

Effect of Groove Angle on Tensile Strength and Micro-hardness of AISI 304 SS GTA Welded Joints

Rupinder Singh¹, Gautam Kocher²

¹Ramgarhia Institute of Engineering & Technology, Phagwara, Punjab (India)

²Head & Assistant Professor, Department of Mechanical Engineering, Ramgarhia Institute of Engineering & Technology, Phagwara, Punjab (India)

Abstract - The current study presents the outcome of investigation being done on determining the effect of weld groove angle on the tensile performance and micro-hardness of the austenitic (AISI 304 SS) stainless steel welds. Due to its excellent resistance to corrosion and high temperature as well as good weldability, austenitic stainless steels have been extensively utilized in the fabrication industry. In this study three joints of the above discussed material with different groove angles were fabricated in triple passes of welding with E 308 L filler material. Apart from this, test sample for tensile test and micro-hardness test were extracted from each joint for investigation purpose. According to experimental results, the maximum UTS obtained is 652 MPa for joint-1 having groove angle 45° with root gap 1 mm and minimum of 631 MPa for joint - 3 with groove angle of 75° with root gap 2 mm. Furthermore, it was found that the weld joint made using the smallest groove angle possessed maximum tensile strength and hardness.

Key Words: AISI 304 SS (Austenitic), gas tungsten arc welding process, groove angle, tensile strength, micro-hardness.

1. INTRODUCTION

Austenitic is amongst the type of steel which is used very commonly. Unarguably, presence of nickel (7%) makes this particular steel's structure fully austenitic and renders its properties such as non-magnetic, ductility as well as good weldability. Stainless steel (austenitic) finds wider applications in the fabrication industry – stainless steel is used in the fabrication of industrial piping & vessels, house wares, structures utilized in the construction work, automotive & aerospace components and many more. It goes without saying that, austenitic steel possesses excellent resistance to corrosion and high temperature due to the presence of high chromium and nickel content [1, 2].

For carrying out the welding process efficiently, it is obtrusive to select the proper weld geometry and dimension on groove angle or in other words groove design. In addition to this, the process becomes easier, makes cooling of weld material controllable and offers better penetration [3]. As per literature survey, limited work has been reported in regard to effect of groove design on tensile strength and micro-

hardness of AISI 304 SS (Austenitic). Apart from this, there are many types of weld groove such as U type, X type, bevel groove, J type and many more but the design indeed plays vital role in carrying out the welding process without compromising the quality of weld and material.

1.1 Problem Statement

The present experimental work is conducted with the aim of to analyzing the influence of groove angle on the tensile and micro-hardness of AISI 304 SS welds. This experimental work would be beneficial for strengthening the data base of AISI 304 SS welded joints where this material is used.

1.2 Objective

In this research work an attempt has been made to check effect of groove angle on the tensile strength along with hardness of AISI 304 Stainless steel. As per literature GTAW welding technique is best for suited for welding of stainless steel.

2. LITERATURE SURVEY

A. Ahmed Khalid et al. - The tensile specimens of suitable dimensions were extracted. The research concludes that with the increase in bevel height of v-belt joint the penetration depth is affected. Besides this, tensile strength is greatest at low weld speed that is at 0.6 cm per second. Bevel angle also plays vital role in influencing the strength. Angle from 30° to 45° comes out to be best suited [4].

B. Gite Kailas A et al. - Shows the research work done for analyzing the UTS, tensile strength and micro-hardness of AISI 304 SS in TIG welding. As per results, the maximum UTS obtained is 646 MPa for weld sample with groove angle 45° , root face - 1.5 mm and root gap - 1.5 mm. Furthermore, TIG GRA reveals that the micro-hardness 236 HV and tensile strength 641MPa is obtained for optimum parameters of groove angle 60° having root face and root gap 1 mm & 1.5 mm respectively [5].

C. Ipek Nazli Ezgi - Revealed that X type groove has greater strength as compared to V groove design. Besides this, weld joints having V groove geometry and 54 degree groove angle as well as X type joint having X groove (48° degree) attains the highest strength both in tension & compression [1].

D. Kumar Suresh L et al. - Shows the influence of welding parameters on 304 SS and 316 n TIG as well as MIG welding.

Taguchi technique has been adopted for optimum result. The results shows that the ultimate tensile strength of joint made with TIG welding is 675.22 MPa which higher than that of sample prepared by MIG welding (652.029 MPa). On the other hand, hardness of TIG welded joint is 162.53 BHN and for MIG welded joint is 196.54 BHN [6].

E. Mousavi S.A.A. Akbari et al -The outcomes of the research showed that the samples with V- groove had minimum tension zone and least tensile residual stress as compared to samples having U- groove. As the welding process goes on, the peak temperature increases along the length of weld which was shown by 3d computer simulation [7].

F. Ravi kumar Jadav – Carry out the analysis of the influence of welding variables on mechanical properties of AISI 304SS GTA weld joints. The higher tensile strength obtained is for groove angle 75°, 120 A and 15 LPM flow rate whereas the lowest value of hardness is at 45° and 70° groove angle,, 100A and gas flow rate of 12 LPM [2].

G. Singh Tejpal et al. - Carried out experimental work to study the influence of groove angle on the tensile strength and Charpy v notch impact strength of mild steel weld joints. As per results the maximum average tensile strength obtained is 513.68 MPa for joint-1 having groove angle 50° and minimum tensile strength reported is 471.29 MPa for joint-3 having groove angle 30°. Besides this, Charpy v notch strength is highest (53.47 J) for joint -1 and minimum for joint 3 [8].

H. Singh Jastej et al. - As per results, single-v joint performs better in terms of corrosion properties as compared to double-v joint. Post weld thermal aging and varying design of joint subsequently affect the pitting corrosion and resistance to sensitization [9].

3. MATERIAL AND METHODOLOGY

3.1 Material – In the present study, the type of material preferred for the investigation purpose is AISI 304 SS on the basis of literature survey and wider industrial applications. The table shown below shows the chemical composition of AISI 304 SS.

Table 1: Chemical composition of AISI 304 SS (Austenitic)

Material	Chemical Composition, max wt %									
	C	Mn	Si	P	S	Ni	Cr	Mo	V	Co
AISI 304	0.23	0.36	0.14	0.6	0.4	0.99	0.13	0.38	0.1	0.25

3.2 Filler Metal

The filler material selected for the research work was 308 L. First of all, it would be apt to mention that 308 L filler material is predominantly used on austenitic steel such as type 301, 302, 304, 305 and cast alloys CF8 and CF3.

Table 2: chemical composition of 308 L

Designation	Chemical Composition, max wt %							
	C	Mn	Si	Pb	S	Ni	Cr	Fe
308 L SS (Filler metal)	0.03	1.42	0.42	0.02	0.01	10	19.2	bal

3.3 Sample Preparation Prior to Welding

After that surface finishing of AISI 304 SS hot rolled steel plates was done on milling machine and were further cut into size 300 mm x 100 mm x 6 mm.

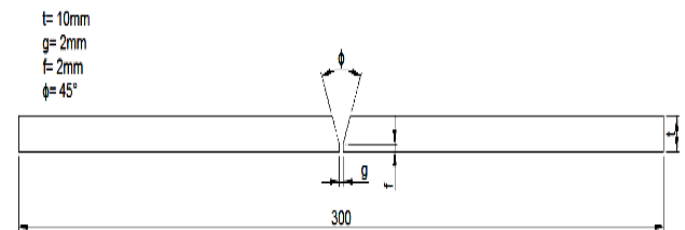


Figure 1: Sample preparation

For the same, three samples (Sample No-1, 2 & 3) have a single-v groove at 45 degree, 60 degree and 75 degree respectively along with root gap of 1 mm, 1.5 mm & 2 mm respectively were provided the bottom of each sample to avoid burn-through.

Table 3: Shows Groove design

Joint	Groove Angle	Root Gap
Joint 1	45 degree	1 mm
Joint 2	60 degree	1.5 mm
Joint 3	75 degree	2 mm

3.4 Welding Procedure

GTAW is considered to be the widely accepted high quality amalgamation welding technique. TIG welding process is best suited for metal plate of thickness around 5-6 mm. GTAW is welding process in which fusion arc or an electric arc is struck between base metal and electrode (tungsten electrode) which is responsible for the generation of heat to melt the edges of the metal for the purpose of making weld.

4. EXPERIMENTATION

The joints prepared were welded with GTAW welding process at HR Tool, Jalandhar. The welding process was conducted through a certified welder to ensure the quality and soundness of weld joint. Total three samples were prepared and from these tensile specimens were extracted along with the hardness test samples.

4.1 Ultimate Tensile Testing

The results of UTS are reported in the table number 4.

Table 4: Shows Tensile Test results

Specimen	Groove Angle	Root Gap	UTS
Joint - 1 [A]	45°	1 mm	652 MPa
Joint - 2 [B]	60°	1.5 mm	644 MPa
Joint - 3 [C]	75°	2 mm	631 MPa

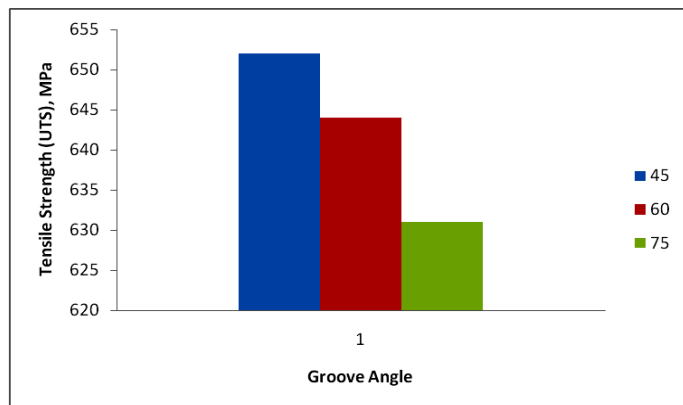


Figure 2: plot shows the effect of groove angle on the UTS.

4.2 Micro Hardness Test

The result of hardness test is reported in the table No. 5 shown below.

Table 5: Reports hardness of AISI 304 SS GTA weld joints

Specimen	Groove Angle	Root Gap	Hardness
Joint - 1 [A]	45°	1 mm	236 HVN
Joint - 2 [B]	60°	1.5 mm	221 HVN
Joint - 3 [C]	75°	2 mm	216 HVN

5. CONCLUSIONS

Following are the possible outcomes of the experimental work conducted regarding effects of groove angle on AISI 304 SS (Austenitic).

1. Groove angle affects the UTS value of the welded joints, maximum tensile strength possessed by the joints having least groove angle and UTS value decreases with increase in groove angle.
2. Heat dissipation characteristics changes with variation in groove angle.
3. Maximum hardness is achieved in welded joint having minimum groove angle, this maximum hardness is due to the fast cooling rate of the weld metal which directly affects the solidification of the weld metal.

4. Based on the experimental results, it is suggested that for better UTS and hardness of the welded joints of AISI 304 SS, small groove angle should be preferred.

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