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EFFECT OF REVOLVING CUTTING PLATES COATING ON MACHINING ECONOMY

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Abstract

Based on the tests of coated revolving (changeable) plates of hard metal (HM) on milling heads, conducted in real production conditions, this paper presents some effects which are obtained by coating (the quality of cutting tools, having significantly better tribological properties so by that even longer lifetime), from which basic elements of this operation economy calculation result. It can be concluded that, in the beginning, more expensive coated revolving cutting plates of hard metal have lower total costs of cutting tools for 30 % so even more than 50 % comparing to non-coated cutting plates.

Testing was conducted in real production conditions in the plant for parts machining from automotive industry field.

Keywords: *tooling costs, coatings, productivity*

1. INTRODUCTION

In its developmental component, machining deals with problems of improving machinability parameters by developing factors of machining system. One of important factors with which can be influenced on machining system is the tool quality. Development of machining system through tools development assumes improvement of tool material properties and improvement of tool surface properties.

In modern industry of tools manufacturing, researches in this field are directed towards researches and development of single layer and multilayer coatings application on tool surface. Within this complexity of problems, tools consistency and all types of tool wearing are currently being intensively researched.

Based on the tests of coated revolving (changeable) plates on milling heads, conducted in real production conditions, the purpose of this paper is to present all effects obtained by coating, from which basic elements of this operation economy calculation result.

2. TEST CONDITIONS

So as to optimise utilisation of complex geometry tools and higher values tools within regular activivities of Tools Department, Zastava automobili in Kragujevac, constant monitoring of tool lifetime and analysis of machining costs are under way. This is especially important with machining by milling with milling heads which have even more than 20 cutting plates, which are necessary to be positioned along the perimeter without front deviations.

Apart from monitoring state of tools and number of processed workpieces, a special attention is paid to the maximum usage and analysis of possibilities for costs reduction. When it comes to any milling cutter with revolving cutting plates of hard metal (HM), after reaching critical wearing out, turning of plates is performed and in the end concurrent replacement of worn set.

A part of testing results obtained during 2006 is shown in the paper, and it can be stated that relevant savings have been achieved. Table 1, 2 show basic characteristics of two machining processes during which test with tools with and without coatings were conducted. During monitoring state of tools and number of processed workpieces, improper operation preparation and tools positioning by workers leads to significant tools damage, trimming and significant reduction of total lifetime, and by that the economy of manufacturing as well.

During test, while performing cutting operation, by choosing suitable high-quality multilayer coated revolving cutting plate of hard metal, large number of mutually completely the same cutting tools participate, but they do not machine the same surfaces, that is, they do not have the same length and depth of cutting, which leads to the fact that consistency of each unit of the same cutting tool is different, depending on processing conditions and machinability of corresponding area. This fact, that when it comes to multi-cutting machines, consistency of single tool is different, creates difficulties with moment of optimum replacement due to necessity for stopping operation of machining system, along with reduction of their individual consistency.

Table 1. Basic characteristics of process 1

Machine: PRVOMAJSKA GHK – 3P milling machine
Operation: Milling of gaps for disc and surface of metal part of plate
n=280 r.p.m., Vs=40 mm/min, tg=0,94 min, δ=2 mm
Material of workpiece: Nodular casting GH 60-38-10
Cutting tool HM plate – TPAN 1603 PP K13A
Special milling head ø250x50 with 16 cutting revolving plates

Table 2. Basic characteristics of process 2

Machine: ILR milling machine
Operation: Final milling of connecting plane of gearbox casing and bell casing
n=640 r.p.m., s=1,53 mm/o, tm=0,57 min, δ=0,5 mm
Material of workpiece: Silumin – Al 132
Cutting tool HM plate – SFAN 1203 30
Special milling head ø400 with 20 cutting revolving plates

3. RESULTS AND ANALYSIS OF TEST RESULTS

By continuous following of state of cutting tools, number of machined work pieces and calculation of tools costs, one comes to the data in Tables 3 and 4. The tables show average values of number of processed workpieces, tools price expresseed in euros and tools costs per piece, with and without coatings.

Table 3. Test results of machining process 1

Tool Price (euro)	No. of machined pieces with 1 cutting edge	Total value of tools	Total No. of machin-ed pieces	Tools costs per piece Euro
a) Costs review of cutting tools without coating				
7.65	650	122.4	1950	0,063
b) Costs review of cutting tools with coating				
9.568	1250	153.1	3750	0,041

Table 4. Test results of machining process 2

Tool Price (euro)	No. of machined pieces with 1 cutting edge	Total value of tools	Total No. of machin-ed pieces	Tools costs per piece Euro
a) Costs review of cutting tools without coating				
9.38	700	187.6	2800	0,067
b) Costs review of cutting tools with coating				
11.72	1150	234.4	4600	0,05

In case of cutting tools in the form of revolving cutting plates, which are mechanically clamped in special holders and when their sharpening is not performed, which is the principle with these tools, then all costs related to sharpening and sharpener fall off. When time for replacing tools is already contained in manufacturing time, then expression for calculating costs of cutting revolving plates (T) has shorter form, such as:

$$T = \frac{V_p}{q_p},$$

where: V_p – is the value of one revolving plates set,

q_p – total number of machined pieces with all cutting edges.

The following histograms contain the display of tool costs, number of machined pieces with one cutting egde and tool price with and without application of coatings on HM plates for both described machining processes.

The aim of experimental researches, initiated in this paper, is to study effects of coatings of cutting tools on economy of its machining.

Since larger number of revolving plates on milling head participates in milling operation at the same time, the tables and histograms show costs of cutting tools per number of machined pieces.

Large number of factors influence on the size of cutting tools costs, among which cutting tool geometry and improvement of tool cutting surfaces, i.e. application of different coating types, number of machined pieces that directly influences on economy of manufacturing, as well as price and method of tool purchase and its tribological characteristic etc.

The influence of the mentioned factors is complex and Figures 1 and 2 clearly confirm the fact that quality of cutting tool in so much affect economy of machining and that application of more expensive tools with coatings often results in significantly lower total costs.

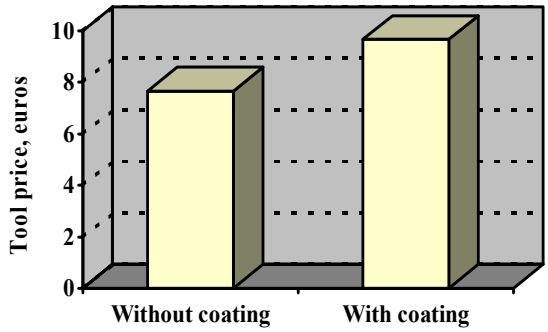

Fig. 1. Tools price of HM cutting plates with and without coating

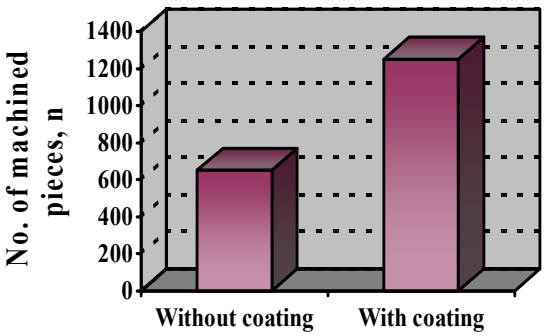

Fig. 2. Number of machined pieces with one cutting edge – machining process 1

The Fig. 3 shows tools costs per piece for tested cutting plates for machining process 1.

It can be perceived that tools costs without coating are more than 50% higher. This justifies the fact that tools with coatings are used in Zastava automobili. Tools without coatings are used only in deficiency of tools with coatings.

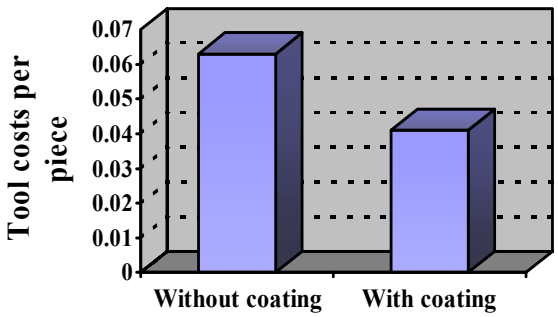

Fig. 3. Tool costs per piece for machining process 1

It can be stated that minimum tools costs are reachable with maximum application of work instructions on machine and quality application and operation performing. In this case, it does not come to tools failure because of trimming or intensive wearing. Continuous wearing is dominant up to adopted wearing criteria 0,02 – 0,05 mm, which impairs the surface quality.

Based on conducted researches for machining process 2, individual price of revolving HM cutting plates with and without coatings is shown in Fig. 4. It can be perceived that the price of plate with coatings is higher than 25% for this process. However, the coated plates can under the same conditions, for a concrete case, make for about 65% higher number of pieces, which can be clearly seen in histogram in Fig. 5.

The total effects of applying coated plates are shown in Fig. 6. By analysing, it can be concluded that, in the beginning, more expensive coated plates give lower costs of cutting tools per one such piece for machining process 2, that is, costs of plates without coating are more than 30% higher per piece.

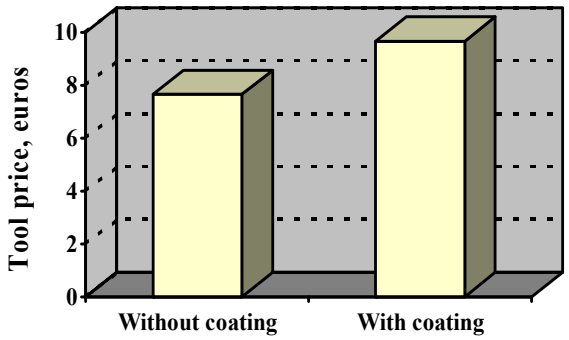

Fig. 4. Tool price of HM cutting plates with and without coatings

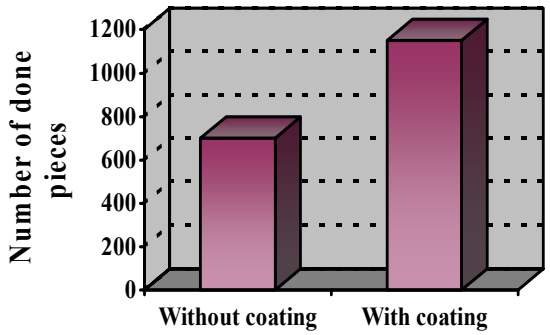

Fig. 5. Number of machined pieces with one cutting edge – machining process 2

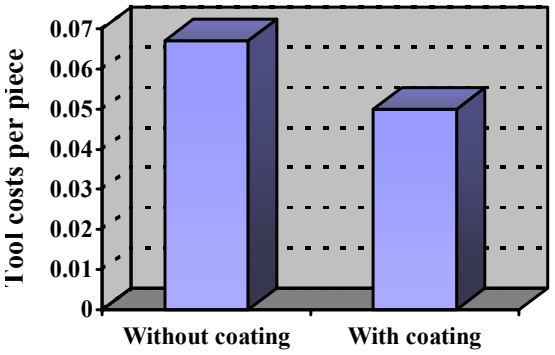

Fig. 6. Tool costs per piece for machining process 2

Machining process 2 confirms that costs of cutting tools with coatings are often far lower than tool costs without coatings.

The increased number of machined pieces, for analysed concrete cases, justifies higher price of revolving cutting plates of hard metal with coatings.

For calculating costs of cutting tools, it is necessary to have available higher number of data without which there are no conditions for requested analysis whose result would point out to directions of further action with the aim of reducing cutting tools costs and increasing productivity of machining system.

For identification of machining systems productivity structure P, we started from basic and general definition of productivity (P) as follows:

$$P = \frac{OUTPUT}{INPUT}.$$

For the level of machining system OUTPUT is usually finally machined part (FP) or some of its operations, i.e. the machining phase, depending on configurationand complexity of the machining system and production series. As INPUT stands for assigned machining costs (V_o), namely labor costs (L), tool costs (T) and amortisation of machine (A_m). While consumption of energy (E), material (M), coolants and lubricants costs (CL), and others, are usually recorded on the level of production system. It is more convenient to work with reciprocal value of productivity (1/P), thus it follows:

$$\frac{1}{P} = \frac{V_o}{FP} = \frac{L + T + A_m}{FP}$$

As an example, for the analysed process 1, Fig. 7 shows the structure of machining costs elements (L,T,A_m) and total machining costs on the level of machining system V_o, in case of use of coated and non-coated cutting revolving plates.

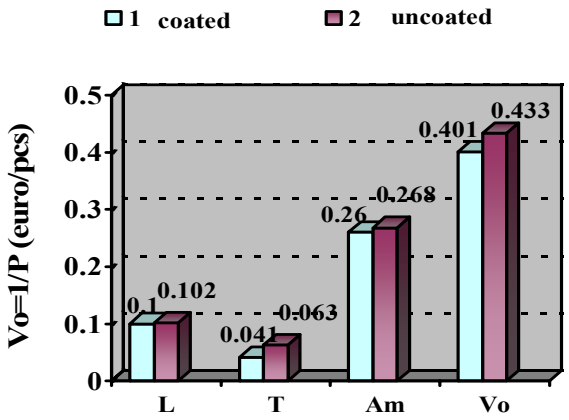

Fig. 7. The structure of machining costs for process 1

It can be observed that with coated plates, labour (L) costs are lower per product unit and costs of machine amortization (A_m) are lower because due to higher lifetime of these plates, replacement of worn plates is more rare perfomed in relation to non-coated cutting plates, so capacity of machine is better used (in concrete case for process 1 for 3%).

Lower costs of cutting tool (T), as previously emphasised for process 1 when coated cutting plates and lower costs L and A_m are used, totally give lower costs V_o, so thus more suitable reciprocal value of productivity 1/P, as illustrated in Fig. 8.

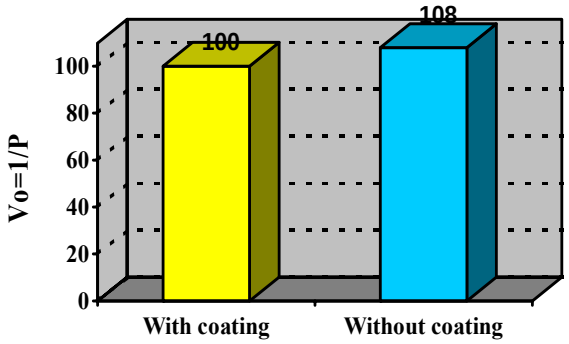

Fig. 8. Reciprocal productivity index Vo=1/P for process 1

Figure 8 clearly shows that productivity on the level of machining system, expressed in value-based form, has increased for an essential amount of around 8 % when instead of non-coated cutting plates under the same other conditions, coated cutting plates are used. This is the important data for managing machining systems with note that for each concrete case, extensive researches and analyses should be conducted.

4. CONCLUSION

Presented test results point out to the significance of tools monitoring and results of costs reduction that can be achieved by improving tools cutting surface. It is obvious that application of more expensive tools with coatings results in significantly lower costs. Also, operation preparation and performing have very important effect on costs. In most cases, worker's lack of attention leads to tool damage and improper wearing. That causes reduction of tools lifetime, reduction of number of machined pieces and by this, increase of tool costs.

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