APPLICATION OF THE CRITERION OF TECHNOLOGICAL DAMAGEABILITY IN MECHANICAL ENGINEERING

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Abstract. Development and implementation in mechanical engineering practice of integrated information systems for control of technological processes of manufacturing products is the main driver of economic growth of developed countries. The priority of modern engineering technology is to provide the specified operational characteristics of products in accordance with the accuracy parameters, set by designer and quality of surface layers in contrast to achieving the minimum technological cost with maximum performance for traditional approaches. Technological providing of the main operational characteristics of the product (bearing strength, wear resistance, fatigue strength, joint strength etc.) require a systematic approach, which consists in the investigation of real physical processes at submicroscopic, microscopic and macroscopic levels of research, and step-by-step tracking required parameters at all stages of the Product Life Cycle from the position of technological inheritability. It is proposed to use the method of LM-hardness to control the quality of the structure of the material from castings in the design of functionally-oriented processes. The magnitude of the technological damage of the product material serves as a criterion for optimization when choosing a variant of surface treatment of the casting. A method for providing experimental studies of castings of aluminium alloys has been developed. On the basis of the carried-out experimental researches the rational route of processing of surfaces of casting is chosen.

Key words: surface engineering, technological inheritability, functionally-oriented process
1. Introduction and Major Challenges

Figure 1. Relationships between parameters of technological process, surface quality parameters, operational characteristics and reliability indicators
1. Introduction and Major Challenges

**Figure 2.** Classification of unacceptable failures associated with technological processes imperfections

At this stage of mechanical engineering development, the third group of causes of unacceptable failures is the least studied. The third group is related to residual and side effects that are formed during the process (Figure 2).
2. Material and methods of work

![Diagram of Life Cycle of a Product]

**Figure 3.** Analise of Life Cycle of a Product by means of its technological damageability
2. Material and methods of work

2.1. Method of research

According to LM-hardness method, the degree of dispersion of the characteristics of the material mechanical properties after operating time at various stress levels is taken as a parameter of damageability. The scattering of the measurement results performed by identical devices and identical conditions is more representative regarding the correlation of the mechanical properties of the material and the structure state than the absolute values of the characteristics. This method is easier to implement using hardness as a mechanical characteristic. The hardness value is used for indirect evaluation of properties.

The Weibul homogeneity coefficient \( (m) \) is calculated by:

\[
m = \frac{d(n)}{2,30259 \cdot S(\log(H))}
\]

where \( d(n) \) is a parameter that depends on the number of measurements, \( n \);

\[
S(\log(H)) = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} \left( \log(H_i) - \bar{\log(H)} \right)^2}
\]

\[
\bar{\log(H)} = \frac{1}{n} \cdot \sum_{i=1}^{n} \log(H_i)
\]

With a known distribution of the coefficient of homogeneity of Weibull \( (m) \) it is advisable to assess the degradation of the material structure by its technological damageability \( D \):

\[
D = 1 - \frac{m_i}{m_{matr}}
\]
3. Results and discussion

3.1. Experimental samples
The blank (145x60x15) was made of material AK21M2.5H2.5 State standard-GOST 1853-93.

3.2. Machine-cutting tools and equipment
Machine-cutting tools were end mills: for rough milling of diameter \( \varnothing 12 \) mm \((z=2)\), for semi-rough milling and finishing of diameter \( \varnothing 16 \) mm \((z=4)\).

Experimental sample was machined on the universal milling machine 676 series.

3.3. Technological rote and cutting parameters

<table>
<thead>
<tr>
<th>Table 1. Technological route of blank’s manufacturing and next machining</th>
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<tbody>
<tr>
<td>1 variant</td>
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<td>casting in cold and warmed-over metal mold</td>
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<tr>
<td>rough milling</td>
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<td>finishing</td>
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<th>Table 2. Cutting parameters for type of machining</th>
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<td>Type of machining</td>
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<td>Rough Machining</td>
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<td>Finishing</td>
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3.4. The measurement device
Hardness was measured on the device TP-5006 by means of a ball \( \varnothing 3.175 \) mm under loading with 588.4 N. In each experiment 30-35 measurements were performed.
3. Results and discussion

Figure 4. Change of Weibull homogeneity coefficient ($m$) in the surface layer of the casting for the first (a) and second (b) variants of the technological route (1, 2 are the castings spilled in cold metal mold, 3, 4, 5 are the castings spilled into heated metal mold; indexes 1, 2 are indicate the number of the melting blank)
3. Results and discussion

Figure 5. Change of technological damageability ($D$) in the surface layer of the casting for the first (a) and second (b) variants of the technological route (1, 2 - castings spilled in cold metal mold, 3, 4, 5 - castings spilled into heated metal mold; indexes 1, 2 indicate the number of the blank melting)
3. Results and discussion

The researches results demonstrate a general tendency in the formation of the surface layer of casting after pouring metal into different metal molds (see Figure 4, Figure 5). A heated metal mold has the lower level of heterogeneity development during crystallization in the conditions of decrease in the temperature field between the crystallized metal and the form to compare with a cold one. Therefore, the value of the Weibull coefficient \((m)\) on the blank surface is less, and the tendency to technological damageability \((D)\) is higher when pouring liquid melt into a cold mold than into a heated one.

The choice of a rational technological way of product production plays an important role for its further operation.

After rough milling for the first variant of the technological route (blank - rough machining - finishing) to a depth of 1 mm a decrease in the value of the Weibull homogeneity coefficient \((m)\) and an increase in the values of technological damageability \((D)\), compared to similar measurements on the surface, are found. This is explained by the growing tendency to damageability of the material in the deformation zone of the processed layer and the presence of significant residual tension after preprocessing by milling. Finish milling after preprocessing to a depth of 0.3 mm contributed to the increase in the Weibull homogeneity coefficient \((m)\) and decrease in the values of technological damageability \((D)\), caused by removal of the metal layer with a developed damageability during machining (see Figure 4,a; Figure 5,a).

After semi-rough machining and finish milling to a depth \(h_1 = 0.3\) mm; \(h_2 = 0.6\) mm for the second variant of the technological route (blank – semi-rough machining - finishing) a general trend toward increasing the value of the Weibull homogeneity coefficient \((m)\) and decreasing the value of the technological damageability \((D)\) compared to similar measurements on the surface is observed. In this case the dynamics of the change in the values of the Weibull homogeneity coefficient \((m)\) and technological damageability \((D)\) is more intensive for semi-rough milling. This is due to the removal of the defective surface layer and adjacent layers of oxides and dirt of the blank (see Figure 4, b; Figure 5, b).
4. Conclusions

The main conclusions have been drawn basing on the researches results.

1. The technological damageability \((D)\) is proposed for choosing the rational technological route of product manufacture. The technological damageability \((D)\) for castings is analyzed by the value of the Weibull homogeneity coefficient \((m)\) in terms of the degree of scattering of the characteristics of the mechanical properties of material.

2. Increase in the force loads during preprocessing machining, in particular milling, contributes to the increase of the damageability of the surface layers through the production of a gradient structure in the blanks. Reducing the energy characteristics of the cutting process in the modes of semi-finished and finished processing reduces the number of stress concentrators in the material. This provides a positive effect on the formation of the surface layer parameters and predicts the behavior of the parts during their exploitation.

3. Further research should be carried out for a more wide nomenclature of materials of machine products to introduce the proposed technique into the mechanical engineering practice.
5. References


The presentation is finished. Thank you for your attention.