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INFLUENCE OF SURFACE ROUGHNESS ON SELECTED PROPERTIES OF THE TiAlN COATING

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The HS6-5-2C steel samples with different surface roughness were used for the tests. After grinding had a roughness parameter of Ra = 0,03 μm, and after polishing Ra = 0,01 μm. A TiAlN coating was applied to the substrate prepared in this way. Using a confocal microscope with an interferometric mode, the geometrical structure of the samples was analyzed. The optical strain gauge was used to measure the contact angle. Tribological tests were carried out in conditions of technically dry friction. The polished sample with the coating was characterized by a more stable course of the friction coefficient, lower wear and a smaller wetting angle.

Key words: HS6-5-2C steel, TiAlN coating, wear, friction, wetting angle

INTRODUCTION

Obtaining materials characterised by durability and resistant to wear became one of the main areas under study in recent years. Coatings became one of the solutions in engineering which continues to develop [1, 2]. Hard coatings with anti-wear properties generated the largest interest. They are formed with numerous methods, such as physical vapour deposition (PVD) and chemical vapour deposition (CVD) [1]. In addition, the process of chemical vapour deposition can be supported with plasma – plasma assisted chemical vapour deposition (PACVD) for the purpose of obtaining lower temperatures in the application process [3].

One of the coatings which generated large interest is the TiAlN coating. It is characterised by high durability [5] hardness, excellent tribological properties as well as resistance to oxidation and corrosion [5-7]. In addition, the coating is characterised by high chemical and thermal stability which translates towards excellent resistance to oxidation at elevated temperatures. TiAlN coating shows better tribological properties compared to other ceramic coatings, such as TiN and TiCN [10]. TiAlN coatings are used in many industrial processes, such as milling, forming, as well as in the transport, aviation, space [6], tooling and biomedical sectors [7].

Apart from coating and applying lubricating agents, the tribological properties are impacted by surface porosity. Surface porosity also influences its wetting. When a liquid interacts with the porous surface of a solid [8], the factual wetting angle changes due to the presence of surface unevenness [8, 9]. Wetting informs about the capacity of liquid to spread over the surface of a solid. It can be measured in a system consisting of a liquid drop resting on a flat, stable surface in an appropriate atmosphere. Small wetting angle means good wetting [8].

The article defines the impact of surface porosity over the tribological properties and surface wetting for TiAlN coatings. Before applying the coatings, the steel specimens were grinded and polished, obtaining the arithmetic mean height (Sa) parameters of, respectively: 0,10 and 0,04.

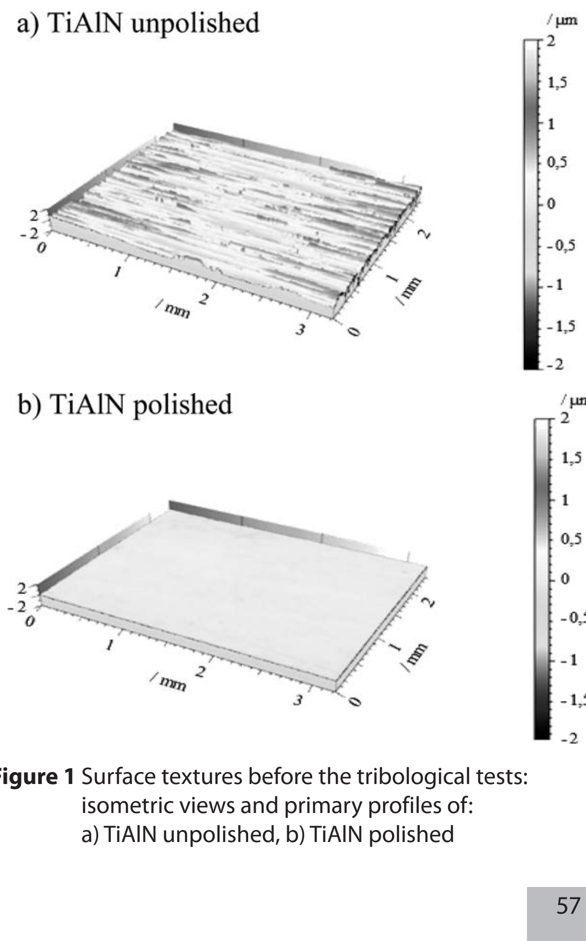

Figure 1 Surface textures before the tribological tests: isometric views and primary profiles of: a) TiAlN unpolished, b) TiAlN polished

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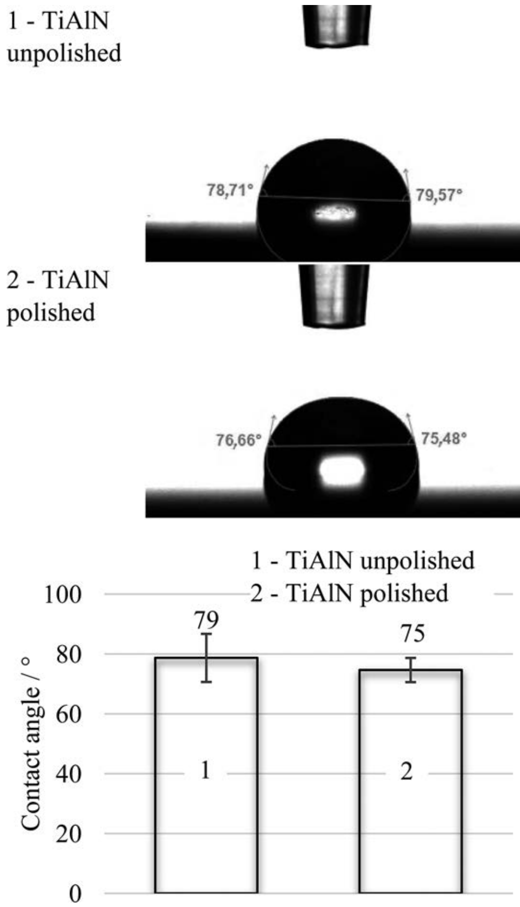

Figure 2 Contact angle for HS6-5-2C steel with TiAlN coating

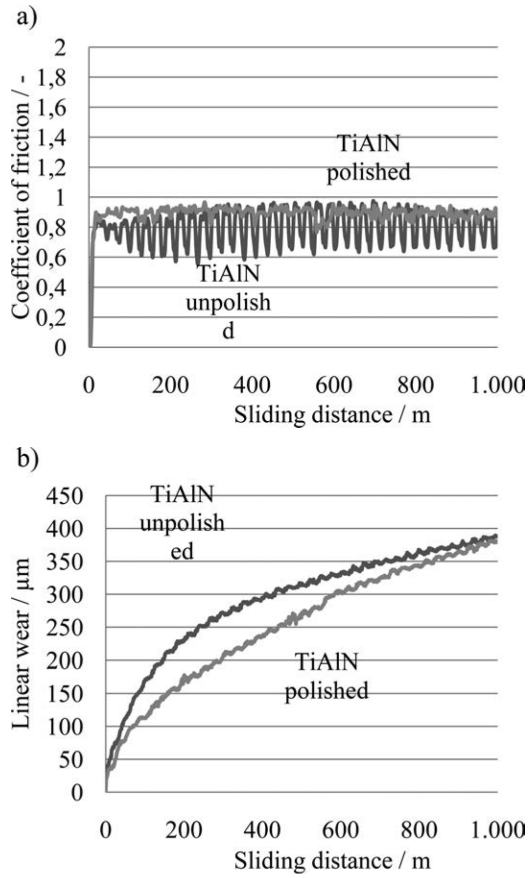

Figure 3 The plotted: a) coefficients of friction and b) linear wear for all the friction configurations

MATERIALS AND METHODS

The testing was conducted with polished and unpolished specimens made of HS6-5-2C steel with TiAlN coating. HS6-5-2C steel is characterized by very good ductility, impact strength and abrasion resistance. The geometric structure of the surface was observed through a Leica DCM-8 (Figure 1) confocal microscope with interferometric mode.

After grinding, the specimen proved to be more porous compared to polishing, it had clearly visible protrusions and depressions.

RESULTS AND DISCUSSION

Figure 2 shows the results of wetting angle measurements for discs with TiAlN coating, polished and non-polished. The analysis was carried out with distilled water.

The analysis of wetting angle shows that the polished surface has lower wetting angle values. The differences are not excessively hight, and amount to 7 % for unpolished and polished specimens.

Figure 3 presents the results of tribological studies for polished and unpolished specimens under technically dry friction conditions.

The comparison of the friction coefficient value course shows that the lower values have been obtained for the unpolished disc. This may be the result of the high oscillation of the friction coefficient value course. Polished disc showed a more stabilized value course.

Figure 4 shows signs of wear of discs and balls after tribological tests.

The comparison of the wear images on the discs shows lower wear for polished disc with the TiAlN coating applied compared to unpolished disc. The maximum wear depth for polished disc was nearly 87 % lower, and the wear area was over 99 % lower compared to unpolished disc. In turn, the wear caused by mutual friction of the balls and the disc with unpolished and polished TiAlN coating showed similar values. The ball which remained in contact with the polished disc showed insignificantly lower wear.

Comparison of the parameters of the geometric structure (Table 1) of the discs showed results before and after tribological tests.

The arithmetic mean height (Sa) parameter decreased after tribological testing for polished disc, which indicates superfinishing of the surface of the disc. In turn, in case of unpolished disc, the root mean square height (Sq) parameter increased after tribological testing, which indicates unevenness: protrusions and depressions. The comparison of the discs after frictional testing, the polished specimen showed lower values of the arithmetic mean height (Sa), root mean square height (Sq), maximum peak height (Sp) and maximum pit depth (Sv) parameters, which proves the achieve-

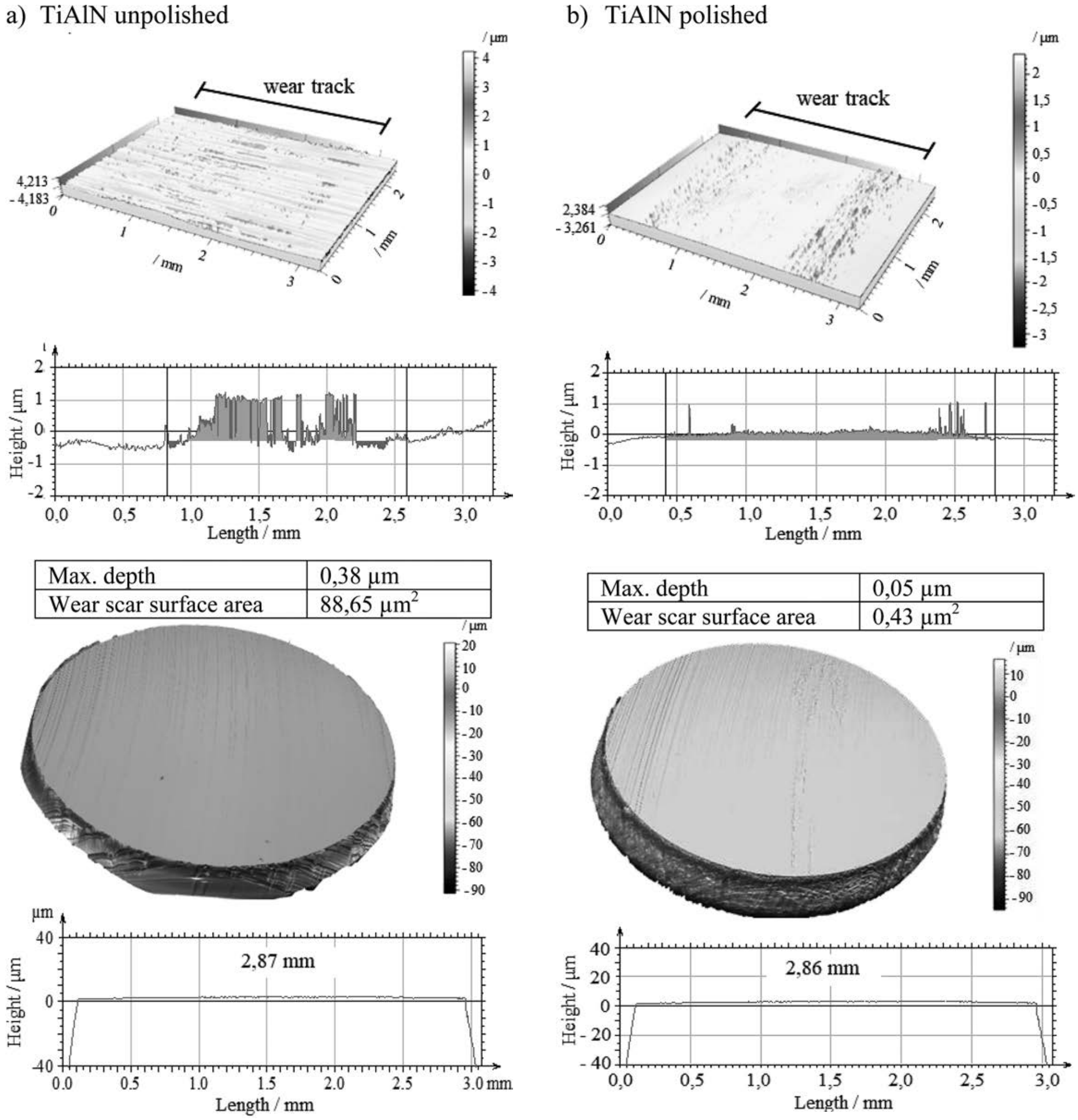

Figure 4 Isometric views and primary profiles of the discs and balls after the tribological tests

Tabele 1 **Surface texture parameters for the steel discs and steel balls: a) before and b) after the tribological tests**

a)

Surface texture parameters	Before test			
	TiAlN unpolished	ball	TiAlN polished	ball
arithmetic mean height (Sa) / µm	0,10	1,52	0,04	1,52
root mean square height (Sq) / µm	0,12	2,07	0,05	2,07
maximum peak height (Sp) / µm	0,25	33,67	0,14	33,67
maximum pit depth (Sv) / µm	2,71	78,97	0,20	78,97
skewness (Ssk) / -	-1,15	-3,00	-0,57	-3,00
kurtosis (Sku) / -	13,60	86,24	6,51	86,24

b)

Surface texture parameters	Past test			
	TiAlN unpolished		TiAlN polished	
	disc	ball	disc	ball
arithmetic mean height (Sa) / µm	0,56	0,06	0,03	0,19
root mean square height (Sq) / µm	0,77	0,08	0,05	0,22
maximum peak height (Sp) / µm	4,05	0,18	1,21	0,57
maximum pit depth (Sv) / µm	4,35	0,75	2,66	0,57
skewness (Ssk) / -	-1,01	-0,55	3,27	0,13
kurtosis (Sku) / -	7,24	3,27	81,06	2,04

ment of smoother surface with lower protrusions and shallower depressions at the wear area.

CONCLUSIONS

The following conclusions were drawn from the obtained results.

Surface porosity impacts wetting and tribological properties.

Polished surface showed wetting angle values lower by 5 %. Polished specimen showed 0,4 % lower linear wear compared to the unpolished specimen, which is within error limits. In spite of the fact that the polished specimen showed higher friction coefficient value compared to the unpolished specimen, the value course was more stabilised for the polished disc. Tribological tests resulted in higher use of balls instead of discs. This was the result of the significant difference in the hardness of specimen and counter-specimen. The comparison of the maximum depth of wear and wear area showed that the wear of polished disc was lower by approximately 87 % and over 99 % compared to the unpolished disc.

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Note: The responsible for English language is Dawit Kowalski, Kielce, Poland