EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTY (TENSILE STRENGTH) OPTICAL INVESTIGATION (SEM & EDAX) OF AUSTENITIC STAINLESS STEEL GRADE (AISI 304L& AISI 310) WITH GAS METAL ARC WELDING (GMAW).

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ABSTRACT

The objective of this research is to study the influence parameters affecting the mechanical property (tensile strength) and optical investigation (SEM & EDAX) of austenitic stainless steel grade (AISI-304L& AISI-310) with Gas Metal Arc Welding (GMAW). The research was applying the different values of wire speed and current for experiment**,** which have following interested parameters: welding current at (180**,** 250 and 320 Amps), welding wire speeds at (2, 3, 5 m/min), shield gas pure CO_2 and (24V)Welding Voltage. The study was done in following aspects: tensile strength and optical investigation. A research study investigate the tensile strength of welding joint is maximum 320.4 N/mm² at wire speed 3m/min and 250 Amps welding current. It has been observed from the SEM analysis that grain of the surface are ultra fine and EDAX analysis conforms the change of chemical composition is small at wire speed 3m/min and 250 Amps welding current.

Keywords: Austenitic stainless steel; Tensile strength; SEM & EDAX.

I INTRODUCTION

Austenitic stainless steel and low alloy steel possess a good combination of mechanical properties, formability, weld ability, and resistance to stress corrosion cracking and other forms of corrosion [1].Austenitic stainless steels have high ductility, low yield stress and relatively high tensile strength, when compared to typical carbon steamed. The composition of Stainless Steel consists of C-0.08%, Mn-2.00%, Si-1.00%, Cr-19.0 to21.0%, Ni-10 to 12%, P-0.45%, S-0.03% etc. The Tensile strength and yield strength is 515 MPa & 205 MPa respectively [2]. Austenitic steel have been developed in this direction, where changes in chemical composition induced by nitrogen addition have been taken advantage [3].310 Stainless Steel is a highly alloyed austenitic stainless steel used for high-temperature applications. The high chromium and nickel contents give the steel excellent oxidation resistance as well as high strength at high temperatures. 310 grade is also very ductile, and has good weld ability enabling its widespread usage in many application [4].The composition of 304 Stainless steel compresses C-0.04%, Mn-2.0%, Si-0.75%, Cr-17-20%, Ni-8-13%, P-0.35%, S-0.15% etc. 304 stainless steel is standard grade and typically comprises 17-20% chromium and 8-13% nickel and fasteners manufactured from this material show excellent resistance to corrosion in all but the harshest environments. Alloys 304 are also resistant to moderately aggressive organic acids such as acetic and reducing acids such as phosphoric. The 9 to 11 percent of nickel contained by these 18-8 alloys assists in providing resistance to moderately reducing environments. The more highly reducing environments such as boiling dilute hydrochloric and sulphuric acids are shown to be too aggressive for these materials [5].

The re-crystallization temperature of AISI 304 is above 900 ºC and the minimum grain size obtained is in the range of 10–30 µm [6].Gas Metal Arc welding (GMAW) is a process that melts and joins metals by heating them with an arc established between a continuously fed filler wire electrode and the metal. The process is used with shielding from an externally supplied gas and without the application of pressure [7]. GMAW are used to weld the metals such as carbon steel, high-strength low alloy steel, stainless steel, aluminium, copper, titanium and nickel [8]. Dissimilar metals (like 310 & 304) are widely used in different areas of applications like power generation plants, food processing and chemical industries. These dissimilar metals can be joined through the different welding process. Austenitic stainless steel and low alloy steel possess a good combination of mechanical properties, formability, weld ability, and resistance to stress corrosion cracking and other forms of corrosion [9,5].

II EXPERIMENTAL PROCEDURES

The experiments were carried on AISI-304L and AISI-310 Austenitic stainless steel rod having diameter 1.5 cm and length 8cm of size is selected.

The chemical compositions of AISI-304L & AISI-310 are presented in Table 1. The filler Welding wire AISI-304L with copper coated which specifies requirements for classification of wire electrodes for gas shielded metal arc welding of non-alloy and fine grain steels 8 mm diameter with copper coated are presented was used in this study. The distance between the nozzle tips to electrode tip (electrode extension) is maintained as 15 mm. The selection of the best shielding gas is based on consideration of the material to be welded and type of metal transfer that will be used. Accordingly, 100% CO2 considered as a shielding gas is selected for the experiments. Co_2 is widely used as the base gas in most of the shielding gases used for stainless steel welding. Before welding Specimen of AISI-304 & AISI-310 rod of diameter 1.5cm was cut in the shape of smaller section, having 8cm length of each piece. Each specimen was machined to obtain v groove, having angle of 20º.

Table 1: Chemical Composition of AISI-304& AISI-310

AISI	C%	SI%	Mn%	P%	S%	Cr%	Ni%	MO%	N%
304L	0.04	0.75	2.0	0.035	0.015	17-19	9.5-11.5	0.20-0.50	0.10-0.18
310	0.04-	0.75	2.0	0.030	0.030	24-26	19-23	-	0.15-0000.030

Table 2: Selection of Parameters Level

Specimen	Wire speed (m/min)	Current (Amps)	Voltage (Volts)	Gas pressure (kg/cm²)
1	2	180	24	3
2	2	250	24	3
3	2	320	24	3
4	3	180	24	3
5	3	250	24	3
6	3	320	24	3
7	5	180	24	3
8	5	250	24	3
9	5	320	24	3

Prior to welding, the groove was thoroughly cleaned with wire brush, followed by cleaning with acetone, to remove the oxide layer, if any dirt or grease adhering to the groove surface after proper preparation rods of steel are placed on the workbench. In each placement, distance between the nozzle and work piece and the electrode extension were 19 and 10 millimeters, respectively. The orientation of the welding electrode with respect to the weld joint was 55°.-60° after checking the pressure of shielding gas cylinder, which was set to 3 kg/cm^2 , welding was started. One piece of AISI 304L and one piece of AISI 310 having 8cm length for one and 8cm length for other piece can be welded with GMAW. Both rods were welded at single pass.

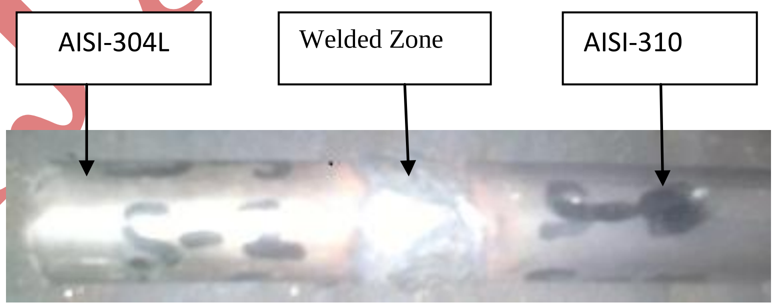

Fig. 1 Welded specimen

2.1 Procedure to carry out tensile strength: After welding the turning process is carried out on specimen to make homogenous rod for tensile test. Tensile test were carried on Universal Testing Machine for all the specimen welded by GMAW at different value of welding wire speed (2, 3 & 5m/min) and welding current (180, 250 & 320 amps). The table 3 given below shows the result of tensile test.

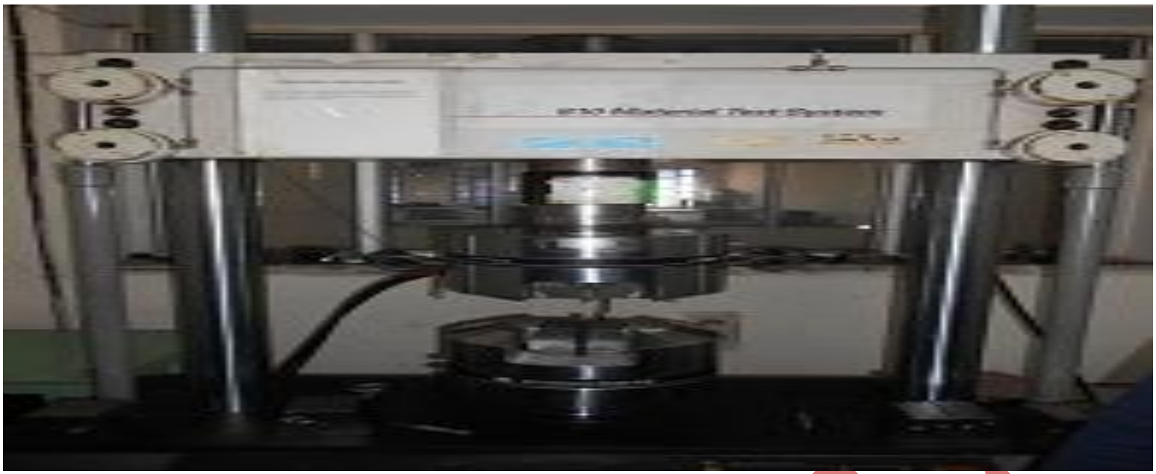

Fig 2. UTM for Testing of Tensile Strength.

Fig 3. After Testing the Specimen on UTM

2.2 Result : Experiment were conducted at different value of AC current (180,250&320 Amps) keeping gas flow rate 3kg/cm² at three different values of welding wire speed(2,3&5 M/Min). Tensile strength were measured and tabulated. Table 4 show the result of tensile strength their variation with current.

Table 3: Tensile Strength of Specimen on different values of Speed and Current.

Specimen	Speed M/Min	Current (Amps)	Tensile Strength (N/MM^2) **(average of 3 reading)**
1	2	180	177.4
2		250	190.5
3		320	143.4
4	3	180	150.4
5		250	320.4
6		320	200.4
7	5	180	207.3
8		250	220.6
9		320	137.5

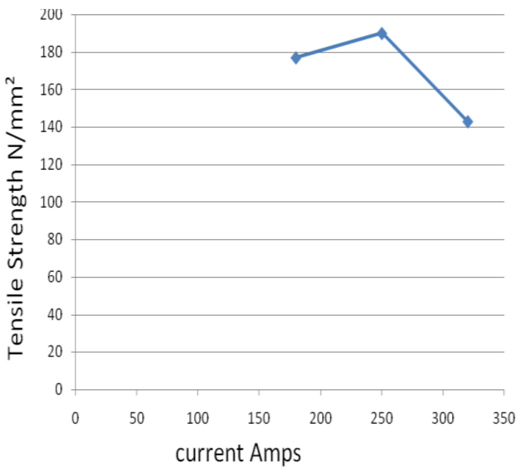

Fig. 4: Current v/s tensile strength at wire speed of 2m/min

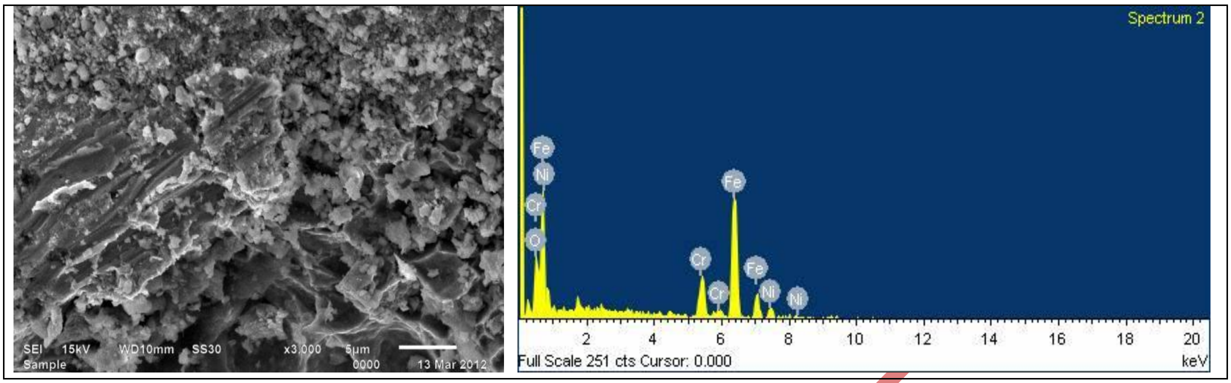

Fig.5: SEM Image with EDAX Analysis of Specimen after Tensile Test at Wire Speed 2m/Min And 180 Amps Current.

SEM image showed in Fig. 4 shows that there are some part contains voids on the surface of fractured specimen. There are also the presences of some cracks. EDAX analysis shows there is no evidence of oxide formation.

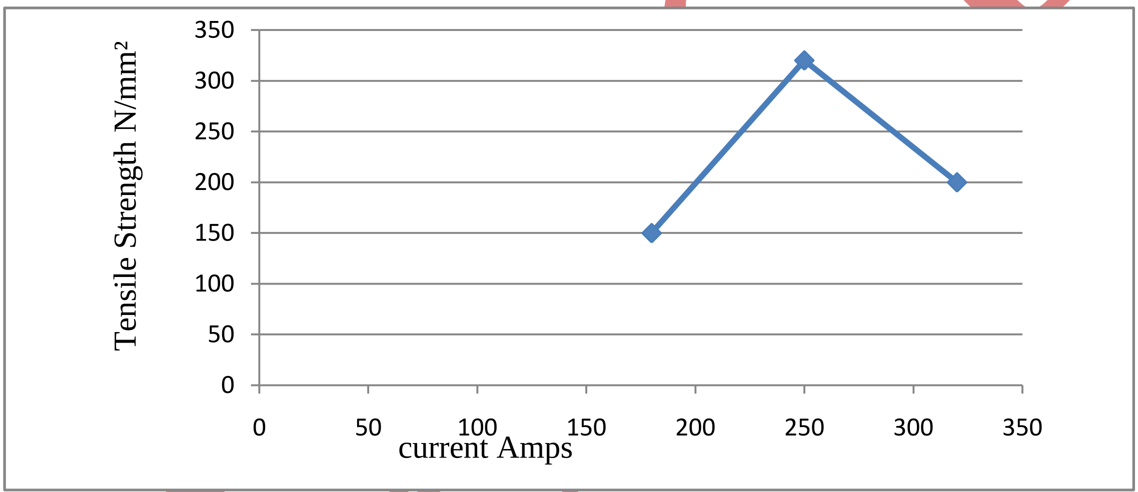

Fig 6. Current v/s tensile strength at wire speed of 3m/min

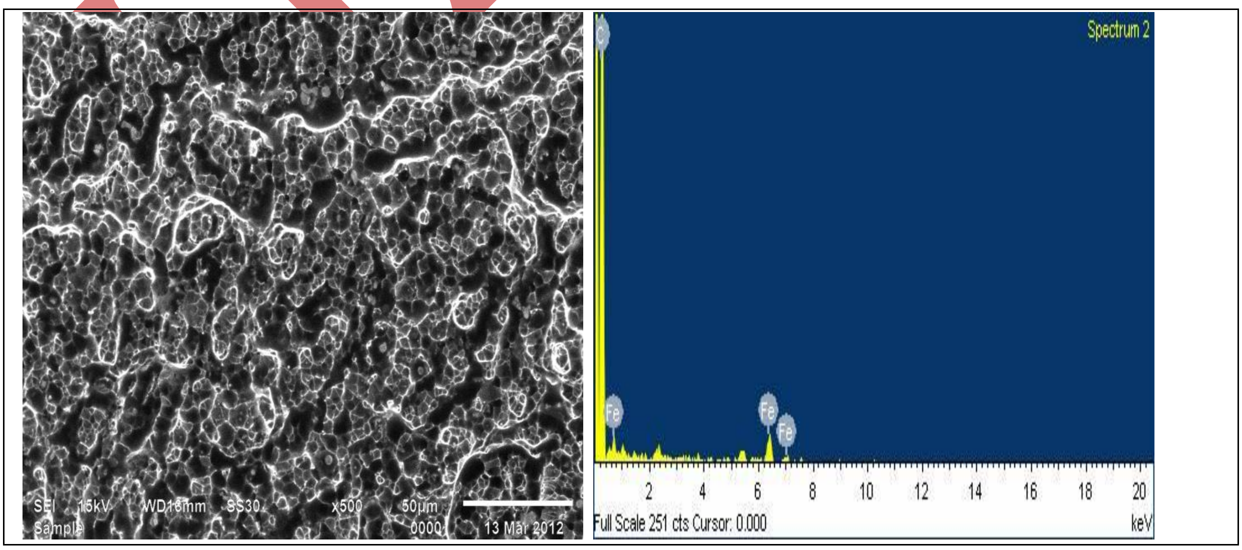

Fig. 7. SEM Image with EDAX analysis of specimen after tensile test at wire speed 3m/min and 180 Amps current.

SEM image shows that the fractured surface having some porous voids, the grain are arranged properly and the same in nature, until the fracture surface that tested at wire speed 2m/min, shows there is no evidence of cracks on surface and EDAX analysis conform that the variation of specimen composition is very small.

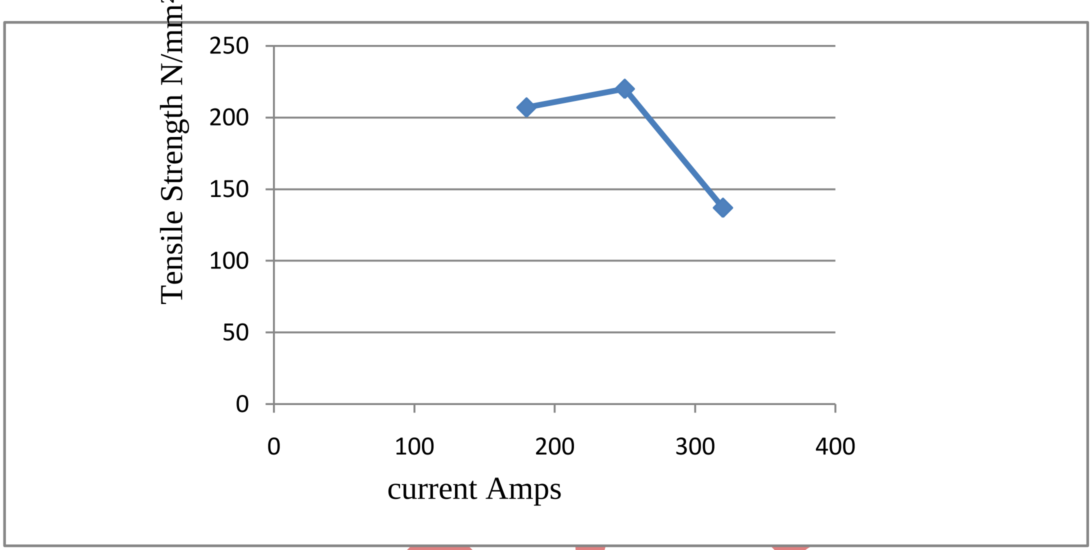

Fig7. 3.3 Current v/s tensile strength at wire speed of 5m/min.

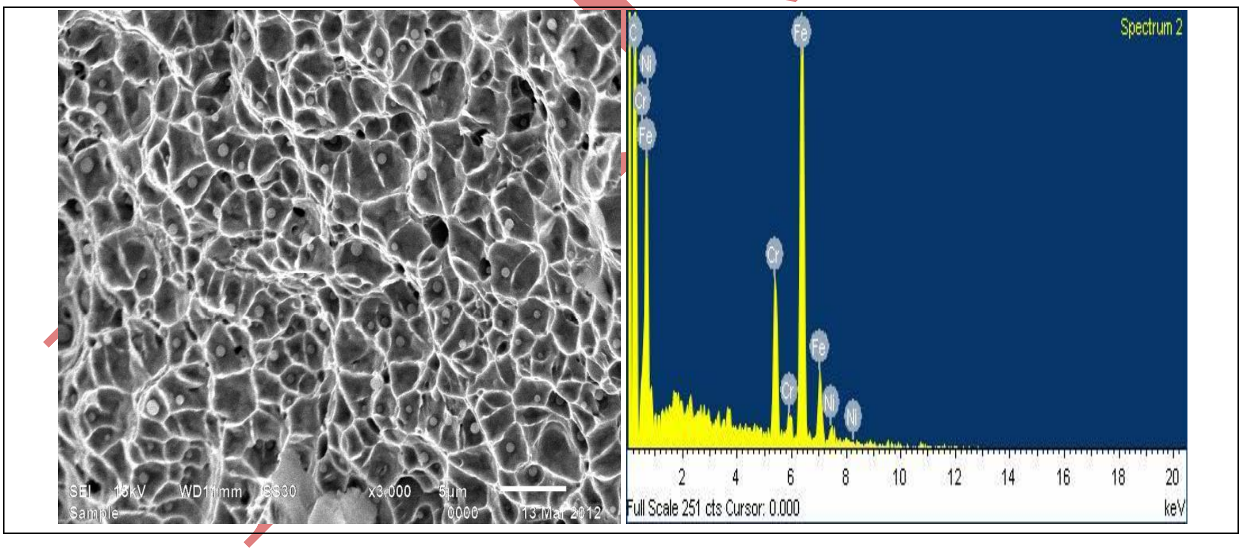

Fig.8. 4.46 SEM Image with EDAX analysis of specimen after tensile test at wire speed 5m/min and 180 Amps current.

SEM image shows that relatively large size dimples which are surrounded by coarse dimples and a small quantity of wear and tear, also the variation of chemical composition and EDAX analysis is very large, so this will cause the losses of tensile strength Fig. 9 to 11show the various SEM images and EDAX analysis for tensile specimen test at wire speed (2,3&5m/min) and 250amp.

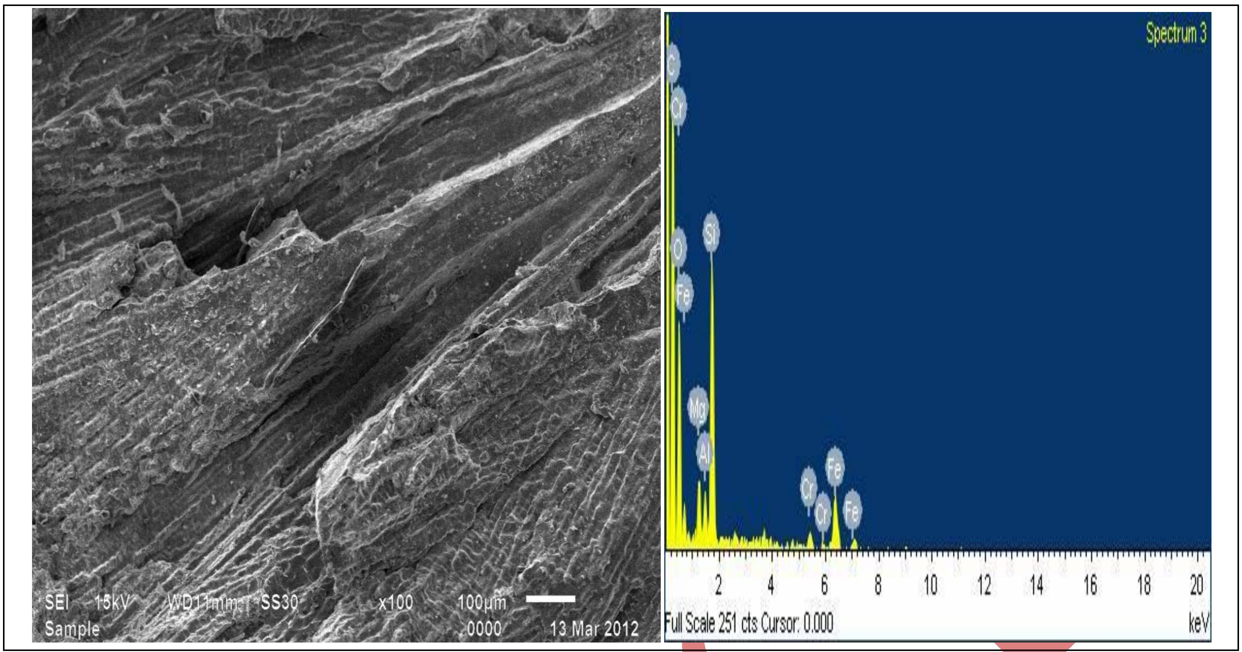

Fig. 9: SEM Image with EDAX analysis of specimen after tensile test at wire speed 2m/min and 250 amps current.

SEM image shows that after breakage of specimen during tensile test the surface of specimen is brittle in nature. This is due the variation of chemical composition of Fe during EDAX analysis.

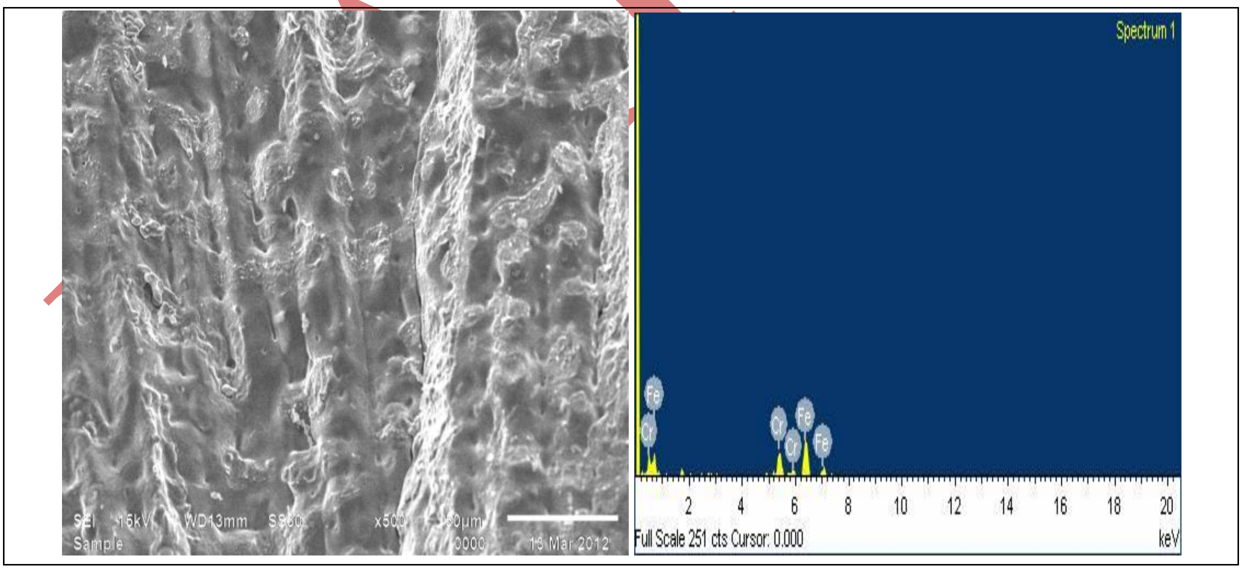

Fig. 10 SEM Image with EDAX analysis of specimen after tensile test at wire speed 3m/min and 250 Amps current.

SEM image shows that the invariably contains of much smaller dimples with some coarse dimples distributed among the fine dimples mean that diffusion of welded metal is taken place properly and material is not brittle also clear and EDAX analysis the variation of chemical composition is small

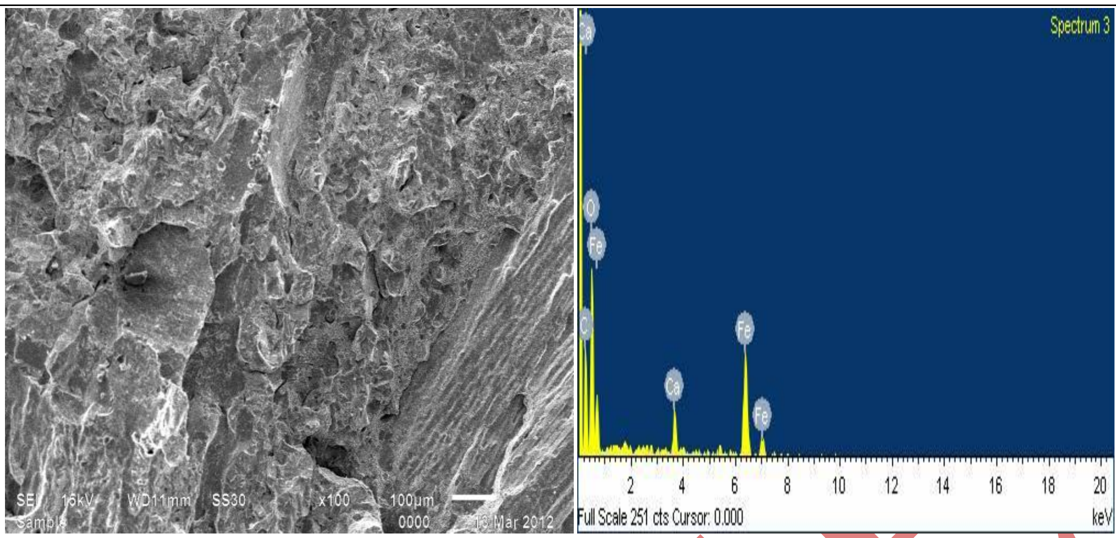

Fig. 11. SEM Image with EDAX analysis of specimen after tensile test at wire speed 5m/min and 250 Amps current.

SEM image shows that after the breakage of specimen during tensile test the some part of surface are columnar in nature which will cause the brittleness of the surface. EDAX analysis that the variation of chemical composition. This will cause the loss of tensile strength .

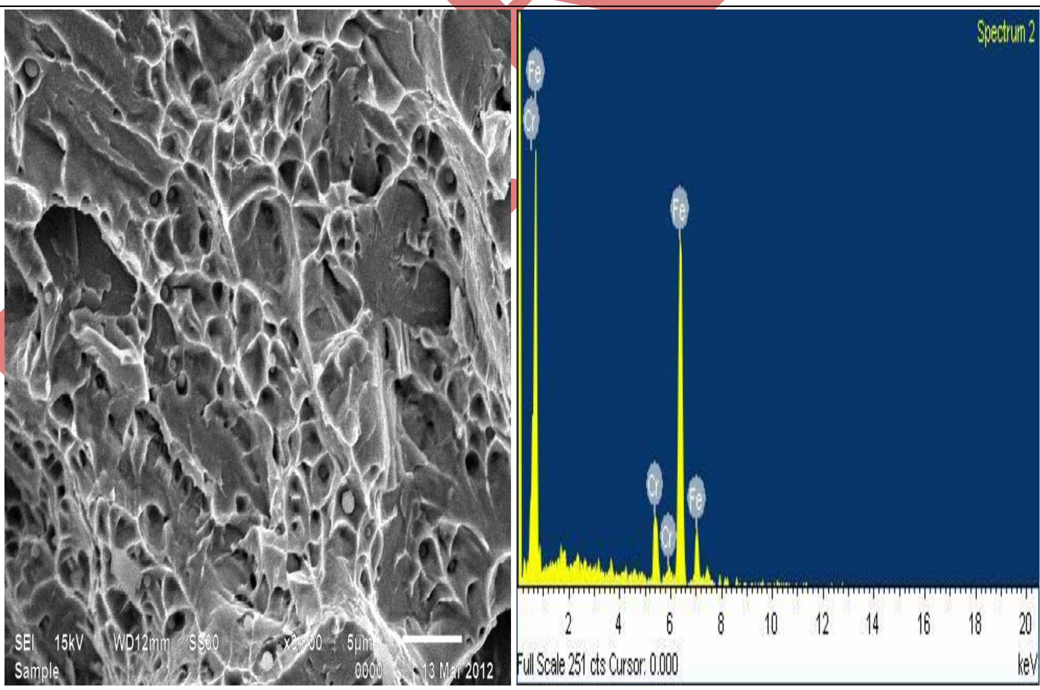

Fig. 12.. SEM Image with EDAX analysis of specimen after tensile test at wire speed 2m/min and 320 Amps current.

SEM image influence that some part of surface contain voids and upper surface wear from various places and EDAX analysis shows the chemical composition varies so this will loss the tensile strength .

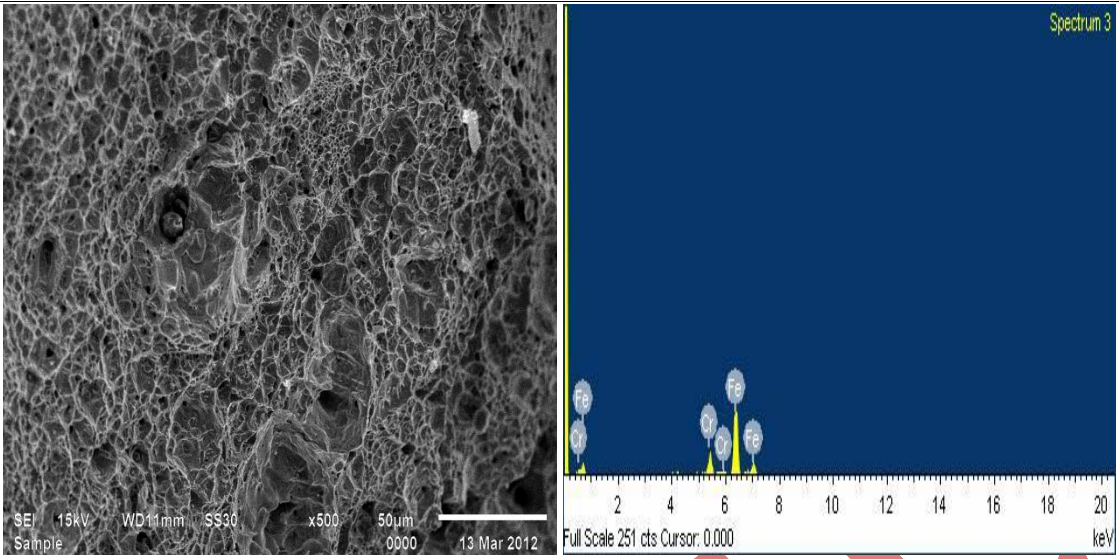

Fig. 13. SEM Image with EDAX analysis of specimen after tensile test at wire speed 3m/min and 320 Amps current.

SEM image that the joint invariably consists of fine and uniform dimples, which indicate that the specimen fails in a ductile manner.

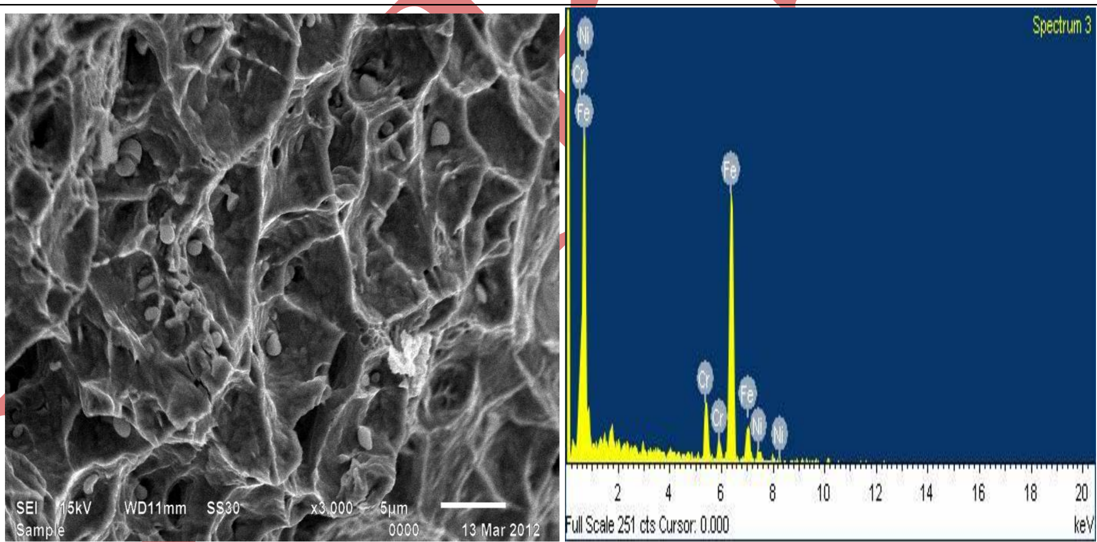

Fig. 14. SEM Image with EDAX analysis of specimen after tensile test at wire speed 5m/min and 320 Amps current.

SEM image shows some part contain voids and also it s observed that surface is cracked from some places that means diffusion not take place properly. Also it is clear from EDAX analysis that the chemical composition (Fe, Cr) of the specimen is varies.

III DISUSSION

Table 4. show the variation of Tensile strength v/s welding current at different value of speed, In all cases of tensile testing of weld joints, the tensile fracture has been found to take place from the weld deposit close to fusion line, this has primarily happened due to accumulation of significant amount of porosity in this region. However during image studies, it was observed that the porosity content of this region varies with the change in welding current, thus affecting the tensile strength. The nature of variation in tensile strength of weld joint with the change in welding current was marked to be in agreement with porosity content weld deposit in the region of fracture. This was qualitatively identified vary closely during the close observation of fracture surfaces. The formation of porosity in the weld deposit is marked to be quite significant in welding current.[10,11] it may be showed that the maximum value of tensile strength 320.4 MPa at 250 Amps current when wire speed is 3m/min. where as in [12] ultimate tensile strength is 289 MPa at 2.5 m/min, this is because due to porosity present. Fig 4. shows that there are some part contain voids on the surface of fractured specimen. There is also the presence of some cracks. EDAX analysis shows there is no evidence of oxide formation which cause the lose of tensile strength 6. SEM image shows that the fractured surface having some porous voids, the grain are arranged properly and the same in nature, until the fracture surface that tested at wire speed 2m/min, shows there is no evidence of cracks on surface and EDAX analysis conform that the variation of specimen composition is very small. Fig 8. SEM image Different micro zones are investigated in detail to establish the nature of fracture. The image shows that relatively large size dimples which are surrounded by coarse dimples and a small quantity of wear and tear, also the variation of chemical composition from EDAX analysis is very large, so this will cause the losses of tensile strength & micro hardness at wire speed 5m/min and welding current is 250 Amps. Fig 10. SEM image that after breakage of specimen during tensile test the surface of specimen is brittle in nature. This is due the variation of chemical composition of Fe during EDAX analysis, As a result loss of tensile strength. It is clear from high tensile strength at 2m/min wire speed and 250 Amps current. Fig 11. SEM image that the invariably contains of much smaller dimples with some coarse dimples distributed among the fine dimples mean that diffusion of welded metal is taken place properly and material is not brittle also clear from EDAX analysis the variation of chemical composition, so this will cause the increase ultimate tensile strength. Fig 12. SEM image showing that after the breakage of specimen during tensile test the some part of surface are columnar in nature which will cause the brittleness of the surface, Also it is clear from EDAX analysis that the variation of chemical composition. This will cause the loss of tensile strength and micro hardness. From fig 13. it is clear from SEM image that the joint invariably consists of fine and uniform dimples, which indicate that the specimen fails in a ductile manner under the action of tensile loading and it is clear from EDAX analysis that variation of chemical composition is very small, So it will cause that at 3m/min wire speed and 250 Amps welding current has maximum tensile strength .From fig 14. it is clear from SEM image some part containing voids and also it s observed that surface is cracked from some places that means diffusion not take place properly. Also it is clear from EDAX analysis that the chemical composition (Fe, Cr) of the specimen is varies which cause the lose of tensile strength.. The image of tensile tested specimen shows that relatively minor sized impels surround coarse dimples and a small quantity of tearing ridge can be observed in GTAW joint. In weldment that brittle fracture was observed as we increase the burn-off length which further supporting the formation of carbides and intermetallic compounds. From the SEM fractogaphic of Tensile tested dissimilar weldment made by GMAW

shows cleavage fracture.[13] Elemental distribution across the interface and predominantly cleavage fracture features suggest that inter-diffusion of elements has lead to creation of low ductility quassi cleavage fracture Similar observation has been made by Cheng and Wang[14,15].

IV CONCLUSIONS

1) Tensile strength of welding joint have optimum value 320.4 N/mm² at 250 Amps of current at 3m/min wire speed..
2) It has been observed from the SEM analysis that at wire speed 3m/min & 250 Amps current the grain of the surface are ultra fine, which will cause the high tensile strength & micro hardness.
3) It has been observed from the EDAX analysis that at 3m/min wire speed and 250 Amps current, the composition of Fe change considerably which will improve in mechanical properties (tensile strength) when tensile load applied at 162 MPa.

REFERENCES

[1] S. Kaewkuekool and B. Amornsin "A Study of Parameters Affecting to Mechanical Property of Dissimilar Welding between Stainless Steel (AISI 304) and Low Carbon Steel" Proceeding of 1st WSEAS International Conference on MATERIALS SCIENCE (MATERIALS'08). Bucharest, Romania. November 7-9, 2008 pp. 105109.

[2] Goodwin, G. M., April , " The effects of heat input and weld process on hot cracking in stainless steel", Welding Journal 67, pp. 1105.

[3] David , JR., 1999, ASM Specialty Handbook Stainless Steel, ASM International Materials Park, Ohio USA

[4] S. Ghosh and V. Kain, "Microstructural changes in AISI 304L stainless steel due to surface machining: effect on its susceptibility to chloride stress corrosion cracking,"J Nuc. Mater., vol. 403, pp. 62-67, 2010.

[5] S. Ghosh and V. Kain, "Effect of surface machining and cold working on the ambient temperature chloride stress corrosion cracking susceptibility of AISI 304L stainless steel" Mater. Sci. Eng. A., vol. 527, pp 62-67,2010.

[6] International Stainless Steel Forum Rue Colonel Bourg 120 B-1140 Brussels Belgium. Stainless Steel Applications – Aerospace. 2007/05/23. pp. 1–2

[7] www.gowelding.com

[8] A. Di Schino, J.M. Kenny, M.G. Mecozzi, M. Barteri, J. Material Sci. 35 (2000) 4803.

[9] Sindo Kou, "*Welding Metallurgy*", second edition, John Wiley & Sons, Inc ,2003.

[10] J. Tueka, M. Suban and k. atal,"Experimental research of the effect of hydrogen in argon as a shielding gas in arc welding of high- alloy stainless steel", international Journal of Hydrogen Energy, [2000], vol.25, p.p. 369-376.

[11] J. M. Paulo,"TIG welding with single- component fluxes",Material Processing Technology, [2003], vol. 99, p.p. 260-265.

[12] MP. Nascimento, RC. Souza, WL. Pigatin, HJC. Voorwald," Effects of surface treatments on the fatigue strength of AISI 4340 steel",[2001] ,vol.23, p.p. 607–618

[13] A. Hascalik, E. Unal, N.Ozdemir, "Fatigue behaviour of AISI 304 steel to AISI 4340 steel weld by friction welding", Material Science, [2006], Vol.41, p.p.3233 -3239.

[14]D.T. Thao, J.W. Jeong, I.S. Kim, J.W.H.J. Kim, " Predicting Lap-Joint bead geo- metry in GMA welding process", Material Science And Engineering, [2008], vol.32, p.p.121-124.

[15] M. Zandrahimi, M. Reza bateni, A. Poladi, J. A. Szpunar, "The form- ation of marten site during wear of AISI 304 stainless steel", [2007], vol.263, p.p. 674-678.