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# A Review on Pre and Post Heating Analysis and Optimization with Mig welding perameters on hot rolled structure steel

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## ABSTRACT

*MIG welding is used in bridges, vessels, industrial machinery, automobile sectors, ships and many other fabrication works. Problem associated with Mig welding are thermal stresses due to non uniform heating and cooling during welding, cold cracking due to maximum hardness of the Heat affected zone (HAZ), and cooling rate which are effected by heat input rate, for given weld section of different thickness. Calculating the preheating temperature from CE, Heat input rate and carbon percentage of given material. Find out the change value of effected parameters such as heat input rate, cooling rate and change in length of HAZ during welding by applying preheating before Mig welding. Also find out the thermal stresses value before and after post heating. Finally compare both simple Mig welding and pre and post heating Mig welding for best one for hot rolled structural steel material. This review paper presents effected parameters by pre and post heating in Mig welding.*

## Keywords

Cooling Rate, Heat Affected Zone (HAZ), weld thermal cycle, Post weld Heat Treatment (PWHT): Carbon equivalent (CE).

## 1. INTRODUCTION

Steels containing excessive carbon exhibit increased strength and hardenability and decreased weld ability [1]. Q. Xue et al stated When High carbon steel is welded, it is heated; the micro structure of heated portion is different from that of the base metal and is described as the Heat Affected Zone (HAZ) [2]. Rapid heating and cooling take place throughout welding, which generate severe thermal cycle near weld line region. Thermal cycle cause non uniform heating and cooling in the material, thus generating harder heat affected zone, residual stress and cold cracking susceptibility in the weld metal and base metal [3,4,5,6], To get rid of these problems some heat treatment before welding (Preheating) and after welding, Post Weld Heat Treatment (PWHT) are employed. Effective preheat and post heat are the primary means by which acceptable heat affected zone properties and minimum potential for hydrogen induced cracking are created[4]. Methods to determine the necessary preheating temperature for the prevention of cold cracking in steel welding include the 1974 British Standard 5135[7].

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## 2. FUNDAMENTALS OF PREHEAT:

A heating procedure applied to parent metal components immediately before welding commences, and considered as an essential part of the welding operation, is called 'Preheat' The purpose of the preheating is to influence the cooling behavior after welding so that shrinkage stresses will be lower and cooling rate will be milder [8]. Basically, preheat puts the parent metal components in a suitable condition for the subsequent welding operation. Preheating may be carried out for any of the following reasons;

- Slow down the cooling rate
- Promote fusion
- Remove moisture
- Reduce shrinkage stress and weld distortion

Pre-heating makes the metal more receptive to welding. The minimum preheating temperature to be assured to avoid cracking depends on the following factors:

- Carbon equivalent expressing carbon
- Condition of base metal prior to welding,
- Thickness of base material,
- Constraint level,
- Hydrogen available risk.

Usually, rapid heating and cooling, characteristics of welding, produce a hard microstructure in the HAZ [9, 3]. The hard micro structure of the HAZ is one factor responsible for the property deterioration of welds. The heat-affected zone (HAZ), which is cooled at different rates and includes different regions of microstructure, is often considered the source of failure in a welded joint [5, 10].

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In C-Mn steels, there is a greater risk of forming a brittle microstructure in the HAZ, and thus most of the hydrogen cracks are likely to be found in the parent metal. Using the correct choice of electrodes, the weld metal will have a lower carbon content than the parent metal and, hence, a lower carbon equivalent (CE).

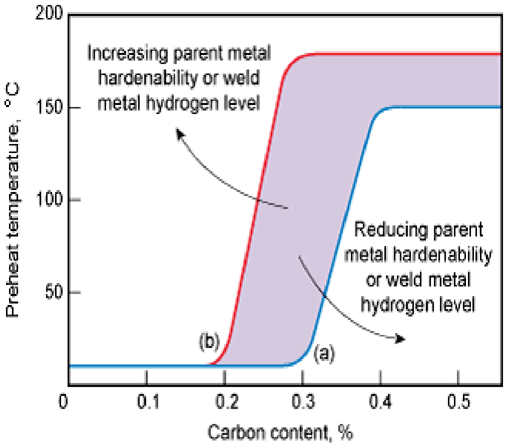


Fig.1 Preheat temperature v/s carbon content

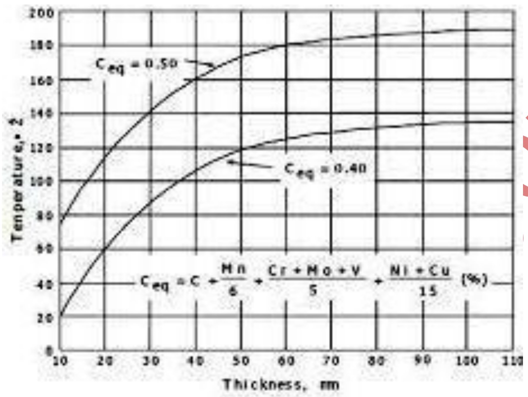


Fig.2 Temperature v/s thickness

However, transverse weld metal cracks can occur especially when welding thick sections. In low alloy steels, as the weld metal structure is more susceptible than the HAZ, cracking may be found in the weld bead. [11]

## 3. POSTWELD HEAT TREATMENT:

High level residual stresses can occur in weldment due to restraint by the parent metal during weld solidification. The stresses may be as high as the yield strength of material itself. When combined with normal load stresses these may exceed the design stresses. The removal of residual stresses takes place due to the fact that the thermal energy received by the metal allows for grain boundary sliding and removal of metallurgical defects like dislocations, vacancies and slip planes. A most important aspect of Post Weld Heat treatment is the prevention of Brittle Fracture. Post weld heat treatment softens the hardened zones and makes the machining easy. Removal of residual stresses becomes necessary where dimensional stability is required [11]. Post Weld Heat Treatment (PWHT), this procedure is used to influence the structure and the properties obtained in the weld and in the heat affected zone.

By implementing proper provisions after welding one can retard the cooling rate after Welding [13]. The functions of a PWHT are to temper the martensite in the weld metal and HAZ, in order to reduce the hardness and increase the toughness, and to decrease residual stresses associated with welding [14, 15]. By reviewing the current literature [16], available on the subject of Post Weld Heat Treatment (PWHT), one can see that recommendations are usually dependent upon specific alloys and filler metals involved, but also on thickness and restraint of welded joints. Post heating is used to minimize the potential for hydrogen induced cracking (HIC) [17].For HIC to occur three variables must be present: a sensitive microstructure, a sufficient level of hydrogen, or a high level of stress. The necessity for PWHT depends on material and service requirements. Other factors that influence the need for PWHT are dimensions, joint design, welding parameters and the likely mechanism of failure.

## 4. THERMAL STRESSES

Preheating reduces the thermal gradients in the weld and slows down the cooling rate of the weld deposit these stress relieving treatments produced little change in the notch toughness of weld metals made with low hydrogen-type electrodes. Stress relief heat treatment is used to reduce the stresses in sheet metal structure of fabrication manufacturing processes. The residual stresses due to welding are of a magnitude roughly equal to the yield strength of the parent material [18]. Uniform heating of a structure to a sufficiently high temperature, but below the lower transformation temperature range, and then uniformly cooling it, can relax these residual stresses [3, 16]. By stress relieving there is greater dimensional stability during machining, the potential for stress corrosion cracking is reduced and finally the chances for hydrogen induced cracking are also reduced. The temperature reached during the stress relief treatment has a far greater effect in relieving stresses than the length of time the specimen is held at that temp [19]. Thermal cycle generates contraction of the weld during cooling and builds up strains in the joint both due to the thermal expansion and to transformation from austenite to ferrite or martensite.

## 5. COOLING RATE EFFECT

The micro structural changes in the weld zone, as well as the weld heat-affected zone(HAZ), are greatly dependent on the heating and cooling rates, which in turn depend on the weld heat input (a function of arc energy, travel speed, and the thermal efficiency of the process), the plate thickness/geometry, and the initial or interpass temperature. The micro structural changes will directly

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affect the property changes (whether mechanical or corrosion related) in the weld zone and the HAZ. Therefore, it is important to be able to predict the actual thermal cycle characteristics such as peak temperature and cooling rate if microstructure is to be characterized and correlation with the proper-ties is sought. This becomes more significant if the effect of heat input on the micro structural changes in the HAZ is to be examined for a given material, as the heat input is only a rough, simplified parameter specific to a welding process. Moreover, knowledge of the cooling rate is required for simulation approaches [1]

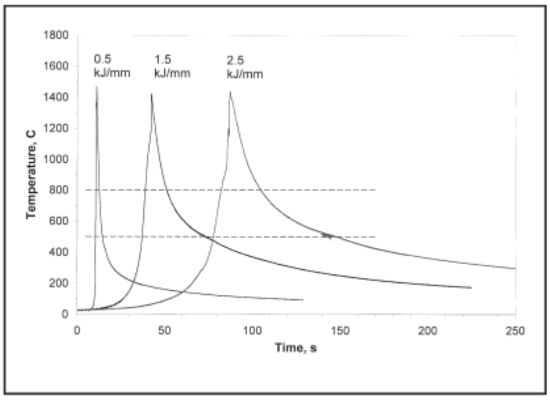


Fig. 3 Temperature v/s time of weld section [20]

The actual weld thermal cycles measured in the HAZ close to the weld interface for different weld samples with heat inputs of 0.5, 1.5, and 2.5 kJ/mm (12.7, 38.1, and 63.5 kJ/in.). The cooling time from 800° to 500°C (1472° to 932°F) increases dramatically as the heat input increases.

## 6. DISCUSSION

The study of the previous work reviews that effective preheat and/or post heat are the primary means minimum heat affected zone properties , minimum potential for hydrogen induced cracking and minimum residual stresses are created.

Some researchers concluded that microstructure of the HAZ is responsible of preheat temperature of weld and cold cracking susceptibility some of the researchers observed that the increase of preheating and/or PWHT coarsened the microstructures of weld and HAZ and significantly influenced the properties of the weld joints. While studying the effects of pre-and post weld Heat Treatment on mechanical properties, some researchers observed that toughness decreases after stress relieve operation on other hand toughness increases if only PWHT is applied. Welding stresses can be reduced.

Also some researchers are conclude that preheating are reduce the cooling rate of welding temperature which optimize the heat input during the welding and create optimum length of heat affected zone around the welding.

## 7. REFERENCES

[1] AU: IPRM, Welding consumables: Stainless steel (2007)
[2] Q. Xue, D. Benson M.A. Meyers, V.F. Nesterenko E.A. Olevsky ,Constitutive response of welded HSLA100 steel, Materials Science and Engineering A354 : 166 to179 (2003)
[3] Tadashi Kasuya, Nobutaka Yurioka,Makoto Okumura ,Methods for predicting maximum hardness of Heat Affected Zone and selecting necessary Preheat temperature for Steel Welding,Nippon Steel Technical Report No.65,: (1995)
[4] Teng, Tso-Liang, Chang, Peng-Hsiang, A study of residual stresses in multi-pass girth-butt welded pipes, International Journal l of Pressure Vessels and Piping 74: 59–70 (1997)
[5] Lee, S., Kim, B.C., Kwon, D., Correlation of microstructure and fracture properties in weld heat-affected zones of thermo mechanically controlled processed steels, Metallurgical Transactions A,:(1992)
[6] Eigenmann, B., Schulze, V., Vo¨hringer, O., Surface residual stress relaxation in steels by thermal or mechanical treatment, In Proceedings of the Fourth International Conference on Residual Stresses, Society of Experimental Mechanics, Bethel, Connecticut, Baltimore, MD,:598–607(1994)
[7] JSSC Study Croup for Weld Cracking.1972. Prediction of suitable preheating condition to prevent weld cracking in steel structures. Japan Steel Structure Construction 8(80):22-50
[8] ASM Handbook: Welding, Brazing & Soldering Olson, David L. 9th Ed. Vol. 6, ASM International,:1299 (1993)
[9] Y.C. Lin, K.H. Lee ,Effect of preheating on the residual stress in type 304 stainless steel weldment , Journal of Materials Processing Technology, Volume 63, Issues 1-3,: 797-801(1997)
[10] Q. Xue, D. Benson M.A. Meyers, V.F. Nesterenko E.A. Olevsky ,Constitutive response of welded HSLA 100 steel, Materials Science and Engineering A354 : 166_ / 179 (2003)
[11] hydrogen cracks in steels - prevention and best practice published by TWI Jan 2000/March 2000
[12] Khaleel Ahmed and J. Krishnan, Post-Weld Heat Treatment – Case Studies Centre for Design and Manufacture ,Bhabha Atomic Research Centre
[13] Elia E.Levi, Welding advisors.com, welding alloy steels.
[14] Hisaki OKABAYASI and Ryochi KUME ,Effects of Pre-and Post- Heating on weld cracking of 9Cr.-1 Mo-Nb-V Steel, Transaction of the Japan Welding Society,Vol.19,No.2: (1988)
[15] Ghosh P. K ; Gupta P. C. ; Potluri N. B. ; Gupta Yogesh ; Influence of pre and post weld heating on weld ability of modified 9Cr-1MoVNb steel plates under SMA and GTA welding processes, Iron and Steel Institute of Japan, Tokyo, vol. 44, no7: 1201-1210 (2004)
[16] An Article on Post Weld Heat Treatment (PWHT), May 2004, Issue No. 09 of Practical Welding Letter., issues -3 :51-

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54(2007-08)

[17] Ghosh P. K.; Gupta P. C.; Potluri N. B. ; Gupta Yogesh Influence of pre and post weld heating on weld ability of modified 9Cr-1MoVNb steel plates under SMA and GTA welding processes, Iron and Steel Institute of Japan, Tokyo, vol. 44, no7: 1201-1210 (2004)

[18] R. Scott Funderburk, Key Concepts in Welding Engineering- Post weld Heat treatment, Welding Innovation Vol. XV, No. 2, (1998)

[19] R. Scott Funderburk ,Key Concepts in Welding Engineering fundamentals of Preheat, Welding Innovation Vol. XIV, No. 2,: (1997)

[20]K. Poorhaydari, B. M. Patchett, And D. G. Ivey In Estimation of Cooling Rate in the Welding of Plates with Intermediate Thickness, supplement to the welding journalin-October2005.

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