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Tribological properties of the Fe-Al intermetallic alloys after annealing

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Abstract
In paper researching results of tribological proprieties Fe_3Al intermetallic alloys after annealing are presented. Studies were conducted in the following environments: a water; an air and oil. For investigation purposes the tribotester pin-on-disk type with the contrsample made of steel 40H quenched and tempered was used. Tests were carried out with the following process parameters: pressure p = 2MPa and linear velocity (circuital) V = 0.46m/s. It was noted, that intermetallic samples with the small distinction in chemical compositions, annealed at different temperatures showed a large difference in the quantity of material loss in the all tested environments. Appropriately selected parameters of the intermetallic alloys annealing, provide their greater resistance to abrasion in the air and oil environments than in the case of steel..

Keywords: Intermetallics; Fe_3Al; Tribological tests; Wear surface; Weight loss;

1. Introduction

Technological development and striving to achieve a better machinery and equipment efficiency causes, that parts of machines and their components must meet stricter conditions. There is a need to look for a new solutions because of the fact, that the technological possibilities of a steels or heatproof and creep-resisting alloys have been already used [1÷3]. Therefore, the development in industry areas such as: automotive, energetic or food give a possibilities to use of intermetallic alloys. Primarily it refers to the Fe-Al alloys. Intermetallics is a group of materials, which has intermediate properties between a ceramics and super-alloys. They have mixed atomic bonds and ordered structure as well [4÷6].

The main goal of paper is to identify and compare to the steel, intermetalic Fe-Al alloy tribological properties after annealing. For the study necessity, the hardness and chemical compositions of the samples were defined. While the trials at the tribo-tester, loss of the samples weight was determined [7÷8].

2. Investigation methodology

The first investigation step was annealing of the Fe-Al intermetallic samples in the selected temperature configurations. In the next step, tribological tests of the annealed samples have been realized. These probes have been carried out in a following environments: an air, a water and the mineral oil Castrol Magnatec 15W-40. Prepared samples have been tested by the "pin-on-disc" method. The tests has been conducted with use the tribotester shown on figure 1. Contrsample was made of steel 40H (hardness is around 62 HRC). The entitative load p = 2 MPa and linear velocity (circuital) V = 0.46 m/s were established. The duration of the trials was the same for all tests and it was 1,5 h. Changes in the samples weight were measured at the following intervals (1; 2; 4; 8; 16; 32; 64; 90 min) by their weighing with an accuracy of 0,001 g.

Fig. 1. Pin-on-disk type tribotester

3. Investigated material

Before the tribological tests, a metallographic specimens of the samples were made. Chemical composition microanalysis of the samples have been also conducted.

Material used for investigation purposes was the intermetalic alloy Fe28-Al. Sample no 1 was annealed at 800°C for 8 h and the hardness 55,9 HRC was obtained (fig. 2). Sample no 2 was annealed at 1000°C for 24 h (hardness 56,6 HRC) (fig. 3.). For the comparative purposes, tribological test of the material 15HM have been carried out.

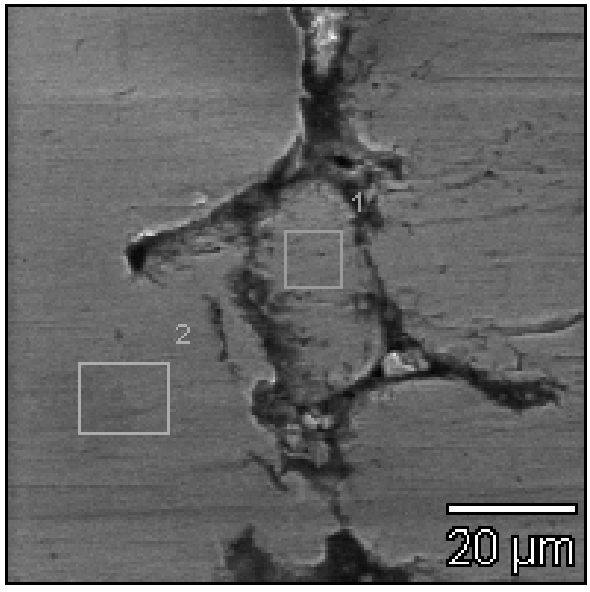

Fig. 2. Metallographic specimen of the Fe-Al intermetallic alloy annealed at 800°C for 8 h

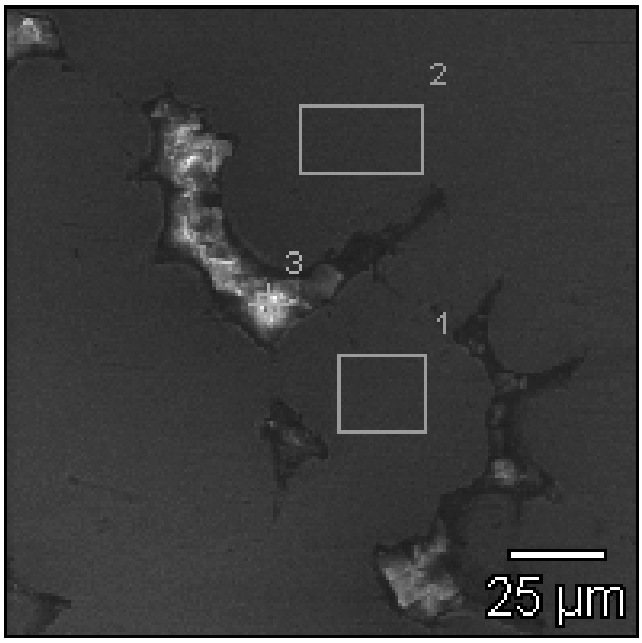

Fig. 3. Metallographic specimen of the Fe-Al intermetallic alloy annealed at 1000°C for 24 h

Figure 4 shows the chemical composition of the tested samples.

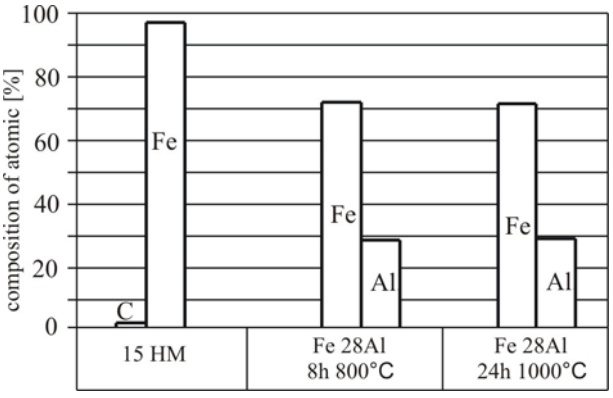

Fig. 4. Chemical composition of the tested samples

3. Experimental work

After the tribological tests realization, abrasive surfaces have been observed under a microscope and the photographs have been taken (fig. 5 and 6). Photos show the wear surface obtained in an air environment.

Loss of the samples weights as a function of time for each environments are shown on figure 7.

Figure 8 shows the result of the weight loss analysis during 90 minutes of abrasion.

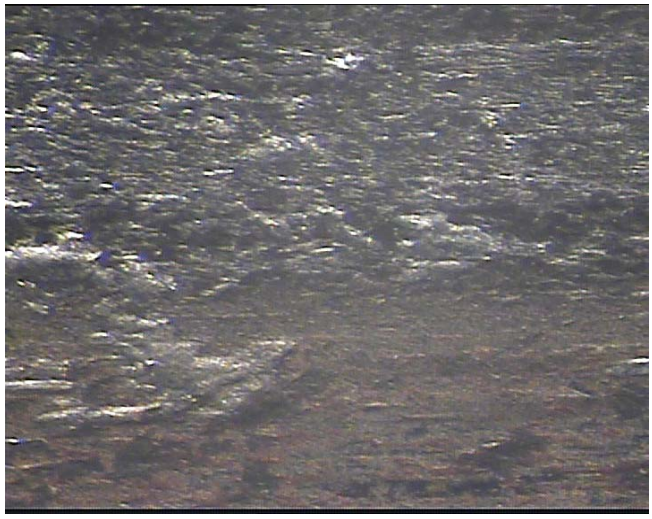

Fig. 5. View of the attrited in an air environment surface of the Fe28-Al intermetallic alloy annealed at 800°C for 8 h, magnify x 100

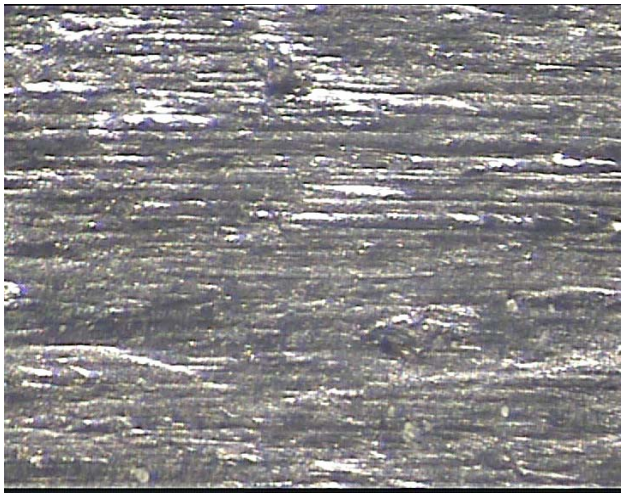

Fig. 6. . View of the attrited in an air environment surface of the Fe28-Al intermetallic alloy annealed at 1000°C for 24 h, magnify x 100

4. Conclusions

As a result of the studies, following conclusions can be formulated:

1. The smallest surface wear appeared in the oil environment for the Fe28-Al intermetalic alloy annealed at1000°C for 24h. Longer annealing gave fine-grained structure, that improves its tribological properties.
2. Sample made from steel 15HM the largest weight loss showed during abrasion in an air environment, less in a water and the smallest in the oil.

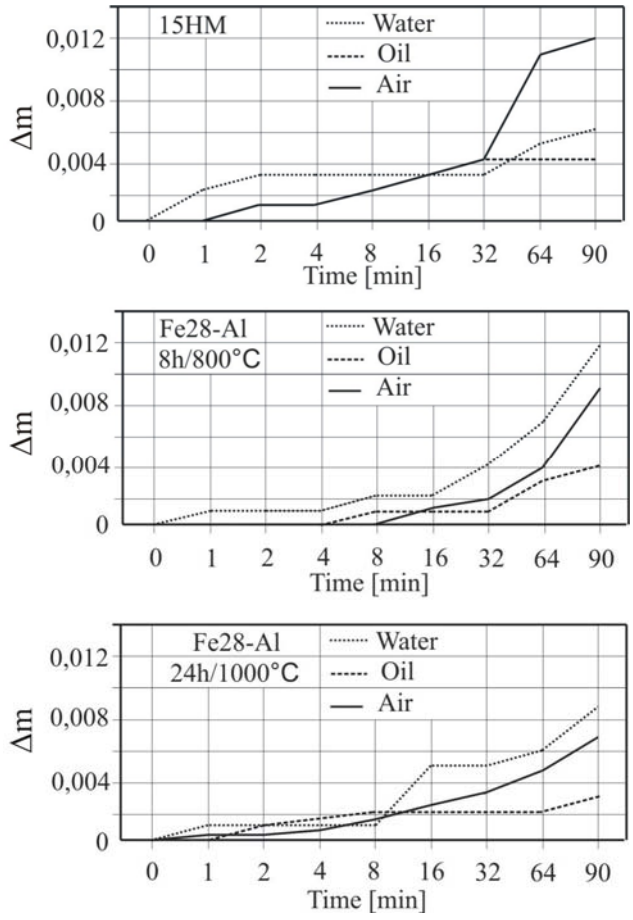

Fig. 7. Loss of weight as a function of time in the environment:

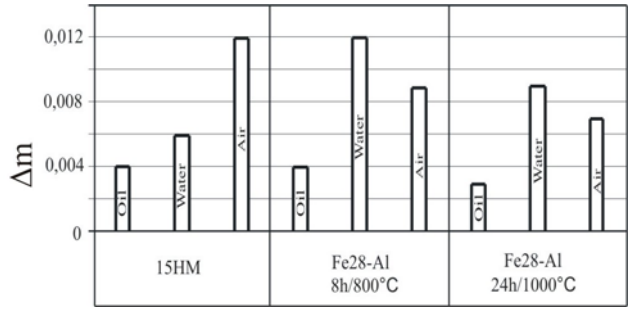

Fig. 8. Diagram of the samples weight loss during 90 minutes of abrasion

3. Intermetallics had the highest surface wear in the water environment because of the fact, that water causes faster oxidation of the abrasive surfaces.
4. The lowest surface wear of the tested samples occurred in the oil environment. The most resistant to abrasion was in this case Fe28-Al alloy annealed at 1000°C for 24h.
5. In all samples, abrasion intensity rapidly grew in the final phase of the process.

Investigations revealed, that the annealing time and temperature far affect on the intermetallic alloys tribological properties. Appropriately selected parameters of the intermetallic alloys heat treatment provide a greater resistance to abrasion in the air and oil environments than in the case of steel.

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