it is noteworthy the high rate of innovation obsolescence of the machinery and equipment, which ranges from 0.58% to 0.99%. It was found that the technical efficiency (Q_t) of the machinery and equipment has not changed and is within permissible limits. Changes have occurred in the actual efficiency (Q), which range from 0.63% to 0.95% and are due to repeated repairs, longer life, innovation obsolescence, losses from poor organization of technological and manufacturing and others.

The dependencies between physical depreciation, obsolescence innovative and climate innovation in productivity are shown in Figure 4, where: 1 – physical deterioration; 2 – innovative ageing; 3- actual performance; W – types of machines.

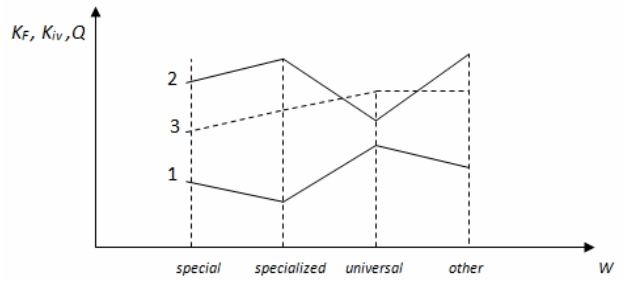

Figure 4. Dependencies between physical deterioration, innovative ageing and actual performance

The coefficient J[%], as a percentage of the residual useful life of theory is definitely moving in the range of 0.29% to 0.94%, which means from 5 to 15 years service life, depending on the group of machines and equipment. This useful life capable of working machines and equipment is not very large, but given the broader scope of their the universality and possibilities for better maintenance, repair and modernization, it appears that they will be able to satisfy the requirements the existing production pace and volume of work in the next period from 5 to 15 years work. In Figure 5 is a given remaining useful life of the machinery and equipment in the surveyed enterprises.

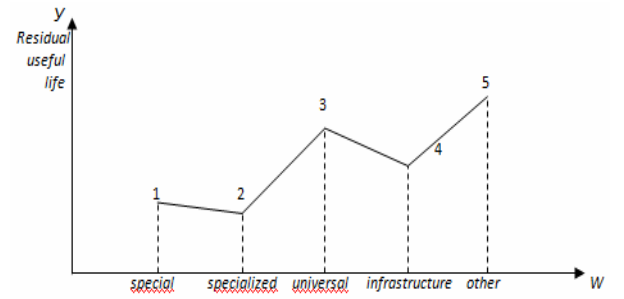

Figure 5. Residual life

In the surveyed enterprises have been developed and implemented planning and warning system repairs and maintenance. It has gradually been rearranged in a "repair status", which does not guarantee security for the development of the technical system. Is not taken into account innovation and obsolescence innovative of equipment does not comply with the inter scheduled maintenance cycles, which increases production costs. There is no plan for repair along with modernization of machinery. There is no plan for a comprehensive renovation and modernization.

3. Conclusions

On the basis of an analytical study can draw the following conclusions:

1. The types machinery and equipment and organization of technological and production processes define conventional type production activities. Such production is characterized by a low degree of automation and lower productivity, but with greater possibilities of flexibility to the customers and the market. This is one of the advantages of the surveyed enterprises.

2. The existing technical condition requires the performance of a comprehensive modernization of technology and production process including repairs and overhauls, modernization, replacement of some technology with new units and others with which remaining useful life of the equipment will be extended.

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