Improving the mechanical performance of welded joints in Pressure vessel by different Welding process parameters in TIG Welding and Increment in current at each layer of weld joint

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Abstract

As we Know that the usage of mild steel at different industrial sector such as pressure vessel, building construction, automobile structure, manufacturing, etc. is high due to their tensile strength and toughness. Therefore, need has arrived to think out in the merger of mild steel with other metal which are compatible and stronger such as mild steel so in this project we have studied the mechanical properties and failure analysis of physical error (which is detected by non-destructive test (radiography test)) of mild steel welded by TIG welding. TIG welding process is mostly used to weld thin section for higher surface finish. We have tried to use the various parameter such current, gas flow rate, which has influence on tensile strength and hardness of welding joint. In a welding joint tensile strength is highly affect the life of weld joint in pressure vessels from this experiment we will find exact when point where tensile strength is highest and which parameter high perfect for excellent quality of weld thin section joint

Keywords: -

1) Current and gas Pressure variation in TIG-Welding.

2) Increment in current at each layer as per design.

3) Optimise the physical failure checks by NDT(RT).

4) Strengthening the Welded Joints in TIG Welding.

5) TIG Welding Process Optimization Parameters.

Introduction: -

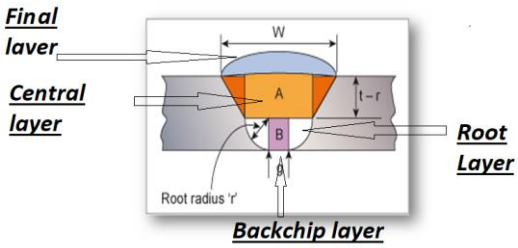
TIG welding is the most popular welding technique used today because it offers a high degree of purity, a clean weld and it can be used in many industrial, residential and commercial applications. TIG is most commonly used to weld stainless steel together, although other metals like magnesium, aluminium, copper and nickel can be welded using TIG.

TIG Welding stands for Tungsten Inert Gas and is a technique that's known for using a non-consumable tungsten electrode along with an inert gas (usually argon). Tungsten is a rare, hard element that offers a high purity, high-quality weld. In TIG welding, the heat is created by running an electric current through a tungsten electrode, creating an arc that is then used to melt a metal wire in order to create the weld pool.

It has been found from the past that sometimes Fabrication Industries could not able to fetch the Repetitive orders because of failure of welded joint after Usage of 4 to 5 years Continuously it means its life cycle of pressure vessel is less compare to its cost so customers are not satisfy due to this problem. During our study I had observed that fabricators are using the Ar gas with 99.997% with current boundary 90A-140A and 15 LPM gas pressure with same current at all layer of weld joint . However it will create several weld defects in long duration.

To Overcome those Problem I did an extensive studies to find out the Long term solution by using the several different mixtures and rigorous testing into the particular problem. During Experiments I have performed numerous current and gas pressure variation into the products and find out the optimal solution which is being describe in detail in the Working & Conclusion section.

Design of Weld Joint: -



"A" = final finishing layer
"B" = central layer filler layer"
"C" = Root Layer base layer

*Bottom layer having some extra penetration and slag formation on face it will remove by grinder and it will be fill with root layer parameter it's call back-chip layer that is substitute layer.

Experimental Method

In this experiment we are using a taguchi method
Here describe below the control factors and noise factor
In this experiment control factors are Current and Gas Flow Rate(GFR)
Selected Factor and their Levels

Factor		Gas Flow Rate (GFR) (Control factor 1)	Current (Control factor 2)
Levels	1	15 LPM	90A
	2	13 LPM	100A
	3		110A
	4		115A
	5		120A
	6		125A
	7		130A
	8		135A
	9		140A

Orthogonal Array

Experiment Number	Control Factor	
	1	2
1	1	1
2	1	2
3	1	3
4	1	4
5	1	5
6	1	6
7	1	7
8	1	8
9	1	9
10	2	1
11	2	2
12	2	3
13	2	4
14	2	5
15	2	6
16	2	7
17	2	8
18	2	9

In next 18 to 36 experiment having increment in current at each layer 1) Root & back-chip layer
2) Central layer 3) Final layer in 3 layer we will increment in current with 5A example 19 experiment root & back-chip layer having 90A central layer having 95A and final layer having 100A so root current and Gas Flow Rate (GFR) of 18-36 same as 1-18 but changes only current of central layer and final layer.

Materials and Equipment used in Experiment: -

Base Metal: IS 2062 (mild steel) B
Filler Metal: ER70s-2 (mild steel)
Tungsten electrode thoriated with dia 2.4 mm
Test piece dimension 170*170*5 mm

Working:-

In the TIG welding process having lots of parameter but main 2 parameter are affect the strength of weld joint, Current and Gas flow rate(GFR) which is observed in previous study.
In first 9 experiment having constant gas flow rate(GFR) 15 LPM with same current at each layer of weld joint with current variation 90A- 140A.Voltage is varying with distance between electrode and base metal which is set by machine automatically.

When current is 90A arc is very small very unstable and heat input is very slow so it take more time to weld the plate and finishing is not good as compare to 140A. In this experiment same current at each layer means suppose in the first experiment root & back chip layer having 90A same as central layer and final layer having a 90A current .

In next 9-18 experiments having gas flow rate (GFR) 13 LPM with current variation 90A- 140A at same current at each layer.

In next 18 – 24 experiment having Gas Flow Rate is 15 LPM, current variation 90A-140A with increment in 5A current at each layer of weld which is describe in experimental methodology.

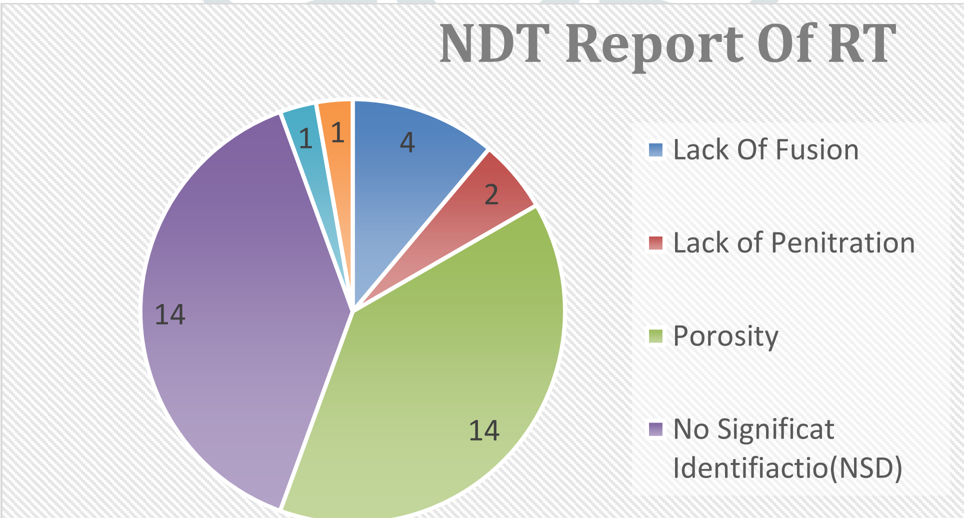
In next 24-36 experiments having Gas Flow Rate is 13 LPM current variation 90A-140A with increment in 5A current at each layer of weld.

Testing and Results: -

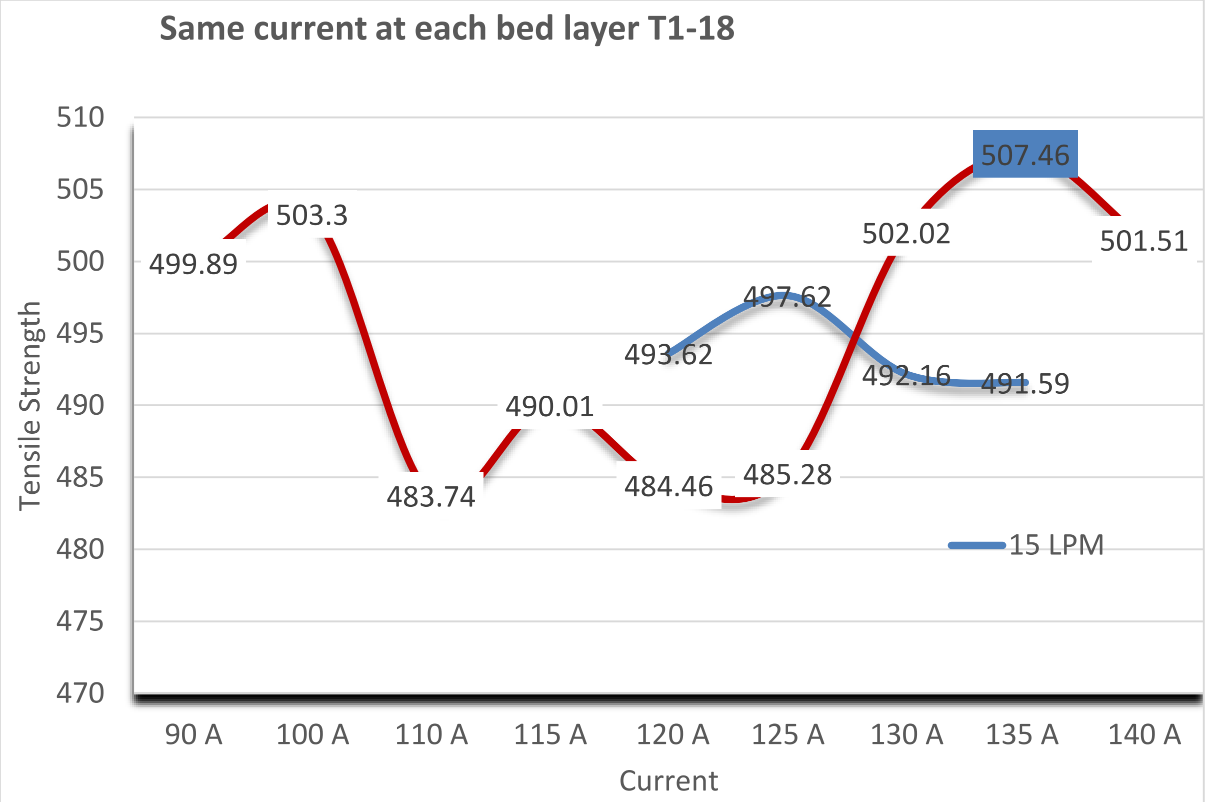
Test Piece	Bed layer	Current	GFR(Gas	Voltage	Time (s)	Tensile strength	Root bend	Facebend	RT TEST
	Root	90 A			3.28				
T1	Center	90 A	15 LPM	12-12.9V	2.33	–	–	–	Fail
	Final	90 A			3.23				
	Back Chip	90 A			2.4				
	Root	100 A			2.45				
T2	Center	100 A	15 LPM	12.7-13.3V	2.02	–	–	–	Fail
	Final	100 A			2.57				
	Back Chip	100 A			2.35				
	Root	110A			2.53				
T3	Center	110A	15 LPM	13-14.2V	1.58	–	–	–	Fail
	Final	110A			2.46				
	Back Chip	110A			2.17				
	Root	115A			2.5				
T4	Center	115A	15 LPM	14.1-15.1V	1.49	–	–	–	Fail
	Final	115A			2.35				
	Back Chip	115A			2.02				
	Root	120A			3.12				
T5	Center	120A	15 LPM	14.3-15.2V	2.1	493.62 U/mm²	Satisfacory	Satisfacory	Pass
	Final	120A			2.37				
	Back Chip	120A			1.26				
	Root	125A			2.55				
T6	Center	125A	15 LPM	14.5-15.4V	1.51	497.62 U/mm²	Satisfacory	Satisfacory	Pass
	Final	125A			2.24				
	Back Chip	125A			1.2				
	Root	130A			2.03				
T7	Center	130A	15 LPM	15-15.7 V	1.54	492.16 U/mm²	Satisfacory	Satisfacory	Pass
	Final	130A			2.32				
	Back Chip	130A			1.27				
	Root	135A			2.14				
T8	Center	135A	15 LPM	15.4-16.2V	1.58	491.59 U/mm²	Satisfacory	Satisfacory	Pass
	Final	135A			2.18				
	Back Chip	135A			1.07				

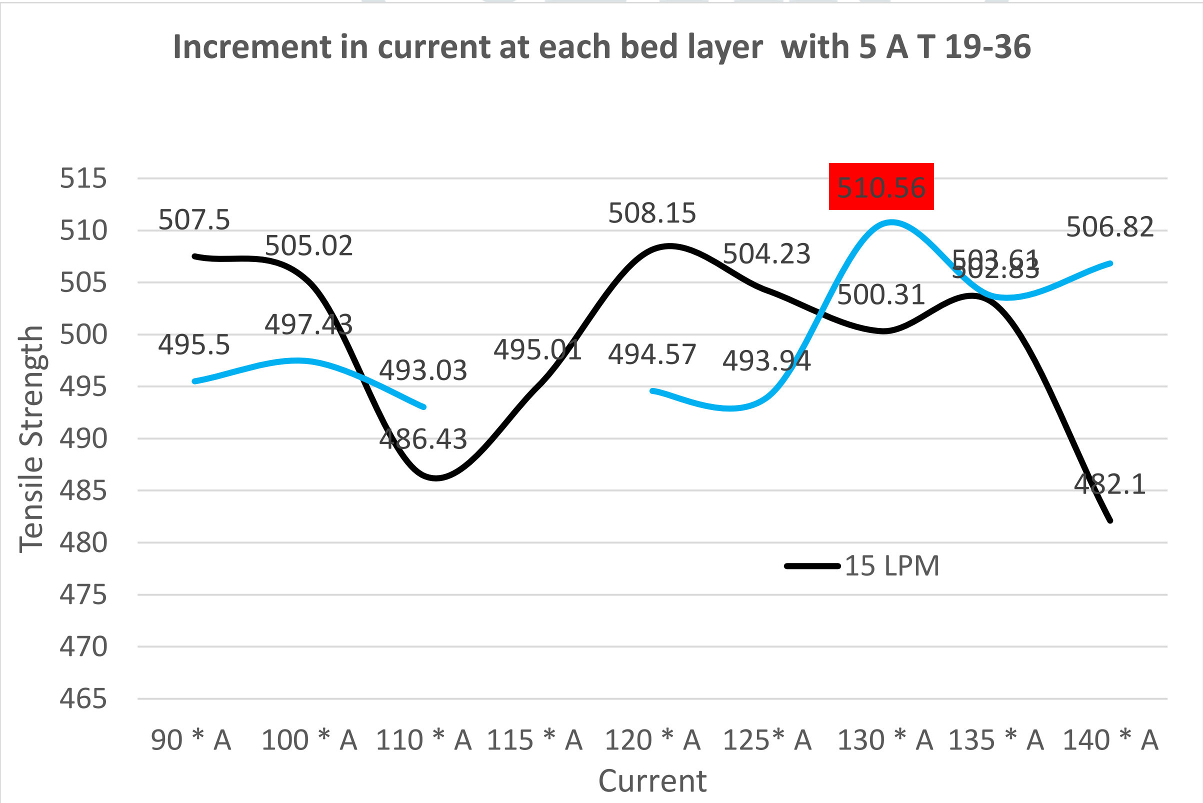
T9	Root	140A	15 LPM	15.4-16.9V	2.19	_	_	_	Fail
	Center	140A			1.46				
	Final	140A			2.02				
	Back Chip	140A			1.09				
T10	Root	90 A	13 LPM	12-12.9V	3	499089 U/mm²	Satisfacory	Satisfacory	Pass
	Center	90 A			3.17				
	Final	90 A			3.17				
	Back Chip	90 A			1.32				
T11	Root	100 A	13 LPM	12.7-13.3V	2.51	503.30 U/mm²	Satisfacory	Satisfacory	Pass
	Center	100 A			2.44				
	Final	100 A			3.08				
	Back Chip	100 A			1.3				
T12	Root	110A	13 LPM	13-14.2V	2.5	483.74 U/mm²	Satisfacory	Satisfacory	Pass
	Center	110A			2.42				
	Final	110A			2.58				
	Back Chip	110A			1.27				
T13	Root	115A	13 LPM	14.1-15.1V	2.43	490.01 U/mm²	Satisfacory	Satisfacory	Pass
	Center	115A			2.38				
	Final	115A			2.24				
	Back Chip	115A			1.18				
T14	Root	120A	13 LPM	14.3-15.2V	2.34	484.46 U/mm²	Satisfacory	Satisfacory	Pass
	Center	120A			2.42				
	Final	120A			2.51				
	Back Chip	120A			1.14				
T15	Root	125A	13 LPM	14.5-15.4V	2.32	485.28 U/mm²	Satisfacory	Satisfacory	Pass
	Center	125A			2.28				
	Final	125A			2.5				
	Back Chip	125A			1.05				
T16	Root	130A	13 LPM	15-15.7 V	2.1	502.02 U/mm²	Satisfacory	Satisfacory	Pass
	Center	130A			2.31				
	Final	130A			2.3				
	Back Chip	130A			1.04				
T17	Root	135A	13 LPM	15.4-16.2V	2.06	507.46 U/mm²	Satisfacory	Satisfacory	Pass
	Center	135A			2.19				
	Final	135A			2.05				
	Back Chip	135A			0.45				
T18	Root	140A	13 LPM	15.4-16.9V	1.53	501.51 U/mm²	Satisfacory	Satisfacory	Pass
	Center	140A			2.4				
	Final	140A			2.33				
	Back Chip	140A			1.19				
T19	Root	90A	15 LPM	12-12.9V	3.3	507.5 U/mm²	Satisfacory	Satisfacory	Pass
	Center	95A			3.36				
	Final	100A			3.36				
	Back Chip	90A			1.5				
T20	Root	100A	15 LPM	12.7-13.3V	2	505.02 U/mm²	Satisfacory	Satisfacory	Pass
	Center	105A			2.58				
	Final	110A			2.45				
	Back Chip	100A			1.34				
T21	Root	110A	15 LPM	13-14.2V	2.4	486.43 U/mm²	Satisfacory	Crack Observed	Pass
	Center	115A			2.5				
	Final	120A			2.26				
	Back Chip	110A			1.19				
T22	Root	115A	15 LPM	14.1-15.1V	2.05	495.01 U/mm²	Satisfacory	Satisfacory	Pass
	Center	120A			2.18				
	Final	125A			2.1				
	Back Chip	115A			1.09				
T23	Root	120A	15 LPM	14.3-15.2V	2.02	508.15 U/mm²	Satisfacory	Satisfacory	Pass
	Center	125A			2.4				
	Final	130A			2.43				
	Back Chip	120A			1.15				
T24	Root	125A	15 LPM	14.5-15.4V	1.54	504.23 U/mm²	Satisfacory	Satisfacory	Pass
	Center	130A			2.19				
	Final	135A			2.03				
	Back Chip	125A			1.13				

T25	Root	130A	15 LPM	15-15.7 V	1.49	500.31 U/mm²	Satisfacory	Satisfacory	Pass
	Center	135A			2				
	Final	140A			1.53				
	Back Chip	130A			1.16				
T26	Root	135A	15 LPM	15.4-16.2V	1.56	502.83 U/mm²	Satisfacory	Satisfacory	Pass
	Center	140A			1.39				
	Final	145A			1.58				
	Back Chip	135A			1				
T27	Root	140A	15 LPM	15.4-16.9V	2.05	482.1 U/mm²	Satisfacory	Satisfacory	Pass
	Center	145A			2				
	Final	150A			1.57				
	Back Chip	140A			1.23				
T28	Root	90A	13 LPM	12-12.9V	2.24	495.50 U/mm²	Satisfacory	Satisfacory	Pass
	Center	95A			2.28				
	Final	100A			2.46				
	Back Chip	90A			1.54				
T29	Root	100A	13 LPM	12.7-13.3V	2.02	497.43 U/mm²	Satisfacory	Satisfacory	Pass
	Center	105A			1.59				
	Final	110A			2.03				
	Back Chip	100A			1.49				
T30	Root	110A	13 LPM	13-14.2V	2.36	493.03 U/mm²	Satisfacory	Satisfacory	Pass
	Center	115A			2.13				
	Final	120A			2.1				
	Back Chip	110A			1.3				
T31	Root	115A	13 LPM	14.1-15.1V	2.14	_	_	_	Fail
	Center	120A			2.03				
	Final	125A			2.16				
	Back Chip	115A			1.19				
T32	Root	120A	13 LPM	14.3-15.2V	2.1	494.57 U/mm²	Satisfacory	Satisfacory	Pass
	Center	125A			2.12				
	Final	130A			2.12				
	Back Chip	120A			1.38				
T33	Root	125A	13 LPM	14.5-15.4V	1.54	493.94 U/mm²	Satisfacory	Satisfacory	Pass
	Center	130A			2.08				
	Final	135A			2.12				
	Back Chip	125A			1.3				
T34	Root	130A	13 LPM	15-15.7 V	1.47	510.56 U/mm²	Satisfacory	Satisfacory	***BEST***
	Center	135A			2.17				
	Final	140A			2.09				
	Back Chip	130A			1.04				
T35	Root	135A	13 LPM	15.4-16.2V	1.51	503.56 U/mm²	Satisfacory	Satisfacory	Pass
	Center	140A			2.22				
	Final	145A			2.34				
	Back Chip	135A			1.06				
T36	Root	140A	13 LPM	15.4-16.9V	1.58	506.82 U/mm²	Satisfacory	Satisfacory	Pass
	Center	145A			2.15				
	Final	150A			2.25				
	Back Chip	140A			1				



In the NDT Radiography report says only Experiment number 1,2,3,4,9,31 are physical failure





SUMMARY

- The project carried by us is a step to move towards better strength solution GTAW welding Process.
- Several Industries who are not aware about the increment in current at each layer, Now they can try to use this for better Product and enhancement of the customer retention ratio.
- Increase in strength which increase the life cycle of pressure vessel from fatigue load.
- We find exact point parameter which having maximum strength, Now they can try to use this for better Product.
- That will help the Organization to create their Brand image among the customers.

CONCLUTION

- For 13 LPM with current for root layer 130A, centre layer 135A and final finish layer 140A, tensile strength is coming as 510U/mm² which is the maximum over all experiences.
- For 15 LPM with increment in current, the performances for all current variations are coming nearer to maximum tensile strength but which is not greater than maximum strength is coming while testing on 13 LPM with current. So we can say that performance is better than coming in 13LPM with increment in current as it is maintained at all current variations.
- But If you will take very high current in 15 LPM with increment in current like current for root layer 140A, centre layer 145A and final finish layer 150A, then metal strength is getting very poor because of high inputs in heat and which increases the heat affected zone. That is why it is decreasing the strength of weld joint, which is 482.1 U/mm²