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# Experimental Investigation and Mechanical Characterization Analysis of Sa387 Gr12 By Using TIG Welding Process

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**ABSTRACT:** Tungsten inert gas (TIG) welding is the most popular gas shielding arc welding process used in many industrial fields. Other arc welding processes have limited quality when they are compared to TIG welding processes. However, TIG welding also needs improvements regarding spatter reduction and weld quality of the bead. Shielding gas in TIG welding is desirable for protection of atmospheric contamination. TIG welding process has the possibility of becoming a new welding process giving high quality and provides relatively pollution free.A387 Grade 12 chrome moly steel is a boiler plate steel according to the ASTM/ASME standard A387/A387M.A387 Grade 12 is designed for use in pressure vessels and heat exchangers where there is an elevated temperature.it is described as an alloyed high temperature pressure vessel steel. The addition of chrome and molybdenum in the steel making makes this plate suitable for use at high temperatures whilst also giving them some corrosion resistant properties. whilst not as corrosion resistant stainless steels, chrome moly plates in the A387 family are often a cost effective substitute in lower risk areas.

# I. INTRODUCTION

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to forma weld pool of molten material which after solidification gives a strong bond between the materials. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position. In which TIG welding is an arc welding process that uses a non-consumable tungsten electrodeto produce the weld. The weld area is protected from atmosphere by an inert shielding gas(argon or helium), and a filler metal is normally used. The power is supplied from the powersource (rectifier), through a hand-piece or welding torch and is delivered to a tungstenelectrode which is fitted into the hand piece. An electric arc is then created between thetungsten electrode and the work piece using a constantcurrent welding power supply thatproduces energy and conducted across the arc through a column of highly ionized gas andmetal vapour [1]. The tungsten electrode and the welding zone are protected from thesurrounding air by inert gas. The electric arc can produce temperatures of up to 20,0000C andthis heat can be focused to melt and join two different part of material. The weld pool canbeused to join the base metal with or without filler material.



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Fig 1.1: Schematic Diagram of TIG Welding System.

Process parameters of TIG welding Welding Current Welding Voltage Inert Gases Welding speed:

#### **II. LITERATURE REVIEW**

**J. Dutta**, et al<sup>[1]</sup> investigated reveals an elaborate analysis of variation of thermal properties of high carbon steel plate butt joints formed by DC Gas Tungsten Arc (GTA) welding. Vishnu V.S. et al[2] analyzed 3D thermo-mechanical simulation model was developed to predict distribution of temperature and residual stresses during Tungsten Inert Gas (TIG) double-side arc welding (DSAW) process on a low carbon steel plate. The simulated results show that the residual stresses are tensile at the weld poolregion and as the distance from the weld line increase it tends to compressive. Also found that welding process parameters in welded structures are the most influential parameter for the occurrence and control of residual stresses. M.PalPandi, et al[3] carried out thermo-mechanical finite element analysis has been performed to assess the residual stress in the butt weld joints of aluminum Alloy AA7075 plates by utilizing the commercial software package ABAQUS. The study shows the effects of varying heat input, welding speed on the thermo-mechanical responses of the weldment after cooling down to room temperature. M SUNDAR, et al[4] analyzed welding is a reliable and effective metal fabrication process which is widely used in industries and study on a single pass butt-welding specimen by using Finite Element Method to illustrate the temperature distribution, distortion and residual stress field developed in the weldment. They developed relationships between the parameters and response based on the simulation result, which are found to be in good agreement. A.RASOOL MOHAIDEEN, et al[14] studied the heterogeneous nature of weldments demands an additional processing to retain and/or improve the joint properties. They studied the influence of postweld heat treatment on the fracture toughness on alloy steel weldments. Fracture toughness soft heattreated weldments was determined using standard CTOD test and the results were correlated.

#### **III. PROBLEM IDENTIFICATION**

In many cases the welder needs only to know the techniques of actual welding and does not need to be concerned about the type or grade of steel being welded. This is because a large amount of steel used in fabricating a metal structure is low Carbon or plain carbon steel (also called mild steel). When welding these steels with any of the common arc welding processes like Stick Mig or Tig there are generally few precautions necessary to prevent changing the properties of the steel.

Steels that have higher amounts of Carbon or other alloys added may require special procedures such as preheating and slow cooling, to prevent cracking or changing the strength characteristics of the steel. The welder may



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be involved in following a specific welding procedure to ensure weld metal and base metal has the desired strength characteristics.

### IV. EXPERIMENTAL DESIGN

#### **DESIGN OF EXPERIMENT**

Table 4.1 Process	parameters and	their levels

Levels	Process parameters					
	PEAK CURRENT	BASE CURRENT	GAS PR			
1	25	130	4			
2	30	150	5			
3	35	170	6			

## 4.2 DESIGN OF ORTHOGONAL ARRAY

### Table: 4.2 AN ORTHOGONAL ARRAY L9 FORMATION

TRIAL NO.	DESIGNATION	BASE	PEAK	Gas pr
1	$A_1B_1C_1$	25	130	4
2	$A_1B_2C_2$	25	150	5
3	$A_1B_3C_3$	25	170	6
4	$A_2B_1C_2$	30	130	5
5	$A_2B_2C_3$	30	150	6
6	$A_2B_3C_1$	30	170	4
7	$A_3B_1C_3$	35	130	6
8	$A_3B_2C_1$	35	150	5
9	$A_3B_3C_2$	35	170	4

#### V. EXPERIMENTAL ANALYSIS

#### 5.6HARDNESS TEST-Rockwell HRB TABLE 5.1: (AFTER WELDING)-TIG

Materials	BASE	PEAK	Gas pr	HARDNESS
SA387	25	130	4	91
	25	150	5	88
	25	170	6	85
	30	130	5	87
	30	150	6	77
	30	170	4	93
	35	130	6	80



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35	150	5	77
35	170	4	77

#### **DEPTH OF PENETRATION**



Fig 6.1 view of test plate

### VI. VARIOUS SIZES OF BEAD WIDTH, DEPTH OF PENETRATION AND HEAT AFFECTED ZONE-SA387Gr12-GTAW

### Table 6.1 VARIOUS SIZES OF BEAD WIDTH, DEPTH OF PENETRATION

TEST		Area	Mean	Mixin M	Max Anagled	e Lenegeth	
SAMPLE	LOCATION		15 M@ah	20.4 <b>47</b> 1in 187	.731 Max0.272	A <b>h§l2</b> 86	Length
SAMPLE-1	BW	0.6	116.413	37.496	180.345	178.668	6.61
	DOP	0.313	151.336	42.05	247.467	91.061	4.15
SAMPLE-2	BW	0.51	136.293	113.49	207.421	-1.051	8.377
	DOP	0.249	170.289	111.407	220.232	88.755	3.536
SAMPLE-3	BW	0.531	97.065	46.887	138.422	-0.591	7.454
	DOP	0.292	105.5	55.549	120	90	3.15
SAMPLE-4	BW	0.698	110.581	19.707	164.766	-0.498	8.837
	DOP	0.337	123.722	60.618	148.667	90.909	4.842
	BW	0.506	114.088	35.333	181	0.494	8.914
SAMPLE-5	DOP						
		0.377	86.576	24.489	155.4	90	3.996
SAMPLE-6	BW	0.53	108.535	77.28	162.69	0.63	6.993
	DOP	0.263	105.531	33.396	155.396	90	3.227
SAMPLE-7	BW	0.569	153.884	112.953	188.667	180	8.99
	DOP	0.398	216.282	158	234.256	91.193	3.689



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SAMPLE-8	BW	0.499	99.125	43.826	123.873	-178.379	8.148
	DOP						
		0.364	104.479	50.333	132.333	90	3.381
SAMPLE-9	BW	0.671	184.613	119.244	211.759	179.597	10.912
	DOP						
		0.304	214.453	176	233.667	90	3.919

#### **6.2 TENSILE TEST**

#### Table 6.2 TENSILE TEST REPORT

SAMPLES	WIDTH	AREAmm <sup>2</sup>	T.LOAD	TENSILE
	XTHICK		Ν	STRENGTH
				Mpa
T3-LEVEL1	31.20X5.00	156.00	322.00	206
T6-LEVEL2	31.50X5.50	157.50	568.00	361
T9-LEVEL-3	31.12X5.00	155.80	437	238

Level 2 is more Tensile stress compared than other level

### VII. ULTRASONIC RESULT

### MACHINESPECIFICATION

UT INSTRUMENT: PX20

Transducer angle : 70° 4 MHZ, Technique : pulse Echo, Material ; D3 Thickness : 5MM

Table7.1 Ultrasonic report						
S.NO	BASE CURRENT	PEAK CURRENT	GAS PRESSURE	INDICATIONS		
1.	25	130	4	ICP &Por		
2.	25	150	5	ICP		
3.	25	170	6	NI		
4.	30	130	5	NI		
5.	30	150	6	Cr		
6.	30	170	4	Cr		
7	35	130	6	UC		
8	35	150	5	EP		
9	35	170	6	EP		



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#### VIII. RESULT AND DISCUSSION

#### Table 8.1 process parameter optimization

TRIAL NO.	DESIGNATION	VOLT	AMPS	GAS PRESSURE	HARDNESS	SNRATIO VALUE
1	$A_1B_1C_1$	25	130	4	91	-39.1808
2	$A_1B_2C_2$	25	150	5	88	-38.8897
3	$A_1B_3C_3$	25	170	6	85	-38.5884
4	$A_2B_1C_2$	30	130	5	87	-38.7904
5	$A_2B_2C_3$	30	150	6	77	-37.7298
6	$A_2B_3C_1$	30	170	4	93	-39.3697
7	$A_3B_1C_3$	35	130	6	80	-38.0618
8	$A_3B_2C_1$	35	150	5	77	-37.7298
9	$A_3B_3C_2$	35	170	6	77	-37.7298

#### Taguchi Analysis: HARD versus VOLT, AMPS, GASPRESSURE

Table: 8.2Response Table for Signal to Noise Ratios Larger is better

Level	BASE	PEAK	GAS PR
1	-38.89	-38.68	-39.28
2	-38.63	-38.12	-38.47
3	-37.84	-38.56	-38.03
Delta	1.05	0.56	1.25
Rank	2	3	1

### Main Effects Plot for SN ratios



Fig: 8.1:main effects plot for SN rations



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### Main Effects Plot for Means



Fig 8.2:main effects plot for means

Table: 8.3	3 analysis	of variance	for hard.	using ad	justed ss	for tests
1 4010. 0.2	anaryono	or variance	ioi naia,	abing ad	Jubica bb	101 10010

SOURCE	DF	SeqSS	Adj SS	Adj MS	F	Р	% OF CONTRIBUTION
BASE	2	164.22	70.34	35.17	3.00	0.250	51
PEAK	2	48.22	32.99	16.50	1.41	0.415	15
GAS PR	2	83.00	83.00	41.50	3.54	0.220	26
Error	2	23.44	23.44	11.72			8
Total	8	318.89					

Level BASE PEAK GAS PR 1 -38.89 -38.68 -39.28 2 -38.63 -38.12 -38.47 3 -37.84 -38.56 -38.03 Delta 1.05 0.56 1.25 Rank 2 3 1 **Response Table for Means** Level BASE PEAK GAS PR 88.00 86.00 92.00 1 2 85.67 80.67 84.00 78.00 85.00 79.75 3 Delta 10.00 5.33 12.25 3 Rank 2 1



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#### General Linear Model: HARD versus BASE, PEAK, GAS PR

Factor	Туре	Levels	Values		
BASE	fixed		3	25, 30	), 35
PEAK		fixed		3130,	150, 170
GAS PR		fixed		3	4, 5, 6

Analysis of Variance for HARD, using Adjusted SS for Tests

 Source DF Seq SS Adj SS Adj MS
 F
 P

 BASE
 2
 164.22
 70.34
 35.17
 3.00
 0.250

 PEAK
 2
 48.22
 32.99
 16.50
 1.41
 0.415

 GAS PR
 2
 83.00
 83.00
 41.50
 3.54
 0.220

 Error
 2
 23.44
 23.44
 11.72
 Total
 8
 318.89

S = 3.42355 R-Sq = 92.65% R-Sq(adj) = 70.60%

#### **IX. CONCLUSION**

Many attempts have made for test piece on to predict the process parameter by GTAW for getting the maximum weldment and good weld deposition best mechanical properties and min HAZ. The planned experiments were conducted in the TIG welding machine; the test piece examination is carried out by following process. 1) Hardnesstesting.2) Bead Geometry measurements.3) Ultrasonic test testing 4)Tensile test Finally weConcluded the suitable input parameter for SA387 in GTAW process is**30A/130A/5Kg/cm2**.Tensile strength also obtained 36lMpa in second level welding parameter.According to the Taguchi design and optimized parameter value obtained for the 5 mm plate of SA387 steel for hardness property is **30 AMPS 170AMPS GAS PRESSURE 4Kg/cm<sup>2</sup>** 

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