Erosion Wear of Cast Al-Si Alloys

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Al-Si alloys are widely used in various components such as liner-less engine blocks, piston, compressor bodies and pumps for automobile sector and aerospace industries due to their excellent combination of properties like low thermal expansion coefficient, low density, excellent wear resistance, high corrosion resistance, excellent cast ability, and high hardness. The low density and high hardness of primary Si phase results in significant reduction in density and improvement in wear resistance of hypereutectic Al-Si alloys.

Keeping in view of the industrial importance of the alloys, hypereutectic Al-Si alloys containing 14, 16, 18 and 20 wt. % of Si were prepared in a resistance furnace using adequate amount of deoxidizer and degasser and their erosion behavior was evaluated by conducting tests at impingement angles of 30°, 60°, and 90° with an erodent discharge rate of 7.5 Hz, pressure 1 bar using erosion test rig. Microstructures of the cast alloys were examined using Optical microscopy (OM) and scanning electron microscopy (SEM) and the presence of Si particles was confirmed by x-ray diffractometer (XRD). The mechanical properties and hardness were measured using uniaxial tension tests at a strain rate of 10^{-3}/s and Vickers hardness tester. Microstructures of the alloys and X-ray examination revealed the presence of primary and eutectic Si particles in the shape of cuboids or polyhedral and finer needles. Yield strength (YS), ultimate tensile strength (UTS), and uniform elongation of the hypereutectic Al-Si alloys were observed to increase with increasing content of Si. The optimal strength and ductility was observed for Al-20 wt. % Si alloy which is significantly higher than the Al-14 wt. % Si alloy. The increased hardness and the strength of the alloys with increasing amount of Si has been attributed presence of Si in the solid solution which creates strain, and this strain interacts with dislocations resulting in solid-solution strengthening. The interactions between distributed primary Si particles and dislocations also provide Orowan strengthening leading to increased strength. The steady state erosion rate was found to decrease with increasing angle of impact as well as Si content for all the alloys except at 90^0 where it was observed to increase with the increase in the Si content. The minimum erosion rate is observed in Al-20 wt. % Si alloy at 30^0 and 60^0 impingement angles because of its higher hardness in comparison to other alloys. However, at 90° impingement angle the wear rate for Al-20 wt. % Si alloy is found to be the minimum due to deformation, subsequent cracking and chipping off material.

Keywords: Al-Si alloy, Erosion wear, Cast alloys, Dislocation, Strengthening.

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