RESEARCH ON INCREASING THE PRODUCTIVITY OF MECHANICALLY CLAMPED CUTTING INSERTS IN FLAT SURFACE MILLING

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Abstract

This article investigates the issue 1of increasing the productivity of mechanically clamped cutting inserts in the process of milling flat surfaces. The influence of cutting speed, feed rate, cutting depth, insert material, geometry, and clamping method on machining efficiency was analyzed. In the study, wear of carbide inserts, cutting forces, surface roughness, and machining time were taken as the main evaluation criteria. The results showed that productivity in flat surface milling can be significantly increased by selecting optimal cutting conditions, properly determining insert geometry, and ensuring the stability of mechanical clamping.

Keywords: milling, flat surface, cutting insert, mechanical clamping, productivity, cutting conditions, surface roughness, wear.

Introduction

In mechanical engineering, machining flat surfaces is one of the most common technological processes. Such surfaces are widely found in housing parts, plates, bed elements, gearbox housings, molds, and fixture components. The accuracy and surface quality of flat surfaces directly affect the operational reliability of the finished product.

In flat surface milling, cutters with mechanically clamped cutting inserts are often used as cutting tools. The main advantage of such tools is that when the insert wears out, it is not necessary to replace the entire milling cutter; only the cutting insert is replaced or another cutting edge is used. This reduces production costs, shortens setup time, and increases process productivity.[1]

However, the performance efficiency of mechanically clamped inserts depends on many factors. In particular, factors such as insert material, coating, rake and clearance angles, cutting edge radius, clamping reliability, cutting speed, feed rate, and depth of cut affect the stability of the milling process. Therefore, conducting scientific research in this direction is considered relevant.[2]

Research Objective

The main objective of the study is to identify the factors affecting the productivity of mechanically clamped cutting inserts in flat surface milling and to justify optimal cutting conditions.

1. Research Tasks
2. To achieve this objective, the following tasks were defined:
3. To analyze the main technological features of the flat surface milling process.
4. To study the structural advantages of mechanically clamped cutting inserts.
5. To evaluate the influence of cutting speed, feed rate, and depth of cut on productivity.
6. To determine the relationship between insert wear and surface roughness.
7. To develop optimal technological recommendations for increasing productivity.
8. Research Material and Method
9. The process of milling flat surfaces was selected as the object of the study. The subject of the study is the technological and structural factors affecting the productivity of mechanically clamped cutting inserts.
10. In the research, a face milling cutter equipped with carbide cutting inserts was considered. A structural steel sample was selected as the workpiece material. During the milling process, the following main parameters were analyzed:

Parameter	Symbol	Unit of Measurement
Cutting speed	V	m/min
Feed rate	S	mm/min
Feed per tooth	Sz	mm/tooth
Depth of cut	t	mm
Cutter diameter	D	mm
Spindle speed	n	rpm
Surface roughness	Ra	μm
Machining time	T	min
Cutting speed	V	m/min
Feed rate	S	mm/min

In evaluating the cutting conditions, milling productivity is determined based on the following indicator:

$Q=B*T*S$

where:

Q — material removal rate, mm^3/min;

B — milling width, mm;

t — depth of cut, mm;

S — table feed, mm/min.

Using this formula, it is determined that productivity increases when the depth of cut and feed rate are increased. However, if these parameters are increased excessively, insert wear, vibration, deterioration of surface quality, and tool breakage may occur.[3]

Main Results

The analysis showed that the productivity of mechanically clamped inserts in flat surface milling mainly depends on cutting conditions and insert geometry. An increase in cutting speed reduces machining time; however, at very high speeds,

the cutting edge wears rapidly. An increase in feed rate improves the material removal rate, but surface roughness and cutting forces also increase.

One of the most important advantages of mechanically clamped inserts is the possibility of their quick replacement. This reduces downtime in production. In addition, the use of multi-edge inserts makes it possible to use one insert several times.

`Table 1. Effect of Cutting Conditions on Milling Productivity

Experiment	Cutting Speed, m/min	Feed Rate, mm/min	Depth of Cut, mm	Surface Roughness Ra, μm	Result
1	120	160	1.0	2.5	Stable
2	160	220	1.5	2.1	Good
3	200	280	2.0	1.8	Optimal
4	240	340	2.5	2.7	Vibration increased
5	280	400	3.0	3.4	Insert wear increased

As can be seen from the table, the milling process remains stable at moderately optimal values of the cutting conditions. At very low cutting conditions, productivity is insufficient, while at very high cutting conditions, insert wear and vibration increase.

Discussion

Increasing only the cutting speed is not sufficient to improve the efficiency of mechanically clamped inserts in flat surface milling. The process requires a comprehensive approach. In this case, the insert material, coating type, cutting edge geometry, clamping strength, and machine tool rigidity should be evaluated together.

Carbide inserts make it possible to operate at high cutting speeds due to their high hardness and heat resistance. If coatings such as TiN, TiAlN, or Al_2O_3 are applied to the surface of the insert, wear resistance increases and the effect of heat in the cutting zone decreases.

The mechanical clamping system must hold the insert accurately and stably in the milling cutter body. If the clamping is insufficient, the insert makes micro-movements, which leads to vibration, uneven surface quality, and cutting edge breakage. Therefore, the accuracy of the insert seat, screw clamping element, and support surfaces is of great importance.

Recommended Technological Solutions

To increase productivity in flat surface milling, the following recommendations are proposed:

Problem	Cause	Recommendation
Rapid insert wear	High cutting speed or improper coating	Select a coated carbide insert
Vibration	Weak clamping or excessive feed rate	Check the insert seat and optimize the feed rate
Poor surface quality	Wear of the cutting edge	Replace the insert in due time
Low productivity	Low cutting conditions	Optimally increase cutting speed and feed rate
Cutting edge breakage	Excessive depth of cut	Select the depth of cut step by step

Conclusion

The use of mechanically clamped cutting inserts in flat surface milling is one of the effective methods for increasing production productivity. Such inserts are distinguished by their quick replacement, multi-edge use, and ability to operate under high cutting conditions.

The analysis showed that cutting speed, feed rate, depth of cut, insert material, and clamping stability directly affect milling productivity. By selecting optimal cutting conditions, it is possible to increase the material removal rate, improve surface quality, and extend the service life of the insert.

The most suitable result is achieved by a balanced selection of cutting speed, feed rate, and depth of cut. Therefore, when using milling cutters with mechanically clamped cutting inserts, it is recommended to select technological conditions according to actual production requirements.

References

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