The International Journal of Engineering and Science (IJES)
|| Volume || 6 || Issue || 12 || Pages || PP 55-63 || 2017 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Using of Coating in Shearing Processes

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--ABSTRACT---

The presented article deals with theoretical and practical summary of knowledge on utilization of tools coating. The experimental part was prepared with shearing tools that are used in process of accurate shearing. Manufacturing companies engaged in shearing steels industry are trying to eliminate the adverse effects of cutting and reduce production costs to a minimum, to streamline profit. Wear of cutting tools is one of the negative factors. Is necessary to eliminate it. The possibility is applying coated layers to eliminate speed of tool wear. Tool life is increased by coating layers. For the experimental research of the issue were used tool steels Boehler Uddeholm K 390 and S 600. The coated layers used in the experiment were TiCN, ZrN and CrN, which were prepared by the method of applying coatings PVD (Physical Vapor Deposition).
Keywords – forming processes, shearing, PVD and CVD coating, tool steel

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Date of Submission: 24-11-2017 Date of acceptance: 12-12-2017

I. INTRODUCTION

The present article deals with the process of shearing and coating methods using in the shearing processess. Experimental part is continuously carried out in manufacturing company. Coated instruments were used in the production of complicated part in the insurance contactor. TiCN layer coated cutting tools were implemented nowadays. The following figure shows the components produced by the accurate shearing method and the procedure of shearing process.

Fig. 1 Produced component

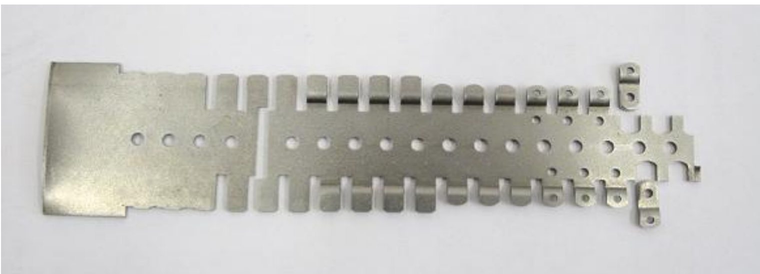


Fig. 2 Procedure of shearing process

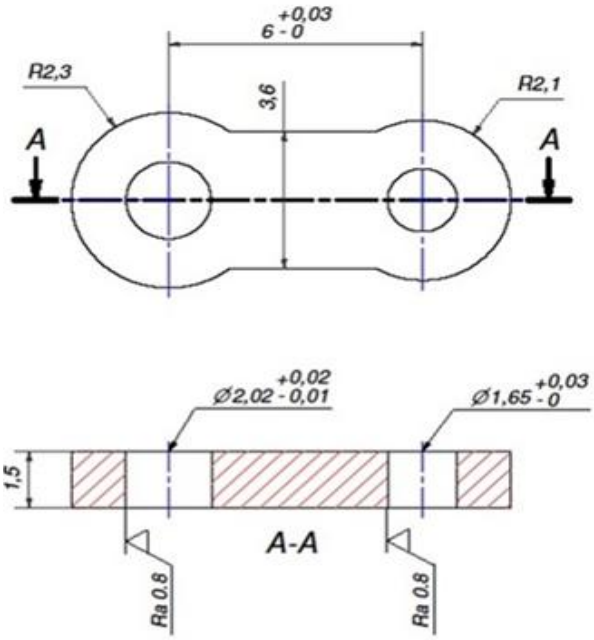


Fig. 3 Drawing of produced component

II. TOOL STEELS AND COATINGS

Two types of tool steel from the company Boehler Uddeholm were used in the experiment. The K 390 tool steel and the S 600 tool steel. TiCN, ZrN, CrN were used for coating the S 600 steel. The S 600 steel is also named as W. Nr. 1.3343, DIN HS6-5-2, STN 19,830th. [1,2]

II.I TOOL STEELS S600 AND K390

Tool steel S 600 is defined as a high-speed steel with improved toughness and easier workability in grinding, but compared to other high-speed steels it is more susceptible to decarburization and it is characterized by worse heat formability compared to other steels of the same category.

High-speed cutting steels are alloyed tool steels which due to alloying elements contained in increased degree improve their cutting characteristics. The most important feature is the steel high resistance and hardness, its ability to remain hard after it is heated, where the shear can withstand temperatures up to 600 ° C. The disadvantage of HSS (High-Speed Steel) is a low durability, rapid wear and changes at the incision site of metal at high temperatures, the steel begins to crumble and becomes unusable.

Steel S 600 is suitable for work at low temperatures and making tools highly stressed in the medium to high hardness machining process, such as those requiring good toughness. These tools are such as follows: cutters, drills, taps, reamers, saws, slotting tools, gearing and punches. The steel is suitable for the surface coating and heat processing in a vacuum oven. [3]

The chemical composition of steel S 600 is as follows:

Table 1 The chemical composition of steel S 600

The chemical composition of steel S 600 %						
C	Mn	Si	Cr	W	Mo	V
0,94	0,23	0,34	4,32	5,94	4,73	1,71

K 390 steels belong to the group of steels for work at the low temperatures. They are used at normal temperature processes such as cutting, bending, forming and stamping. Hardness, high abrasion resistance, wear resistance and toughness are the priority features of steels for work at low temperatures. These properties ensure long shearing edge durability. The K 390 steel is produced by the method of powder metallurgy. Achieved steel hardness is at 62 to 64 HRC. [3]

Table 2 The chemical composition of steel K 390

The chemical composition of steel K 390%						
C	Co	Si	Cr	W	Mo	V
2,45	2,00	0,55	4,15	1,00	3,75	3,00

2.2 APPLIED COATING LAYERS

TiCN coating

These coatings are characterized by high abrasion resistance, low coefficient of friction, and are suitable for milling of steels with a medium carbon content of lower and medium strength and milling of gray cast iron.

The color of the coating is brown-red and the micro-hardness achieved is between 30 and 40 GPa. The maximum working temperature is 400 ° C. It is used mainly in milling operations, shearing, cuttinng, drilling and turning. The hardness of the coating is 3500 HV. TiCN tends to receed from the trend, since it is costly, the chamber maintenance is difficult and surface uniformity is also problematic. Good quality cooling facilities within the coating process are necessary for the effective use of this coating. TiAIN and TiN coatings which exhibit the same tenacity are currently used as a replacement of TiN. TiCN is currently used mainly as a decorative element (coating) because of its characteristic color. The following figure shows the use of TiN coating and its color. [3,4,5]

Fig. 4 TiCN coated shearing tool

CrN coating

CrN coating color is silver, silver-gray. CrN coating is characterized by its high hardness, low brittleness, good adhesion, good corrosion resistance and oxidation properties. This coating can be applied in thicker layers and the coating is air-stable. The upper operating temperature limit is up to 600 ° C and the hardness of the coating is at a level up to 2000 HV. This coating is used particularly for machining titanium and copper based alloys. The following figure shows the possible use of CrN coating and its color. [3,4,5]

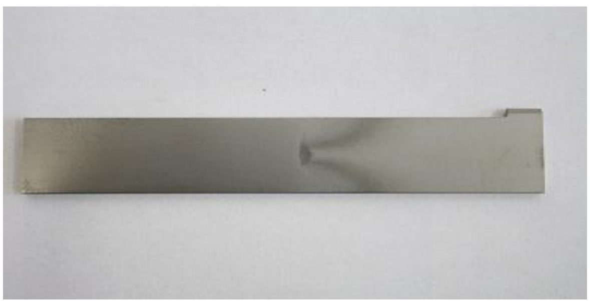


Fig. 5 CrN coated shearing tool

DOI: 10.9790/1813-0612025563

ZrN coating

The features are the same as those of TiN coatings but the price is significantly higher. The use of the coating can be widely used in health care in particular, since it has high biocompatibility (suitable for metal allergic patients, representing about 13% of the population) as well as in the decorative coating which is indistinguishable from the color of gold. ZrN coatings are used for a wide range of applications, especially where it is necessary to reduce the adhesion and abrasive wear.

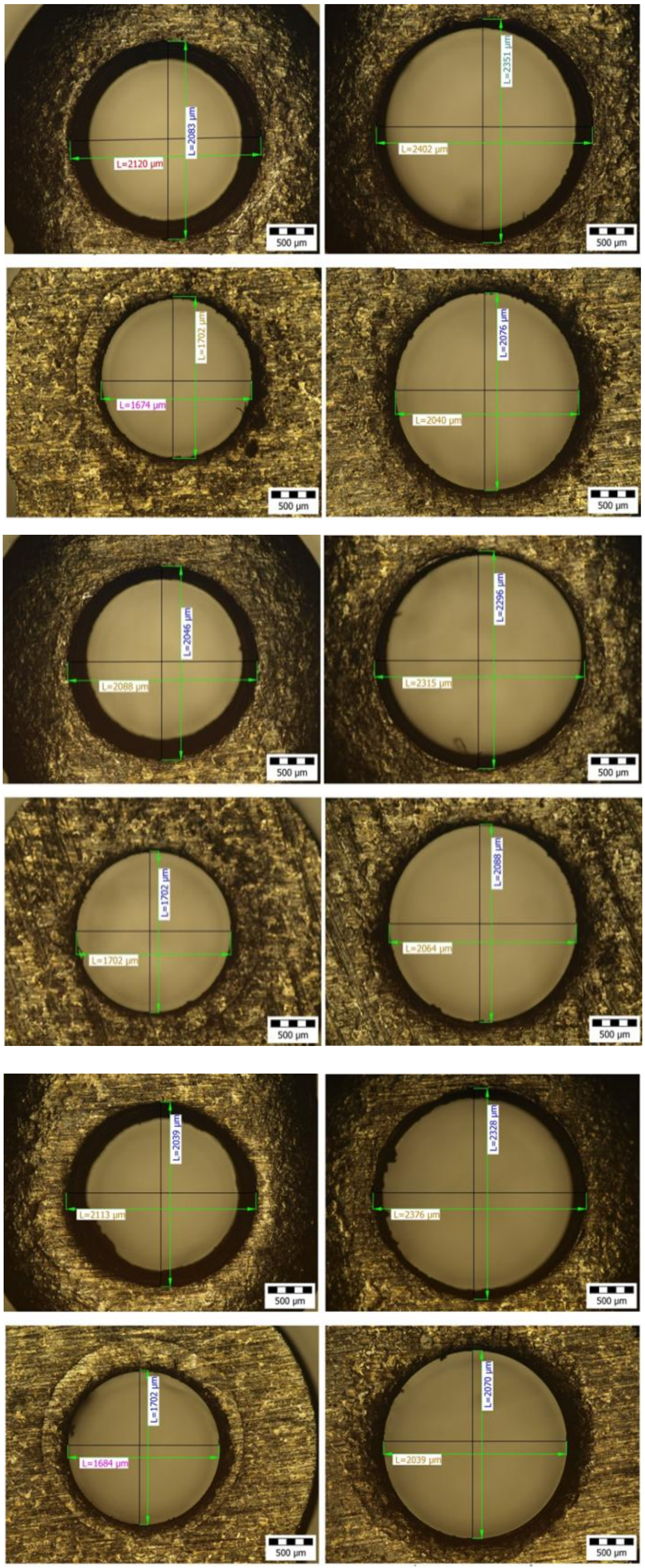
The working temperature of the coating is limited by 600 ° C, and the thickness of the coating is defined in the range of from 1 to 4μm. The hardness of ZrN coating is at a level up to 2600 HV. The coatings are produced by PVD methods, which are applied to substrates such as tool steel, HSS, carbide metals and other materials at temperatures below 450 ° C. ZrN coatings are of a highly corrosive and erosive resistance, high hardness, good lubricity, ductility, good adhesion, low friction and high wear resistance. At higher temperatures, the coating is characterized by good chemical and thermal stability. Tools being coated using this method last from 200 to 1000% more than uncoated tools. [3,4,5]

Fig. 6 ZrN coated shearing tool

III. CONCLUSION

Up to this stage the results associated with the use of TiN coated tools after a series of 8000 pieces of sheared out components were recorded. Individual samples were taken after a series of 1,000. Microscopic observation as well as the associated measurements were done at the Vienna university of Technology at the „Institut für Fertigungstechnik und Hochleistunglasertechnik". In conclusion, the observations say that the coatings have been well chosen, they are characterized by longer durability than conventional uncoated steel tools and are not being excessively weared. The coatings are characterized by higher cost inputs which could possibly be eliminated by longer tool durability and the resulting slower wear. The tool steel showed the same characteristics after the 8000 sheared-out components and 1000 sheared-out components. No significant tool wear was recorded. However, the number of shortcomings that stemmed from a semiproduct, especially of its poor quality in the process of shearing, occured. Semiproduct showed a significant structural material defect which affected the overall outcome measurements.

Material errors occured in an shearing process, such as change in the component shape, precision dimensions, prints and various cracks. Two holes, one of a minor and one of a major character were sheared out and the same deficiencies resulting from defects in material in both cases were recorded. The following figures show the individual measurements over the sampling period (blanks) in the test process. [1,2]


L=2120 µm
L=2083 µm
500 µm
L=2402 µm
L=2351 µm
500 µm
L=1674 µm
L=1702 µm
500 µm
L=2040 µm
L=2076 µm
500 µm
L=2088 µm
L=2046 µm
500 µm
L=2315 µm
L=2296 µm
500 µm
L=1702 µm
L=1702 µm
500 µm
L=2064 µm
L=2088 µm
500 µm
L=2113 µm
L=2039 µm
500 µm
L=2376 µm
L=2328 µm
500 µm
L=1684 µm
L=1702 µm
500 µm
L=2039 µm
L=2070 µm
500 µm

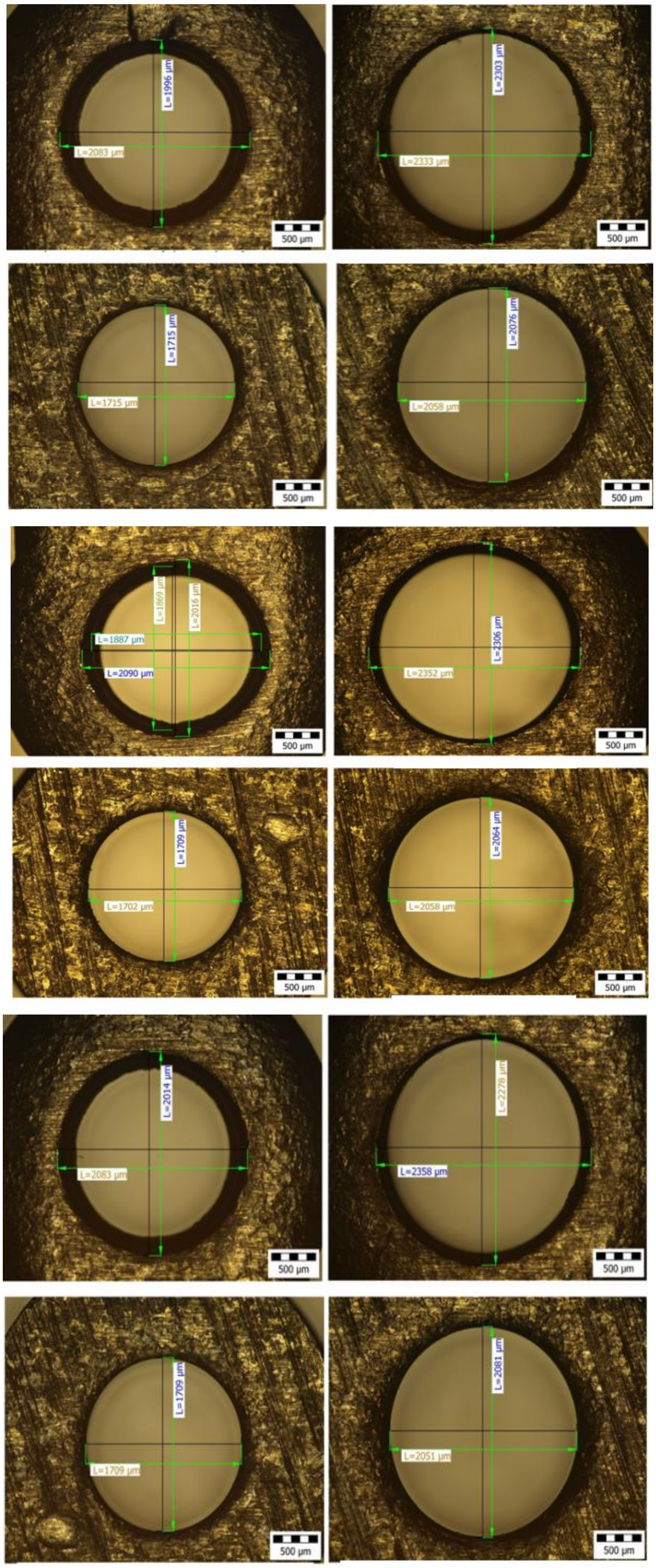


Fig. 7 Dimensional stability of a sheared-out component from 1000 to 8000 pieces

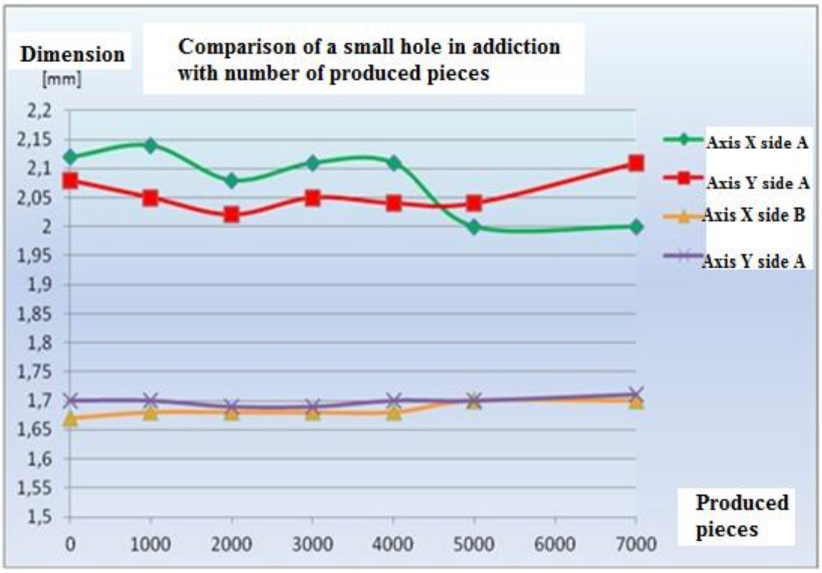


Fig. 8 Comparison of big hole in addition with number of produced pieces

The coated shearing tools were not worn in the process of accurate shearing. Measurements and graphs show us, that the dimensions of the holes did not change and the dimensions of the holes are in the tolerance. Measurement errors were only in interface of admissible deviation. The foregoing figures show, that it is clear, that errors and deficiencies encountered in the experiments are related to the poor quality of the shearing material, in particular with structural defects of the material, which has a wealth of inclusions.

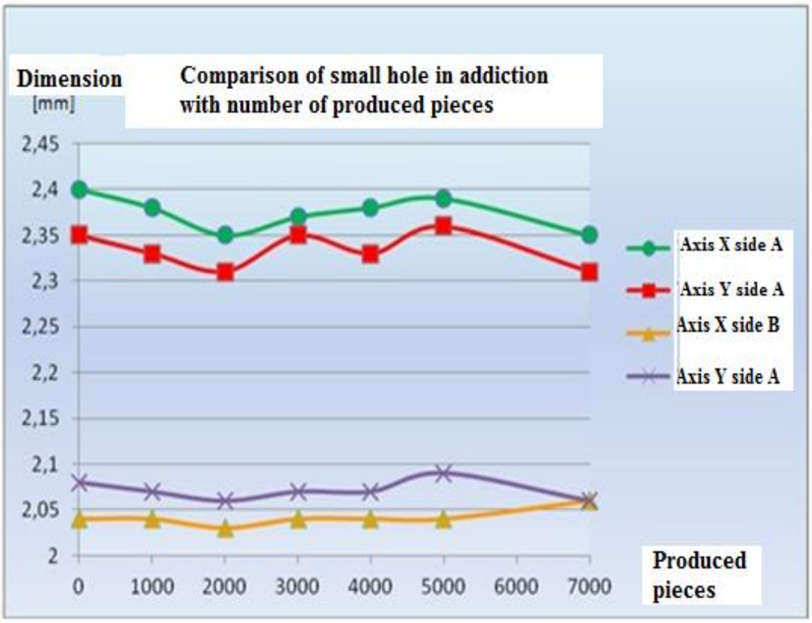


Fig. 9 Comparison of small hole in addition with number of produced pieces

The measurements of roughness were carried out on roughness tester Surftest SJ-310, manufactured by Mitutoyo, dimensional measurements were performed on a micrometer Mitutoyo 293-240. 2D measurements were carried out on the device from Werth Messtechnik GmbH company, specifically Werth Compact 300 IL, Mess und Profilprojektor.
The following figures show the shape errors and anomalies caused by the errors in semiproducts.

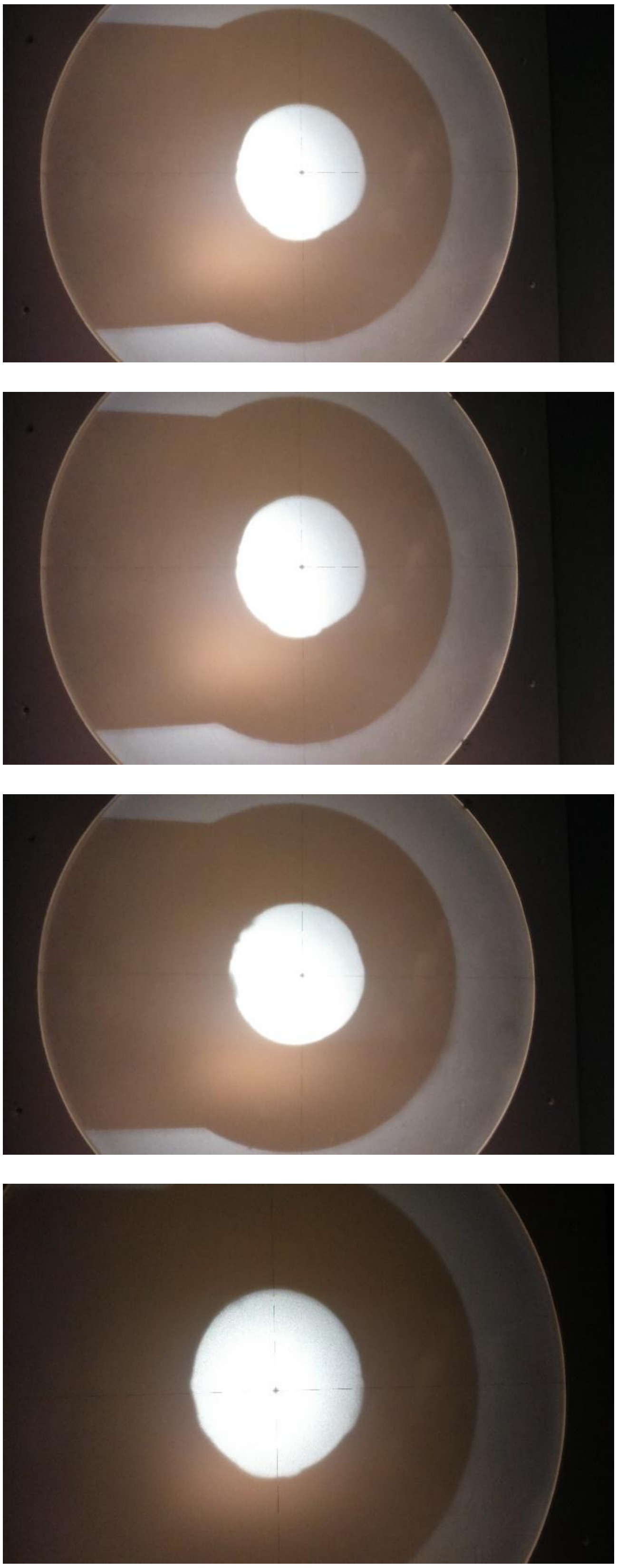


Fig. 10 Shape errors in semiproduct caused by material poorquality

ACKNOWLEDGEMENTS
The Article Was Drafted In Resolving The Grants Vega 1/0441/17.

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Tomáš Sleziak " Using of Coating in Shearing Processes." The International Journal of Engineering and Science (IJES), vol. 06, no. 12, 2017, pp. 55-63.