Development of the design of a laboratory vibro-grinding machine for preparing samples for metallographic research

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Abstract. The article presents the results of testing a prototype vibro-grinding laboratory machine for making samples for metallographic examination. The effectiveness of the method and its suitability for the preparation of thin sections during laboratory studies in the discipline "Material Science" have been established.

1. Introduction

Any manufacturing enterprise of machine-building products necessarily carries out activities to study the material of manufactured products by groups of quality indicators - the properties of the substance, the presence of internal defects and chemical composition.

One of the most laborious from the point of view of preliminary preparation of samples is a metallographic study of the properties of materials. Preliminary preparation consists of the following technological operations - pieces of the sample, pouring or pressing the sample into the section, several grinding and polishing operations, the number of which depends on the type of material being examined, and also the surface etching operation [1]. The methods of research are standardized, and also the quality requirements of the samples [2]. The main task of abrasive surface preparation is to obtain a surface of a thin section without scratches visible in the metallographic microscope with a minimum deviation from flatness. In the sampling route, the quality of the resulting surface of the thin section depends on each operation, but the key operations are grinding and polishing operations.

2. Theoretical part

In metallographic laboratories, abrasive processing of samples is performed on laboratory grinding machines of metallographic preparation. At present, manufacturers offer a variety of grinding and polishing machines both manual and with automatic control. Offers of modern machines by Russian manufacturers are absent. Chinese analogues, depending on the configuration of auxiliary holding devices are offered at a price of $ 2,600. The equipment of European and Asian manufacturers is offered at a price of up to $ 5,000.

To increase the productivity of image processing, machine tools with manual sample preparation are equipped with additional devices that ensure the retention of thin sections from an automated system by controlling the process of polishing the samples. Laboratory machines of this class are offered at a much higher price. It is, depending on the authority of the manufacturer, from $ 10,000 to
$35,000. Successful operation of imported laboratory grinding machines is possible only with branded consumable polishing materials, the cost of which is considerable. This laboratory machine offers a method of vibrating grinding (Figure 1a), in which the site with the abrasive material oscillates at a high frequency, and the samples for changing the cutting abrasive grains and removing the grinding products rotate around the axis of the holder. In this case, the samples can be automatically rotated about their axis because of the unbalance of the resultant forces during the grinding process. The scheme is realized in the form of a constructive solution of a laboratory machine, the three-dimensional model of which is shown in Fig. 1b.

The grinding scheme has the following advantages:
1. The absence of a continuously directed vector of the resultant cutting force during grinding. Provides self-alignment of the polished surface of the samples on the abrasive surface of the grinding material.
2. High-frequency vibration ensures that there are no traces of processing from one and the abrasive grains on the same machined areas of the metal sample and provides an effective control of the intensity of material removal.
3. Safe when manually preparing samples.

To pre-test the machine's performance, a prototype would be assembled. Its design is made of affordable and inexpensive materials - MDF, structural plastic and standard fasteners in the form of a base, on which prisms are mounted for attaching a universal grinder equipped with vibrating platforms [3, 4] and also studs in the form of threaded studs, plates in which the sample holder and the spring mechanism are placed, which ensures constant pressing of the samples to the vibrating platform. As a result of testing the prototype of the machine, the surface quality of the samples after grinding and polishing proved to be sufficient for performing metallographic studies in accordance with [1, 2]. In Fig. 2 shows photographs of the surface of a metallic sample after preliminary grinding with a domestic abrasive sheet of the Belgorod combine, followed by polishing with a solution of aluminum oxide. As we see after polishing, the surface of the thin section without scratches visible with a two-hundred-fold increase is suitable for chemical etching of the surface of the working surface. Measurements of deviation from the flatness of polished samples on an altimeter f. Mahr over the entire surface of the section showed values of not more than 0.1 mm. Undoubtedly, this value can be significantly reduced when manufacturing a working copy of the machine. The photographs after
etching have identified a clear grain structure of the sample, suitable for further metallographic analysis in a specialized package of graphics programs, both at working magnifications of the study 200 times, and 500 times.

3. Application of the prototype machine
Operation of the prototype of the machine showed the possibility of using abrasive materials of both domestic and foreign production. When using domestic abrasive materials, the cost of grinding and polishing the samples was an order of magnitude smaller, relative to the preparation of the same set on the machine tool with the use of imported abrasive materials.

4. Conclusion
A high intensity of the removal of the allowance was confirmed and, as a consequence, the duration of grinding of the samples was short. The measurements of the obtained samples showed a flatness deviation of not more than 0.05 mm and a roughness Ra 0.04 in the working area of the section, which corresponds to the established requirements. The prototype of the machine is used for self-preparation of polished sections by bachelor students in the framework of conducting laboratory works on special disciplines in the direction of "Material Science" [5] and for studying the quality of wear-resistant coatings of cutting tools [6, 7].

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