Cutting tool for turning large workpieces

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Abstract. The article analyzes the existing methods of cutting-off large-size workpieces on turning machines and tools of various constructions for cutting-off operations. The analysis has shown that the process of cutting-off in comparison with the usual processes of operation takes place in the most difficult conditions. In this regard, a new design of cutting tool with a special scheme of fixing a double-sided replaceable cutting insert was proposed.

1. Introduction

It is impossible to imagine modern mechanical engineering without intensification of production based on the wide use of science and technology achievements. One of the main directions in the production intensification is the increase of productivity due to the introduction of new progressive technological processes, which requires the creation of powerful and highly productive metal-processing equipment.

The most important requirement for any machine tool is an ability to achieve the required machining accuracy and cleanliness of the product surface with high productivity. This results in a major trend in modern machine tool construction - an increase in the speed of the main motion and feed motion of the machines. As a result of rate increase of the main motion and feed and in the case of high requirements to the accuracy and cleanliness of the workpiece surface, there is a need to increase the rigidity and resistance to vibrations of the technological system [1], [2], [3].

Edge cutting machining of metals is an integral part of the manufacturing process for most parts. Like other processes, it must be competitive. Regardless of whether it is the machining of individual complex parts in a small plant or the mass production of simple shafts. Gaining profit or loss largely depends on the economic efficiency of the machining process [4]. This process can be improved not in an expensive way, as opposed to purchasing new machine tools. This way is the use of a new high-duty tools or modernization of standard tools.

Cutting tools are the means without which it is impossible to fully realize the technological potential of the machines and achieve high technical and economic performance of workpiece machining. That is why, much attention is paid to improving the design of cutting tools.

Reducing wear and increasing the life period of cutting tools during machining materials, especially those that are difficult to machine, are still the most important and relevant tasks in machine tool technology, especially in automated production, where computer controlled machines are used.

The tendency to create new and improve old designs of cutting tools, and the use of scientifically based machining modes for them is a decisive factor for increasing the durability of the cutting tool and, consequently, the productivity of machining [1], [3], [4]. This trend is also characteristic of tools used for cutting-off operations on turning and boring machines.
2. Materials and methods
Part-off tools operate in harsh conditions, especially when machining large cast iron and steel workpieces obtained by casting or die-casting techniques [4], [6], [7]. Due to the small width of the working part of the tool, the tool may not be strong enough and cutting chip evacuation from the cutting area may be difficult. This leads to a decrease in the speed of cutting the workpiece, which reduces the overall processing performance.

Standard cut-off turning tools (figure 1, a) usually do not remove all metal on the cut, the workpiece is broken off and the core remains in its center.

Using a cutting tool with an major cutting edge angle $\varphi = 90^\circ$, the right side of the workpiece can be broken off from the left side while the cutter is not yet in the middle and a small part remains on the cut-off part, which then has to be removed.

At $\varphi < 90^\circ$ the cut-off part is separated without residue, because the remaining element on the left side of the workpiece will be cut off as the cutter moves further (figure 1, b).

![Figure 1. Cut-off turning tools: a - $\varphi = 90^\circ$; b - $\varphi < 90^\circ$; c - with two cutting edges.](image)

The most heavily loaded part of cutting-edge cutters is the corners at the tip due to the small tool included angle of the cutting-edge. To increase cutting-off performance, cutters with two symmetrically arranged cutting edges at an angle of $\varphi = 60...70^\circ$ (figure 1, c) are used.

In addition to changing the cutting geometry, the tool design itself can be changed [3], [8], [9]. Special cutters are used to increase the vibration resistance during cutting operations (figure 2).

Holder 1 of such a cutter has in its bottom base a semi-circular projection 2, in which there is hole 6, which turns in the bottom part of slot 4. In hole 6 there is a split spring ring 3 with an additional spring ring 7. In the wall of hole 6 and on the inner surface of the rings there are circular grooves 12...14, and on the outer surface of the rings there are circular protrusions 10 and 11, included in these grooves. Spring ring 3 has a lock 8, included in slot 4 holder 1, and ring 7 has lock 5, included in slot 9 rings 3, which prevents the rotation of these rings. Spring rings of different stiffness are used to control the stiffness of the tool and its resistance to vibrations [3], [10].

For cutting large workpieces up to 220 mm in diameter, cutters of other designs are used (figure 3). The flat plate 2 is placed on the working face of the cut-off tool, which is made in the form of a concave circular sector, and it is fixed with the help of conical pins 3, included in the holes of the flat plate. The conical pins, when tightened with the nuts 4 in the tool body, ensure that the plate is pressed tightly and that there is some tension between them. After fixing the pins 3 are additionally fastened with screws 5, and the plate 2 is pressed to the body 1 with the strip 6 and the screw 7. Plate tension prevents its breakage and drift during cutting, which improves the quality of the end faces of the workpiece during cutting-off operations [10].
3. Results and Discussion

The design of the proposed cutting-off tool will help to speed up and improve the quality of machining of large-diameter steel and cast iron workpieces by reducing the vibration at the cutting-off operation.

The proposed new design of cutting tools (figure 5) consists of body structure 1, hold-down tool 2 and replaceable cutter 3 with replaceable carbide cutting plates. The cutting material of the tool is
selected depending on the material of the workpiece to be cut and the expected cutting speed. Before operation, the tool body is installed in the toolholder of the machine 4.

![Figure 5. Construction scheme of the cutting-off device.](image)

This tool design allows you to stabilize the cutting forces in the machining area. This leads to the stabilization of the perturbation forces in the elastic processing system, reduction of the vibration amplitude and increase of the dynamic stability of the processing system.

An essential role in the dynamic stability of the machining system when using the proposed design of the cutting-off tool fails the elastoplastic properties of the cut metal layer in the zone of plastic deformation and in the zone of contact interaction of the cutting chips coming from the tool face. These factors significantly affect the stabilization of self-oscillatory processes when cutting-off workpieces. As a result, there is a decrease in the intensity of wear of the cutting tool inserts, which reduces the time of the workpiece machining while maintaining the quality parameters of the end face of the workpiece.

4. Conclusion
The analysis of existing schemes of cutting-off large-size workpieces on lathes has shown that the cutting process differs from other types of turning by more severe conditions. It is explained by insufficient rigidity of the system, variable values of speed, temperature and dynamics of the cutting process. Taking into account these conditions, the analysis of various designs of cutting tools was carried out, which showed that for a comprehensive solution of the problem it is necessary to have a fundamentally different design of cutting tools.

A new design of cutting tools with a special scheme of double-sided cutting inserts installation was proposed, which allows to increase the productivity of cutting without loss of its quality.

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