INVESTIGATION ON EFFECT OF WELDING CURRENT ON WELDING SPEED AND HARDNESS OF HAZ AND WELD METAL OF MILD STEEL

Merchant Samir Y[1]

[1]*Lecturer, Fabrication Technology Department, Sir B.P. Institute, Bhavnagar, Gujarat, India*

Abstract

The effect of welding current on welding speed and hardness of heat effected zone and weld metal of mild steel material is investigated in this paper. Mild steel weldment was welded under varying welding current i.e. 80, 85, 90, 95 & 100 ampere by using MMAW process in 1G position. The edge preparation, electrode diameter and electrode type, CCV, welding technique, polarity and welder remained constant during the test. The test specimen was then grinded and hardness of each specimen was measured at three point i.e. parent metal, HAZ and weld metal by using Brinell hardness tester. It was observed that with increase in welding current melting rate of electrode was increased hence welding time was reduced. So welding speed was increased. With increase in welding current hardness of HAZ and weld metal was also decreased due to increase in heat input. With increase in welding speed heat input decreased and hardness of the joint increased.

Keywords *- MMAW, welding current, welding speed, Hardness, Parent metal, HAZ, weld metal, cooling rate*

----------***----------

1. INTRODUCTION

Today a wide variety of metal joining processes are used in fabrication industries. The welding is majorly used for metal joining. In this process arc i.e. electric discharge between electrode and parent metal is established. Due to high electrical resistance of welding arc high temperature is produced which is enough to melt the metal. MMAW - Manual Metal Arc welding is one of the oldest arc welding processes. Mild steel is widely applicable in fabrication of structure, process equipment, piping and ship building. The major factors affecting mechanical properties of weld joint are welding current, arc voltage, welding speed, polarity, edge preparation and welding technique. Out of these variables welding current, welding voltage and welding speed are primary variable which controls the fusion, depth of penetration, shape of weld puddle, reinforcement and heat input. Electrode polarity, inclination angle and welding technique are secondary variable which affect on en ergy absorbed, melting rate of base metal and weld metal.

1.1 Heat Input

Heat input rate or energy of arc was an important parameter in welding which can be calculated by following formula[1]

$$\text{Heat input } \frac{J}{\min} = \frac{V \times A \times 60}{S}$$

Where V = arc voltage
A = welding current
S = welding speed or arc travel speed(mm/min)

But for MMAW process the heat transfer efficiency is 0.65 to 0.85 [2]. So we have to multiply this equation by heat transfer efficiency then we will get actual heat input during welding.

1.2 Various Zones of Weld Joint

The steel weld joint mainly divided in three zones i.e. Weld metal zone, Heat affected zone (HAZ) and base metal zone as shown in fig-1 [3]. The HAZ was further classified in three region i.e. grain growth region, grain refined region and transition region[4]. The hardness during weld joint is not uniform. Steel is sensitive for thermal cycle and the metal of weld joint was having highest temperature i.e. above melting point and the parent metal was having temperature very less below the lower critical line. Due to high temperature difference between these two regions the cooling rate was very high and the solidification of weld metal was under non equilibrium conditions. Due to this from austenite to pearlite microconstituent transformation was not occurred and austenite to martensite or binatic lathe was occurred. So hardness of this region was very high and HAZ was become more susceptible to cracking. [2][3][5][6].

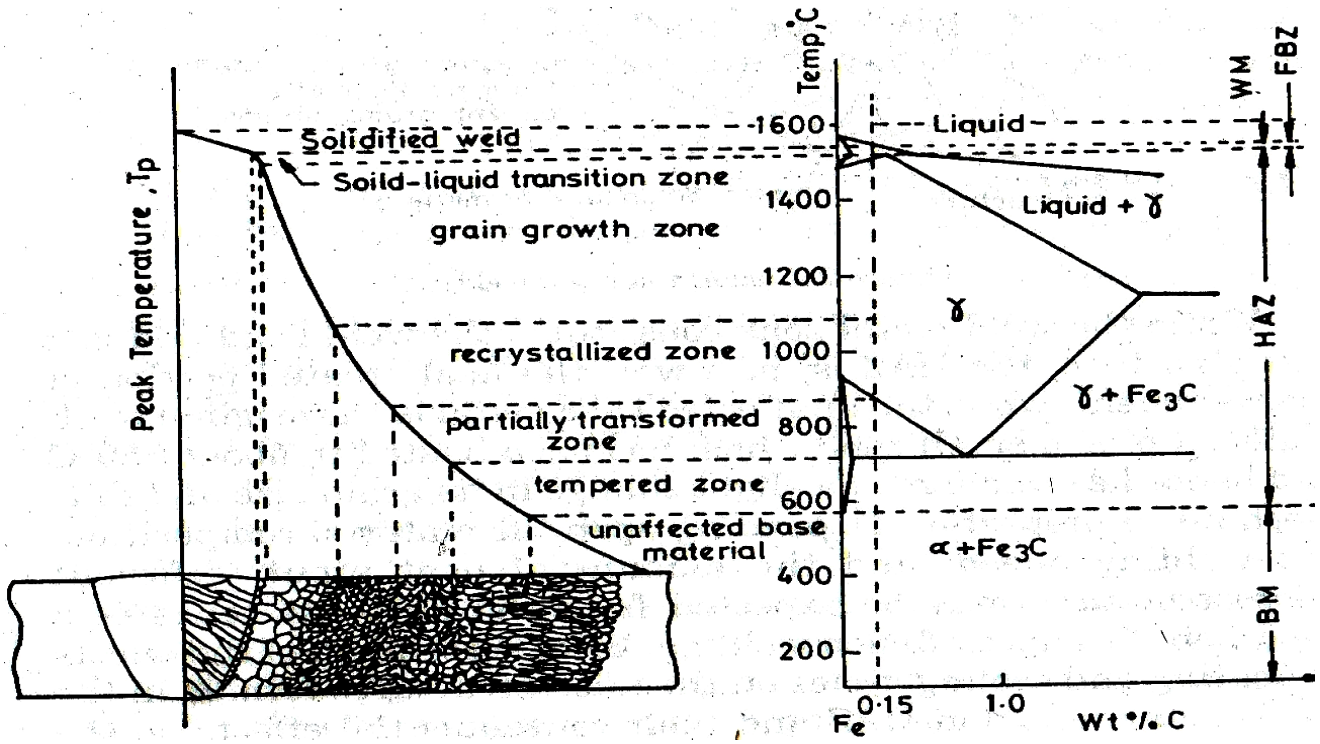

Fig-1 Different zones of weld joint

2. LITERATURE REVIEW

Bhaskar vishvakarma, Manish verma & Tribhuwasn kishor Mishra had concluded in their research that with increased in welding current impact strength of weldmetal increased while hardness decreased[7]. Rakesh kumar, Satish kumar had invstigated on mechanical properties of mild steel 1018 during MIG welding. They concluded welding current was the most significant parameter affecting the mechanical properties and hardness of weld joint. They found that no matrensite formation during MIG welding[8]. Prof. Rohit Jha, Dr. A.K.Jha had concluded in their research with increase in welding current the UTS will increase until an optimum value, increase in further welding current optimum value will result in decreasing UTS[9]. Ajay N. Boob and Prof. G.K.Gattani, have investigated on MMAW welding process parameter of heat affected zone (HAZ) for mild steel 1005. They found that during welding austenite microstructure was refined and converted into bainite so strength and impact toughness of base metal was improved. Heat input rate was most significant parameter for controlling width of HAZ and with increase in welding speed width of HAZ was decreased, proper control on welding speed was became the important parameter for controlling the HAZ[10]. Riyad Mohammed Ali Hamza, Abdulkareem Aloraier, Emad Abdulradh Al-Faraj had investigated effect of welding polarity in joint bead geometry and mechanical properties of SMAW process. They concluded that highest hardness measurement was recorded when welding was performed using DC- polarity. Hardness value was dropped down as the metal moving through the HAZ to the parent metal. The lowest hardness recorded when welding was performed using the AC polarity [11].

3. EXPERIMENTAL METHODOLOGY

3.1 Experiment Procedure

Following steps are followed for experiment

1. First 5 specimen of 100 mm long x 50 mm width x 10 mm thick cut from mild steel flat bar.
2. 45° single V edge preparation was made on these specimens as shown in Fig.-2.
3. Set-up was made by tack welding. Root gap and root face kept 2 mm each.
4. Welding of 5 specimens was performed using 1G welding position as shown in Fig-3. Welding ampere were 80, 85, 90, 95, 100 and voltage 30V remained constant. Welding polarity was DCEP.
5. For welding of each joint time in seconds was measured.
6. After welding grinding of weld joint was done and excess reinforcement was removed.
7. All the specimens were tested on Brinell hardness testing machine and hardness was measured at three points i.e. at base metal, HAZ and weld metal. The readings were noted in observation table-5.

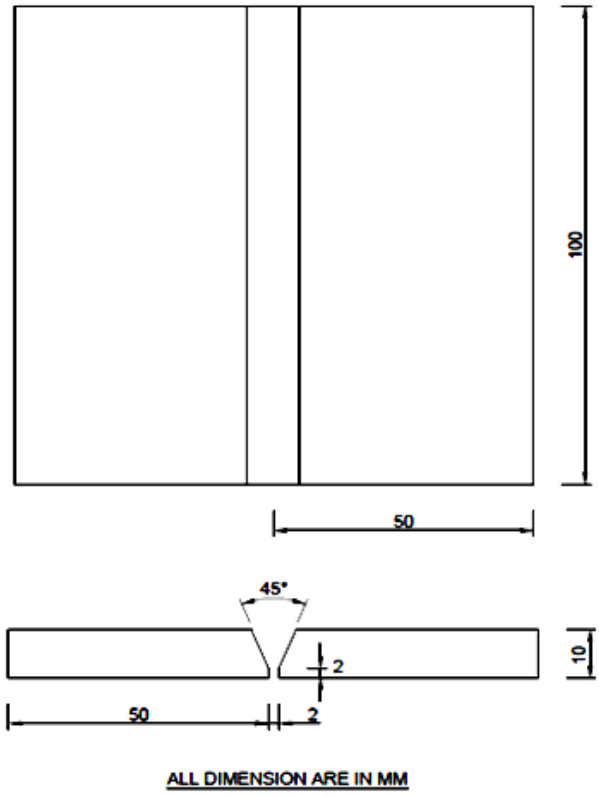

Fig-2 Dimensional sketch of weld joint

Fig-3 Experimental setup

3.2 Parent Metal used & its Chemical Analysis

Mild steel flat pieces of 100 mm x 35 mm x 10 mm thickness. The chemical analysis of mild steel is as shown in Table -1

Table -1 Chemical Composition Of Base Metal

Element	C	Mn	Si	S	P
percent	0.16-0.18	0.70-0.90	0.40 max	0.40 max	0.40 max

3.3 Electrode used & its Chemical Analysis

AWS/SFA 5.1 E-6013 of 3.15 mm diameter and 350 mm long electrode was used for welding. Chemical composition of electrode is shown in Table – 2.

Fig-4 Welding electrode

Table -2 Chemical Composition of E-6013 Electrode

Element	C	Mn	Si	S	P
percent	0.07	0.44	0.22	0.02	0.02

Fig-5 Welding Machine

Table – 3 Technical Specification of welding machine

Model	G-200
Range	0 – 200 Amp
KVA	5
Duty Cycle	50 %
Primary Voltage	230 V
Primary current	25 Amp

Fig-6 Hardness Tester

Table–4 Technical specification of hardness testing machine

Model	Brinell - 150
Type	Table / Bench Mounted
Max. Test Height	250 mm
Throat depth	150 mm

4. RESULT & DISCUSSION

The hardness of weld metal at weld center line, HAZ at the fusion boundary and base metal at 50 mm distance from weld center line was measured for each specimen and noted down in Table – 5. Time required for welding each specimen was recorded also.

Table – 5: Observation table

specimen no	current Amp	voltage	welding time sec.	Hnet J/mm.	Weld Metal BHN	HAZ BHN	Base Metal BHN
1	80	30	65	1336	180	183	131
2	85	30	63	1367	170	175	131
3	90	30	60	1380	166	167	131
4	95	30	57	1389	154	160	131
5	100	30	56	1420	149	154	131

4.1 Effect of Welding Current on Hardness of Specimen:

Form the observation table – 5 it is clear that with increase in welding ampere heat input was increased. So tempering effect of weld metal, HAZ and base metal occurred. Due to this hardness of the weld metal & HAZ was decreased with increased in the welding ampere. At 90 ampere hardness of weld metal and HAZ were almost equal. With increase in welding ampere the grains became coarser. And hence hardness decreased [6]. The variation of hardness with increase in welding current is shown in fig.-7.

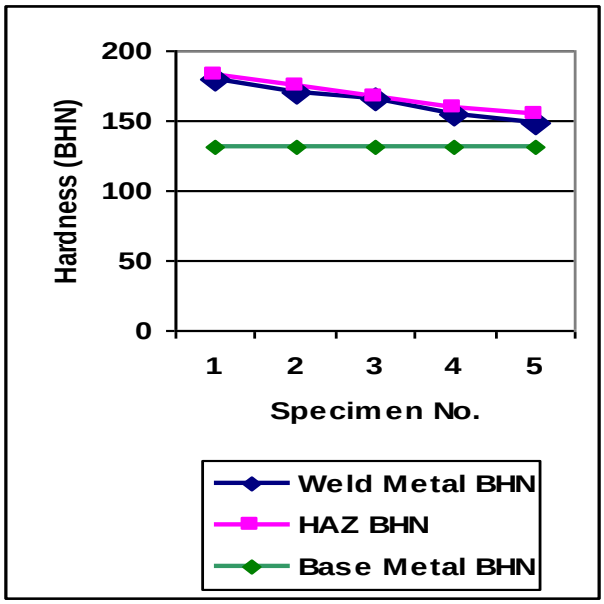

Fig.-7 Variation in hardness with welding current

4.2 Effect of Welding Current on Zone Wise Hardness of Weld Joint

Carbon percentage of filler wire was less than the base metal. But during experiment it was observed that the hardness of weld metal was higher than base metal in all specimens. That was because very rapid heating and cooling of weldmetal and high solidification rate. It was also observed that the hardness of HAZ was higher than the weld metal and base metal. That was because martensite or bainite formation in steel between 800 °C to 500 °C for long duration. The variation of hardness in all three region is shown in fig.-8.

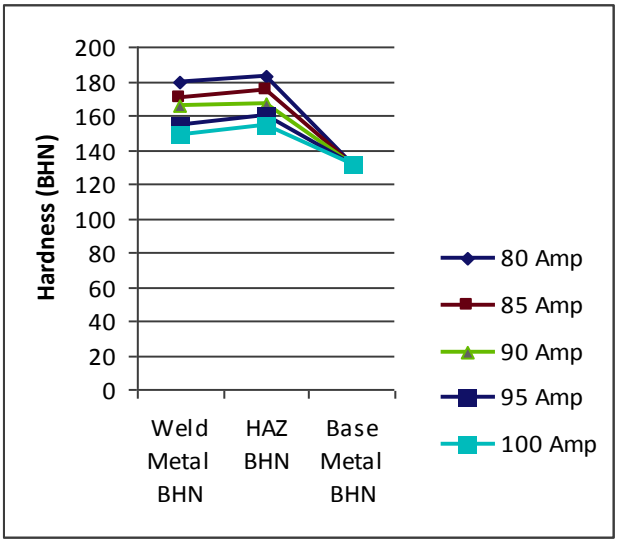

Fig.8 Variation in hardness region wise in weld joint

4.3 Effect of Welding Current on Welding Time

With increase in welding current heat genearion was increased so meltinng rate of electrode was also increased. Hence welding time was decreased from 65 sec to 56 sec. The variation weldinng time with increase in welding current is shown in fig-9.

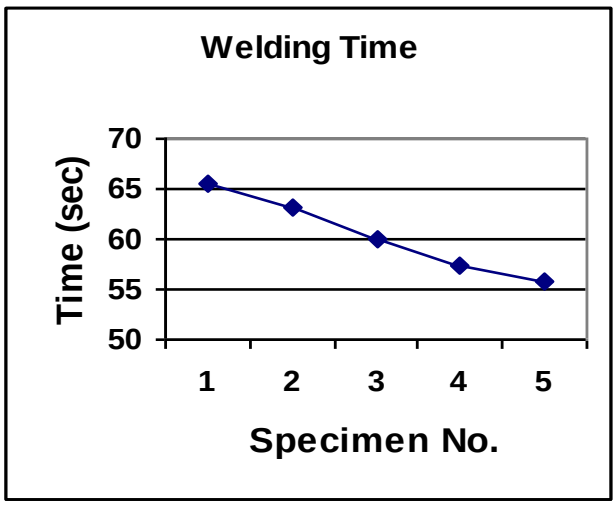

Fig. 9 Variation in welding time with increase in welding current

5. CONCLUSION

From observation table and result analysis following major conclusion are obtained:

1. With increase in welding current heat input was increased. So hardness of weld metal and HAZ were decreased with increased in welding ampere.
2. Hardness of HAZ was higher than weld metal zone and base metal zone.
3. With increase in welding ampere heat generation was increased so melting of electrode became faster hence welding time decreased and welding speed was increased.

6. FUTURE SCOPE

1. During this experiment arc voltage, arc length, welding polarity, angle of joint, thickness of metal remains constant. Theses parameter may also affect on hardness of weld joint.
2. Cooling rate was increased and it will increase hardness due to bainite or martensite formation. So separate effect of welding current and welding speed can be observed.

REFERENCES

[1] "Modern arc welding Technology" by S.V.Nadkarni, Advani Orlikon publicashion, edition 1988 reprint 1996

[2] "Welding technology for engineers", editors : Baldev raj, V Shankar & A. K. Bhaduri, Narosa Publishing House, third reprint – 2009.

[3] "Welding engineering and technology", By Dr. R.S.Parmar, Khanna Publishers, Fifth reprint, 2007.

[4] "A textbook of welding technology", by Dr. O.P.khanna, Dhanpat Rai Publications (P) Ltd., 20th reprint, 2011.

[5] "Welding : Technology & Design" by V.M.Radhakrishnan, New Age International publishers, second edition : 2005, Reprint : 2010.

[6] "Welding Metallurgy", Sindo Kou, Wiley Interscience : A John Wiley & Sons, Inc., Publication, second edition, 2003.

[7] Bhaskar Vishvakarma, Manish verma & Tribhuvan Kishor Mishra, "Investigation of welding parameter on mechanical properties of different joints of mild steel", International journal on mechanical engineering and robotics (IJMER), volume-1, Issue-1,2013, pp 23 - 27.

[8] Rakesh Kumar, Satish Kumar, "Study of mechanical properties in mild steel using metal inert gas welding", International Journal of Research in Engineering and Technology, Volume:3, Issue:4, Apr-2014, pp 751 - 756.

[9] Prof. Rohit Jha, Dr. A. K. Jha," Influence of welding current and joint design on the tensile properties of SMAW welded mild steel joints", International Journal of Engineering Research and Applications(IJERA), Volume-4, Issue-6(version 4), June 2014, pp 106-111.

[10] Ajay N. Boob, Prof. G. K. Gattani, " Study on effect of manual metal arc welding process parameters on width of heat affected zone (HAZ) for Ms 1005 steel", International Journal of Modern Research (IJMER), Vol-3, Issue. -3, May – June, 2013, pp 1493 - 1500.

[11] Riyad Mohammaed, Ali Ramza, Abdulkareem Aloraier, Emad Abdulradh Al-Faraj, " Investigation effect of welding polarity in joint bead geometry and mechanical properties of shielded metal arc welding process", Journal of Engineering and technology, pp 100 - 111.

BIOGRAPHY

Samir Y. Merchant is working as a senior lecturer in Fabrication Technology Department, Sir Bhavsinhji Polytechnic Institute, Bhavnagar, Gujarat, India since 2004. He obtained M.E. Mechanical Engineering (Production Engineering) from M.S. University, Vadodara with First Rank in 2010.