**BALKANTRIB'O5**
**5th INTERNATIONAL CONFERENCE ON TRIBOLOGY**
**JUNE.15-18. 2005**
**Kragujevac, Serbia and Montenegro**

# EFFECTS CAUSED BY IMPLEMENTATION OF CUTTING TOOLS WITH COATINGS

*Zoran STOŠIĆ, Zastava automobili, Kragujevac*
*Dr Miljko KOKIĆ, Grupa Zastava vozila a.d., Kragujevac*
*Nataša VESIĆ, Zastava automobili, Kragujevac*

**Abstract**

*In metal processing by cutting, we also have higher implementation of cutting tools made of hard metal additionally improved with single – and multi-layer coatings. In that way, with higher purchasing price, cutting tools with higher quality, which has significantly better tribological properties and longer life cycle can be obtained, which globally speaking gives satisfactory economic effects.*

*This paper presents some results of the research performed in the factory for mechanical processing of auto parts. The point is the difference in life time of cutting inserts made of hard metal depending on the type of coating. This is particularly significant for process of milling with milling heads which carry over 20 cutting inserts that must be placed around the head without face deviation.*

**Key words:** *hard metal, coating, tool life cycle, costs.*

## 1. INTRODUCTION

The utmost participation in metal processing industry takes up the metal cutting. Because of the presence of tribological process in the cutting zone there is an increased wearing of cutting tools and also increased machining costs on the level of processing system.

Metal cutting is the process that is, in his developing component, occupied with problem of improvement of machining parameters by developing of factors of processing system. One of the cardinal factors with which you can influence on processing system is the quality of tools. Development of processing system through development of tools considers property improvement of tools materials and property improvement of tools surface. In modern industry of manufacturing tools, the researches in this area are directed on researches and development of application of single- and multi - layer coatings on tolls surface. In that problems complex, the tools stability and all category of tools wearing, are the subject of today's intensive researches.

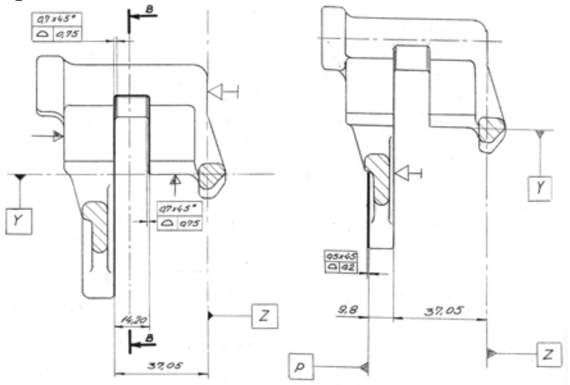
The goal of this paper is precisely presenting all effects caused by coating, based on the analysis of exchangeable coated hard metal inserts on milling heads, carried out in real manufacturing conditions, from which arises primary elements for the calculation of this operation economy.

## 2. TEST CONDITIONS

Within this paper, comparatively test of exchangeable hard metal inserts, with ISO geometry with different manufacturing quality, in real manufacturing conditions on two machines, were carried out. Those machines are:

1. **Special single-spindle horizontal mill with two milling heads, for brake disc caliper support machining:**
   - milling of a disc slot (I phase),
   - milling of external surface (II phase).

Work piece material – nodular cast iron GH 60-38-10.
Milling cutter: disc milling cutter Ø245.5 with rake angle $\gamma=4^{\circ}$.
The machining was carried out simultaneously of 3 surfaces with 2 milling cutters.
Processing system was served by one direct worker.
The machining was carried out simultaneously with total of 40 triangular inserts with 3 tool tips.

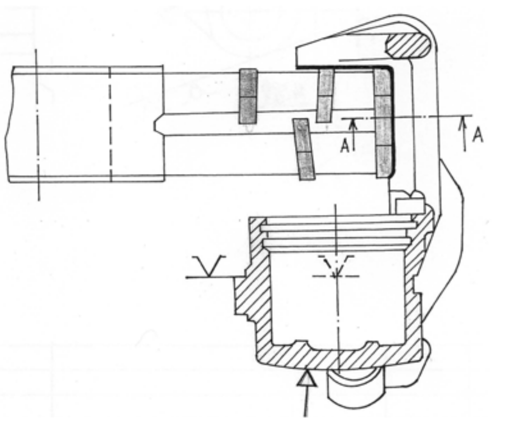



*a)* *b)*

**Picture 1** – *Brake disc caliper support draft: a) I phase, b) II phase*

Exchange of inserts was carried out in 0.3 min, i.e. $t_l$=12min for both milling cutters.
Analysis were carried out on 4 hard metal inserts taken from first and 4 hard metal inserts taken from second milling head.

2. **Single-spindle horizontal mill with rotating table, for machining of brake disc caliper body:**
   - milling of disc slot and pad external surface.




**Picture 2** – *Draft of the milling operations of disc slot and pad external surface*

Part material: nodular cast iron GH 60-38-10.
Milling cutter: double disc milling cutter Ø250x50 with rake angle $\gamma=4^{\circ}$.

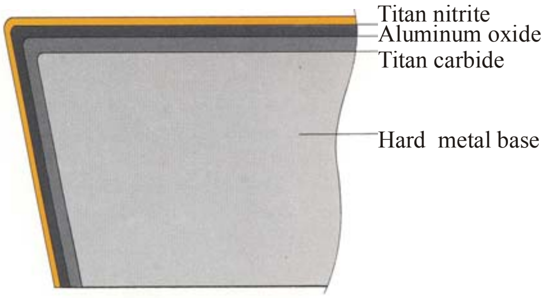
The machining was carried out on one surface with one milling head with two types of triangular inserts (16+16) with 3 tool tips.
Processing system was served by one direct worker.
Exchange of inserts was carried out in 0.2 min, i.e. $t_l$=6.4 min for milling cutter.
All tests are carried out with coolant and lubricant BISOL 200, concentration 3%.
Procedure of tool coating represents new modern technology. In domain of new technologies for manufacturing tools it is considered that the most significant place belongs to new material technology, within which the most important is the forming of thin surface cases (covering) on the surfaces of cutting tools.

For increasing of tribo-mechanical properties of a contact between cutting tool and part on the one side, and cutting tool and chips on the other side, surfaces of cutting tools are covered by special techniques with thin surfaces cases from material which tribological properties are much better than properties of primary cutting tool material.

Extraordinarily properties of primary material (hard metal) which are obtained by combination of very hard particles of wolfram carbide (WC), tantalum carbide (TaC), nobium carbide (NbC), titan carbide (TiC) and binding material – cobalt (Co), are high hardness, resistance to wear, high pressure strength, high stretch modulus.

Hard metal, no matter if it is using for machining the steel, grey iron, nodular cast iron, is covered mostly with three layers.

First layer made from titan carbide, which lays on the base, is very wear resistant and ensure good binding between coating and base. Layer which comes on the top of it, are made from aluminum oxide ($Al_2O_3$) and ensures necessary temperature resistance of the cutting insert, and whit that impede the possibility of sticking of the chips on the blade of a cutting tool. Upper layer of titan nitrite reduces the coefficient of friction between cutting tool and the part on the one side and cutting tool and chips on the other side.

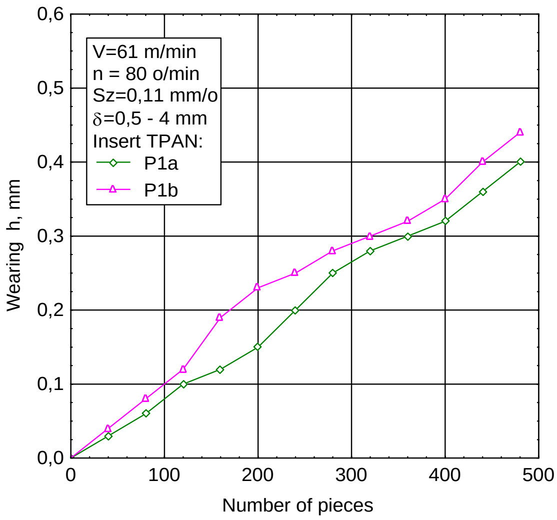



**Picture 3** – *Display of hard metal cutting insert with multi-layer coatings*

During machining of nodular cast iron, this type of coating presents the effective protection of back surface wear, of creation of crater on rake surface, as well as protection of plastic deformation.

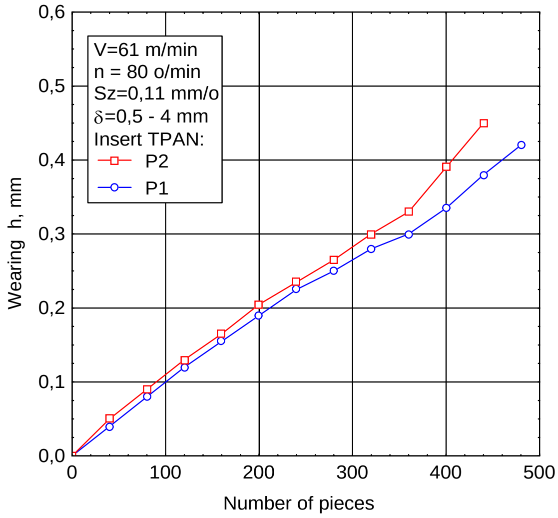
## 3. TEST RESULTS

For stipulated test conditions, graph chart of comparatively wearing curves of hard metal cutting inserts with and without coating is given. Theoretical and experimental tests, initiated in this paper, aim at researching of influence of different cutting tool coatings on his constancy.
As in operation of milling simultaneously participate major number of inserts on milling head, diagrams demonstrate tool constancy according to number of finished parts.
Picture 4 demonstrate wearing curves of two hard metal inserts without coating which are located on milling cutter 90° angular to each other. The differences in wearing zone after defined number of parts can be perceive.



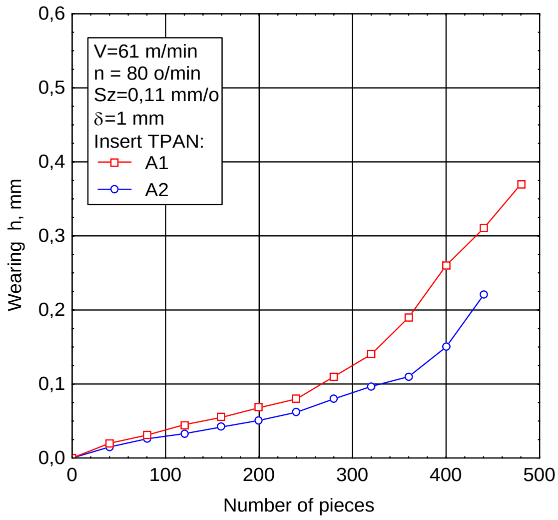

**Picture 4** – *Differences in wearing of two cutting inserts on milling head*

Picture 5 demonstrates average wearing curves in milling of disc slot (I phase). The machining was performed, marked with P1 and P2.



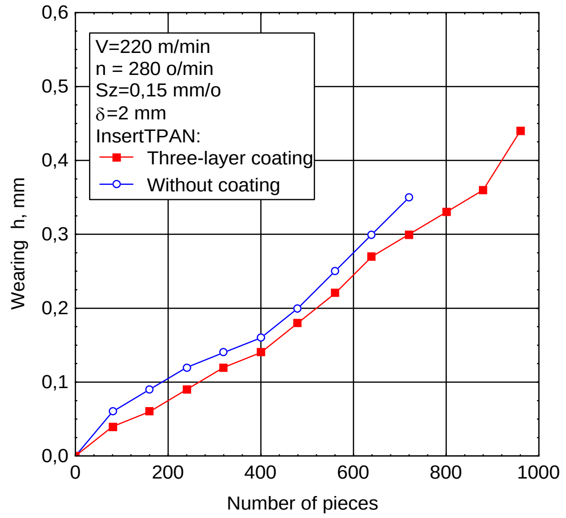

**Picture 5** – *Diagram of wearing of hard metal inserts without coating*

Picture 6 demonstrates wearing curves in milling external surface (II phase), with two different qualities of cutting inserts without coating, marked A1 and A2. The insert with A2 quality showed milder wearing intensity in comparison with A1 insert, but change in quality of machined surface occurred at wearing zone width of 0.13 mm.
Namely, if the semi finished product has non-homogeneous structure with zone which can not be machined, it is for that conditions difficult to ensure adequate machining regime and to predict cutting tool which can keep, under that conditions, the necessarily level of constancy and costs.




**Picture 6** – *The case of catastrophic cutting tool wearing*

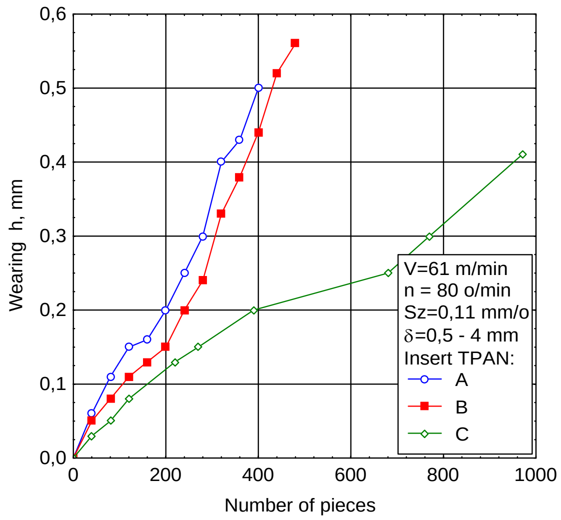
Picture 7 demonstrates comparatively wearing curves of hard metal cutting inserts with and without coating in milling of disc slot and pad external surface.




**Picture 7** – *Diagram of comparatively wearing curves*

It can be perceived that with selection of adequate high quality multi layer coated hard metal cutting inserts, it is possible to get high constancy (about 30%) in respect to classical selected hard metal insert.

Picture 8 shows wearing curves exchangeable high quality coated hard metal inserts in brake disc caliper support machining. The differences in cutting tool constancy according to the type of coating can be seen.




**Picture 8** - *Comparatively wearing curves for different hard metal inserts with different coatings*

Wearing curves on the picture show that tool constancy can be doubled with adequate choice of exchangeable hard metal coated inserts.

We can reach the conclusion that the coating effects in particular machining operations can be ignored in comparison with coating price of basic tool material.

## 4. CONCLUSION

Great problem that is placed before a cutting tool technolog analyst involves implementation test of modern cutting tools, their purchasing and exploatation costs, tool material type, implementation of wearing surface improvement methods, tool geometry definition, ways of working with tools, machining regime check, cutting tool replacement speed. The influence of above mentioned methods is complex and some of them have mutually controversial influence within the aspect of costs and cutting tool constancy.

During the research, in milling operations, higher number of completely different cutting tools was used, but not for the same surfaces, that is for different cutting lengths and depths, which caused the different constancy of every cutting tool unit, depending on machining conditions and machinability of certain zones. This fact that multicutting machines have different constancy of tool unit causes problems regarding the optimal moment of replacement due to necessity of interrupting work of processing system, with decreasing individual constancy.

Nowadays, the following materials have mass implementation for cutting tools:

- high speed steels with or without coating,
- hard metal with or without coating,
- cutting ceramics,
- boron-nitride etc.

Participation of mentioned tool materials in produced tool structure is different, depending on the type of the production process. However, it could be said that the hard metal represses high speed steel, and that the implementation of ceramics, diamond and other modern material is perspective for future development especially for so called hard machining operations with the aspect of machinability and machining regime.

This kind of research should be continued to see the effect of this kind of process: tool constancy, machining quality by comparatively test of cutting tools with or without coating.

## 5. REFERENCES

[1] Ivković B., Obrada metala rezanjem, Mašinski fakultet u Kragujevcu, Kragujevac, 1994. god.

[2] M. Kokić, Produktivnost industrijskih sistema, Mašinski fakultet u Kragujevcu, Kragujevac, 1998. god.

[3] Lazić M., Tehnologija obrade metala rezanjem, Mašinski fakultet u Kragujevcu, Kragujevac, 2002. god.