VOL. 12, NO. 19, OCTOBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MATERIAL CHARACTERISTIC STUDY OF COLD ROLLED GRADED THIN SHEET BY USING TIG WELDING PROCESS FOR RAIL COACHES

S. Ravikumar[1], J. Vishal[1], K. Vigram and A. N. Ganesh Babu[2]
[1]Department of Mechanical Engineering, School of Mechanical Engineering, Sathyabama University, Chennai, Tamil Nadu, India
[2]Advanced Welding Training Institute, Integral Coach Factory, Chennai, Tamil Nadu, India
E-Mail: vigramvigu@gmail.com

ABSTRACT

In this paper, the mechanical properties of the welded joints of corten steel sheets that has been using in the integrated coach factory in making the coaches of rails obtained by TIG welding done with three different parameters like current, welding speed and gas flow rate as a constant are studied. The performance of the welded joints is identified using the Tensile, Micro hardness, Bending, Micro and Macrostructure examination. The better strength of welding is obtained with the specific current and welding speed of TIG welding process. Thus the result provides the alternative welding method of TIG welding instead of MIG welding.

Keywords: corten steel (ASTM A242), TIG welding, mechanical properties.

1. INTRODUCTION

The corten steel sheets are widely used in manufacturing the rail coaches in integrated coach factory which is a weathering steel which has the high corrosion resistance. The MIG welding is used in joining the two metal sheets (1.6mm) which will lead for the deformation of the material and the deformation leads to the formation of the defects. The alternative method of welding will provide the best results for joining the sheet in the manufacturing of the rail coaches. The TIG welding with the different parameters used and welded on the sheet. In the TIG welding process is the tungsten inert gas welding that uses the non-consumable tungsten electrode. The filler material is made up of copper coated mild steel and the grade of the electrode is GR-ER70S6 of 2mm diameter the shielding gas used in the TIG welding is the mixture of argon and tungsten. The TIG welding is widely used in many applications and it is used for its precise welding of the materials, ability to weld various materials, uses less ampere when compared to other welding methods, it is considered as the clean welding with high contro [1, 5] The TIG welding plays a main role in the automobile and construction industries, bridges, ships due to this high strength of bonding it gives perfect finishing for the welding joints, there are several joints in TIG welding process like lap joint, butt joint, tee-joint, edge joint and corner joint. The TIG welding is also called GTAW (Gas Tungsten Arc Welding). TIG welding uses a non-consumable tungsten electrode to weld. The weld area is protected by theinert gas shielding from the atmospheric contamination. The most common of TIG welding is welding of thin sheets of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys [6, 7]. The Butt joint is the most basic and commonly used joint and it is also called square-groove joint. The butt joint is done by keeping the two metal sheets parallel to each other and the welding is done in between the two metal sheets. In the integrated coach factory the mainly used joint is butt joint for the manufacturing of bogies and other railway coach bodies. More significantly the TIG welding is slightly slower than any other welding techniques but the results will be better than other welding process. Thus from the testing the welding done with different values of parameters such as welding speed and current, at some extent at the specific parameters the welding strength is maximum and thus it is concluded from the results.

2. MATERIALS AND METHODS

2.1. Materials

The corten steel is the high-strength low-alloy steel that provides the better mechanical properties and atmospheric corrosion resistance than carbon steel. The corten steel is the low-carbon steel that provides the high corrosion resistance character. The corten steel is of two grades and they are corten A and corten B. they have slight variations in their compositions. Both of the two grades consist of small amount of carbon, manganese, silicon, nickel, chromium, copper, phosphorous, sulphur and some alloying element for the strengthening purpose.

Figure-1. Corten A (ASTM A 242) sheets and welded sheets.

VOL. 12, NO. 19, OCTOBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

The copper, silicon, chromium and phosphorous are added in specific quantity for increasing the character of the corrosion resistance property. The other elements such as zirconium, calcium, and rare earth elements are added for the shape control which increases formability. The corten A is weather resistant steel that is highly suited for the heavy constructions and load bearing structures. The material does not require any maintenance such as paint coating and this plays a main role in the effective cost maintenance. The chemical analysis has been conducted on the material for find the composition of the steel. The composition of the materials are given below.

Table-1. [Corten A (ASTM A 242) Chemical composition].

C	Mn	Si	Ni	Cr	Cu	P	S
0.1 (max)	0.25 to 0.45	0.28 to 0.72	0.2 to 0.47	0.3 to 0.6	0.35 to 0.6	0.075 to 0.14	0.03 (max)

The sheets of the corten steel of 1.6mm is cut into the required size of 300*150mm by the shear cutting process. The TIG welding is to be done on a TIG welding machine. The process was performed with the filler rod of mild steel coated with copper. The grade of electrode or filler rod is GR-ER70S2. The six sample sheets are taken and they are welded by the butt joint which is done by placing the sample sheets parallel to each other. The each pair of sample sheets are welded with different parameters like welding speed of 2.50mm/sec, 3.125mm/sec and 3.26mm/sec also change in the current of 105amps, 112amps, 117amps respectively. The argon and carbon di oxide mixture is used as the shielding gas to protect the welding from the external atmospheric contaminations. The welded sample sheets are shown in the Figure-1. The TIG welding provides the strong bonding between the metal sheets. The diameter of the filler rod is selected with respect to the thickness of the sheet of the metal. Therefore the thickness of the sample sheets are 1.6mm and so the filler rod of 2mm will be the apt size of the filler rod that will be perfectly suited for these sheets of 1.6mm.During welding the values of the parameters plays a main role and it determines the strength of the bonding of the material and the quality of welding. The parameter chart of various values are given below in Table-2.

Table-2. Tig welding parameters.

Samples	**Current** (amps)	**Gas flow rate** (Kg/cm^2)	**Welding time** (min)	**Welding speed** (mm/s)
1	105	0.5	2min	2.50
2	112	0.5	1min 36sec	3.125
3	117	0.5	1min 32sec	3.26

The welded piece are cut into pieces for the testing purposes like tensile test, bending test, micro hardness, micro structural examination and macro structural examination. The welded sheets are cut by the EDM wire cutting process to the standard dimensions and so the specimens are easy for the testing. The cut specimens for tensile, bending and hardness tests are shown in Figure-2.

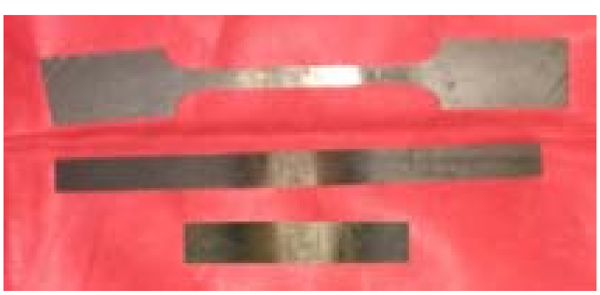


Figure-2. Test specimens for tensile, impact and hardness.

The welded specimens are tested under the standard conditions for strength, structure and stress. The tests such as Tensile testing, Bending testing, Micro hardness, Micro examination and Macro examination. The result of the testing determines the best welding parameters.

3. MECHANICAL TESTINGS

3.1 Tensile strength

The tensile test is done with the sample-1 and in the results which gets ultimate Tensile strength (N/mm2) is [546.76] and the maximum displacement (mm) is [10.27] if the displacement increases the ultimate tensile strength and yield stress also increases.

VOL. 12, NO. 19, OCTOBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Input Parameters			Output Results		
Sr.No.	:	Nevin_T-TIG-2	Ultimate Load (kN)	:	6.60
Specimen Width (mm)	:	5.98	Ult. Tensile Strength (N/mm²)	:	546.376
Specimen Thickness (mm)	:	2.02	Disp. At Ult. Load (mm)	:	7.96
Cross Section Area (mm²)	:	12.080	Breaking Load (kN)	:	4.69
Test Temp	:	1282	Breaking Stress (N/mm²)	:	388.258
Test Speed (mm / min)	:	2.00	Maximum Displacement (mm)	:	10.27
Original Gauge Length(mm)	:	40.00	% Elongation (%)	:	18.3
Final Gauge Length(mm)	:	47.32	Yield Load (kN)	:	5.360
			Yield Stress(N/mm²)	:	443.709

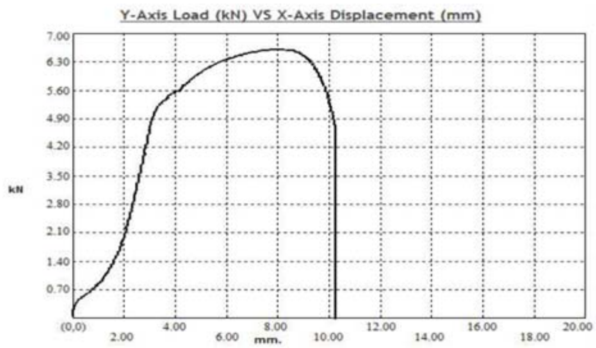


Figure-3. Sample 1 tensile test and its graph.

Input Parameters			Output Results		
Sr.No.	:	Nevin_T-TIG-3	Ultimate Load (kN)	:	6.55
Specimen Width (mm)	:	5.97	Ult. Tensile Strength (N/mm²)	:	543.145
Specimen Thickness (mm)	:	2.02	Disp. At Ult. Load (mm)	:	6.25
Cross Section Area (mm²)	:	12.059	Breaking Load (kN)	:	4.76
Test Temp	:	1282	Breaking Stress (N/mm²)	:	394.713
Test Speed (mm / min)	:	2.00	Maximum Displacement (mm)	:	8.67
Original Gauge Length(mm)	:	40.00	% Elongation (%)	:	18.875
Final Gauge Length(mm)	:	47.55	Yield Load (kN)	:	5.270
			Yield Stress(N/mm²)	:	436.982

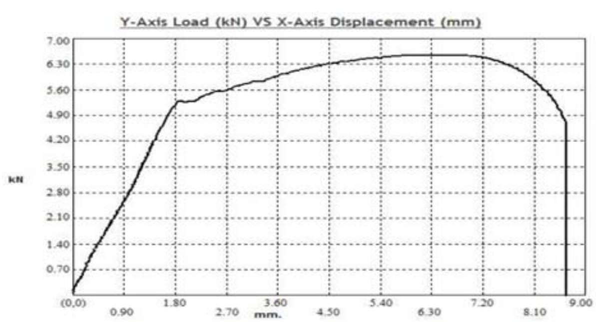


Figure-4. Sample 2 tensile test and its graph.

Input Parameters			Output Results		
Sr.No.	:	Nevin_T-TIG-5	Ultimate Load (kN)	:	6.41
Specimen Width (mm)	:	6.10	Ult. Tensile Strength (N/mm²)	:	520.208
Specimen Thickness (mm)	:	2.02	Disp. At Ult. Load (mm)	:	7.06
Cross Section Area (mm²)	:	12.322	Breaking Load (kN)	:	4.86
Test Temp	:	1282	Breaking Stress (N/mm²)	:	394.417
Test Speed (mm / min)	:	2.00	Maximum Displacement (mm)	:	9.33
Original Gauge Length(mm)	:	40.00	% Elongation (%)	:	18.05
Final Gauge Length(mm)	:	47.22	Yield Load (kN)	:	5.220
			Yield Stress(N/mm²)	:	423.701

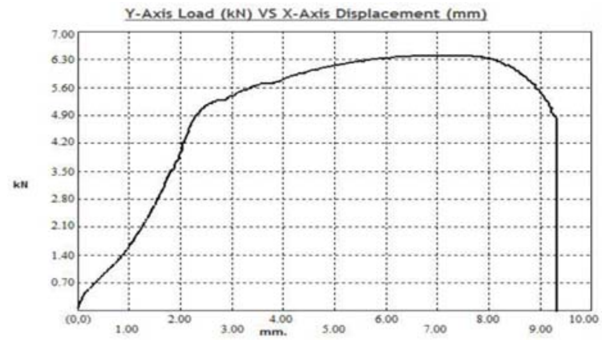


Figure-5. Sample 3 tensile test and its graph.

In the all the tensile tested graphs from Figures [3-5] the gradual increase shows the elongation of the material and the sudden down in the graph shows the breakage of the material.

3.2 Bending strength

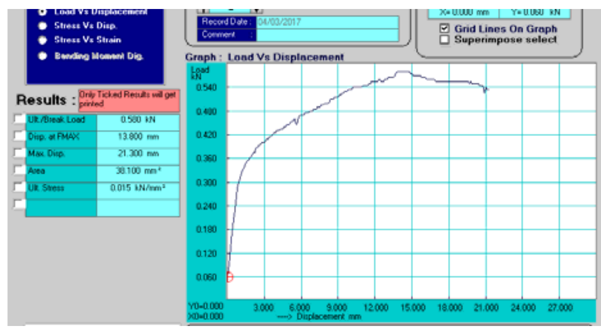


Figure-6. Sample 1 bend test graph.

In all the bend tested graph from Figures [6-8] the gradual increase shows the elongation of the material at the welded place, the peak point shows the fracture.

Figure-7. Sample 2 bend test graph.

VOL. 12, NO. 19, OCTOBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

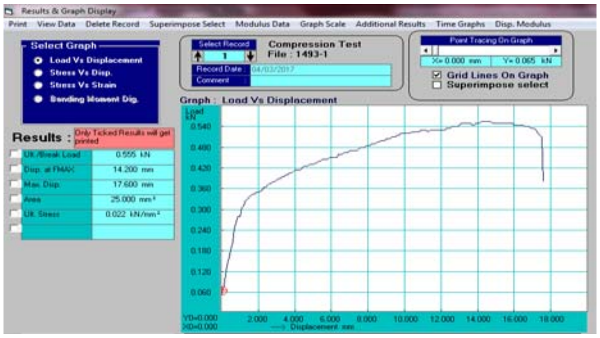


Figure-8. Sample 3 bend test graph.

3.3 Micro hardness and structure examinations

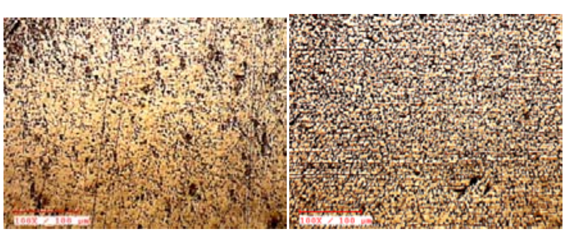
Table-3 refers the micro hardness valus foe all the three samples.

Table-3. Micro Hardness of 3 samples.

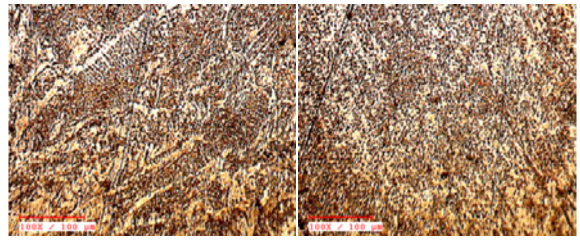
Sample	Parent	HAZ zone	Weld Zone	HAZ zone	Parent
Sample 1	153.6	201.5	211.8	168.2	153.9
Sample 2	152.5	198.8	175.2	151.8	152.8
Sample 3	151.7	173.3	210.5	189.2	151.9

3.3.1 Sample 1 micro structure

(a)



(b) (c)

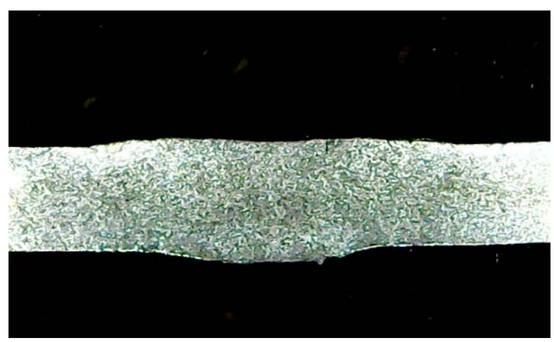


(d) (e)

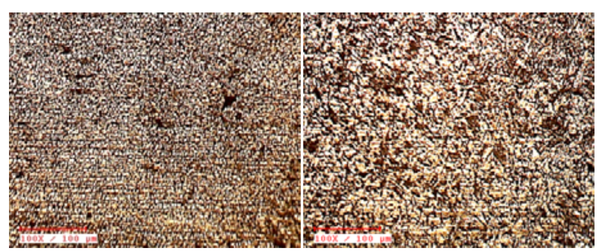
Figure-9. Test specimens for tensile, impact and hardness.

Figure-10 represents the parent metal micro structure shows typical low carbon steel with uniform grains of pearlite in ferrite matrix. Fine dispersion of carbides of chromium present in the ferrite matrix. HAZ shows recrystallization grains of pearlite in ferrite the grains size varies from 25-30 microns .The grain number corresponds to ASTM grain size number six. Welded region shows the dendritic pattern of grains weld deposit due to rapid cooling from liquidous to solidus state. The formation of finer dendrites is a phenomenon of solidification of liquid metal.

3.3.2 Sample 2 micro structure



(a)



(b) **(c)**

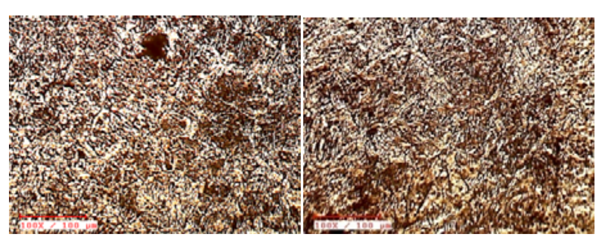


Figure-10. Test specimens for tensile, impact and hardness.

Figure-13 reveals the basic metal micro structure along the direction of rolling in longitudinal direction. The gain shows uniformly formed pearlite in ferrite grains with grain boundary carbides of chromium. HAZ of the parent metal with grains of pearlite recrystallized to a bigger size compare to parent metal due to heat of the weld. The welded zone shows the dendritic pattern of grains weld deposit due to rapid cooling from liquidous to solidus state. The formation of closer dendrites is a phenomenon of solidification of liquid metal.

3.3.3 Sample 3 micro structures

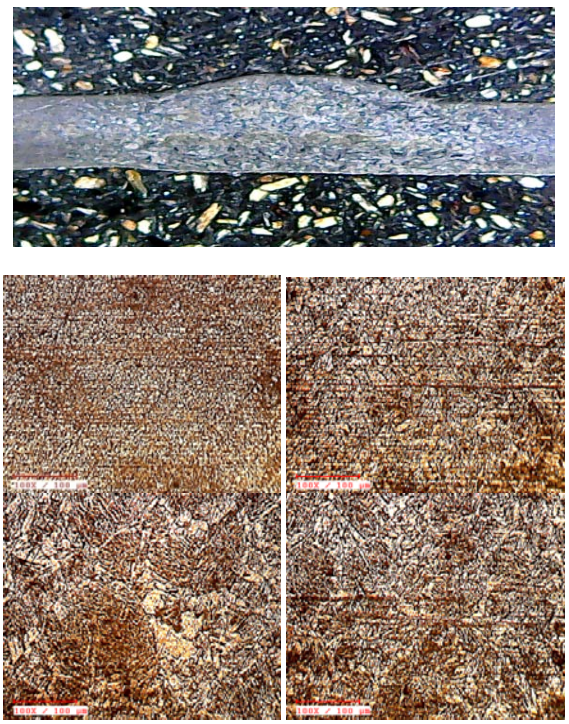


Figure-11. Test specimens for tensile, impact and hardness.

Figure-11 refers the basic metal micro structure along the direction of rolling in longitudinal direction. The gain shows uniformly formed pearlite in ferrite grains with grain boundary carbides of chromium. HAZ shows the pearlite grains affected by heat of the weld resulting in the grain growth of low carbon steel. The size increased to 30-40 microns. The micro graph shows the weld metal zone at the centre with coarse grained dendrites due to slower rate of cooling as it is not contact with base metal.

CONCLUSIONS

Thereby comparing the above tests the welding that has been done on the first sample with the certain parameters has the best hardness, high bending strength, micro structure and macro structure. The output result shows the ultimate load of 6.60kN, ultimate tensile strength of 546.376N/mm2, the breaking load of 4.69kN, maximum displacement of 10.27mm and the yield stress of 443.709N/mm^2. The graph peak shows the maximum elongation of the material and the sudden down in the graph shows the breakage of the material in the tensile test

REFERENCES

[1] Rattana Borrisutthekul, Pusit Mitsomwang, Sirirat Rattanachan and Yoshiharu Mutoh. 2010. Feasibility of Using TIG Welding in Dissimilar Metals between Steel/Aluminum Alloy. Published by Science Publications.

[2] Robert Talalaeva, Renno Veinthala, Andres Laansooa and Martinš Sarkansb. 2012. Cold metal transfer (CMT) welding of thin sheet metal Products. Published by Estonian Journal of Engineering.

[3] N.Jeyaprakash, Adisu Haile, and M.Arunprasath. 2015. The Parameters and Equipments Used in TIG Welding: A Review. Published by The International Journal of Engineering and Science.

[4] Pierre-jean cunat, Joinville-le-pont. 2007. The Welding of Stainless steel. >Published by Euro Inox.

[5] D. Devakumar and D. B Jabaraj. 2014. Research on Gas Tungsten Arc Welding of Stainless Steel - An Overview. Published by International Journal of Scientific & Engineering Research.

[6] Roshan W. Ttulankar and Suraj S. Dehankar. 2013. Automation in Sheet Metal Tig Welding Process: A Case Study. Published by International Journal of Engineering Trends and Technology (IJETT). 4(7).

[7] J. Pasupathy and V. Ravisankar. 2013. Detailed Study on Dissimilar Welding of Low Carbon Steel with AA1050 using TIG Welding. Published by International Journal of Engineering Research & Technology (IJERT). 2(11).

[8] Hussain Zuhailawati, Muhammad Afiq Jamaluddin, Anasyida Abu Seman and Suhaina Ismail. 2015. Welding Investigation and Prediction of Tensile Strength of 304 Stainless Steel Sheet Metal Joint by Response Surface Methodology published by Science Direct.

[9] http://www.gowelding.org/welding/tig-gtaw/.