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ВЫБОР СОСТАВА РАБОЧЕЙ СРЕДЫ ДЛЯ АБРАЗИВНО-ЭКСТРУЗИОННОЙ ОБРАБОТКИ

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Ключевые слова: абразивно-экструзионная обработка, рабочая среда, абразивное зерно.
Аннотация. Рассмотрены различные составы рабочих сред, применяемые для абразивно-экструзионной обработки.

In modern engineering, the proportion of parts with complex profiles has increased dramatically. Increased requirements for the reliability of aircraft, parts of which operate in conditions of high temperatures and corrosive medium, lead to the need to improve the quality of their processing. Most of the workpieces of complex and highly loaded parts are made of chemically resistant heat-resistant and heat-resistant alloys by casting on investment casting. The surface quality of such castings is characterized by an increased roughness of Ra = 20...40 μm, a large depth of thermally modified layer, the presence of cracks, pores and gases in the surface layer and high residual stresses. The design of the parts makes it difficult to supply the cutting tool to the internal machined surfaces, necessitating the use of non-standard processing methods.

One of the most effective methods of processing hard-to-reach and complex-profiled surfaces of parts that satisfy the requirements for accuracy, surface quality and processing performance is currently the method of abrasive flow machining (AFM). This method, patented in 1965 by Ralph McCarty, made it possible to significantly expand the technological capabilities of processing difficult-to-access surfaces of multi-profile parts.

The essence of the method consists in extrusion along the processed surfaces of viscoelastic working media filled with abrasive grains.

In contrast to cutting with fixed abrasive, the process of extrusion honing has some peculiarities: in contact with the surface being treated there is a part of the abrasive mixture compressed under pressure equal to the area of the channel being processed; the geometric shape of the tool and the cutting parameters change during the movement of the abrasive "bundle" along the surface being processed due to a possible change in the channel section and pressure of the medium; active grains are in prolonged contact with the surface being treated, etc.

But along with a variety of factors affecting the provision of dimensional accuracy and quality of the surface layer of parts for abrasive extrusion processing, special attention should be paid to their achievement by selecting the optimal composition of working medium (WM).

When processing, where Newtonian fluids are used as a basis, the main value is the flow rate, the content in it and the size of the abrasive and the angle of contact of the grain with the surface being treated, since the main metal removal is realized due to the impact of ab-grains with the surface. In contrast to the abrasive-liquid treatment during the AFM of the base WM, polymers are used that are capable of large elastic deformations during their movement in the channel being processed. It is this foundation that gives WM in addition to viscous properties, also elastic. The composition of the WM should provide the optimum ratio of viscous and elastic properties: viscous properties of the medium affect its fluidity-rigidity, allowing for shear flow in the channel being processed, and the elastic recovery of the substrate base in the flow creates a significant additional effort on the abrasive grain, allowing to provide the required values of cutting force at lower flow rates. At the same time, the processing uniformity does not depend on the angle of impact of the abrasive grain on the surface, as in the case of jet processing [6].

The choice of the composition of the WM depends on the processing conditions: the geometrical characteristics of the machined part, dimensional accuracy and quality of the surface layer (required and initial).

The working environment for AFM consists of a polymer base (silicone and other polymers are capable of large elastic deformations as they move in the channel being processed), working elements and components that change its properties (plasticizers and modifiers).

Synthetic heat-resistant rubber (GOST 14680-74) (high molecular weight dimethylsiloxane, molecular weight 420-670) with the addition of fine fluoroplast-4 (to reduce friction), silicone liquid and ground mica are used as the basis [1]. The main advantage of the base is the high resistance of rubbers to heat aging, which is important because It was experimentally established that with AFM, 56% of heat released during friction, plastic deforming and cutting with active abrasive grains goes to heat WM, and when WM is heated over 40°C, metal micro- and submicroelectrodes of abrasive grain and the process of its interaction with the surface being processed goes into friction, which affects the processing efficiency [11].

Silicone mastic SS-91 or plasticized rubber is also used as a base for WM, silicon carbide or aluminum oxide is used as working elements, modifier is isotropyl stearate or tetrafluoroethylene powder, and plasticizer is silicone lubricant, silicone mastic or methyl siloxane liquid -bone.

In WM based on guar gum with the addition of boric acid and borax, the main deficiency is the harmful effect on equipment and personnel.

The use of silicone polymer with the addition of rubber particles of thermoplastic polymers — silicone, polystyrene, polyurethane, ethylene, polyvinyl, polyamide, polypropylene, and polycaprolactan — makes it possible to increase the elasticity of the WM, the resistance to compression, and the relaxation time of the medium compared to traditional compositions.

It was also proposed to use clay of betonite with the addition of water and alkali KOH [5].

It has been proposed to use nitrolignin obtained by nitration of hydrolignin with the addition of 1 to 5% sodium nitrate (surfactant), kerosene, triethanolamine, sulfofresol, and potassium soap as the basis of WM [10]. Such a composition, on the one hand, solves the problem of utilization of waste from hydrolysis production, but on the other hand, especially in the case of incomplete nitration, is characterized by considerable chemical aggressiveness and requires additional protection costs. In addition, the level of arising elastic stresses in such an environment is much lower than in an environment based on silicone rubber. In the course of long-term use of such a

WM, water evaporates, which leads to an irreversible loss of the ability to retain the abrasive grain.

Stearin, paraffin and wax were also suggested as the basis for WM.

Grains of silicon carbide or aluminum oxide [8, 9], corundum of white grade 24A, grain size 250 μm, content in a mixture of 50% [10] were used as work elements of the WM.

In the literature, natural diamond, synthetic diamond [3], synthetic polycrystalline ballas diamonds and carbonado [4], grinding powders made of synthetic polycrystalline diamonds are indicated as abrasives for the production of abrasive tools on a rigid and flexible basis. Synthetic diamond grinding powders (GOST 9206-70) and also micropowders from synthetic diamonds (GOST 9206-70). But, despite the increased wear resistance, their use is limited by the high cost of processing and the shortage of these grades of coarse-grained diamonds (with a grain size of 250/200 and above) [3].

Natural corundum, natural emery, natural flint [3], cubic boron nitride - synthetic superhard material and superhard polycrystalline technical boron nitride can also be used as work items. High abrasive ability and hardness of synthetic superhard material and superhard polycrystalline technical boron nitride is close to diamond hardness. In addition, unlike diamond, they are inert to iron and do not enter into chemical interaction with it. Consequently, their diffusion and adhesive wear are small [2, 4].

For grinding materials with high tensile strength (steel, forged cast iron, soft bronze, etc.), electrocorundum is used as an abrasive: normal, white, mono corundum, alloyed electrocorundum of various brands. In order to improve the cutting properties, silicon carbides are used: green and black. The choice of work items for the WM should be determined by the optimal ratio of maximum productivity and economic viability of processing. The percentage of each component varies depending on the processing conditions [7].

The selection of the composition of the WM and the percentage of each of its components for the AFM has so far been made empirically, requiring long and costly technological preparation. On this basis, it is necessary to develop a method for selecting the composition of the WM for certain processing conditions, based on the theoretical dependence of the optimal ratio of viscous and elastic properties of WM on the geometric characteristics of the channel being processed, taking into account the required dimensional accuracy and quality of the surface layer.

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COMPOSITION SELECTION OF THE WORKING MEDIUM COMPOSITION FOR ABRASIVE FLOW MACHINING

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Keywords: abrasive flow machining, work medium, abrasive grain.

Abstract. Considered various compositions of working medium used for abrasive flow machining.

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