The influence of iron microstructure on tool capacity during cutting process

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Abstract. An overview of machinability by cutting cast irons is given. The effect of the microstructure of cast iron on the tool's working capacity during cutting has been studied. The reasons for the tool failure during drilling are revealed.

Despite a significant amount of research on the study of machinability of materials by cutting, currently conventional units of measurement of this characteristic have not been established. It is generally accepted [1-6] that the material has good workability if during cutting, the cutting force and depreciation of the tool are negligible, and the tool life and the quality of the treated surface are sufficiently high.

The machinability parameters depend on the structure and properties of the cast iron, which are determined by its grade, the composition of the raw materials, the production technology, heat treatment regimes and other technological factors. It is impossible to evaluate the machinability for only one of the parameters of the cutting process, since processing of different materials with even one hardness can be characterized by different values of cutting forces or temperatures [7-9].

The machinability of cast irons is determined by the specific features of the form of castings, the conditions of casting and, but above all, their microstructure.

No less important is the microstructure of the metal base (matrix) of cast iron. The features of the structure of the matrix of high-strength cast iron with nodular graphite are: a) the location of ferrite mainly in the form of rims around inclusions of globular graphite; b) thinner than gray cast iron, the structure of lamellar perlite, often resembling sorbitolike perlite. The microstructure of the matrix affects the stability of the cutting tool, the level of optimum cutting conditions and the processing efficiency [10, 11].

The main drawback of high-strength cast iron during machining is the varying resistance of the cutting tool. The processing of high-strength cast iron products requires a three-fold increase in the number of tools compared to the treatment of gray cast iron. High-strength cast iron contains more silicon and alloying elements in the form of hard-to-digest carbides. This results in more intensive abrasive depreciation of the working surfaces of the cutting tool and the release of a significant amount of heat, which further reduces the resistance of the tool due to a decrease in the ability to resist...
depreciation. With a low rigidity of the technological system, the tool also wears out as quickly because of the unevenness of the cut layer, high shock loads and oscillations in cutting forces. [12,13].

Studies have been conducted on the machinability of parts made of cast iron which is widely used in automotive industry. The experiment included the processing of 10 samples. Cutting tools – drill diameter 10...16 mm. Chemical composition of cast iron was determined by spectroscopy by using microphotometry MFS-51 and spectrograph, AFS-51. Selection and preparation of samples for investigations were conducted in accordance with State Standard 3443-87. A 4% solution of nitric acid was used as a reagent for etching pig iron.

As a result of the research, the influence of the microstructure of the cast iron on the operability of the cutting tool was revealed. Thus, when drilling with high-strength cast iron, with a different microstructure, a metal base and the presence of graphite of a spherical regular and irregular shape, which is uniformly and unevenly distributed in an amount of 8-12% (State Standart3443-87), the cutting tool breaks down (Table).

Table 1

Parameters of cast iron properties in castings

| Partname | Hardness, HB | Metalbase | Extrafactors |
|----------|--------------|-----------|--------------|
| Body 6520-3104055 | 187-197 | Perlite plate 30 ... 60% and ferrite | Inclusions of vermicular graphite, unevenly distributed |
| Plate 4326-3105040 | 477 | Needle martensite and residual austenite and ferrite (F6-10%) perlite in some places 80-90% | Martensite in a metal base. Hardness is too high |
| Bearingcover 5320-2402079 | 285 | Perlite plate is approximately 60% and ferrite. | Hardness is too high |
| Body 6520-3104055 | 156 | Perlite lamellar in an amount of 10 to 30% and of 30 to 60% | From the surface to a depth of 1.0 mm, clusters of rectilinear graphite are observed, joined together by a film of particles of the undecomposed modifier; in the defect zone, there is a duster and pearlitic rim - "oxide deposit" - a defect in the casting. |
| Cover 53205-2502209 | 143-149 | Ferrite | From the surface to a depth of 0.18 mm there is a ferrite rim. Also there are accumulations of rectilinear graphite joined together by a film with particles of undecomposed modifier propagating to a depth of up to 4.5 mm - defect of casting production - "oxide deposit" |
| Body 5320-2402112 | 217 | Perlite granular ≈40%; ferrite ≈ 40%; | Troostite with microhardness HV 349-371 |
The results of the study are as follows: the structural factors of the non-diffusive decomposition of austenite (troostite, martensite, etc.) with high microhardness are the main factors of the cutting tool failure during drilling operations. In cast iron with a ferritic base, defects in casting are observed, which also have an effect on the performance of the tool during machining.

Thus, in order to reduce breakage of tools when drilling cast iron, it is necessary to provide stable characteristics in structure, hardness and purity of the alloy.

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