Journal of Minerals & Materials Characterization & Engineering, Vol. 11, No.2 pp.153-158, 2012
jmmce.org Printed in the USA.

Corrosion-Wear of ST60-Mn Steel in Cassava Juice

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ABSTRACT

Steels are used widely for production of machine components due to their versatility, low cost, ease of production and modification of their properties through heat-treatment. ST60Mn Steel is one of the common high strength steel produced in Nigeria and utilized for machine building purposes. Components made from this materials failed by wear, corrosion or both mechanism. The aim of this paper is to determine the influence of austempering heat-treatment on the corrosion-wear resistance of ST60Mn steel in cassava juice. The heat-treatment was performed by varying the austenitizing temperature, austempering temperature and time. The corrosion wear resistance was investigated under an instrumented pin-on-disc wear testing machine with the steel samples dipped in the cassava juice. The results obtained showed that the austempered ST60Mn steel has a wear rate of 3.0µg/cycle. While, the un-heat-treatment sample possess 70.1µg/cycle. This is a tremendous improvement in corrosion wear rate through the austempering heat treatment.

Keywords: *Corrosion, wear, Austempering, Heat-treatment, Cassava-juice.*

1. INTRODUCTION

ST60Mn Steel is a common medium carbon steel produced in Nigeria. It has strength comparable to those of imported machine building steels and is used for the production of components such as shafts, gears, bolts and nuts and other machine components that are subjected to rubbing actions in a corrosive medium as well as non-corrosive medium.

Greater abrasive resistance for low bainite matrix, with the same hardness, under a pin-on-disc test has been reported [1]. In recent time, heat treatment of steels with bainite structure ensures a good complex of mechanical properties has been observed [2]. Evidence showed that the

ST60Mn steel reliability in these applications in terms of wear characteristic is lower than its imported counterparts [3].

The wear failures of steels depend on the intrinsic parameters such as chemical composition, microstructure, and smoothness of the mating surfaces as well as the extrinsic parameters like the applied load, sliding velocity, sliding distance or number of cycles. The failure also depends on the service environment such as the presence of corrosive agents. The presence of liquid or solid films on mating (rubbing) surfaces have marked influence on their wear rate has also be noted [4]. The simultaneous actions of corrosion and wear often lead to rapid deterioration of component. This is due to the continuous Mechanical removal of oxidized metal as a result of which a protective layer can not be sustained.

Machine components steels are required to have a bainite microstructure. The institution of Metallurgist [5] reported that an austempered bainitic steel consisting of two phase matrix of mixed bainitic ferrite and retained austenite superior wear resistance. The positive mechanical strength and corrosion resistance of bainite structure depend on number of factors such as bainite ferrite grain size, dislocation density, internal stress and carbide dispersion.

2. MATERIAL AND METHODOLOGY

The ST60Mn steel sample hot rolled 12mm diameter rod used was obtained from Osogbo Steel rolling Mill, Osun State, Nigeria. The Steel has chemical composition: C(0.35-0.42), Si (0.20-0.30), Mn (0.90-1.20), P(0.04), CU(0.25), S(0.04), Cr(010).

Sixty-five test specimens of 14mm length and 12mm diameter were cut from the as-received steel samples. Five of the test specimens were retained as the as-received specimen while the rest were subjected to austempering heat-treatment under different austempering conditions. The steel specimens austempered using different austenitizing temperature TS(780, 820, 860 and 9000C), soaked for one hour, were quenched isothermally in salt bath containing 55% KNO3 and 45% NaNO3 at different transformation temperatures TT (340, 400, 480 and 5000C) and transformation times tT (1, 15, 45 and 60 minutes). The samples were then air cooled to ambient temperature. Macro hardness test was conducted on the as-received and the austempered specimens using the Rockwell component of Briro V.A. (0-7300) universal hardness machine. The hardness values were read after a 1200 diamond cone indenter was pressed on the samples with a load of 1400N for about 15 minutes. Prior to exposing samples to cassava juice, their weights were measured on PB 153 Meltler Toledo digital weighing balance.

The cassava juice which was used as a corrosive medium was obtained by pressing a freshly harvested and ground cassava tubers obtained from a research farm using a screw press with a bucket underneath to collect the cassava juice that was later preserved in a refrigerator. The pH of the freshly extracted cassava juice was determined before and after the corrosion wear test. The corrosion wear test was carried out by dipping the samples in the cassava juice inside the pin on disc wear rig and running the machine for 2000 cycles under an applied load of 500g. After each run (i.e. 2000 cycles) the sample was removed, washed, dried and weighed.

3. RESULTS AND DISCUSSION

Figure 1 illustrates the effect of different austenitizing temperatures on the wear-rate of ST60Mn steel solution quenched at 340^{0}C at various quenching time. Generally, the figure shows that there is a decrease in the wear rate as the austentizing temperature increases from 780^{0}C until at about 820^{0}C and above when the wear rate increases with increasing austenitizing temperature. This behaviour may be attributed to formation of homogeneous austenite at 820^{0}C and above. Conversely at below 820^{0}C non-homogeneous austenite is formed. Transformation of non-homogeneous austenite gives a mixture of pearlite and bainite while austenite at temperatures above 820^{0}C attributes to formation of a low strength bainite due to grain growth effect hence, such structure possess high wear rate as shown in Figure 1.

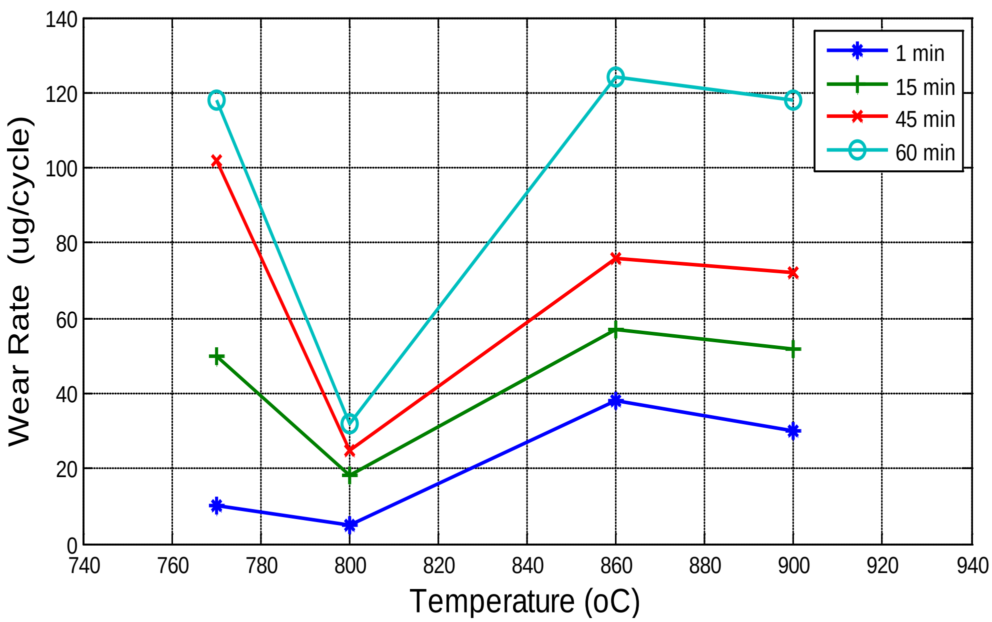

Figure 1. The Effect of Austenitizing Temperature on the Wear-Rate of ST60Mn Steel Transformed at 340ºC at various Intervals

Figure 2 depicts the effect of transformation temperature on the wear rate of ST60Mn steel which was earlier austenitized at 820^{0}C and solution quenched at different temperatures and maintained at varying different time. It is evident from figure 2 that wears rate increases with increase in transformation temperature.

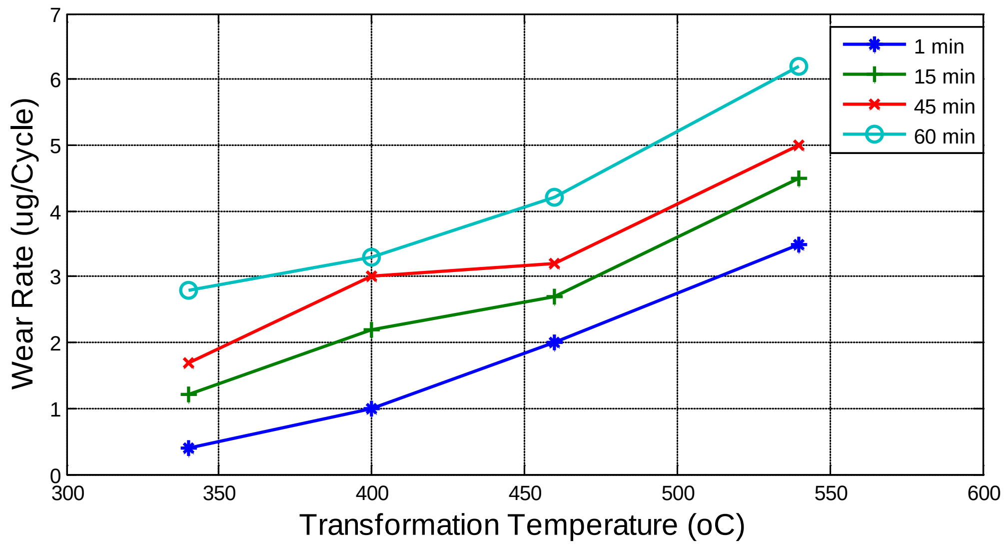

Figure 2. The Effect of Transformation Temperature on the Wear-Rate of ST60Mn Steel Austenitized at 820ºC at varying Time

Figure 3 shows the influence of transformation time on the wear rate of ST60Mn steel austenitized at different temperatures and transformed at 340^{0}C. Figure 3 shows that the wear rate increases with increase in transformation time. This behaviour may be linked to the fact that bainite formation involves carbon diffusion and ferrite shift type reactions which are time dependent.

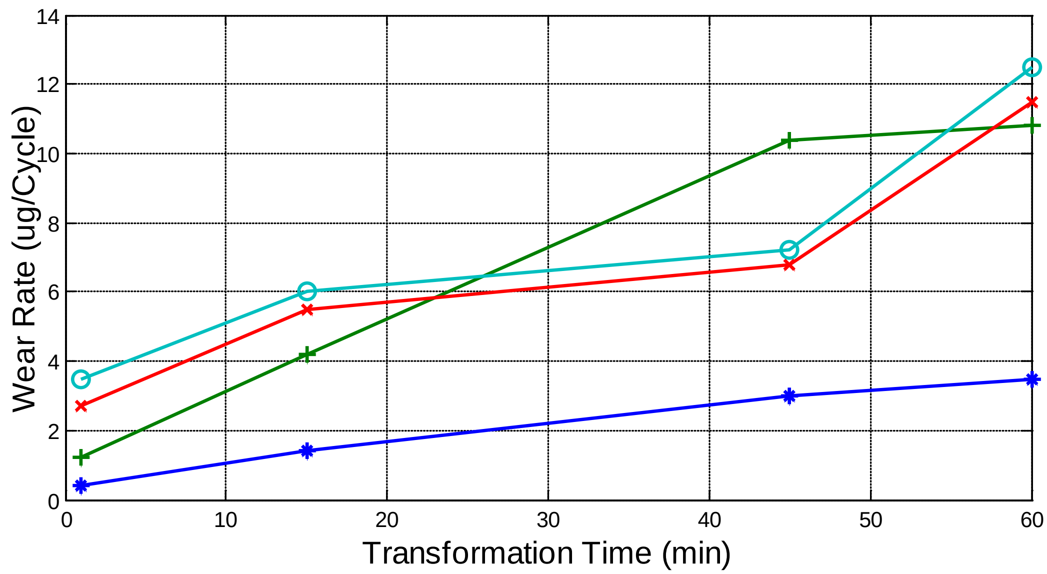

Figure 3. The Effect of Transformation on the Wear-Rate of ST60Mn Steel Austenitized at Different Temperature and transformed at 340ºC

Table 1 shows the hardness values of samples austenitized at 820^{0}C and transformed at varying temperature and time. From the table it could be seen that austempering heat-treatment has positive impact on the hardness value of the steel when compared with that of the as received whose hardness value is 9.5 HRC.

TABLE 1. Hardness value of specimen austenitised at 820^{0}c

TRANSFORMATON TEMPERATURE T;C.	**TRANSFORMATION TIME TI.**	**HARDNESS VALUE HRC.**
340	1	56.0
340	15	53.5
340	45	53.0
340	60	51.0
400	1	32.5
400	15	31.0
400	45	30.0
400	60	28.0
450	1	38.4
450	15	38.2
450	45	37.5
450	60	34.5
500	1	25.0
500	15	24.0
500	45	23.5
500	60	21.3

4. CONCLUSION

From the outcome of the analysis of results obtained on the ST60Mn steel, the following conclusions could be made.

1. Austempering heat-treatment is an effective technique for improving the corrosive wear resistance of ST60Mn steel.

2. Corrosion wear rate as well as hardness values are dependent on the austenitizing temperature , transformation temperature and time.

3 Austempering heat-treatment is capable of improving the structural integrity of ST60Mn steel in cassava juice

REFERENCES

1. Zum-Gahr K. H., (1982): Relation between abrasive wear rate and the microstructure of metals, proceedings of the International Conference on wear of Materials, Reston.
2. Kaleten, A. Y; Lyzhkov, A. G. (2007): Alloying and heat treatment of steels with baintic structure. Metal Science and Heat-treatment. Vol. November 10 pp. 731 – 735.
3. Umorus, L.E.; A. O. Akinola and M. O. Adeoye (2006): Corrosion-wear. Journal of Applied Sciences Research Vol. 2. No. 9 pp. 529 – 532.
4. Williams, K. (2000): Plant Engineering Hardbook 2nd ed. McGraw – Hill Book Copy pp. 5 – 44.
5. Institution of Metallurgists (1984): Development for future foundry property. The metallurgists and Materials Technologists, Vol. 16 No. 9 pp. 433.