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Oxidation and abrasive wear in Fe-Si and Fe-Al intermetallic alloys

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Abstract – Intermetallic alloys based in Fe-Si and Fe-Al (Fe_3Si-C-Cr and Fe_3Al-C) were casted in an induction furnace. These materials have interesting corrosion, oxidation and wear resistance properties but show brittleness and poor ductility. In this study, the alloys were evaluated by isothermal oxidation (Fig.1) and rubber wheel abrasion tests (Fig.2). As reference, the ASTM A297 HH alloy was tested in the same conditions for comparison. The results present the potential use of the alloys as oxidation and abrasive wear resistant materials, the best oxidation result was found for Fe-Al and the best abrasive wear result for Fe-Si.

The main advantages of intermetallic alloys are the low density and the good corrosion and oxidation resistance when compared with usual materials like stainless steel [1]. This corrosion resistance is achieved due to a surface oxide layer formation, Al_2O_3 on Fe_3Al and SiO_2 (hydrated) on Fe_3Si [2,3]. However, the main disadvantages of Fe-Al alloys are the low creep resistance and brittleness, due to low ductility. This problem is also observed in Fe-Si alloys. In both intermetallics the brittleness is intrinsic, but in the Fe_3Al alloys hydrogen embrittlement can also occurs [1, 4].

In this study isothermal oxidation and rubber wheel abrasion test were performed in Fe_3Al-C, Fe_3Si-C-Cr alloys and in ASTM A297 HH austenitic cast steel for comparison. The isothermal oxidation tests were carried out in air at 800°C and the rubber wheel abrasion tests followed the ASTM G65 standard recommendation, using specimens from two conditions: as cast and oxidized.

The figure 1 shows the isothermal oxidation tests results, in terms of mass variation against time. The Fe_3Al alloy showed the best results with the minor mass change. The higher mass variation was observed for Fe_3Si alloy, with mass gain, and reverse behavior of HH alloy that had mass loss. These behaviors can be explained by the surface oxide layers formation. In the Fe_3Al the surface oxide amount does not change because the alumina (Al_2O_3) seems to be very stable, dense and adherent. For the Fe-Si alloy, the mass increase was caused by the SiO_2 oxide layer increase. For HH steel the oxide layer spalled off the samples causing mass loss. Figure 2 present the average volume loss under the rubber wheel abrasion test for as-cast (Fe-Al and Fe-Si only) and oxidized specimens, for nearly 700 hours. Among the oxidized samples the Fe-Si alloy suffered the minor wear (~ 8mm^3), better than HH (~ 9,5mm^3) and Fe-Al (~ 12mm^3). Fe-Si alloy shows also the best result in the as cast condition. Comparing the materials individually, it can be noted that the oxidized material presents better results, probably because the higher initial wear resistance due to the oxide layer.

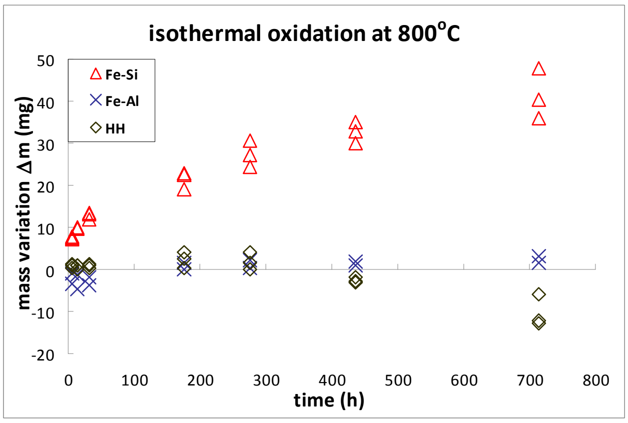

Figure 1: Mass variation for isothermal oxidation tests under 800°C.

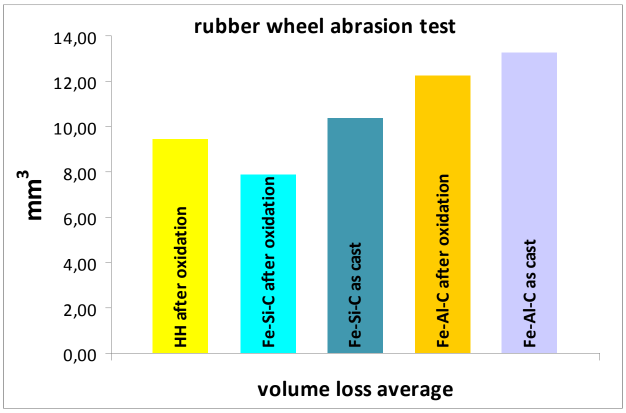

Figure 2: Average volume loss under rubber wheel abrasion test.

[1] D.G. Morris, M.A. Muñoz-Morris and L.M. Requejo, Acta Materialia. 54 (2006), pp. 2335-2341.
[2] I.G. Wright, B.A. Pint and P.F. Tortorelli, Oxidation of Metals. 55 (2001), pp. 333-357.
[3] D.B.V. Castro, L.S. Rossino, A.M.S. Malafaia, C.P.O. Silva and O. Maluf, Fundição e Serviços 18 (2008), pp.66-73.
[4] B. H. Kim, J. S. Shin, S. M. Lee and B. M. Moon, Journal of Materials Science. 42 (2007), pp. 109-117.