EFFECT OF FILLER ON THE SURFACE ROUGHNESS OF HARD CHROMIUM COMPOSITE COATINGS

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Abstract

Hard chromium surface treatments are widely used as functional coatings for piston rings. Since the properties of hard chromium coating are not longer sufficient for new applications composite hard chromium coatings with various fillers are used. Fillers are especially particles of hard materials for example Al_2O_3, CBN, diamond, UDD, UDDG, etc. This paper deals with the use of fillers based on nanodiamond - graphite (UDDG) and its influence on surface roughness of the chromium coating. There were prepared samples of coatings with varying amount of UDDG samples of Cr- Al_2O_3 coating and samples of conventional hard chromium. The surface roughness was measured by surface roughness tester. The results show that the roughness is increased with the amount of filler.

Keywords: Hard chromium plating, Composite chromium, Hard particles, Roughness,

1. INTRODUCTION

Hard chromium plating

The beginning of chromium plating technology dates back to the 19th century. In the years 1848 - 1849 Junot de Bussy first performed electrolytic deposition of chromium. Use of chromium coatings is very diverse. Hard chromium (functional) plating is very widespread. Hard chromium coatings are used in many industries in applications where a high wear resistance and high coefficient of friction are needed. These include aerospace, agriculture, food processing and printing industries.

Composite hard chromium coatings

The first publication dealing with composite galvanic coatings was published already in 1929. Development of new composite electrodeposited coatings is currently one of the main directions of functional electroplating.

The principle of deposition of composite hard chromium coatings is that particles of various hard materials are dispersed as suspension in the electrolyte and during the deposition process are trapped in the chromium matrix. Dispersed particles in the layer significantly improve its functional characteristics (e.g. hardness, wear resistance, corrosion resistance...). These surface treatments are widely used in engineering, medical chemical and in automotive industries. [3,4,5]

As filler particles can be used various materials: Al_2O_3, TiO_2, SiO_2, TiN, TiB_2, ZrC, WC, Cr_2C_3, Cr, Mo, W, graphite diamond, $BaSO_4$, CaF_2, Teflon, SiC.

Several publication deals with chromium-UDD composites. UDD (Ultra Dispersed Diamond) is diamond manufactured by detonation method. [3,4,5]

Kinetics of electrochemical composite coatings are as follows: the transfer of dispersed particles of filler to the cathode, their accumulation on the surface of the substrate and their overlap by deposited

Special chapter are composite chromium coatings for piston rings. There are microcracks created in chrome coatings. This microcracks hold oil lubricant. Another improvement is to use hard particles as filler of these microcracks. Examples are shown in Fig. 1 and Fig. 2. Usually used fillers are Al_2O_3,[6] CBN [7] and diamond.

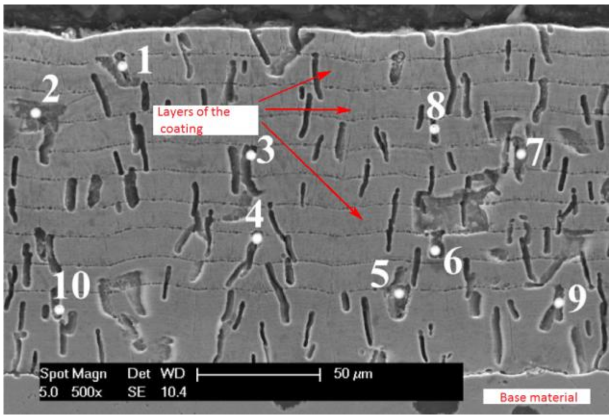

Fig. 1 Cross section of chromium coating reinforced with Al_2O_3 (BCr coating, Buzuluk a.s.)

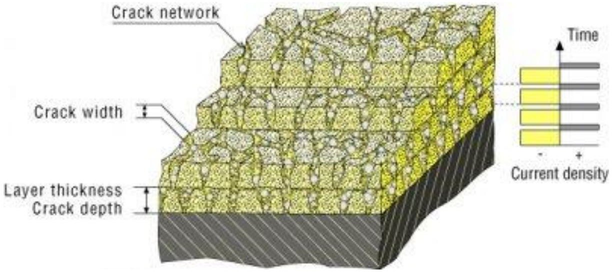

Fig. 2 Scheme of Cr coating reinforced with hard particles (CKS 36 coating) Federal Mogul) [6]

Use of certain fillers causes problems with the stability of the chromium plating process. The filler also affect the properties of the final chromium surface. For example the use of graphite as filler occurs the increase of surface roughness of the chromium coatings. [3] Just as it has been demonstrated that graphite globules contained in ductile cast iron can affect the state of chromium surface Fig. 3 and Fig. 4 [8]

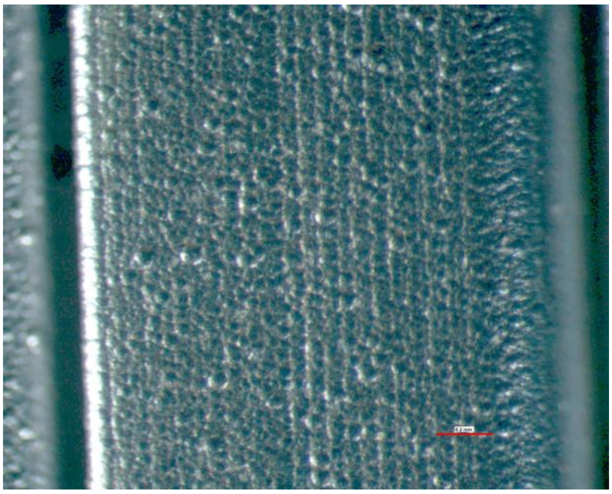

Fig. 3 Hard chromium coating without nodules [8]

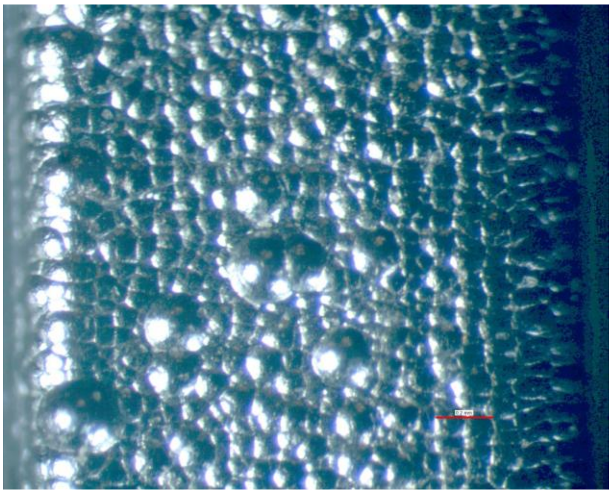

Fig. 4 Nodules on the surface of hard chromium [8]

One of the modern composite coatings used for piston rings is Cr-UDDG layer. UDDG (Ultra Dispersed Diamond Graphite) is a mixture of nano-graphite and nanodiamond. Since the filler contains graphite nano-particles can be assumed the influence of graphite to the final surface of chromium coating. Roughness of the surface of coating can cause problems with subsequent machining. The aim of the experiment was to determine the dependence of the amount of UDDG filler in the electrolyte on the surface roughness of Cr layer. Another objective is to determine the maximum acceptable amount of UDDG in the electrolyte for production.

2. EXPERIMENT

Samples

There were prepared samples of composite chromium coating Cr-UDDG. To compare the properties there were deposited mass produced coatings: hard chromium, porous chromium and BCr layer (Cr-Al_2O_3).

Samples of coatings were deposited on a carbon steel substrate. The chemical composition of the substrate is shown in Tab. 1.

Tab. 1 Chemical composition of substrate

Fe	C	Si	Mn	P	S	Cr	Ni	Mo	Al
%	%	%	%	%	%	%	%	%	%
97,97	< 1,20	<0,00	0,58	0,01	0,005	0,08	0,04	0,01	0,04
Cu	**Ti**	**V**	**W**	**Pb**	**Sn**	**Mg**	**Sb**	**Sr**	
%	%	%	%	%	%	%	%	%	
0,05	0	0	0,01	0,001	0	0,0008	0	0,001 2	

Shielding was used during chromium plating process because of higher current density at the edges of the sample. Constant distribution of the layer thickness was obtained by used shielding. Thickness of the layer was from 110 to 140 μm.

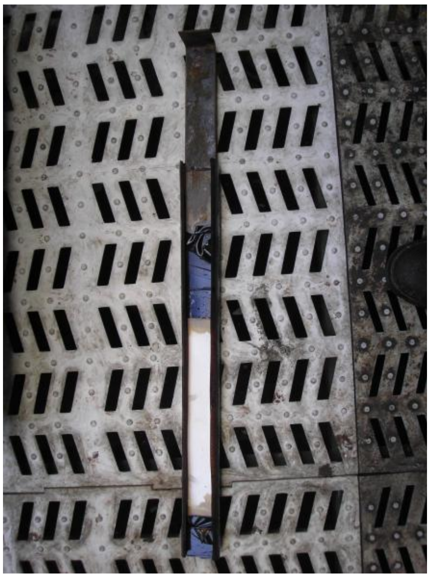

Fig. 5 Shielding of the sample

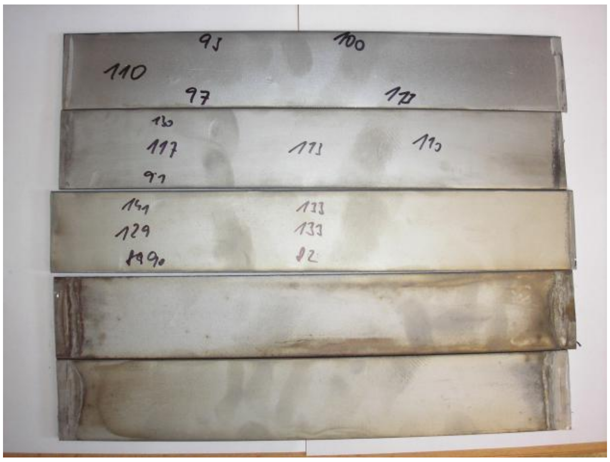

Fig. 6 Samples

A list and the description of samples used in the experiment is presented in the Tab. 2

Tab. 2 List of samples

Sample	Matrix	Microcracks	Filler	Vol. Of filler in electrolyte
1	Cr	NO	-	-
2	Cr	YES	-	-
3	Cr	YES	UDDG	5 g/l
4	Cr	YES	UDDG	10 g/l
5	Cr	YES	UDDG	15 g/l
6	Cr	YES	UDDG	15 g/l
7	Cr	YES	Al2O3	7 % vol.

Hardness measurement

Roughness of coatings was measured on the Hommel Tester T800. Measurement conditions are indicated in the Tab. 3

Tab. 3 Measurement conditions

Type of sensor	TK 100
Measuring range	80mm
Measuring track	4,80mm
Drift speed	0,50mm/s
Filter	M1 DIN4777

Values of R_z R_a and R_{max} was measured by hardness tester.

3. RESULTS

Roughness measurement

Results of hardness measurement are shown in the Tab. 4 and graphs in Fig. 7, Fig. 8 and Fig. 9.

Tab. 4 Mesurement results

Sample	UDDG [g/l]	Ra [µm]	Rz [µm]	Rmax [µm]
1	0	1,71	9,37	10,78
2	0	1,64	9,43	11,76
3	5	2,07	10,98	12,41
4	10	1,89	10,74	16,23
5	15	3,9	21,63	27,25
6	15	4,05	22,15	28,53
7	0	1,54	9,35	12,49

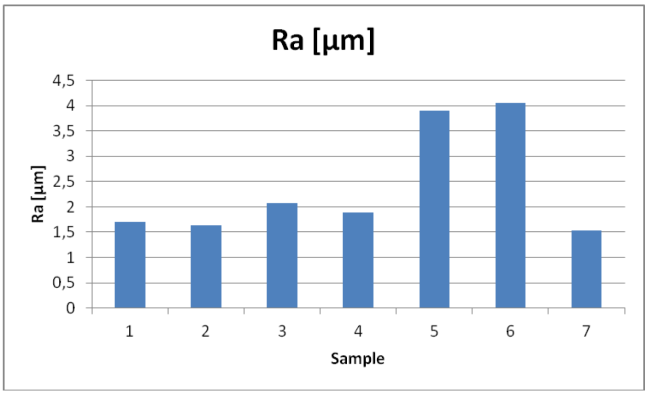

Fig. 7 R_a values

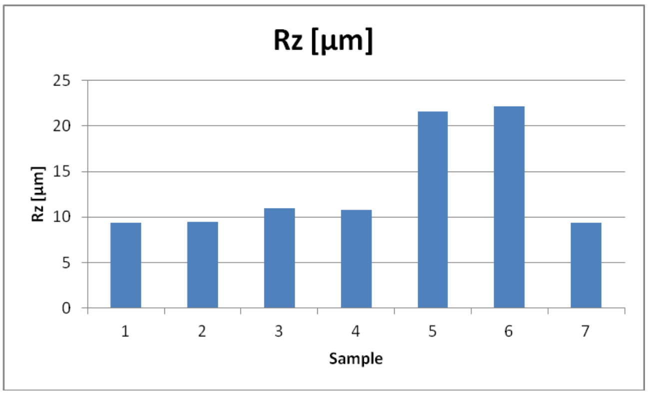

Fig. 8 R_z values

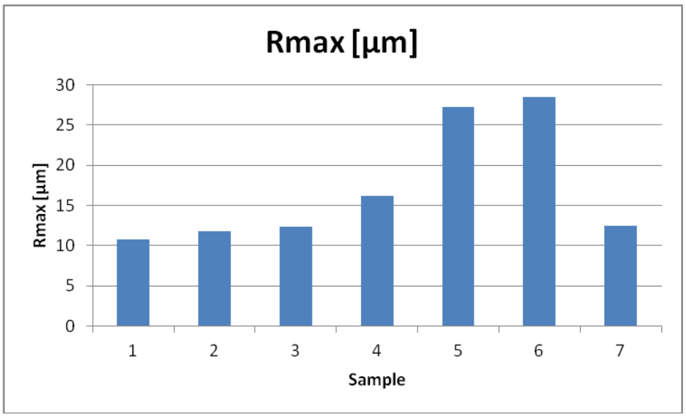

Fig. 9 R_{max} values

The measurement results show that increasing the concentration of the UDDG content in the electrolyte increases roughness of the surface of chromium coating.

CONCLUSION

The results show that with increasing of concentration of UDDG filler increases surface roughness of coating. The question is whether is this caused by filler that is built in the coating or whatever is this caused by filler presented on the surface of the substrate at the beginning of chromium plating process. Due to the earlier findings which showed that the surface conditions can be influenced by globular graphite can be assumed that the surface roughness affects the exposed graphite during early plating on the surface of the substrate.

In view of the subsequent operations is acceptable UDDG concentration in the electrolyte up to 10 g/l. At a concentration of 15 g/l is already state of the surface of the resulting coating unsatisfactory.

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