Influence of Thermal Spray Coatings on the Thermal Endurance of Magnesium Alloy ML-5

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Abstract: Authors of the article evaluate the influence of temperature and thickness of coating onto the thermal endurance of magnesium alloy ML-5 with a 0,5 mm thickness NiAl coating METCO 404. Described are both of experiments and also samples preparation.

Keywords: coating, plasma spraying, thermal endurance

1 Introduction

Magnesium and aluminium alloys are used in machine industry, especially in the aircraft industry [1, 2]. These alloys have very good physical and mechanical properties. Disadvantage of them is low resistance to corrosion. Resistance to fatigue is reduced by defects of magnesium alloys (for example structural inhomogenities). The measured accounts can be different [3].

The Mg-Al-Zn-based ternary alloy and the Mg-Mn, Mg-Si-based binary alloys are of great importance. The magnesium alloy ML-5 is used for manufacturing of engineering parts in aircraft building, e.g. consoles, pylons which can operate for longer periods of time at temperatures between 140-150°C and for shorter time even at the temperature of 250°C. Problems can be handled by deposition of a thin coatings and thermal sprayed coatings as well. Better mechanical properties and fatigue resistance of magnesium alloys can be achieved by heat-treatment [4].

2 Preparation of Samples

Influence of chosen thermal coating to change of thermal stress was realized on the cylindrical samples (30 mm in diameter and 2 mm thick). As an investigated material, magnesium alloy ML-5 (by STN EN 42 4911) was used. The experiment was accomplished by using the EUROTHERM apparatus.

Functional surfaces of samples were ungreased, shot peened with electrocorund No. 30 using a Swiss made HUNZIKER shot peening apparatus with the parameters as follows: distance of thermal cover of pattern from aperture 1=50 mm, eventual asperity of pattern coating R_a=5-6 µm. Deposition of thermal coating was realized by gas, by a regulated plasma burner of an apparatus manufactured by the PLASMATECHNIK AG, a Swiss company, with the following parameters: plasma flood I_p=450 A, plasma intensity U_p=60 V, spill amount of plasma gas Q=33 dm.min^{-1}, compound of gas Ar+22%H_2, distance of sample from burner aperture l=140 mm, amount of conveying gas Ar=2.1 dm^3.min^{-1}, thickness of coating h=0.5 mm. Microstructure of sample with coating is in Fig. 1.

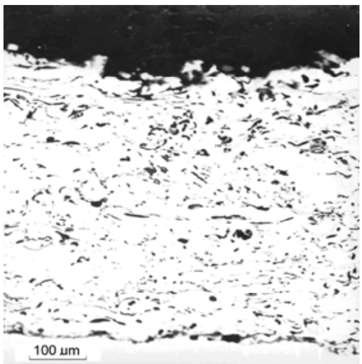

Figure 1
The microstructure of deposited NiAl coating METCO 404, thickness 0.5 mm

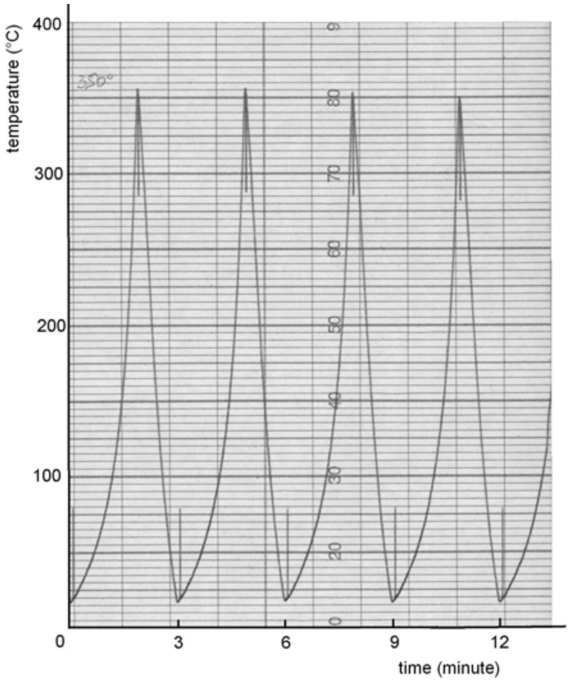

Figure 2
The cyclic thermal strain curve of the evaluated samples

3 Experiment Description

The thermal fatigue of samples with mentioned thermal coating has been evaluated with following condition: circular heating on temperature 150 and 250°C [5].

In the listed temperatures, the samples with evaluated coating did not account for structural either phase's changes in the coating not even in the main sample matter. For this reason the temperature of cyclic heat was chosen for 350°C (Figure 2). Time of heating and cooling was chosen for three minutes. The next temperature increasing with responsive cycles is shoved in Figure 3.

4 Experiment Results

The experiments have showed, that:

- magnesium alloy samples, type ML-5 with NiAl, the coating of h=0.5 mm in size deposited by thermal spraying with gas regulated arc are able to resist the cyclic thermal stresses secularly in the cycle of temperatures 0-350°C,
- metallographic analysis shows that thermal stress does not result onto structural changes in the coating either in the matter of samples. When the temperature was up to 450°C the coating got scaling off, and at the temperature of 560°C, after two cycles, the magnesium alloy ML-5 got flashed and so it loosed its value.
- the developed coating decreases melting temperature of the magnesium alloy ML-5 from 620°C to 565°C, as a result of high heat accumulation in the external layer of the coating.

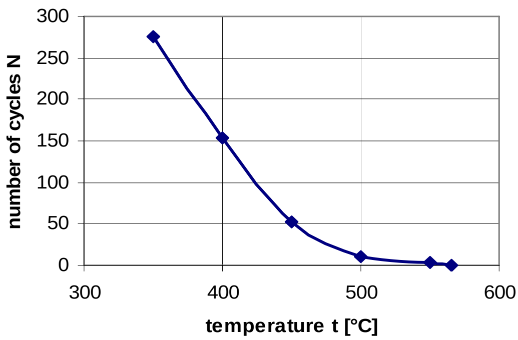

Figure 3
The Curve of thermal endurance of material the ML-5 with NiAl coating METCO 404, deposited by plasma spraying technique of 0.5 mm thickness

Conclusion

The evaluated coating contains aluminides of NiAl (Ni_3Al and other) [6] type, which melting temperature is considerably higher than the melting temperature of the alloy ML-5. Thereby it improves the resistance of coated components to cyclic thermal stress. It prevents the creation of scratches even in the main material.

The components of the material ML-5 restored by deposition of the NiAl coating METCO 404, of thickness h=0.5 mm deposited by plasma spraying are able to work securely and reliably when the cyclic changes of temperature in the cycle 20-350°C in comparison with the components without coating. Those components resist the temperature changes during the heavy duty operations at 140-150°C.

These results form the base for developing of engineering components improved technology, produced from magnesium alloys, operated in extreme conditions.

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