Experimental Studies on Effect of Heat Input on the Mechanical Properties of V Butt Joints Produced by GTAW To Weld AISI 202 SS

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Abstract:- **The objective of this research is to find the suitable joint for weld the AISI 202 by GTAW.TIG welding was use to obtained single V butt and double V butt joint at different current rate by taking the other parameters constant. Comparison between single v butt joints and double v butt joints was done on the basis of tensile strength, micro hardness and microstructure of weldment, which gives the result that double v joint obtained at high current has more tensile strength and good micro hardness which is optimum joint for weld AISI 202.**

Keywords:-GTA welding, AISI 202, Single & Double V Butt Joint, microstructure, mechanical properties

1. INTRODUCTION

AISI 202 has more toughness at low temperature. In industry, it is mostly use as hardened grade, and possesses good corrosion resistance strength and toughness. Long gummy chips are produce during machining. Besides this, in annealed condition it can also machined. Fusion and resistance welding can join AISI 202. However, oxyacetylene welding is not useful to join this metal. The recommended filler metal is 'aws e/er630'.AISI202 commonly use for manufacturing cooking utensils, sink and for architectural applications.

While carrying out research AISI 202 was chosen over AISI 304 because 200 grades is preferred more in Asia over 300 grade and also as 200 grade has less nickel content than 300 grade and is available at **less cost** in the market. SHARIFITABAR et al stated that stainless steels perform a crucial role in the advanced world. Austenitic stainless steels represent more than 75% of the total stainless steel production [1]. AISI have some nitrogen content, which makes it harder and tough, it have good yield strength [2]. V.S Vigneshvar et al states that the material properties of AISI 202 are increase by implement the flux coating in weldment region [3]. Microstructure of AISI 202 is depended upon solid-state transformation after welding, subsequent cooling rate and solidification behavior [4]. Microstructure of base metal (AISI 202) has equi-axed austenite grains and some carbide particles spread out towards boundaries of austenite grains as stated by R SUDHAKARAN et al [5].

As finding from previous researchers show that there has been no work done on the comparative study between single V and double V joint made by GTAW based on tensile strength, hardness and microstructure. Thus, a research was carry out, in order to find the optimum condition and joint for weld bead, which will be better for joining AISI 202, from industrial point of view to make the work of industry simpler. GTAW welding leads to high productivity, good surface finish and low cost. *GTAW is an all position welding process and use for the welding of thin metals. The process can use by the manual, semiautomatic and automatic methods*. In between a non-consumable electrode and the work metal, the arc is produce. The oxidation of the tungsten electrode, the molten weld puddle prevent by shielding gas as well as it also prevent the heat-affected zone adjacent to the weld bead. It is commonly use to weld metals, such as aluminum, stainless steel, magnesium and titanium [6]. In GTA welding process by increase welding current width of bead is increase respectively and by increase gas flow rate upper height of weld bead is increase respectively [7]. V. VEL MURUGAN et al (2012) states that minimum angular distortion obtained at low welding speed, high current flow and high gas flow [8].welding speed has negative effect on depth of penetration and welding current has strong effect on depth of penetration [9]. During TIG, welding grains, which are coarse and inters granular chromium rich carbides worse the mechanical properties of material. HUAIBEI ZHENG et al states, with increasing input heat

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the size of grains grow up and that Quantity of heat input effect the microstructure of heat-affected zone [10].
Selection of optimum process variable such as welding current, weld speed, gas flow rate highly affects the weld pool geometry and hence, the quality of welded joint.

1. Experimental procedure

Eight plates of grade AISI 202 material cut by using abrasive cutting of dimension160mm × 110mm × 6mm. Moreover, the spectroscopy did after proper cleaning of plates to know the chemical composition by weight percentage, which shows in table 1.

Table 1 Chemical composition of grade 202 AISI stainless steel

ELEMENT	WEIGHT %
C	0.0953
Si	0.34
Mn	9.7
P	0.0418
S	.005
Cr	13.5
Ni	0.195
N	0.25

For the welding process, TIG welding was use and filler material, steel 308L (VENUS) was select because material deposit during welding contains less carbon. Butt joint was use for joining two plates because it provided the advantage of joining the plates in approximately same plane with each other. *V-type joint was choosing, as weld joint type because the expanses involved in making U-type joint was more.*

Table 2 Chemical composition of filler material 308L

Chemical composition %									Mechanical properties	
C	Mn	Si	Ni	P	Cr	S	Mo.	Cu	UTS	Elongation
0.03	1.0-2.5	0.30-.65	9-11	0.03	19.5-22	0.03	0.75	0.75	520	35

For the welding process, two plates were select at a time and held on the platform by means of c-clamps in order to avoid any distortions as shown in **Fig. 1**. For complete filling of the weld pool between two plates, these kept 1-2 mm apart from each other.

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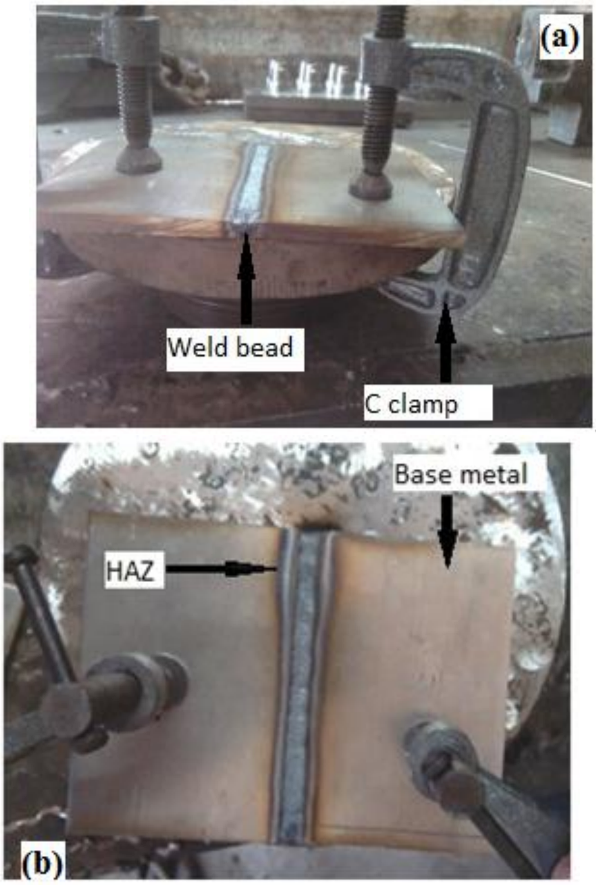

Fig.1 Clamping Position of Plates from Front (a) & Top Angle (b)

Single V grooving at bevel angle of 60º did on four plates for that root was 2 mm through thickness of 4 mm, for obtaining single v butt joints. At a current of 85amps, three welding passes were perform on plates, which include one root pass, and two cover passes respectively, named as sample 'A'. After that, another single v butt joint was obtain at a current 135amps by using three welding passes name as sample 'B'.

Double V grooving performed with a root of 2 mm at bevel angle of 60º on the remaining four plates for obtaining Double V joints. At a current of 85 amps, two welding passes performed on each side of plates, which include one root pass and one cover pass to obtained joint marked as sample 'C'. After that, another double v joint was obtain at a current of 135 amps by using two welding passes, one root and one cover pass on both sides of plates, marked as sample 'D'.

Three set of specimens were obtain from each sample by abrasive cutting. One for tensile test marked as A1, B1, C1, and D1 were prepare by using sand paper and cut that specimen in dumble shape by using wire cutting. Tensile test performed on universal testing machine. One set of specimens for microstructure analysis marked as A2, B2, C2, and D2 were prepare respectively by using sand papers up to grit size of 2000 followed by diamond polishing. Polishing is essential for analysis because metallurgical microscope works on reflection principle. After that etching of specimens did, in order to make grain boundaries visible after polishing. One set of specimen for micro-hardness analysis marked as A3, B3, C3, D3 were prepared by ground using sand paper up to 2000 grit size for remove coarse, fine oxide layers and scratches on the surface.Vicker hardness testing machine was used to test Micro-hardness of specimens at different zones in different weldment at dwell time of 20 seconds and a load of 500 grams. The test carried out in both longitudinal and transverse direction. Consecutive indentations made at distance of 1mm

Table 3 Welding Process Conditions and Parameters Include

PARAMETERS	VALUE
Shielding gas	Argon
Gas flow rate (L·mm^{-1})	15
Welding speed (mm·min.$^{-1}$)	170-190
Welding gun angle	70º
Filler material diameter (mm)	2.4

Objectives of the experiment:

- To identify the process parameters involved in TIG welding process.
- To find tensile strength, micro-hardness and microstructure of single V joint at different parameters by conducting experiments.
- To find tensile strength, micro hardness and microstructure of double V joint at different parameters by conducting experiments.
- To make a comparative study of single v and double v joints.
- To optimize the process parameters

2. RESULTS AND DISCUSSION

3.1 Tensile strength test-: fig. 3 shows the tensile strength of different samples. In all samples fracture occurred in fusion zone. For single V joint, the tensile strength of sample A1 was low because of lack of fusion but sample B1 show the considerable tensile strength, because the current rate was high so that heat input was high and there is no lack of fusion. On the other side for double v joint sample D1 strength was higher than the sample C1 that is also because of current input. However, tensile strength of sample D1 was higher than other samples because high heat input or current input and more welding time or more welding passes.

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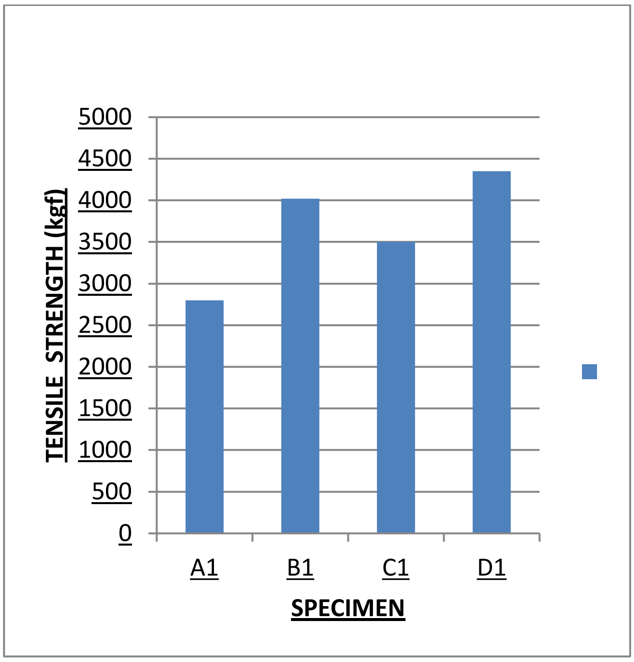

Fig. 2 Tensile Strength of Samples

3.2 Microstructure test-:

During welding process weldment is formed whose metallurgical structure was varies point to point and affect the mechanical properties. Weldment could be divide in three parts-weld metal zone, heat affected zone and unaffected zone. Physical properties and process parameters of welding are responsible for extent of affected zone [11]. In different weldment zones, material composition and parameters are responsible for different microstructures that formed. Weld metal zone was produce as weld metal solidifies from molten state. Adjacent to weld metal zone was the heat-affected zone that composed of parent metal that did not melt but heated to enough high temperature for sufficient time that grain growth occurred.

Fig. 3(a) & 3(b) indicates that there is no complete growth of dendrites due to lack of heat, it result in less coarse or fine grains develop in heat affected zone and there is retained austenite present in fusion zone, microstructure of fusion zone is combination of base metal and filler material. Due to low current there is low heat input because of that cooling rate is high and retention time is high due to that steep thermal gradient in weld metal. Due to high cooling rate, there is proportional amount of marten site, present in fusion zone and small amount of ferrite is present in that zone.

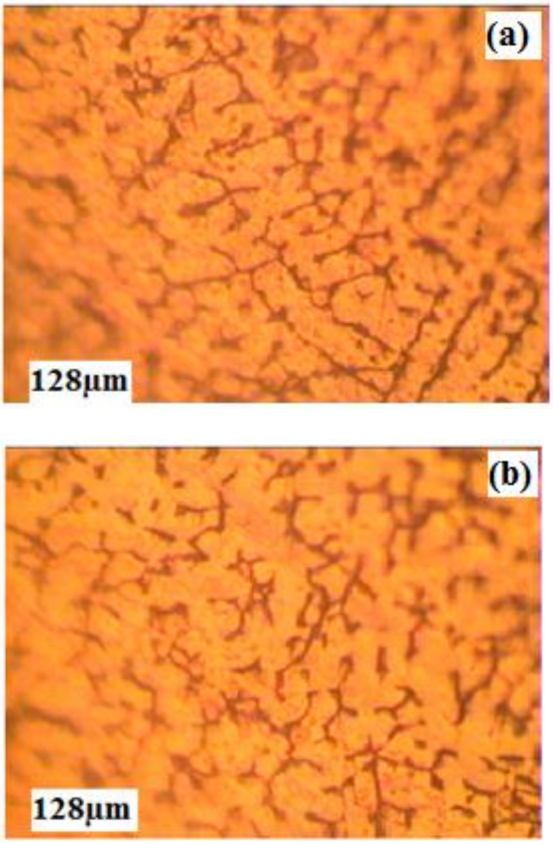

Fig. 3 Microstructure of Sample A2 at Fusion Zone (a) & Heat Affected Zone (b)

From fig. 4 (a) & fig. 4 (b), it observed that there were coarse grains structure in heat affected zone near the fusion boundary because there is enough time for dendrites to grow farther into fusion zone, Due to high current, which result high heat input, slow cooling rate & short retention time. . Due to short retention time, non-homogenous austenite formed at fusion zone. Significant change in microstructure of heat-affected zone obtained due to polymorphous transformation.

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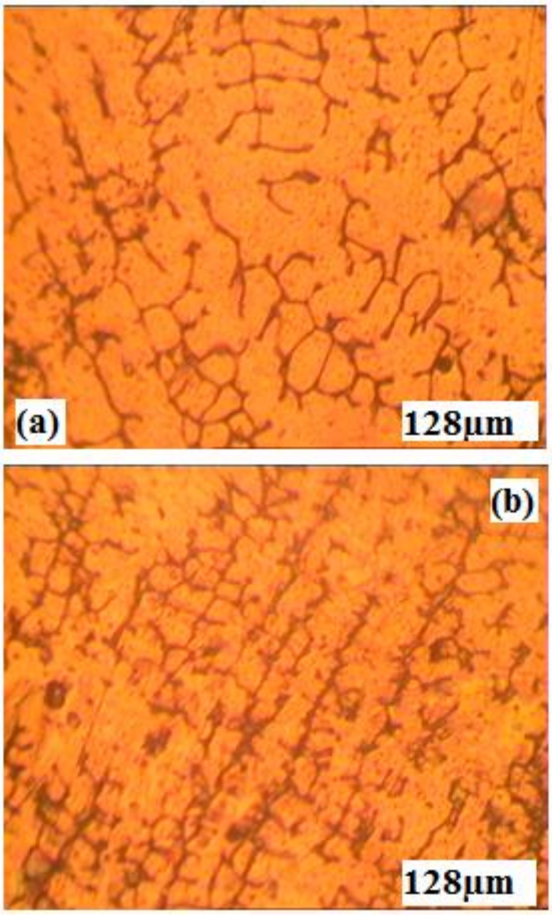

Fig. 4 Microstructure of Sample C2 at Fusion Zone (a) & Heat Affected Zone (b)

Fig. 5(a) &fig. 5(b) was indicated the microstructure of double V joint obtained at 85amps, the current rate was low so that heat flow was low but there was more welding passes. so its microstructure properties are different from microstructure of sample A2, because welding time was more so that heat input time is also more, which effect the grains structure. It observed that there was more grain growth or dendrites growth which result coarse grain structure comparatively less from sample C2.

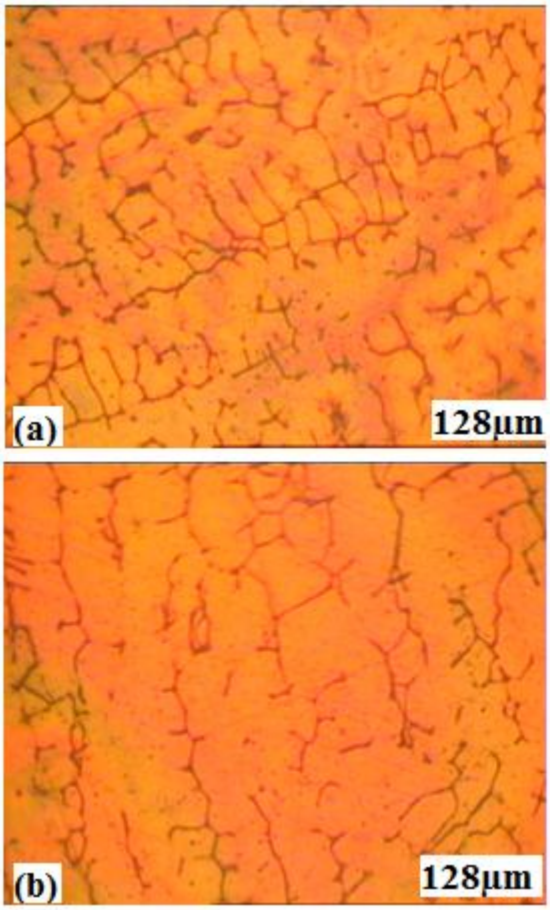

Fig. 5 Microstructure of Sample B2 at Fusion Zone (a) & Heat Affected Zone (b)

Fig. 6(a) & fig. 6(b) indicated the microstructure of double v joint obtained at high current 135amps. Because of high current rate, there was high heat flow so that high coarse grains structure formed at boundary of fusion zone and due to low cooling rate dendrites have sufficient time to grow further into fusion zone but comparatively with faster rate from sample B2, which result coarser grain structure of heat affected zone near the fusion boundary. The significant amount of marten site is present in austenite matrix due to cooling of steel in austenite condition.

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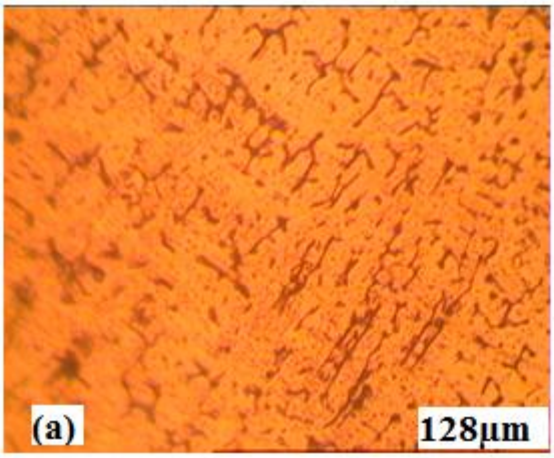

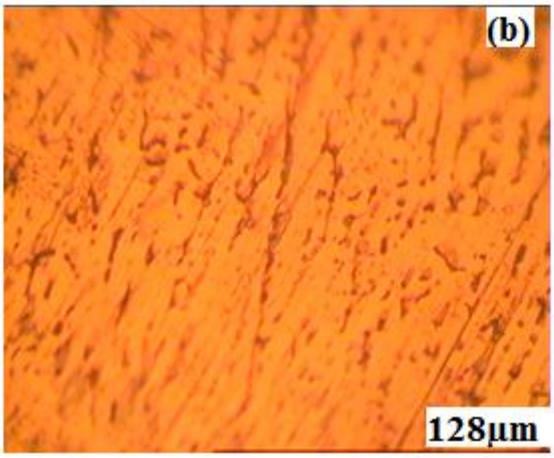

Fig. 6 Microstructure of Sample D2 at Fusion Zone (a) & Heat Affected Zone (b)

3.3 Micro hardness test: - Vickers hardness machine was use to check the longitudinal and transverse hardness of different samples.

From fig. 7 it was obtained that the hardness of material at fusion zone is low but longitudinal and transverse hardness was approximately equal and the hardness of joint along the HAZ is high which increase with increasing the distance from centre of bead respectively on other hand transverse hardness is low than longitudinal.

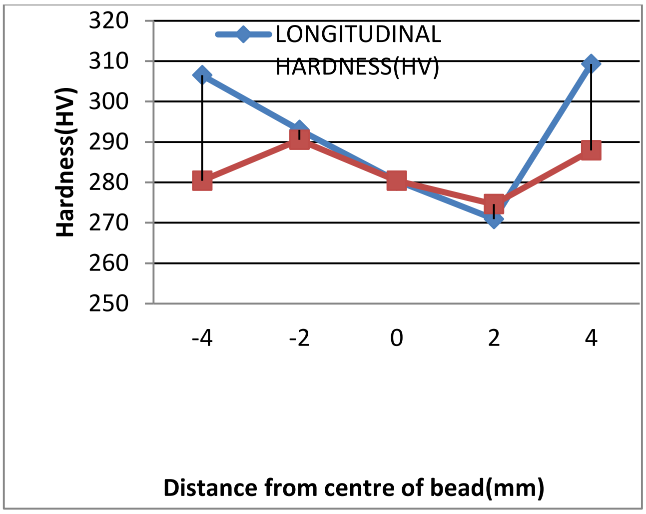

Fig.7 Micro- hardness plot of sample A3

From fig. 8, it was observe that the hardness of double v joint was higher in HAZ due to coarse grain structure. However, transverse hardness was more than the longitudinal hardness at each point.

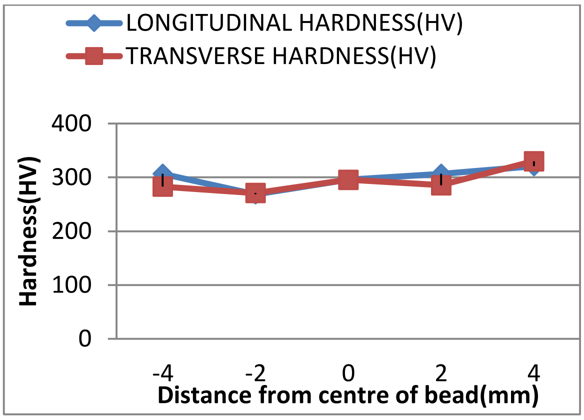

Fig.8 Micro- hardness plot of sample B3

Fig. 9 indicated that the bead centre hardness was more than sample A3 & B3 because of high current rate and coarse grain structure, due to slow cooling rate grains growth was fast, so all grains settled well and made a well-settled structure, which provide high toughness and hardness. The hardness of HAZ was more because high heat flow which helped in growth of dendrites.

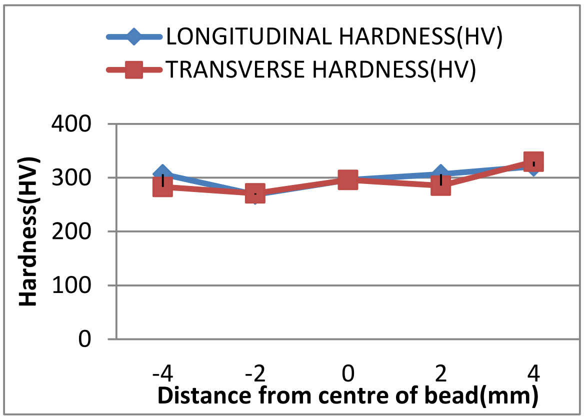

Fig.9 Micro- hardness plot of sample C3

From Fig. 10 it was observe that the bead hardness was approximately same as sample C3 but there was differ in HAZ hardness and toughness, which was high comparatively from other samples.

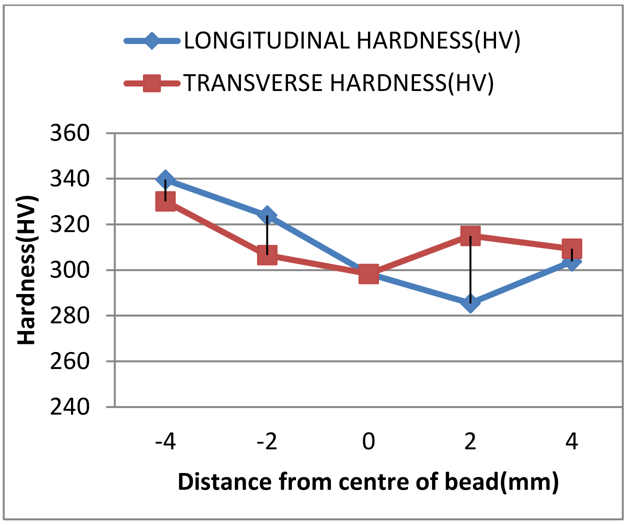

Fig.10 micro hardness plot of sample D3

3. CONCLUSION-:

From above results & discussion it is clear that at high amount of current, heat input and at sufficient condition, coarse grain microstructure is obtained which increase the hardness ,toughness and tensile strength of joint & material. At low current and heat, input fine grain microstructure obtained which provide small tensile strength compare to high current flow joint.

And on other hand from the above results it is also proved that the tensile strength ,hardness and toughness of double v joint is more than the single V butt joint at any current flow rate. Therefore, the best joint for the grade AISI 202 is double V butt joint.

4. ACKNOWLEDGEMENT

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