ABSTRACT

The slurry erosion and sliding wear performance of a newly developed martensitic 0.05C steel have been reported here. The wear performance of the newly developed steel, tempered at 300 (ER1), 400 (ER2), and 500 (ER3) °C, is compared with that of a commercially available wear-resistant steel (Hardox 400). The samples are tested for slurry erosion resistance using a slurry erosion pot tester for 15 h with a rotating speed of 1000 rpm. Their mass loss is related to the microstructure and mechanical properties. The analysis shows that the newly developed low alloy martensitic steel has ~ 3 times higher erosion resistance than Hardox 400. However, Hardox 400 has ~ 2 times the superior sliding wear resistance than the martensitic steel. These findings conclude that hardness and strain hardening tendency are the deciding factors for erosion and sliding wear resistance. The eroded surface microstructure of steel reveals the formation of microcracks and craters. Ploughing and micro-cutting are the primary wear mechanisms in both steels.

The wear performance and corresponding wear mechanism of 0.17C steel containing Mn, Cr, Ni and Mo are reported here. The wear performance of this newly developed steel tempered at 300 °C for 30 (WT1), 60 (WT2), and 90 (WT3) minutes is compared with that of a commercially available wear-resistant steel (Hardox 400) in dry sliding condition. The tests are run in an ambient environment at various normal loads ranging from 50 to 85 N with a sliding velocity of 0.5 m/s. It is found that the wear rate of the HSLA steel is one-third of that of Hardox 400. The analysis of the worn surface indicates that ploughing, micro-cutting, and oxidative wear are the main wear mechanisms. Phase transition is observed across the worn surface of Hardox 400. The work hardening and improved yield strength of the HSLA steel lead to superior wear

performance. It is also found that the WT1 steel exhibits ~ 3 times better erosion resistance than Hardox 400. The eroded surface morphology of WT1 steel reveals that the microcrack and lip formation are the primary material removal process.

The isothermal transformation kinetics, microstructure, and mechanical properties of a 0.23C high silicon steel, isothermally treated below and above the martensite start temperature (Ms), are also investigated. Results show that the small amount of athermal martensite (AM) in the below Ms treated sample gives the additional nucleation sites for bainitic transformation, which accelerates the kinetics of bainitic transformation. The nucleation rate accelerates by two orders of magnitude at below Ms compared to above Ms. The microstructural analysis identifies the isothermal decomposition product formed in below and above Ms treated sample as bainitic ferrite. Furthermore, as compared to above Ms, below Ms isothermal treatment shows higher stability of austenite, giving rise to much-improved ductility. Moreover, the below Ms isothermal treatment refines the bainitic lath more effectively.

The effect of microstructure and mechanical properties on the slurry erosion behavior of carbide-free bainitic (CFB) steel, austempered at 350 (B1), 400 (B2) and 450 (B3) °C and martensitic (QT) steel, tempered at 300 (M1), 400 (M2) and 500 (M3) °C has been investigated using slurry pot tester and silica sand erodent particles. The samples are tested for 15 h with a rotating speed of 1000 rpm. The result shows that the QT steel has better erosion resistance than the CFB steel. The retained austenite (RA) phase fraction (17.75 %) in 350 °C austempered sample, which provides erosion resistance by transformation-induced plasticity effect, is sufficient for outstanding erosion performance among the CFB steels. However, this RA phase fraction in CFB steel is inadequate to provide better erosion resistance than the QT steel. Among all the samples tested, the sample which is tempered at 300 °C shows the best slurry erosion resistance.

The analysis of the results suggests that the hardness and transformation-induced plasticity associated with RA phase fraction, are the deciding factors for erosion resistance in QT and CFB steel, respectively. The material removal mechanism in the CFB steel is the crater formation leading to fatigue failure of lips and coalescence of micro-craters, whereas in QT steel it is only fatigue failure of lips. The M1 steel exhibits the highest final hardness, about ~ 659±30 Hv, resulting in the highest wear resistance among all the steels. The combination of high tensile and yield strength, and high final hardness of M1 is responsible for the best wear resistance among the investigated steels.

A comparative study of the sliding wear and slurry erosion behavior of selected carbide-free bainitic (CFB) and martensitic steel has been carried out. In the case of sliding wear, Hardox 400, ER1, WT1, B3, and M1 steel are selected due to the best wear resistance in each category of steels. The M1 steel shows higher sliding wear resistance than all the other steels. These findings lead to the conclusion that the final hardness, and tensile and yield strength are the deciding factors for sliding wear resistance. The erosion resistance of Hardox 400, ER1, WT1, B1, and M1 are also compared. The WT1 shows the highest slurry erosion resistance among all the selected steels. The slurry erosion resistance of CFB steel, governed by transformation-induced plasticity, is inferior to that of martensitic steel (WT1, ER1, Hardox 400, and M1), where the hardness governs the erosion resistance.

Keywords: Sliding wear, Slurry Erosion, Carbide free bainitic steel, Martensitic steel, Isothermal transformation kinetics, Transformation-induced plasticity, Hardness.