

Babbitt Casting and Babbitt Spraying Processes

Case study

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Abstract—In this paper, the babbiting of a bearing in boiler feed pump of an electromotor has been studied. These bearings have an important role in reducing the shut down times in the pumps, compressors and turbines. The most conventional method in babbiting is casting as a melting method. The comparison between thermal spray and casting methods in babbiting shows that the thermal spraying babbitt layer has better performance and tribological behavior. The metallurgical and tribological analysis such as SEM, EDS and wet chemical analysis has been made in the Babbitt alloys and worn surfaces. Two type of babbitt materials: tin-base and lead-base babbitt was used. The benefits of thermally sprayed babbitt layers are completely clear especially in large bearings.

Keywords—Thermal spray, Babbiting, Bonding, Bearing, BFP, CWP

I. INTRODUCTION

BABBITT, also called Babbitt metal or bearing metal, is an alloy used for the bearing surface in a plain bearing. The original Babbitt metal was invented in 1839 by Isaac Babbitt [1] in Taunton, Massachusetts, USA. To deemphasize the term's eponymous character, modern writers sometimes lowercase it (Babbitt). [2], [3]. It is preferred over the term "white metal," which also refers to bearing metal, because "white metal" has other meanings. Babbitt metal is most commonly used as a thin surface layer in a complex, multi-metal structure, but its original use was as a cast-in-place bulk bearing material. Babbitt metal is characterized by its resistance to galling. Babbitt metal is soft and easily damaged, which suggests that it might be unsuitable for a bearing surface. However, its structure is made up of small hard crystals dispersed in a softer metal, which makes it a metal matrix composite. As the bearing be worn, the softer metal erodes somewhat, which creates paths for lubricant between the hard high spots that provide the actual bearing surface. When tin is used as the softer metal, friction causes the tin to melt and function as a lubricant, which protects the bearing from wear when other lubricants are absent. Thermal spraying techniques are coating processes in which melted materials are sprayed onto a surface. The "feedstock" is heated by electrical (plasma or arc) or combustion flame. Coating quality is usually assessed by measuring its porosity, oxide content, macro and micro-hardness, bond strength and surface roughness. Generally, the coating quality increases with increasing particle velocities. [4]

Several variations of thermal spraying are distinguished:

- Cold spraying
- Detonation spraying
- Flame spraying(wire and arc)
- High-velocity oxy-fuel coating spraying (HVOF)
- Plasma spraying
- Warm spraying
- Wire arc spraying

In this study we use the flame spraying and casting processes for babbiting a bearing in the boiler feed pump of an electromotor with tin and lead base babbitt.

II. EXPERIMENTAL PROCEDURE

The main DE and NDE bearings of an electromotor (Fig.1) and circulation water pump (CWP) (Fig.2) are selected as substrates. The revolution per minute for shafts in boiler feed pump is 3000 RPM and in CW pump is 400 RPM. So we selected tin based babbitt for DE and NDE bearing (No.11) and lead based (No.13) babbitt (both according to ASTM B-23) for CWP bearing. Table 1 shows the chemical composition of used babbitt by wet chemical composition analysis (according to ASTM E354). AISI 1045 steel (according to DIN1.1191) was used as substrate material. Two method of coating processes have been used: wire flame spray and conventional casting. For thermal spray method treading and sandblasting was used to achieve the good bonding to substrate. For casting method the tin layer was used and the melting temperature was 500 and 300 degree Celsius for tin and lead base babbitt respectively. The scanning electron microscopy (SEM) used to have an observation on worn surface. EDAS analysis has been used to have a point analysis from the chemical composition. Ultrasonic test ($A = 0^\circ, f = 4MHz, D = 10mm$) and penetration test (penetrant: Red, spraying, 10min, 25°C & developer: Wet, 10min) has been used for inspect the surface and through of the thickness from cracks and porosity after the final machining.

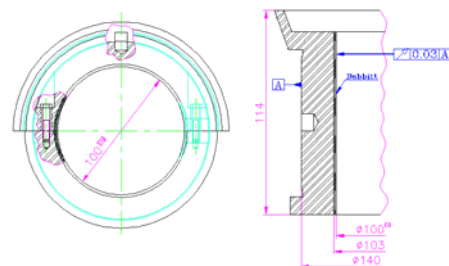


Fig. 1 boiler feed pump bearing in electromotor (tin based babbitt)

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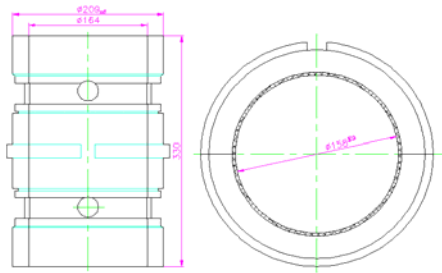


Fig. 2 CWP bearing in electromotor (tin based babbitt)

TABLE I
 HOBBING TRIBOSYSTEM

Wt%	Sn	Sb	P	Cu	Fe	As
SAE11	86-89	6-7.5	0 .5	5-6.5	0.08	0.1
Wire babbitt	88.1	7.3	0 .4	4	0.05	0.0 8
Melted babbitt	91	2	1	4	0.06	0.0 5

III. RESULT AND DISCUSSION

In this study two type of bearing have been selected to be used as substrate. Tin based babbitt was selected for boiler feed pump bearing with RPM more than 3000. The work temperature is 100 degree Celsius. The tin based babbitt is a good choice for this condition. Fig.3 illustrates the result of EDAS Analysis in coated babbitt thermally sprayed by wire flame spray. As can be see only the principal elements are present in the coating and there is not any thing from the corrosion product. Then it seems that the wear mechanism is the predominant mechanism in coating failure. Fig. 4 shows the SEM topography of worn surface. The wear mechanism is abrasion wear. Fig. 5 shows the SEM topography of penetrated particle and Fig.6 shows the results of adhesive wear that was caused cavities in the babbitt surface. Fig.7 shows a crack in the coating. All the figures 5 to 7 are from cast babbitt coatings. The presence of porosity and inclusions in the coating cause cracks through the coating. The oil film in the gap between the shaft and bearing could reach the coating-substrate interface and play a thermal barrier role at the interface. So the heat generated in the bearing-shaft contact zone could not pass this thermal barrier wall so make hot spot

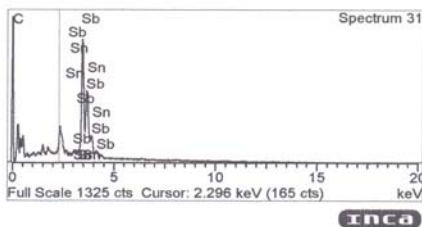


Fig. 3 EDS point analysis of babbitt coating

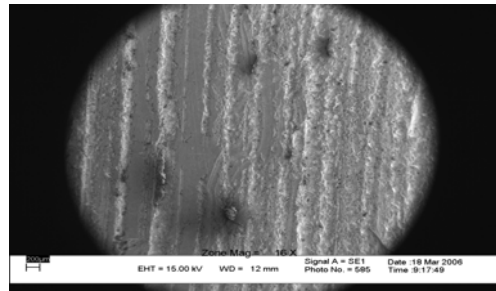


Fig. 4 SEM topography of babbitt abrasive wear mechanism

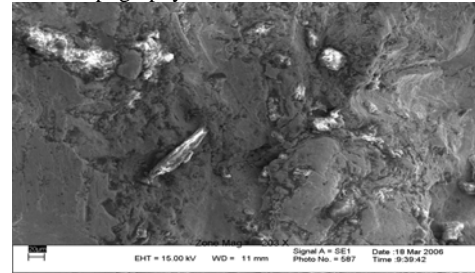


Fig5: SEM topography of wear particle (debris)

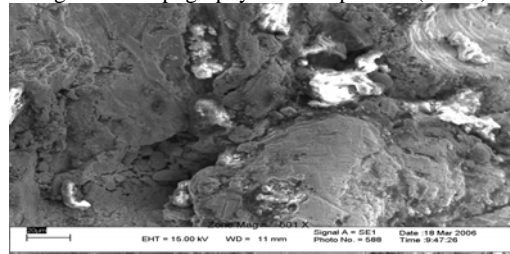


Fig. 6 SEM topography of wear particle (debris) in higher magnification

Zoon is formed at the babbitt-substrate interface. This phenomenon could be led to debonding of babbitt layer from substrate [5].

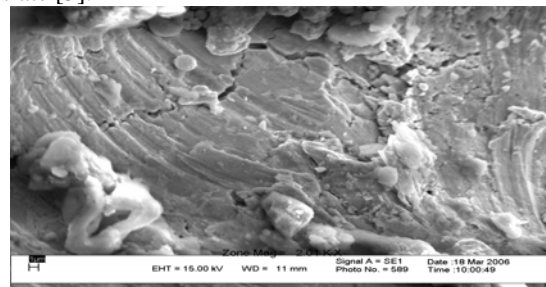


Fig. 7 SEM micrograph of longitudinal continues crack in babbitt (coated by melting process)

The result of ultrasonic test shows that there is not any segregation between the babbitt coating and substrate. The result of penetration test did not show any micro crack and the babbitt has homogenize surface completely in flame thermally sprayed coating. The result of field test shows that the thermal sprayed babbitt has good performance and tribological condition and after 7000 hours in service. The babbitt layer coated by casting process experiences same condition is shown in Fig.8. The debonding of babbitt layer is clear in the bearing-babbitt interface.

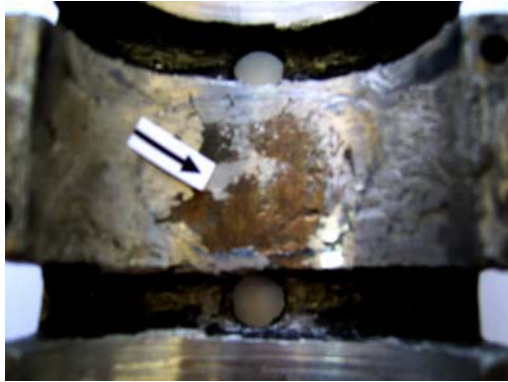


Fig. 8 debonding the babbitt coated by melting process

IV. CONCLUSIONS

The coating and repairing of boiler feed pump bearing and CWP pump has been investigated. Wire flame thermally spraying process, melting process and metallurgical analyses are employed for this purpose. A summary of conclusions is as follow:

- The bonding strength of thermally sprayed babbitt layer is higher than melting processes.
- The hot spots which are the result of thermal barrier oil film in the babbitt-substrate interface eliminated completely in thermally sprayed coatings.
- The lower percentages of porosity could increase the bearing property of babbitt layer.
- The benefit of thermal spray process is has higher importance when the bearing is large in dimension. Babbitting these bearing with melting process could damage the geometrical tolerances because of the high temperature nature of melting process.

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