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Evaluation of white metal adhesion (conventional casting and thermal wire arc spraying) by ultrasonic non-destructive method

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Slide bearings can be classified (as follows): bearing shells, radial and axial segments, used for turbogenerators and hydrogenerators. Slide bearings work in heavy operating conditions including their size of load, middle peripheral velocity, number of revolutions and operating temperature. Causes of the slide bearing damage is possible to divide into these types: casting defects, adhesion defects, steel substrate break, assembling defects, operating defects on the white metal surface (scribbling), insufficiency of lubricating oil, dynamic overload of the bearing, cavitation and corrosion. [5]

The article presents that adhesion defects can be dependend on used technology for the deposition of the white metal on the steel substrate. Two types of deposition technology, conventional casting and thermal spraying, are compared by help of ultrasonic and penetrant method, metallography and X-ray diffraction.

1. WHILE METAL

Non-iron metal alloys can be divided into the groups: copper alloys, aluminium alloys, plastics and white metals on the tin and lead base. Tin white metals are used for heavy loaded slide bearings of the capacious electric rotatory machines. The maximum acceptable operation temperature is 100°C. Chemical composition of the tin white metal Stanit according to the Standard ČSN 42 3753 is described in table 1 [12].

Table 1:

%Sb	%Cu	%Ni	%Pb	%As	%Fe	%Zn	%Sn
min 9	2	0,4					the rest
max 11	4	0,8	0,5	0,1	0,1	0,015	

The structure of the white metal Stanit is created by the Cu_3Sn and SnSb crystals. These crystals build hard skeleton of white metal. All structure phases are deposited in the matrix of

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the solid solution α. The solid solution is rich on the tin and therefore it is soft, tough and fatique resistant material.

Wire is the initial material for the thermal spraying of the tin white metal Babbitt. Chemical composition of the tin white metal Babbitt wire is described in table 2.

2. TECHNOLOGY OF THE WHITE METAL DEPOSITION

Conventional casting of white metal Stanit is the famous method of deposition. Problems of non-adhesion of this technology consist in high demanding metallurgical operation. Steel substrate surface shall be regulary prepared by blasting, degreasing, pickling by HCl, pre-heating of steel substrate to 300°C, perfect deposition of tin interlayer and regular cooling speed. Bonding agent paste $ZnCl_2$ have been used before cast tin interlayer for better diffusion. The absence of continuous tin interlayer rises the number of local non-adhesion places. White metal Stanit: pouring temperature is 510-520°C (lead based Asmit: 480-500°C). Thickness of the white metal Stanit is from 3 to 5 mm.

Table 2:

%Sb	%Cu	%Pb	%As	%Sn
7,1	2,7	0,5	0,02	the rest

Wire arc spraying technology have been used for the deposition of tin white metal Babbitt or copper based $CuSn_8$ and Ni-based interlayer NiAl.

Dye penetrant and ultrasonic methods (PT and UT) have been used for evaluation of the white metal adhesion to the steel substrate.

3. EXPERIMENTAL PROGRAMME

UT and PT non-destructive tests, metallographical and occasionally X-ray diffraction were made on all choosed samples of the slide bearings.

Conventional casting samples

Journal segments 2A/D (3B/D) – the segments were set aside from manufacturing. Duplication cracks were found by UT and they were verified by PT method. Planing view dimension of segment is 150x150 mm and thickness of the white metal Stanit is 5 mm.
Result of the test is evaluted as a perfect white metal adhesion to the steel substrate. Result of UT test is in agreement with metallographical analysis.

Thermal spraying samples

Steel – NiAl – Babbitt: thermal spraying of the tin white metal on the steel substrate. Thickness of deposit is 1.4 mm and the dimensions of sample are 100x50x21.4 mm. The sample was machined to improve acoustic the contact for UT. Penetrant test gave thin red indication along the whole NiAl interlayer and revealed high porosity of the white metal Babbitt. Full thickness of sample is 21.4 mm. Cavities and oxide envelops are mainly characteristic for NiAl interlayer and transition of white metal-to-steel substrat. Thickness of the formation (presence of Sn,Sb and Cu elements was analysed). The bond between the white metal Babbitt and the NiAl interlayer is possible to evaluate like mixed bond. Propagation speed of longitudinal waves in the tin white metal Babbitt was measured: c_L=2910 m/s.

Steel – NiAl – NiAl + Babbitt – Babbitt: sandwich sample with the thickness of thermal spraying 2,9 mm. Dimension of sample are 100x50x9,6 mm. Penetrant test was made after machining of the latteral sides. Test indicated the continuous thin red indication, it means the sample is evaluated as unacceptable.

Steel – NiAl – CuSn8: thickness of the thermal copper-based spraying is 1,7 mm. Dimensions of the sample are 100x50x21,7 mm. Penetrant test was made and the result is evaluated as unacceptable. Ultrasonic test was provided by three types of ultrasound devices – USN 50, USN 52 and KB 6000 and 17 types of direct or double probes. Result of ultrasonic test is unacceptable – strong attenuation of the ultrasound waves.

4. X-RAY DIFFRACTION

1 The white tin metal Stanit: majority of crystals SnSb are bigger than 30 µm, some of them up to 100 µm. The white metal Stanit is evaluated as coarsegrained material. Wave length of the longitudinal waves is λ=0,9 mm (testing frequency 4 MHz). It supports the conviction that the structure of the Stanit isn´t obstacle to acoustic transmittion of the ultrasound waves. Attenuation of the Stanit is: α=0,021 dB/mm.

2 The white tin metal Babbitt: majority of structural crystals are smaller than 10 µm. Wave length of the longitudinal wave is λ=0,7 mm (f=4 MHz). The Babbitt is possible acoustic transmittend for ultrasound waves. Layered structure with many interfaces between deformed and non-deformed particles and single layers of the coating result in strong attenuation of the ultrasound waves: α=0,147 up to 0,441 dB/mm. NiAl interlayer have attenuation of the ultrasound waves: α=0,15 dB/mm.

3 The copper based $CuSn_8$ thermal spraying: majority of structural crystals CuSn are smaller than 10 µm. Layered structure was documentated by metalographical analysis. Single splatter of coating reaches up to millimeters size. Ultrasonic test couldn´t be provided due to no acoustic transmittion at all. The splatters are distinct obstacles for the ultrasound waves.

5 CONCLUSION

For the evaluation of adhesion between the steel substrate and the coatings prepared by conventional casting, the suitability of the ultrasonic test was proved with the dye penetrant test as a suplementary method. Measurement parameters were defined for the ultrasonic test.

For the WAS (wire arc spraying) technology the non-destructive methods didn´t prove to be reasonably applicable in practise, because significant changes in the morphology of the structure occur in this case. Layered structure with interfaces between the splatters of the coating, non-deformed particles and single layers of the coating acoustic transmittion or no acoustic transmittion at all.

Results obtained by the non-destructive methods and other experimental methods used have been compared and a good agreement was found.

REFERENCES

1. Pluhař, J. a kol.: Nauka o materiálech. SNTL Praha, 1989
2. Pluhař, J. – Korita, J.: Strojírenské materiály. SNTL Praha, 1981
3. Píšek, F. – Jeníček, Z. – Ryš, P.: Nauka o materiálu I/3. Academia Praha, 1973
4. Sedláček, V.: Neželezné kovy a slitiny. SNTL Praha, 1979
5. Ševčík, V. – Knotek, M.: Segmentová ložiska. SNTL Praha, 1985
6. Obraz, J.: Zkoušení materiálu ultrazvukem. SNTL Praha, 1989
7. Ambrož, O. – Kašpar, J.: Žárové nástřiky a jejich průmyslové využití. SNTL Praha 1990
8. Kundračík, J.: Hodnocení přilnavosti žárově stříkaných povlaků. ZČU Plzeň, 1998
9. Nováček, P.: Aplikace ultrazvukové defektoskopie při řešení přilnavosti ložiskové výstelky. ZČU Plzeň, 1998
10. Koutský, E. – Kříž, A.: Cínové kompozice kluzných ložisek (technická zpráva). ZČU Plzeň, 1999
11. Veselá, J. – Kubeš, Z.: Nedestruktivní kontrola a metalografické hodnocení kvality přilnutí ložiskové výstelky k základu materiálu ložiska. ŠKODA Energo, závod Elektrické stroje, 1997
12. Metals Handbook: Metallography, Structures and Phase Diagrams. American Society or Metals, 1973
13. ČSN 42 3753, r. 1981 (cínová kompozice)
14. Lexikon technických materiálů se zahraničními ekvivalenty, svazek 3 a 4 – Neželezné kovy, Nakladatelství Verlag Dashöfer, Prah, 2001
15. Schmiertechnik und Tribology, odborný časopis, 1977