International Journal of Mechanical and Materials Engineering (IJMME), Vol. 4 (2009), No. 2, 103-105

INFLUENCE OF Cu ON STRENGTH AND ELONGATION OF DUAL PHASE STEEL

H. Nofriady, J. Syarif, M. Z. Omar and Z. Sajuri

Department of Mechanical and Materials Engineering,
Faculty of Engineering and Built Environment,
Universiti Kebangsaan Malaysia 43600, Bangi Selangor, Malaysia

ABSTRACT

This study aim is to determine Cu on tensile properties of dual phase steel. 0.1% C steel (Base steel) and 1% Cu bearing Base steel (Cu steel) are applied as specimens. The temperatures of dual phase for heat treatment were determined using JMatPro 4.1 software. Specimens were austenised at 1273K for 1.8ks and followed by water quenching. Then, specimens were heat treated at specific temperatures in order to obtain 20 vol.% and 80 vol.% of martensite. Hardness increases with increasing temperature for both steels. In annealed samples, hardness of Cu steel is higher than that of Base steel. Moreover it is found that the yield strength and ultimate tensile strength of Cu steel were higher than those of Base steel. The vol.% of martensite is around 80 vol.%, total elongation for Base steel and Cu steel are 15% and 19%, respectively. Therefore, the addition of Cu can improve hardness and tensile properties of dual phase steel.

***Keywords*:** Strength, Cu steel, Elongation, Dual Phase steel

INTRODUCTION

Dual phase steel are becoming more important in the automotive industry, where the high strength and high ductility permit weight reduction without sacrificing formability and low carbon. Dual phase steels derive their characteristic properties from presence of martensite and austenite islands dispersed in a ferrite matrix (Tayan *et al.*, 2007). One way of achieving this microstructure is by heating the steels into the intercritical region, which is between the A_1 and A_3 critical temperature. The obtained microstructure consists mainly of ferrite and martensite are an excellent choice for applications where low yield strength, high tensile strength, continuous yielding and good uniform elongation are required (Maleque *et al.*, 2004; Nouo Nakada *et al.*, 2003; Honeycombe and Bhadeshi, 1995; Ekrami, 205; Yoshiyuki Tomifa, 1990).

It is known that strength of the steel can be easily increased by increasing C content, but ductility and toughness could be lowered. Thus, increase of C content could not be applied. On the other hand, addition of substitutional elements such as Cu is thought to be effective to improve the tensile properties of dual phase steel (Nouo Nakada *et al.*, 2003). It is reported that addition of substitutional elements such as Cu can increase the strength, hardness and the toughness of the steels (Junaidi *et al.*, 2007). Therefore, influence of Cu on strength and elongation of dual phase steel is investigated in this study.

EXPERIMENTAL PROCEDURE

Table 1. The chemical composition of the steels (wt%).

	C	Mn	Si	Mo	Cr	Cu	Ni	Fe
Base steel	0.10	1.57	0.48	0.12	0.5	0.01	0.01	Bal
Cu steel	0.11	1.65	0.51	0.10	0.5	1.0	0.01	Bal

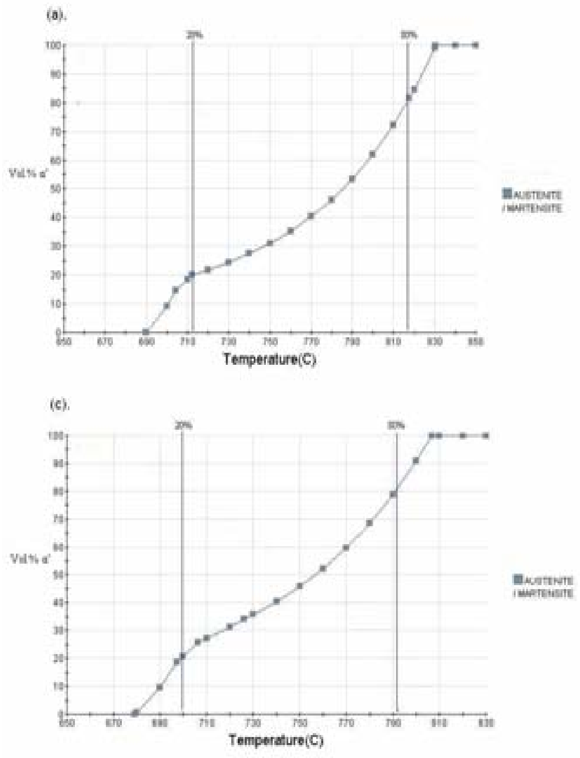

Fig. 1. Relation between temperature and volume fraction of phases of Base steel (a) and Cu steel (b).

The material used in the experiments are 0.1% C steel (Base steel) and 1% Cu bearing 0.1% C steel (Cu steel). Chemical compositions of the steels are listed in Table 1. The specimens were austenised at 1273K for 1.8ks and followed by water quenching. Then, the specimens were annealed in the intercritical region to obtain 20 vol.% and 80 vol.% of martensite. The temperatures for annealing were determined using JMatPro 4.1 software as shows Figure 1. Microstructures of the specimens were observed with optical microscopy (OM) and samples were etched with 2% Nital etchant. The tensile test was perfomed using an Instron Universal Testing Machine model 5567 with 30 kN load capacity. The strain rate applied was 10^{-3}/sec up to specimen failure. Specimens for tensile testing were cut into the dumbbell shape for tensile test experiment. Hardness of the samples was measured using the microhardness tester with application of 20 N loads.

RESULTS AND DISCUSSION

Microstructure and Hardness Measurement

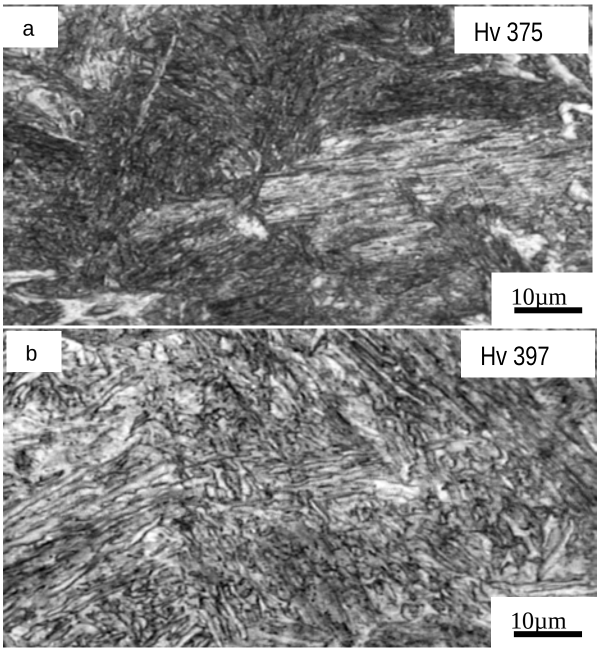

Fig. 2. Microstructures of the as-quenched steels; Base steel (a) and Cu steel (b). The steels were subjected to solution treatment at 1273K for 1.8ks and water-quenching.

Figure 2 shows optical micrographs of as-quenched steels. The as-quenched steels exhibit a typical lath-martensitic structure. Hardness of the as-quenched steels are also shown in Fig. 2. It is found that the hardness of the steels is more than Hv 350 and the values are almost the some with that of a conventional 0.1% C steel (Honeycombe and Bhadeshi, 1995). No significant difference is found in morphology of martensitic structure for all steels. Figures 2 show microstructure of the steels, which are annealed in dual phase region. The samples were heated treated for obtaining 80 vol.% of austenite at dual phase region and 80 vol.% of martensite at ambient temperature. It is found that ferrite exists within martensite matrix. Distribution and shape of ferrite are almost the same in both steels.

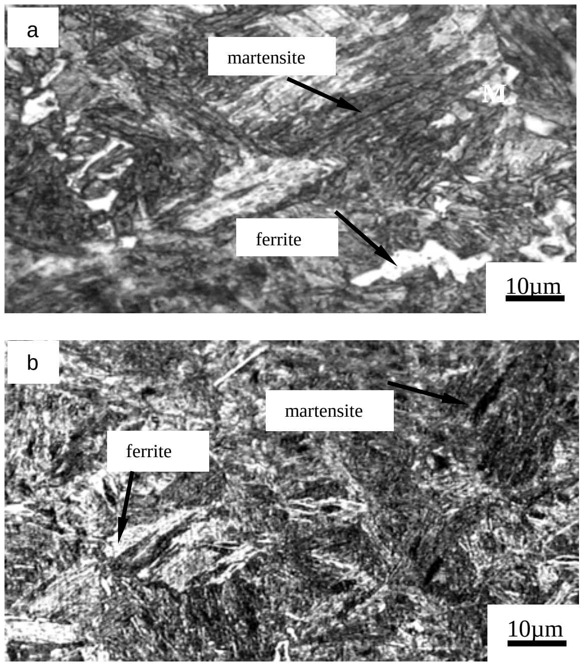

Fig. 3. Microstructures of the annealed steels; Base steel (a) and Cu steel (b). The steels were annealed at temperature to form 80 vol.% of martensite.

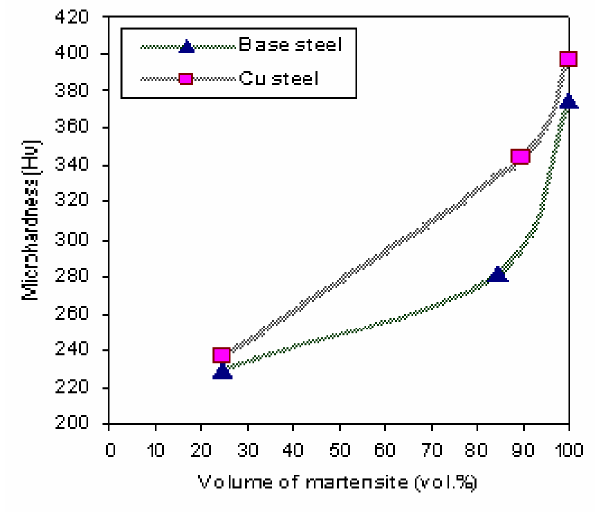

Fig. 4. Relation between Vol.% of martensite and hardness of the steels.

Figure 4 shows change in hardness of the steels as a function of vol.% of martensite by increasing the annealing temperature in intercritical temperature. Hardness of samples increases with increasing vol.% of martensite it is found that hardness of the Cu steel is higher hardness than that of the Base steel. Although the hardness of the steels added by Cu is higher, increments of the hardness are almost the same in both steels.

Result Of Tensile Test

Table 2 shows tensile properties of the annealed steels. It is found that yield and tensile stresses of the steels increase with increasing vol.% of martensite. On the other hand, elongation of the steels decrease when the vol.% of martensite of the Base steel, although the tensile stress increases increase. Figure 5 shows relation between U.E and T.S of Base steel and Cu steel, which vol.% that martensite are 20 vol.% and 80 vol.% it is found that elongation of the Cu steel are higher than that owing to addition of Cu. Therefore, it is concluded addition of Cu can improve hardness and tensile properties of dual phase steel.

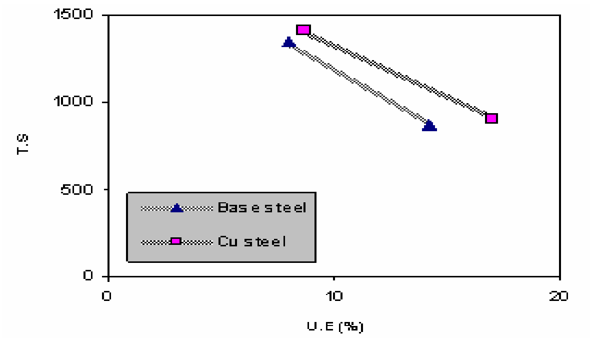

Fig. 5 Relation between U.E (%) and T.S in Cu and Base steel, which are annealed at dual phase steel region and water quenched.

Table 2: Tensile Properties of Base Steel and Cu Steel

Material	Vol. of Martensite	TS (MPa)	YS (MPa)	Uniform Elongation	Total Elongation (%)	YS / TS Ratio
Base steel	84.5	1351	471	8	15	0.35
	24.6	875	470	14.2	18	0.54
Cu steel	89.6	1410	575	8.7	19	0.41
	24.7	910	450	17	30	0.49

CONCLUSION

Influence of Cu on strength and elongation of dual phase steel was investigated. The following finding can be concluded as below:

As-quenched dual phase steel exhibit a typical martensite structure. Hardness of as-quenched steel increase with addition of Cu.

Microstructure of the steel become dual phase after annealing at dual phase region and water quenching. Hardness of the dual phase steel increases with increasing vol.% of martensite.

The addition of Cu improve not only hardness but also strength and elongation of the dual phase steel.

ACKNOWLEDGEMENT

The authors would like to thank to Ministry of Science, Technology and Innovation (MOSTI) for sponsoring this work under 03-01-02-SF0264 grant and Kyushu University for providing steels for specimens.

REFERENCES

Ekrami, A. 2005. High Temperature Mechanical Properties of Dual phase steels. Material Letter, 59: 2027-2074.

Honeycombe. R.W.K. and Bhadeshia. H.K.D.H., 1995. *Steel*. Second Edition, Edward Arnold.158-160.

Junaidi Syarif, Koichi Nakashima, Toshihiro Tsuchiyama and Setsuo Takaki. 2007. Effect of Solute Copper on Yield Strength in Dislocation strengthened steels. ISIJ International vol. 47. No. 2, pp. 340-345

Maleque, M.A. Poon, Y.M. Masjuki. H.H. 2004. The Effect of Intercritical Heat Treatment on the Mechanical Properties of AISI 3115 steel. Journal Materials Processing Technology, Elsevier, 152-154: 482-487.

Nobuo Nakada, Junaidi Syarif, Toshihro Tsuchiyama, Setsuo Takaki. 2003. Improvement of Strength -ductility Balance by Copper Addition in 9%Ni steels. Materials Science and Engineering, A374: 137-144.

Sawar, M. Priestner, R. 1996. Influence of Ferrite-mertensite Microstructural Morphology on Tensile Properties of Dual Phase steels. Journal Material Science, 31: 2091-2095.

Tayanc, m. Aytac, a, a. Bayram. A. 2007. The effect of carbon content on fatigue strength of dual-phase steels. Materials and design, 28: 1827-1835.

Yoshiyuki Tomita. 1990. Effect of Morphology of Second Phase Martensite on Tensile Properties of Fe-0.1C Dual phase steels. Journal Material Science, 25 : 5179 - 5184.