Features of the influence of process media of plant origin on power characteristics during cutting and quality of the processed surface

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Abstract. In laboratory conditions, the influence of lubricating and cooling process media of plant origin on power characteristics of the cutting process and quality of processed surfaces during countersinking of structural materials with different chemical activity has been established. The use of methyl esters of rapeseed and sunflower oils fed using a minimized supply of lubricant, in comparison with base oils and traditionally used lubricants, is shown to reduce the roughness of the treated surface and the unit cutting work.

1. Problem statement

The quality improvement of machinery and mechanisms remains an important engineering task. The product performance largely depends on the accuracy of the manufacture of mating surfaces. Threaded connections make up 20% of their total number, and in some cases it reaches up to 70% of the total number of mating surfaces. Processing of threaded surfaces is one of the final machining operations, therefore, the tool performance will directly affect the economic efficiency of production. The accuracy of threaded surfaces is according to 11 - 13 quality class, while the accuracy of the majority of holes in the housing parts made after casting or drilling corresponds to 12 - 14 quality class. Countersinking provides accuracy degree 10 - 11 with a reserve for accuracy improvement. An important factor affecting the quality of processing is the characteristics of the used lubricating and cooling process medium (LCPM) and the method of their supply to the cutting zone. In spite of the existing variety of compositions of external media is remains, the problem of switching to environmentally friendly compositions of LCPM and minimizing their supply, while maintaining technological functions.

2. Materials and methods of research

There are many works dedicated to the effect of liquid and solid lubricants on the chip formation process. Their mechanism of influence consists of many parallel physical and chemical phenomena generally associated with a decrease in the strength and service life of the adhesive spots of the processed material on the tool blade [1 - 8]. Increasing the effectiveness of this function is usually implemented by increasing the penetrating ability of the medium or by introducing triboactive additives into the composition [6].
The use of vegetable oils and animal fats, as an alternative to industrial oils and emulsions, was limited by the high cost of raw materials and the problem of drying a number of oils with the formation of insoluble films on the surface of the machine and parts. The advantage of these media is the increased viscosity and tribological properties, which in some cases make it possible to limit the use of harmful chemically active additives, such as chlorine, nitrogen, sulfur, phosphorus, up to their complete elimination [1, 2, 4, 5].

Analysis of the existing information shows that the creation and practical use of compositions based on vegetable oils as external media is not represented in full and can be expanded.

3. Statement of the main material

Laboratory experiments were carried out at the department of engineering technology, steel 41Cr4, chemically inert AISI 304 stainless steel and chemically active to environmental influences Ti2 titanium alloy were used as the processed material. The tool used was a three-tooth counterbore made of HSS steel with a diameter of 20.85 mm, standard sharpening (γ = 12°, α = 6°, φ = 53°). The studies were carried out on a 2K522 radial drilling machine in the modes corresponding to the production ones.

The influence of the lubricating and cooling process medium was evaluated upon the introduction to the processing zone of the industrial oil I20A, mineral oil with Garia 404 M-10 additives by Shell, sunflower and rapeseed oils, as well as their methyl esters, which have a large wetting angle compared to base oils and are environmentally friendly.

The LCPM was transported to the cutting zone by a special Noga Minicool metering device and was supplied in the form of air-oil mist, the lubricant consumption was 5 ml/min.

The components of the cutting forces, namely, torque Mt and axial force Pa, were measured on a M30-3-6-K model dynamometer, the analog signal from the strain gauges of which was converted into digital on the basis of a four-channel amplifier and recorded using special Profi 2.0.2.3 software.

The microroughness of the processed surfaces was evaluated on a TR200 portable profiler along the measured hole at a base length of 4 mm according to Ra.

Considering the conditions of axial blade processing (high temperatures, contact pressures, continuous chip removal along the helical grooves of the tool) in order to ensure the supply of process media to the cutting zone, the workpieces with a pre-drilled hole were fixed in the collet so that the nozzle of the metering device was directed immediately against the cutting tool movement, Figure 1.

![Figure 1. General view of the experimental stand](image-url)
Figure 2 summarizes and presents the results of the obtained values of torque and axial force during countersinking, depending on the type of lubricating and cooling process medium used.

The histograms of Figure 2 summarize and present the results of the obtained values of torque and axial force during countersinking, depending on the type of lubricating and cooling process medium used.

The cutting modes were taken on the basis of reference data and were as follows: cutting speed 16.7 m/min, feed 0.18 mm/rev, cutting depth 0.5 mm.
The microroughness of the processed surfaces is presented in the histograms in Figure 3. To the right of the histograms for each type of material, roughness graphs are shown during processing without the use of LCPM and using technical ester of sunflower oil, as the most contrasting of the results obtained.

Analyzing the data obtained, it can be noted that the use of LCPM of plant origin in almost all cases considered led to a decrease in torque, axial cutting force and surface roughness relative to "dry" cutting and in the I20-A medium.

The negative role of industrial oil during Ti2 titanium alloy countersinking can be explained by shielding by the lubricant of the contact zone against oxygen. The greatest effect associated with a
decrease in torque and axial cutting force, when using technical esters of vegetable oils as a medium, shows their increased lubricating role in this process. Moreover, the results obtained show a significant decrease in the profile microroughnesses height and, as a consequence, an almost three-fold decrease in the average Ra parameter.

4. Conclusion
The use of technical esters of vegetable oils as LCPM affects the progress of contact processes due to the high lubricating ability, as a result of which the cutting forces are significantly reduced and the quality of the processed surfaces is improved. Physical properties of the esters eliminate the problem of the formation of poorly soluble films after drying of vegetable oils. The use of minimal lubrication technique confirms the economic feasibility of the process.

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