Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 7, July-2016

Prediction of heat treatment parameters for low alloy steel by using JMATPRO

Ravinder Kumar[1], Dr. Uma Batra[2]

[1,2]*Materials and Metallurgical Engineering Department, PEC University of Technology chandigarh*

Abstract- *The purpose of this study is presentation of the JMATPRO Java-based Materials Properties software for calculating the Continuous Cooling Transformation diagrams for automotive and engineering steels. The JMATPRO used for prediction of steel properties before heat treatment. Input data are chemical composition and austenitizing temperature. Results of calculation consist of temperature of the beginning and the end of transformation in the cooling rate function, the relative amount of phases presents, tensile strength, 0.2% of proof stress and hardness of steel cooled from austenitizing temperature with a fixed cooling rate. The results can be used in designing new chemical compositions of steels with assumed properties before heat treatment. The JMATPRO computer program can be used for selecting steel with required structure after heat treatment.*

I. INTRODUCTION

The CCT diagrams containing the quantitative data that will show dependence of steel structure and hardness on temperature and time of the super-cooled austenite transformations are used for determination of the structure, hardness, tensile strength and 0.2% of proof stress of the quenched, normalized, or fully annealed steels [1]. The elaboration of CCT is time consuming and requires expensive testing equipment. Additionally, different relation between chemical composition and austenitizing conditions and form of transformation curves of super-cooled austenite causes the difference between CCT diagrams for given steel grade [2].Therefore, many attempts of modeling austenite transformations in the steel during cooling are being undertaken. The basis of temperature calculations and time of particular transformations of super-cooled austenite and volume fraction of particular structural components , as well as hardness obtained after cooling is finished, are most often mathematical models of processes proceeding in the steel during heat treatment or empirical dependences elaborated according to sufficiently big number of experimental data [3] [4]. The dependences allowing for modeling super-cooled austenite transformations in isothermal cooling conditions, are based most often on Jonson-Mehl and Avramy equations [5]. Mass concentrations of elements and austenitising temperature were used as input data, obtaining the temperature values of the particular transformations depending on cooling rate at the output [6]. Presented results indicate to the correct representation of transformation temperature change trends versus cooling time.

II. MATERIAL SELECTION AND CALCULATION OF MATERIALS PROPERTIES

In the investigation low alloy steel with chemical composition giving in table 1 is selected as a material for present work. This material is generally used for manufacturing automobile components. Chemical composition and grain size ASTM 9 for this grade of steel is used as input parameter for obtaining the results from JMATPRO.

Table 1: Chemical composition of Steel (Wt.%)

Element	C	Mn	Si	S	P	Fe (bal.)
Wt. %	0.495	0.887	0.266	0.014	0.015	96.261

2.1 Determination of CCT diagram

The CCT diagram as X-axis as cooling rate and X-axis as time is determined from JMATPRO software to find relative amount of phases, Hardness, tensile strength and 0.2% of proof stress. CCT diagram shows the upper critical temperature from where the uniform formation of austenite starts and lower critical temperature that is the working temperature range for heat treatment [7].

2.2 Determination of relative amount of phases

The CCT diagram is used to find the relative amount of phases ferrite, pealite, bainite, austenite and martensite starting and end point at particular temperature with specific cooling rate and time for the prediction of the properties of steel as according to the phases present [8].

2.3 Determination of hardness

CCT diagram is used to find the hardness of the material as function of temperature and cooling rate or time.

2.4 Determination of tensile strength

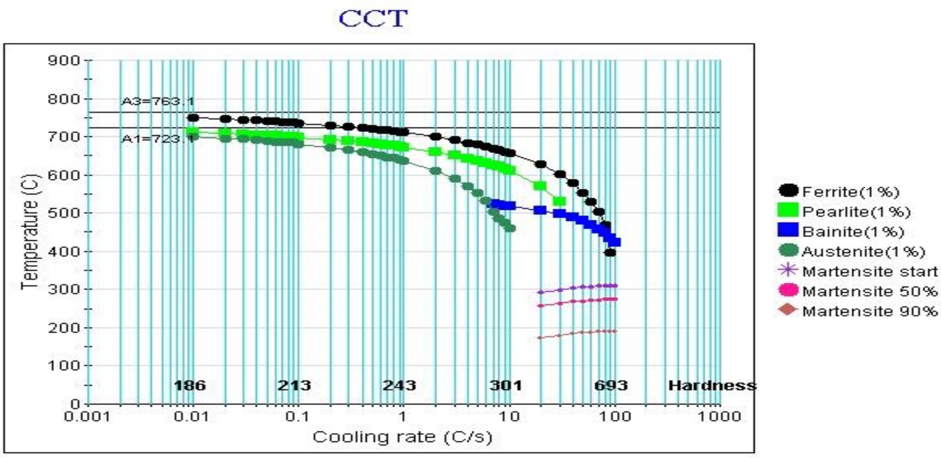
Tensile strength of the material was determined by CCT diagram at particular cooling rate or time.

2.5 Determination of 0.2% of proof stress

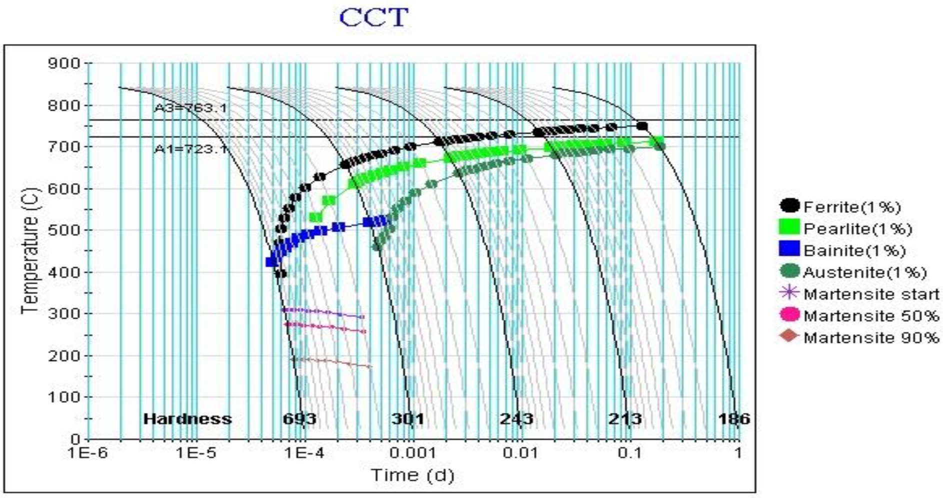
CCT diagram is used to find the 0.2% of proof stress of the material at particular cooling rate or time.

III. RESULTS AND DISCUSSION

Continuous cooling transformation (CCT) diagrams (a) X-axis as cooling rate and (b) X-axis as time is determined from JMATPRO software as shown in Fig.1 by input parameter 820^{0}C as upper critical temperature and 9 ASTM as a grain size.



(a)



(b)

Fig.1 CCT diagram (a) X-axis as cooling rate and (b) X-axis as time

CCT is transformation diagram as a function of time or cooling for a continuously decreasing temperature from where we find the relative amount of phases present, hardness, tensile strength and 0.2% of proof stress for predetermined annealing, normalizing and quenched samples. The cooling rate for annealing is 0.074^0C/s, normalizing is 0.447^0C/s and for quenching is 53^0C/s.

Relative amount of phases present ferrite, pearlite, cementite, austenite and martensite from staring to end point of transformation for annealing, Normalizing and quenching cooling rates are determined by CCT diagram obtained from JMATPRO as shown in fig.2

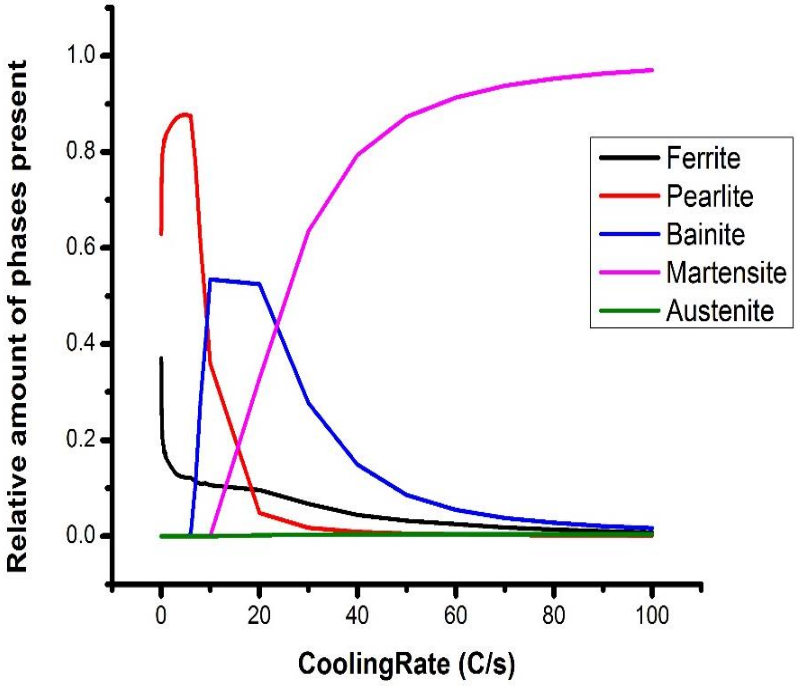


Fig. 2 Relative amount of phases present

Annealed sampled contained 0.919 % ferrite and 0.081 % of cementite, normalized sample contained 0.910 % ferrite and 0.089 % of cementite and quenched sample contain of 0.887 % martensite, 0.029% of ferrite, 0.00377% retained austenite, 0.0746% of bainite and 0.00456% of pearlite.

Hardness determined from CCT diagram for annealed, normalized and quenched cooling rates are 210VPN, 235VPN and 674VPN as shown in fig.3

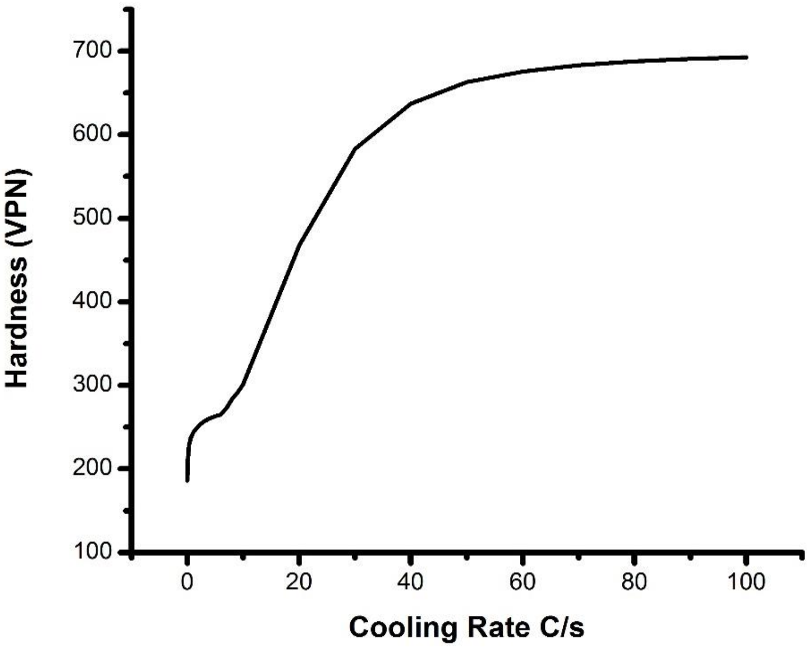


Fig 3 Hardness values determined from CCT diagram

Tensile strength determined from CCT diagram for annealed, normalized and quenched cooling rates are 602MPa, 708MPa and 2249MPa as shown in fig. 4

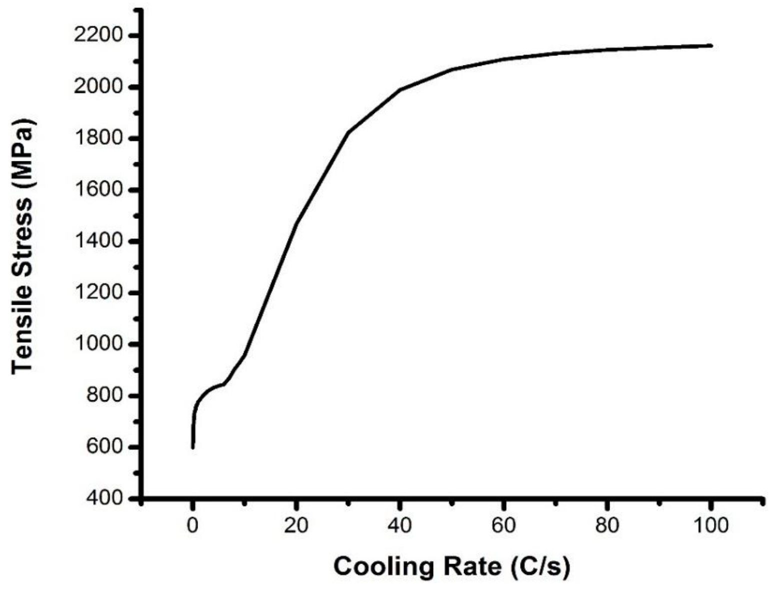


Fig. 4 Tensile strength determined from CCT diagram

0.2% of proof stress determined from CCT diagram for annealed, normalized and quenched cooling rates are 481 MPa, 566.4 MPa and 1799.2 MPa as shown in fig. 5

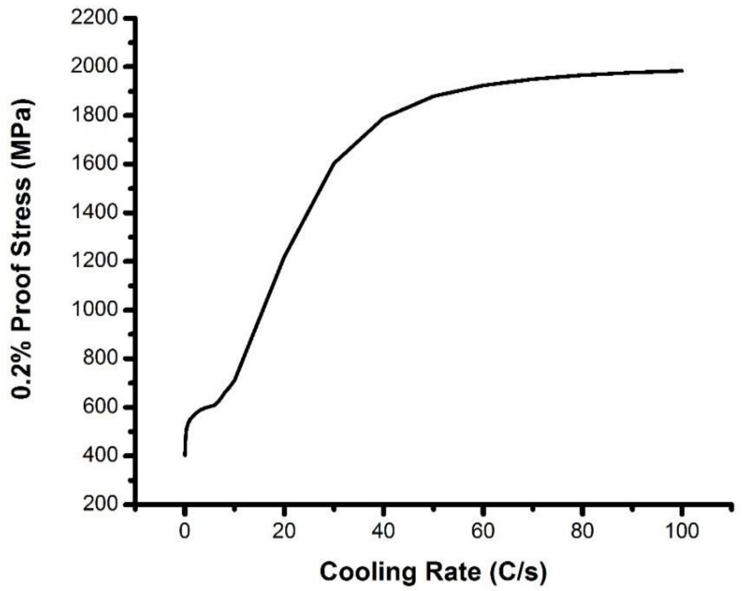


Fig. 5. 0.2% of proof stress determined from CCT diagram

As we discuss above the result obtained from CCT diagram for annealed, normalized and quenched cooling rates hardness, tensile strength and 0.2% proof stress increases as the cooling rate increases as from the figure given above and this due to the reason that in annealed cooling rate ferrite and cementite is present. Ferrite soft that will decrease the hardness, tensile strength and 0.2% of proof stress. On the other hand in normalizing cooling rate ferrite present in less amount as compare to anneal so its hardness, tensile strength and 0.2% of proof stress is more than the annealed cooling rate. Where as in case quenched cooling rate major amount of martensite is present that is very hard and brittle due that reason its hardness, tensile strength and 0.2% of proof stress is more than as comparison to other two cooling rate.

IV. Conclusion

JMATPRO software used to obtained CCT diagram of require material and it will helpful in predicting the relative amount of phases present, hardness, tensile strength and 0.2% of proof stress at required cooling rate. It will also use to modify the properties of the material by varying alloying elements in the material as per properties requirement. The experiments and wastage of material can be reduced by using JMATPRO software.

REFERENCE

[1] J. Markowski, M. Knapiński, B. Koczurkiewicz, H. Dyja, and A. Kawałek, "The analysis of the microstructure of steel S460NL1 in the conditions of thermo-mechanical treatment," vol. 25, no. 2, pp. 61–64, 2007.

[2] J. Trzaska, L. A. Dobrzański, and A. Jagiełło, "Computer programme for prediction steel parameters after heat treatment," vol. 24, no. 2, pp. 171–174, 2007.

[3] J. Trzaska, a. Jagiełło, and L. a. Dobrzañski, "The calculation of CCT diagrams for engineering steels," *Arch. Mater. Sci. Eng.*, vol. 39, no. 1, pp. 13–20, 2009.

[4] Z. Guo, N. Saunders, P. Miodownik, and J. P. Schille, "Modelling phase transformations and material properties critical to the prediction of distortion during the heat treatment of steels," *Int. J. Microstruct. Mater. Prop.*, vol. 4, no. 2, p. 187, 2009.

[5] N. Saunders, U. K. Z. Guo, X. Li, a. P. Miodownik, and J.-P. Schillé, "Using JMatPro to model materials properties and behavior," *Jom*, vol. 55, no. 12, pp. 60–65, 2003.

[6] "No Title."

[7] N. Saunders, Z. Guo, a P. Miodownik, and J.-P. Schillé, "The Calculation of TTT and CCT diagrams for General Steels," pp. 1–12, 2004.

[8] A. Gołaszewski, J. Szawłowski, and W. A. Świątnicki, "FERRITIC-BAINITIC-AUSTENITIC MICROSTRUCTURE IN THE STRUCTURAL STEEL," 2014.