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Carbon and titanium based layers for wood-based materials

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ABSTRACT

Purpose: The main purpose of this work was to work out the technology of manufacturing carbon and titanium based layers on the surfaces of sintered carbides machining edges used in furniture industry.
Design/methodology/approach: A hybrid deposition system employing DC magnetron sputtering and radio frequency plasma assisted chemical vapour deposition (RF PACVD) in one reaction chamber was used to manufacture Ti:C gradient layers. For the laboratory investigation layers were deposited on sintered carbide samples. Friction coefficient and SEM EDS analysis were made. For the exploitation tests layers were deposited on the commercial sintered carbide tools widely used in furniture industry.
Findings: As the result of investigation it was noticed that Ti and C based gradient layers deposited on sintered carbides surfaces seems to be a very interesting alternative for standard non modified machining tools because of they noticeably decreased friction coefficient and improved durability.
Practical implications: Presented technology is dedicated for furniture industry as a layer improving the cutting properties of the machining tools
Originality/value: Application of carbon and titanium based layers deposited by hybrid deposition method on sintered carbide cutting edges for wood and wood-based materials machining.
Keywords: Thin and thick coatings; Chipboards machining; Sintered carbide; Carbon

1. Introduction

Due to composite character of chipboards, mechanical machining of wood-based materials doesn't belong to the easiest one. Chipboards because of the decoration and stamina properties are covered with hard and difficult in machining laminates.

Additional machining difficulties make wood-based materials, chipboards impregnants, laminates etc. with heterogeneous structure which consist in their composition also resin and sand. That kind of material require high demands prior to the cutting toll like high hardness, low abrasibility and low brittleness. Keeping as long as it is possible high quality of the cutting edge is directly connected with getting a good quality of machined surfaces. Together with the enlarged obtundation of the cutting edges not only the machining forces are increased, but also the quality of machined surfaces is getting worse.

Specific structure of chipboards causes irregular wear out of machining edges. Character of tools obtundation is quite different than in case of steel or color metals machining. On today's market of machining tool used in furniture making industry a more and more visible is a trend of modern material engineering solutions application. Tools covered with coatings which increase their durability like: TiN, TiCN, CrN are available. Among many modern solutions of layers deposited on tools used in wood and wood-based materials machining polycrystalline diamond (PCD) coatings can be found. But the most important drawback of these layers is their low impact resistance. Even small inclusions in chipboards can cause devastation of the edge covered with PCD [1,2].

Since years in many research centers of the world a development works concerning improvement of durability of sinter carbide cutting edges used in massive industry has been conducted by the deposition of thin [3-5] also diamond and diamond-like layers [6-8]. Similar researches are conducted in

furniture industry [9-12] The area of application of carbon layers embraces also tool and medical industry as a protective layers on medical tools and implants surfaces [13,14].

In this work a preliminary results of investigation of Ti and C based nanocomposite layers used as the tool durability improvement during a laminated chipboards machining are presented.

2. Experimental

2.1. Material and coating deposition procedures

Layers were manufactured with use of method of simultaneous magnetron sputtering process and radio frequency discharge.It's view is presented on Fig. 1

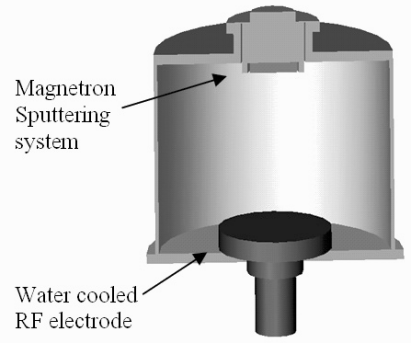

Fig. 1. Schematic of hybrid deposition system

Presented method was wide introduced and discussed in our earlier publications[15]. For carbon and based layers a Ti cathode with 99,99 % purity was applied. Ti target was sputtered in Ar atmosphere, however as a carboniferous gas a methane was employed. Surfaces used in the examinations were sintered carbides with commercial symbols ISO K05. A reason of this choice was dictated by low concentration of cobalt. Too much amount of this component is the reason of problems during the manufacturing of carbon layers. Sintered carbides chosen for the investigation are the most propagated materials in furniture industry production.

Prior to the deposition, the substrates were ultrasonically pre-cleaned in an acetone bath for 15 minutes and then eached in argon plasma directly in the reaction chamber. Due to computerised system of the atmosphere composition control fluent regulations of the reactive gases flow during the deposition process were obtained. Wide range of output power of the radio frequency power generator let to manufacture C and Ti based layers with the specified properties.

2.2. Morphology and properties

After the deposition process coatings were examined with use of SEM EDS techniques. On basis of these investigations thickness and surface topography were characterized. On Fig. 2 typical fracture of sintered carbide covered with layer on C and Ti basis is presented.

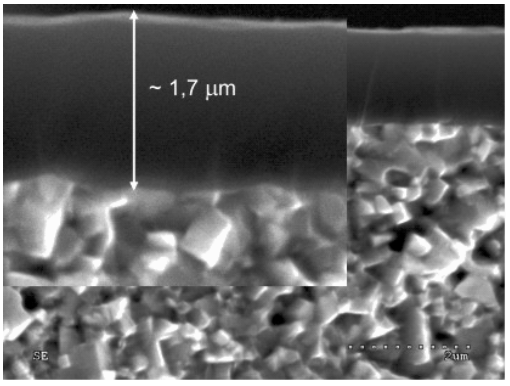

Fig. 2. Fracture of sintered carbide covered with Ti:C layer

Thickness of obtained films into furniture industry application didn't exceed of 2 micrometers. Presented on Fig. 3 coating area EDS analysis results confirm the existence of titanium as well as carbon. The character of these layers is analogical to the earlier described [11,12]. Directly on the substrate surface is thin Ti interlayer which pass across the gradient intermediate carbon and titanium based layer into typical carbon film.

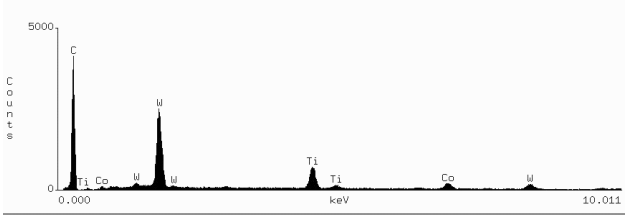

Fig. 3. Results of chemical composition analysis obtained on SEM

Presented composite layers have a great tribological properties. During the tests with use of T-11 tribological tester (ball-on-disc) it was proved that due to them it is possible to decrease the friction coefficient from 0,7 (which is characteristic for non modified sintered carbide) to about 0,37 (Fig. 4). The investigations were conducted for 100Cr6 steel ball and modified or non modified sintered carbide friction couple. Sliding speed was 0,1 m/s with 10 N load on the 500 m distance. These results are a very similar to that obtained for Ti:C gradient layers deposited on 15HN steel substrates [15].

2.3. Exploitation tests

Manufactured and characterized carbon and titanium based gradient layers were used in operating tests in real machining conditions. In the investigation tri-ply laminated 18 mm thick chipboard was used. This selection was dictated by the universality of its' application in furniture production. The tests was conducted with use of milling cutter head with presented on Fig. 5 angles of the machining edges in the tool configuration.

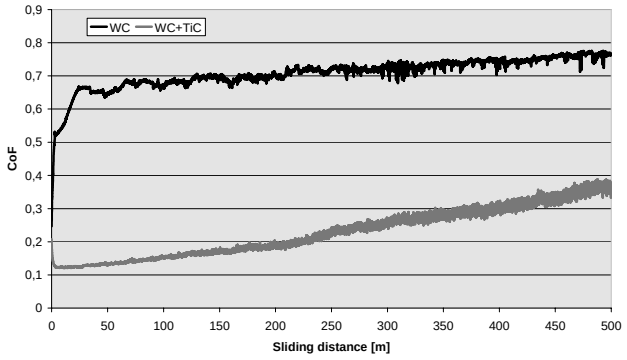

Fig. 4. Friction coefficient investigation results obtained in ball-on-disc method with use of 100Cr6 steel ball, load 10 N

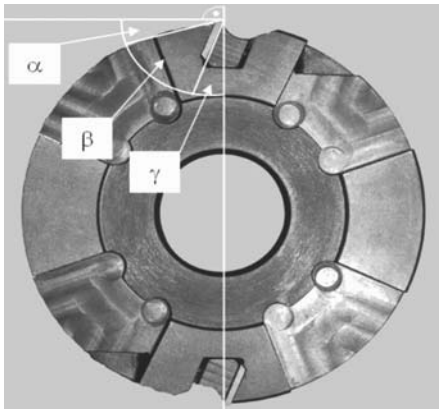

Fig. 5. Picture of the milling cutter heat used in presented investigation

Obtained investigation results indicate on the possibility of wear resistance improvement of sintered carbide tools by their surface modification with C and Ti based layers. On Fig. 6 the typical view of wear of the edge after 500 m of the machining distance is presented. As it is introduced due to Ti:C layers the wear of the tools has been limited, especially in the area where the hard in machining laminate appears.

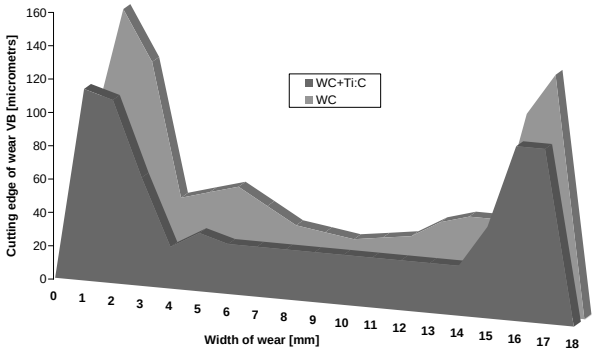

Fig. 6. View of the diminution of the edge after 500 m machining distance

On the graph on Fig. 7 diminution of the edges as a function of machining distance from 300 to 500 m is presented.

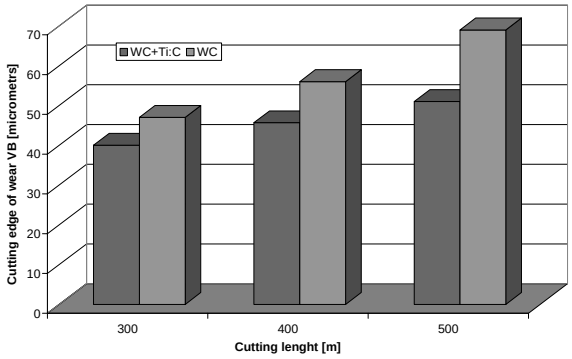

Fig. 7. Diminution rate of the edges after 300, 400 and 500 m machining distance

It was noticed that tool made of non modified sintered carbides undergo quicker wear versus the tools covered with C and Ti based layers.

Maximum difference between the durability of these tools was observed when the machining distance was about 500 m. Obtained level of wear was decreased about 30 % for the edges covered with Ti:C coatings. Introduced results are the effect of preliminary developmental investigation concerning initiation of presented technology into furniture industry.

3. Conclusions

Ti and C based gradient layers deposited on sintered carbides surfaces seems to be a very interesting alternative for standard non modified machining tools. Presented method let to obtain 2μm thick layers with a very good triblogical parameters. The preliminary results from the investigation in real operating tests proves their usability. In the long term tests growth of the durability was obtained to about 30 % in comparison to the pure sintered carbide tools. Works concerning the optimization of recommended method for the furniture industry requirements are still being continued.

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