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Prolonging the tool life of the cutting tools in press production

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This paper proposes information and results for computer aided manage in press production as an advanced technology. In our research, it is requested carrying out an expertise for the purposes of finding a way of prolonging the tool life of the cutting tools. This paper deals with development of methodology for prolonging the tool life of the cutting tools in order to improve the performances of the cutting tools intended for cardboard blanking for the production of light cardboard packing products. It is proposed two methodologies, as a coating and ion implantation of cutting tools.

1. VIEW OF OBJECTIVES AND GOALS OF THE PROJECT

This paper proposes methodology for prolonging the tool life of the cutting tools in order to improve the performances of the cutting tools intended for cardboard blanking for the production of light cardboard packing products. For this purpose, it is necessary to carry out an analysis of the significance of the influencing factors on the durability of the cutting tools because this influences directly their performance in the manufacturing process.

The cutting tools, applicable on modern CNC machines for folding carton and cardboard product industry, are based on the following constructive solution: a set of cutting tools is mounted on a basic steel plate, according to previously designed contour with a CAD model. Basic plate is in sheet steel with an intermediate epoxy resin layer and plastic type - creasing plate die board. Cutting tools are for orthogonal cutting with geometric and stereo metric characteristics.

The technological features of CNC machines for this production process determine conditions in which the production is performed by orthogonal cutting that is significantly less appropriate than the oblique cutting with regard to the intensity of wearing out of the cutting edge.

This paper aim to implementation a technological solution for prolonging the tool life of the cutting tools from two aspects: processing the cutting edges by two methods (coating and ion implantation and determination of the optimal operating conditions.

2. ANALYSING OF CUTTING TOOLS CARACTERISTICS USED IN CARBOARD PROCESSING

Cutting tools use in the process for cutting the paper have the standard form shown in Figure 1, with basically geometric characteristics: angle a=52^{o} and width s=0.71 [mm].

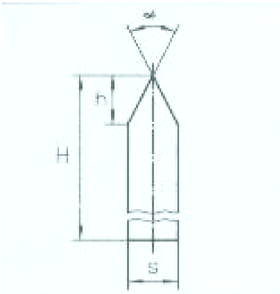


Figure 1. Geometrical form of the cutting tool

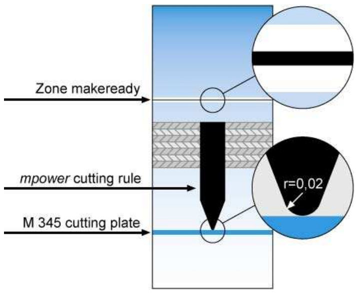


Figure 2. Cutting tool on the cutting plate

For detected the chemical and mechanical characteristics of the cutting material and recognized the microstructure, it is made these analyses:

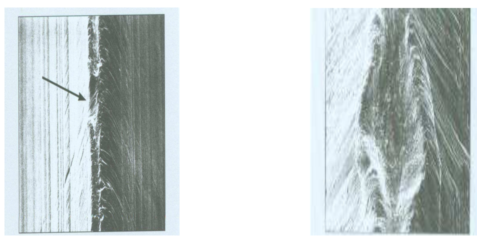
1. Chemical analysis is made in report (*number: FM.HL.01.23 from 11.06.03*), which done the follows parameters: material of the cutting tool is tool steel Ck45 (DIN) or C1531 (JUS) and chemical structure.
2. Microstructure test report (*number: FM.ML.02.04 from 13.06.03*) is done the microstructure/morphology results detected by electron microscope. In the report, it is done the scanning electron micrographs showing the material structure.
3. Mechanical test report (*number FM.ML.01.06 from 11.06.03*) is done the hardness of the cutting material (311 HB or 316 HV) on use of diamond sphere hardness measurement.

2.2. Cutting tool wear

In the cutting process, the cutting tip penetrates into the material in order to separate it. There is intensive contact between the metal surface of the cutting tip and the material being cut. Here the geometry, structure and surface material of the cutting tip play a major role as wear factors. Similarly, the material, type of carton or cardboard, the composition of the material, carton density and quantity of fillers also determine the wear. The cutting tip of the unused tool shows a very uniform cutting tip contour with minor irregularities on the surface (Fig.3). After the use, wear as a significant factor is destroyed the cutting tool (Fig.4). The process "wear" is an extraordinarily complex issue. In the die cutting sector have the "wear" complex as an abrasion phenomenon, adhesion phenomenon, tribochemical reaction, surface destruction etc.

(Magnified 100 : 1) (100 : 1)

Figure 3. Cutting tool edges before use



(500 : 1) (1000 : 1)

Figure 4. Cutting tool edges after use

2.5. PVD-deposition for cutting tools coating

In this research, we were made analysis of mechanical properties of the basic cutting tool material (as a substrate) applied during the blanking cardboard. Also, we have paid attention to a more general look on the deformation mechanisms of the thin films during loading. We are interested on the influence of various parameters (coating thickness, substrate hardness, proceeding treatment etc.) on micro hardness, adhesion and internal stress. Of special interest was the crack appearance and the coating failure linked to it.

In all kinds of thin films the diffusion processes play a major role, especially at the boundary film-air (oxidation, corrosion) and substrate-film (diffusion of substrate elements into the film and reverse). These processes are made at different temperatures, where it is done the changes of the concentration profile and crack appearance.

After preliminary analysis, we have decided that optimal type of coating for analyzed cutting tool material, is thin film of titanium nitride (TiN), with follows characteristics: deposition temperature 200^0C in accordance with material characteristics of the substrate and thickness 2-3 μm. The hard coating process for the cutting tool analyzed in this paper, has been made with PVD technique on the device for deposition - Sputtering apparatus Ceme Con CC800/7, with working pressure during deposition $1\text{-}2\cdot 10^{-3}$ mbar.

Figure 5 shows cutting tool for cardboard blanking with coating thin film of TiN. On the figure 6, it is presented cutting plate with assembled TiN coating cutting tools.

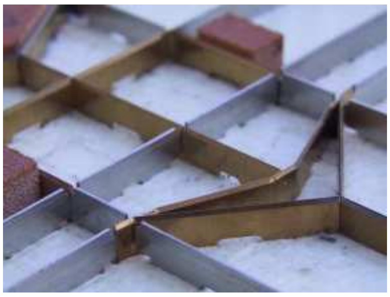


Figure 5. Coating cutting tool with TiN

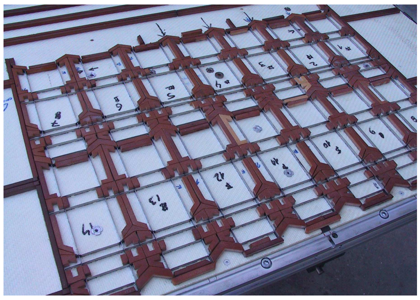


Figure 6. Assembled coating cutting tools

2.6. Ionic implantation for cutting tools

Ionic implantation is a methodology for cutting tools processing, using the atoms of nitrogen and their implanting in crystal structure-grate of the tool material, with out of deposition of hard thin layer. Implantation is a methodology for improvement of the mechanical characteristics of the basic material. This process is a unique surface treatment for reducing wear, friction and corrosion. It can make tools and machine parts a few times longer. The essential difference between ion implantation and other surface treatment is that it is not an “add-on” process, but the ions are embedded inside the surface layer without any dimensional change.

During the ion implantation process the surface is bombarded with ions at very high speeds. The ions penetrate into the surface and stay in the outermost layer of the surface. In this way a re-alloyed surface layer with outstanding properties is created. The ion implantation process, over the surface as a cutting tools analyzed in this research, was made in the implanter equipment for industrial application. The process was made with nitrogen ions, energy range 200 keV, beam current 5 mA and doses 5.10^{17} [atoms/cm^2].

Ion implanted cutting tools for cardboard blanking have the same metal-gray color, show on the fig.7 and cutting plate with assembled ion implantation cutting tools (figure 8).

Figure 7. Ion implanted cutting tool

Figure 8. Assembled ion implanted cutting tools

3. EXPERIMENTS WITH TiN-COATING CUTTING TOOLS AND IONIC IMPLANTED CUTTING TOOLS

The experiments are made as a testing of coating cutting tools in real production conditions, during the cardboard sheets blanking process. Previously, in production process short toollife was done inferior quality of cutting blankets after a few cutting cardboard sheets. Results, from this activity, are done:

Increase in efficiency of the production process by lengthening the period of use until the replacement of the old tool with a new set.

Increase in productivity as a result of the improvement of the tool performance i.e. the total number of cardboard sheets blanked with a single tool is increased.

4. CONCLUSIONS

Expectation of direct influence of new solution, proposed in this project, into the improvement of productivity and efficiency of the production process is demonstrated as a justification. It is expected to have a direct influence on the improvement of productivity and the economy of the production process. By prolonging the tool life of the cutting tools, the effective production (measured per number of sheets) was significantly enlarged 2 to 6 times. This is become obvious by carrying out a cost-benefit analysis i.e. a cost estimate of the conditions incorporated in the production process. The cost benefit analysis is done: extending of tool life, favorite solution is ionic implantation of cutting tools, reduce of product price by reduce the cutting tool participation, cost-benefit effect and improvement of productivity and efficiency.

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