Malaysian Technical Universities Conference
on Engineering & Technology (MUCET) 2013

Experimental Analysis on Martensite Formation of Low Carbon Steel During Rapid Cooling Process

Mohd Zaidi Sidek, Nur Adjla Binti Mohamad Hafizin,
Ahmad Nasser Mohd Rose, Khairul Azha Abd Jalal

Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang,

*E-mail: zaidisidek@ump.edu.my

Keywords: Sheet metal forming, heat treatment process, rapid cooling, low carbon steel

Abstract

Rapid cooling is one of the heat treatment techniques, which has been adopted in manufacturing sheet metal forming products such as structural beam and automotive parts. It involves heating of the carbon steel, and then followed by fast cooling process inside the cooling medium such as water and oil. Formation of martensites is beneficial to obtain stronger products. At present, it is most not really known how material thickness affecting martensite formation. Therefore, this study was conducted to study martensite formations inside low carbon steel for three selected part thicknesses; i.e 2, 4 and 6 mm.

Mild steel is one of engineering material that has been selected in this project which mostly used in many structural and vehicle components and other domestic applications [Machado, *et al.*]. At high temperature condition, material characteristic performs differently in comparing to normal room condition. Microstructure transformation is their advantage, in term of lower working force and higher material flow rate deformation. Top of that, it is able to produce high strength material, with an addition of a heat treatment process [Adnan, 2005]. Heat treated components can be extensively improved due to microstructure recrystalizations in rapid cooling process. It is known that carbon steels can be processed differently.

From the previous studies, it was revelaed that the diffusionless transformations contribute to martensite formation which is the hardest microstructure in iron-carbon system [Wen *et al.*, 2005]. The lowest hardness is obtained due to a diffusion transformation, which cause the ferrite and/or pearlite formation by a eutectoid reaction. Martensite is obtained during rapid cooling while ferrite and pearlite obtained from austenite during slow cooling near the equilibrium. On the other hand, with the applied cooling rate increasing, the transformed structure evolves from granular bainite, lower bainite, self-tempered martensite, to finally martensite without self tempering [Qiao *et al.*, 2009].

The experiment was conducted as the specimens were heated to 950^{o}C before immediately quenched in the water. Then, the specimens were analysed with the metallurgical microscope and the hardness test. The results show that martensite forms is at the highest for 2mm specimen (90% of austenite phase), while about 70% for 4mm specimen and 50% for the 6 mm specimen as depicted in Figure 1.

(a) (b) (c)

Figure 1: Microstructures after water quenching process (a) 2mm (b) 4mm (c) 6 mm (etchant: 2% nital, magnification 50X)

From the hardness tests, it was determined that 2mm had a highest value of average hardness for water quench specimens which is 69.3HRA compared to 4mm and 6mm specimens. For 4mm the average surface hardness archived is 64.5HRA while 6mm is 57.1HRA which is the lowest hardness as shown in Figure 2.

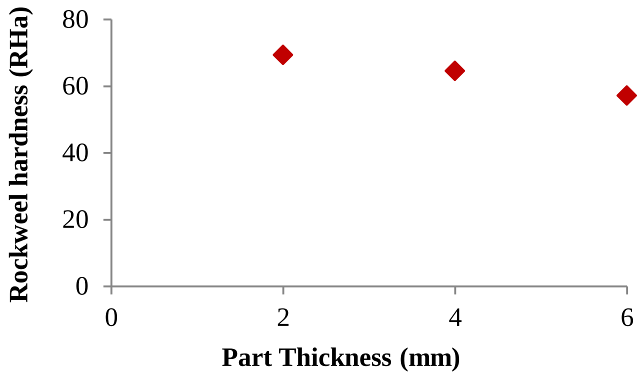

Figure 2: Rockwell hardness test results

Acknowledgement: The authors thank University Malaysia Pahang for the internal grant RDU130348.

References

I. F. Machado, Technological Advances in Steel Heat Treatment, Mechatronic and Mechanical Systems Engineering Department, Polytechnic School, University Of Sav Paulo, Feb 2005.

Adnan C., Effect of Cooling Rate on Hardness and Microstructure of AISI 1020 Steels, Suleyman Demirel University, Technical Education Faculty, Machine education department, July 2009

W. Wen, Y. Zhao, J.G. Morris, The Effect of mg Precipitation on The Mechanical Properties of 5xxx Aluminum Alloys, Mater. Sci. Eng. A 392, 136-144, 2005.

Muhammad H. J., et. Al, Effect of Heat Treatment on the Microstructure and Mechanical Properties of Low Carbon SAE 101, Quaid-E-Awam University Research Journal of Engineering, Science & Technology Volume 1, No. 1, January-June, 2000.

Qiao Z.X., Liu Y.C., Yu L.M., Gao Z.M., Effect of cooling rate on microstructural formation and hardness of 30CrNi3Mo steel. App. Phy. A. 95, 917, 2009.

M. H. Jokhio, S. A. Memon, and M. J. Sangi, Effect Of Heat Treatment On The Microstructure And Mechanical Properties Of Low Carbon SAE 1010 Steel, Metallurgy Eng., Mehran University of Eng. and Technology, June 2000.

Mebarki N, Delagnes D, Lamelse P, Delmas F, Levaillant C, Relationship between microstructure and mechanical properties of a 5% Cr tempered martensitic tool steel. Mat. Sci. Eng. A. 387-389, 171-175, 2004.