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Comparison of HCR gears coated by PVD coating AlCrN with non-coated HCR gears lubricated by bio-friendly lubricant

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SUMMARY

The submitted scientific poster deals with application PVD coating AlCrN on HCR gears in conditions lubricated by eco-friendly lubricant and with the comparison of coated and non-coated HCR gears. HCR gears were made from material 16MnCr5. As lubrication environment was chosen eco-friendly lubricant OMV Biogear S150. Experimental tests were performed on the Niemann M01 FZG testing rig. In the experiment, we followed standard STN 65 6280. After each load level were measured values of the maximum height of the assessed profile Rz for tip and reference diameters. Results of experimental tests were statistically processed and on a basis on them were established relations between the maximum height of the assessed profile Rz and load level.

Key words: *bio-friendly lubricant, HCR gears, PVD coating AlCrN, FZG test rig*

INTRODUCTION

Gears and power transmissions are among the oldest mechanisms used in engineering. They were used whenever a man wanted to transfer mechanical energy to a working machine. Gears have undergone a long way of development in today's modern form of technology [5].

High Contact Ratio (HCR) gears are non- standard gears with a modified form of a basic involute profile. Changes relate to addendum height, it is not equal 1 like for standard involute gears. Addendum height ha* is increased and bigger than one, ha*> 1. The results are gears with a contact ratio εα ≥ 2. The teeth with this profile can reach contact ratio up to 4 [2], [7].

The principle of Physical Vapor Deposition (PVD) is to convert deposited material to the gas phase (evaporation, sputtering) in a vacuum, followed by application to a substrate at low temperatures (150-500 °C). The coating material or its components must be present directly in the deposition chamber, where they are transferred to the gaseous state. Typical layer thicknesses are 1 - 5 μm [4], [6].

We used the PVD coating method due to a more appropriate temperature course during coating and lower procurement cost. We could not use another method of coating with higher deposition temperatures because the gears were surface hardened and the deposition temperature would be higher than the quench temperature [3]. After considering these factors and possibilities in cooperation with LISS, we decided to use PVD coatings. The production of coatings was carried out in laboratories of LISS. The selected coatings were deposited using the ARC PVD method on the device π411PLUS. Parameters of coatings used are described in chapter Materials and Methods.

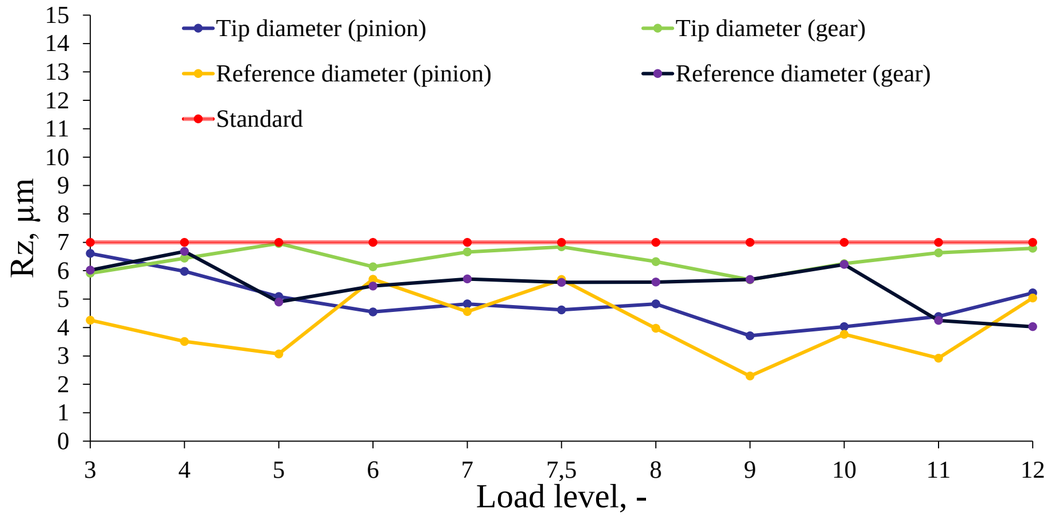

Fig. 1. Dependance of change parameter Rz on load level (AlCrN)

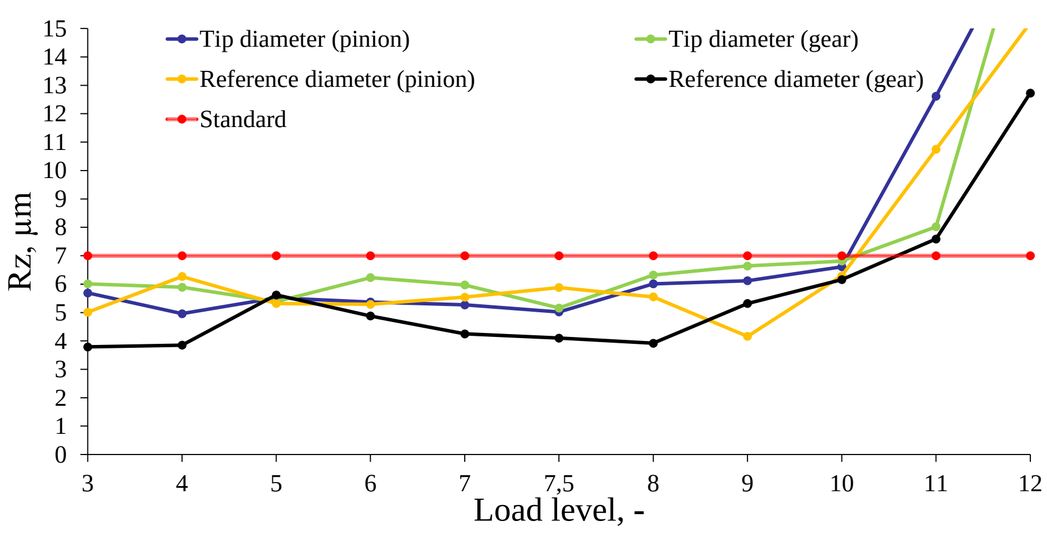

Fig. 2. Dependance of change parameter Rz on load level (non-coated)

Table 1. Values of the parameter *Rz* (non-coated)

Load level	Pinion				Gear			
	Tip diameter		Reference diameter		Tip diameter		Reference diameter	
	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)
8	6,010	0,145	5,550	0,158	6,320	0,167	3,920	0,172
9	6,120	0,144	4,160	0,134	6,640	0,165	5,320	0,142
10	6,610	0,113	6,290	0,171	6,810	0,112	6,160	0,149
11	12,620	0,148	10,750	0,179	8,020	0,144	7,590	0,138
12	18,840	0,148	15,200	0,203	19,470	0,140	12,730	0,137

Table 2. Values of the parameter *Rz* (AlCrN)

Load level	Pinion				Gear			
	Tip diameter		Reference diameter		Tip diameter		Reference diameter	
	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)	$\overline{Rz}$ (μm)	S (μm)
8	4,830	0,111	3,970	0,099	6,320	0,109	5,600	0,101
9	3,710	0,114	2,290	0,127	5,680	0,167	5,690	0,128
10	4,030	0,147	3,760	0,130	6,250	0,127	6,220	0,106
11	4,390	0,144	2,920	0,122	6,630	0,133	4,250	0,091
12	5,220	0,103	5,040	0,145	6,790	0,105	4,030	0,096

CONCLUSION

The experimental work was carried out on 2 surface variation of HCR gears. In the first case, the surface was without coating and in the second case, surface was coated by PVD coating AlCrN. As lubrication environment was selected bio-friendly lubricant OMV Biogear S150. The coating was deposited in ACR PVD mode with π411PLUS device. The coating was produced at a thickness of 7 μm and tested according to STN 65 6280 standard. The measured values were evaluated statistically in the tables and graphically as the dependency of the maximum height of the assessed profile *Rz* in relation to the load level. From obtained values, it is evident that in the first case, the maximum height of the assessed profile *Rz* did not exceed interval 7 μm established by the standard. In the second case, the maximum height of the assessed profile *Rz* exceeds interval 7 μm established by the standard. Thus, we can conclude that scuffing occurred on the 11load level in case of non-coated gears. Adhesive properties and the wear resistance of PVD coating AlCrN prolonged the lifetime of gear.

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LITERATURE

1. STN 656280:1985 (1985) Lubricants. Mechanical testing of lubricants in the FZG gear ring test machine. Slovak Standard Institute.
2. KUČERA M., RUSNÁK J., (2008). Study of tribological properties of surface applied materials by selected welding technologies: methods, instruments and interpretation. SUA in Nitra, Nitra.
3. BOBZIN, K., BAGCIVAN, N., GOEBBELS, N., YILMAZ, K., HOEHN, B.R., MICHAELIS, K., HOCHMANN, M., Lubricated PVD coatings for automotive applications, Surface and Coatings Technology, Vol- 204, pp 1097-1101,2009
4. HATAMLEH O., et. al., (2009) Surface roughness and friction coefficent in peened friction stir welded 2195 aluminum alloy. Apllied surface science.
5. HOEHN B.R., et.al. (2008) Test methods for gear lubricants. Goriva i maziva, Vol. 47, No. 2, pp. 129 – 157.
6. BOŠANSKÝ M., VANYA A., VEREŠ M., (2013) Evaluation of properties of selected coatings on steel C60E in terms of their use in gearing. Advanced Materials Research, No. 25, pp. 81-85.
7. MICHALCZEWSKI R., et al. (2013) New scuffing test methods for the determination of the scufing resistance of coated gears. Tribology - Fundamentals and advancements, Vol. 12, No. 4, pp.187 – 215.