SSRG International Journal of Mechanical Engineering
ISSN: 2348 – 8360 /doi:10.14445/23488360/IJME-V5I4P104
Volume 5 Issue 4, 15-21, April 2018

Effect of TiO_2 Flux and SiO_2 Flux Coating on Weld Penetration by A-TIG

Nithin Surendran[a], Kalpesh Luhar[a], Dinesh Mistry[a], Mohit Teacher[b], Swetank Srivastava

[a] *UG Student, Mechanical Dept. ACET, Gujarat Technical University, Gujarat-382721, India*

[b] *Assistant Professor, Mechanical Dept. Islamic University of Science & Technology, Awantipora, Jammu and Kashmir-192122, India*

[c] *PG Student, Mechanical Dept. Indian Institute of Technology, Roorkee-247667, India*

Abstract — *Present study work is based on weld penetration of A-TIG performed on stainless steel (UNS S30400). An attempt was made to develop Activated TIG welding for stainless steel of 10mm thickness by single-pass full penetration weld without edge preparation; Study includes the variation in weld penetration by using TiO_2 Flux, Sio_2 Flux, and without Flux at different parameters. The result is based on the Vickers hardness test, Tensile test, and Macroscopic tests.*

Keywords — *Activated TIG welding, Titanium dioxide flux, Silicon dioxide flux, Stainless steel.*

I. INTRODUCTION

Tungsten inert gas(TIG) welding, known as Gas tungsten arc welding (GTAW), is generally used in the stainless steel fabrication factory. It is the most conventional choice of welding when high precision and quality are required. The key limitation of this welding technique is low productivity due to its shallow weld penetration. To overcome this problem, a variant technique is developed, which is known as Activated TIG welding.

Activated TIG is a procedure that allows it to join two metals by a single pass full penetration welding of 10-12 mm thick metals without having edge preparation. This technique has been receiving more considerations due to its high productivity. The arc constriction and Marangoni effect are the reason for the increase in weld penetration of the subject. This study's objective was to analyze the A-TIG weld penetration of 10 mm stainless steel in a single pass welding. The chemical composition of stainless steel (UNS S30400) is given in Table-1

This review's main focus is to summarize the improvements that can be achieved in terms of weld penetration.
It is evident from the previously published research paper that even a 300% increase in weld penetration could be achieved by using A-TIG. Flux reduces the need for edge preparation; thus, it increased productivity.

It is clear from the published research papers that fluxes like TiO_2, SiO_2, and Cr_2O_3 increase the maximum weld penetration, so TiO_2 Flux and SiO_2 Flux are selected for the welding procedure. Different types of Flux which can be used to increase the weld penetration are listed in Table-2**.**

Table-1

Designation			**Chemical composition % by mass max unless stated**								
UNS No	SAE No	AISI No / Common Name	C	Si	Mn	P	S	Cr	Mo	Ni	Others
S30400	30304	304	0.07	0.75	2.00	0.045	0.030	17.5	-	8.0	N 0.10

Table-2

S.No.	IUPAC* Name of Flux	The molecular formula of Flux
1	Titanium (IV) oxide	TiO_2
2	Silicon dioxide	SiO_2
3	Chromium (VI) oxide	Cr_2O_3
4	Aluminum oxide	Al_2O_3
5	Calcium chloride	$CaCl_2$
6	Potassium chloride	KCl
7	Manganese dioxide	MnO_2

II. EXPERIMENTAL PROCEDURE

A. Base metal and Experimental parameters of A-TIG welding

The material used for the study was stainless steel (UNS S30400) of 10mm thickness. A total of 18 Workpieces were prepared. The dimensions of the workpiece were 75*100 mm. Types of Flux used for the procedure were titanium dioxide and silicon dioxide. 9 different experiment was conducted with different parameters which are shown in Table-3.

B. Welding procedure

To study the effect of Activated TIG, the metal plates were cleaned with acetone before experimenting, and then Flux is prepared by adding acetone as a binder. The Flux and binder ratios are kept 1:1. The Flux is coated on the metal plates with the spray before welding and completely dry before welding. The Tungsten electrode of 3.0 mm diameter was used for this welding. After welding, specimens were prepared to conduct the macroscopic test, Vickers hardness test, and tensile test.

Table-3

Experimental study on a workpiece	Parameters Flux used	Welding current(amps)
1	TiO_2	210
2	SiO_2	210
3	Without Flux	210
4	TiO_2	230
5	SiO_2	230
6	Without Flux	230
7	TiO_2	250
8	SiO_2	250
9	Without Flux	250

III. RESULT AND DISCUSSION

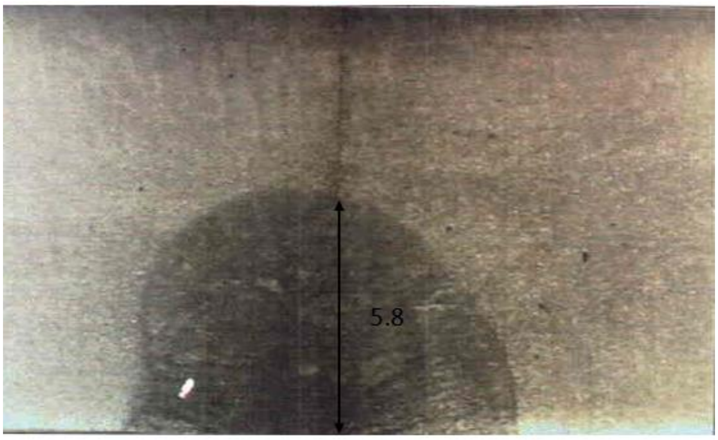
A. Weld penetration (macroscopic examination):

After welding 10mm thick stainless steel, the specimen was subjected to microscopic examination to find the weld penetration depth. Several tests were carried out to determine the Flux, which increases maximum weld penetration. Table-4 shows the effect of SiO_2 flux coating on the Activated TIG welding technique. Better weld penetration was achieved in the case of SiO_2 Flux. It was found that weld penetration was increased more than twice that of conventional TIG welding. The maximum 7.1 mm DOP was achieved in the case of 230 amps.Table-5 shows the effect of TiO_2 flux coating on Activated

TIG. Better weld penetration was achieved compared to normal conventional TIG welding. It was found that a more than 100% increase in weld penetration of 3.3 mm was achieved in the case of TiO_2 Flux at 230 amps. Table-6 shows the weld penetration of conventional TIG Welding(without Flux). As we can see from the results that the conventional TIG welding exhibits shallow weld penetration. The maximum weld penetration secured without Flux was at 230 amps(2.9mm DOP).

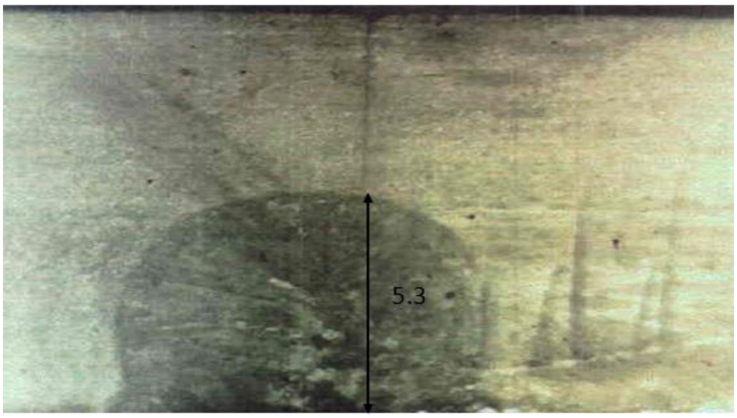
Table-4 Weld penetration of TIG Welding of UNS S30400- with SiO_2 Flux.

a



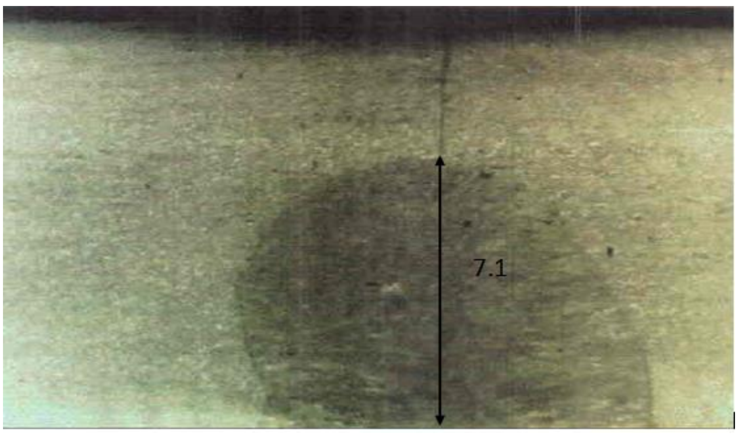
Current:	210 amps
The depth of penetration:	5.8 mm
Tensile stress (Mpa):	304.5
Ultimate Load (N):	56150
Vickers hardness test: At,	
Weld:	158
HAZ:	162
Parent:	160

b



Current:	230 amps
The depth of penetration:	5.3 mm
Tensile stress (Mpa):	321.0
Ultimate Load (N):	59410
Vickers hardness test: At,	
Weld:	160
HAZ:	162
Parent:	158

c



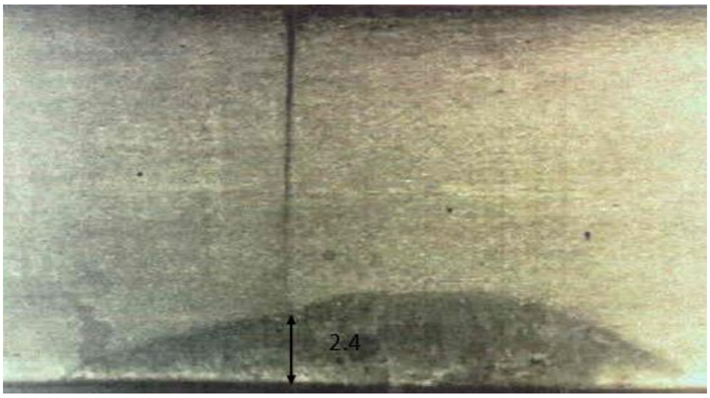
Current:	250 amps
The depth of penetration:	7.1 mm
Tensile stress (Mpa):	298.6
Ultimate Load (N):	55680
Vickers hardness test: At,	
Weld:	158
HAZ:	160
Parent:	146

B. Tensile test:

Test specimen prepared for tensile test and readings of tensile stress are listed in the table. This lab-tested 9 different specimens of stainless steel (UNS S30400). Each test's data gives out valuable material properties such as Ultimate load(N) and tensile stress(Mpa). The result obtained from using Silicon dioxide flux is listed in Table-4. The result obtained from Titanium diode flux is listed in Table-5. The result acquired from Conventional welding(without Flux) is listed in Table-6. The tensile tests result showed that the highest Ultimate strength(321 Mpa) is acquired in Silicon dioxide flux.

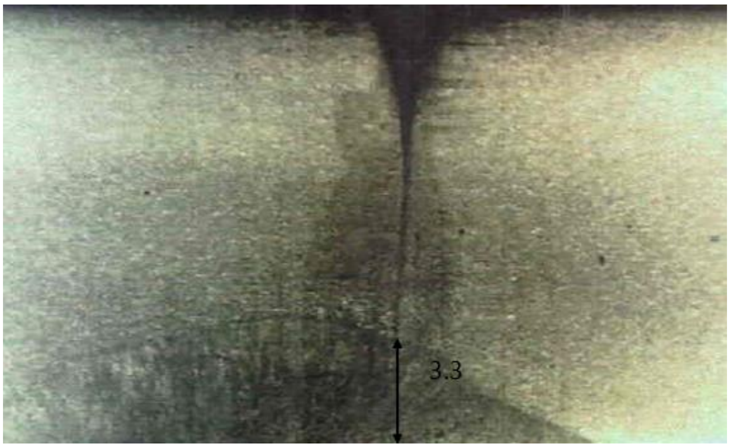
Table-5 Weld penetration of TIG Welding of UNS S30400- with TiO_2 Flux.

a



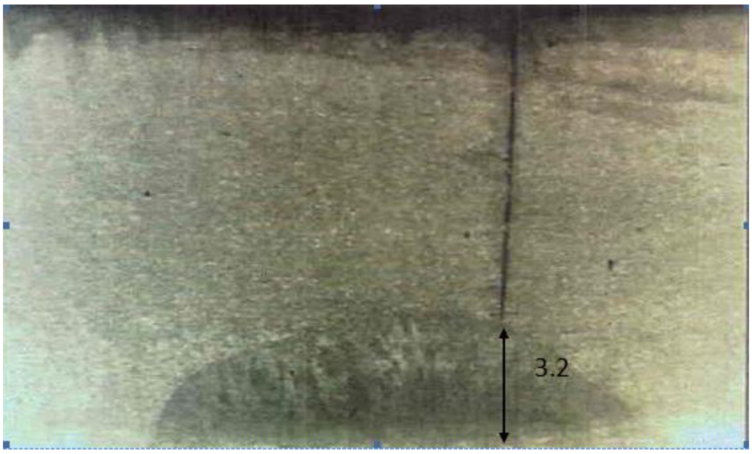
Current:	210 amps
The depth of penetration:	2.4 mm
Tensile stress (Mpa):	167.0
Ultimate Load (N):	30960
Vickers hardness test:	
At,	
Weld:	146
HAZ:	162
Parent:	158

b



Current:	230 amps
The depth of penetration:	3.3 mm
Tensile stress (Mpa):	187.6
Ultimate Load (N):	35060
Vickers hardness test:	
At,	
Weld:	149
HAZ:	158
Parent:	152

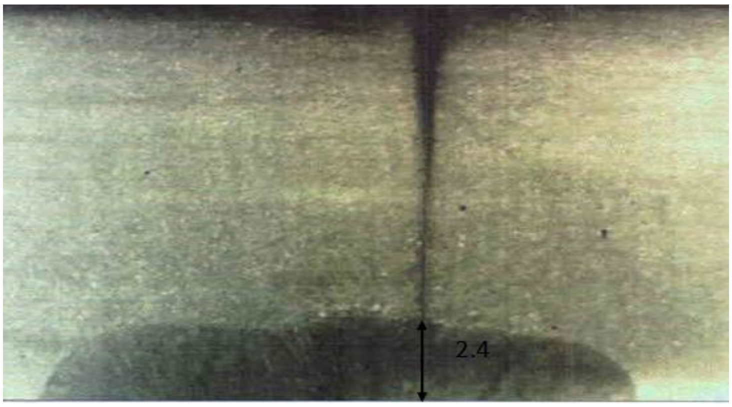
c



Current:	250 amps
The depth of penetration:	3.2 mm
Tensile stress (Mpa):	218.2
Ultimate Load (N):	40590
Vickers hardness test:	
At,	
Weld:	158
HAZ:	162
Parent:	158

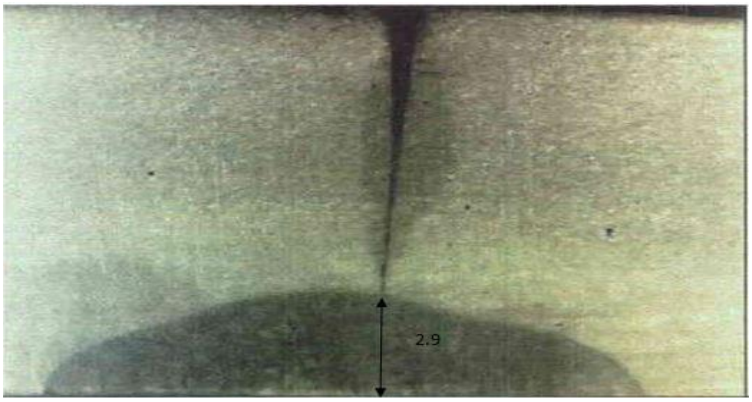
Table-6 Weld penetration of TIG Welding of UNS S30400- without Flux.

a



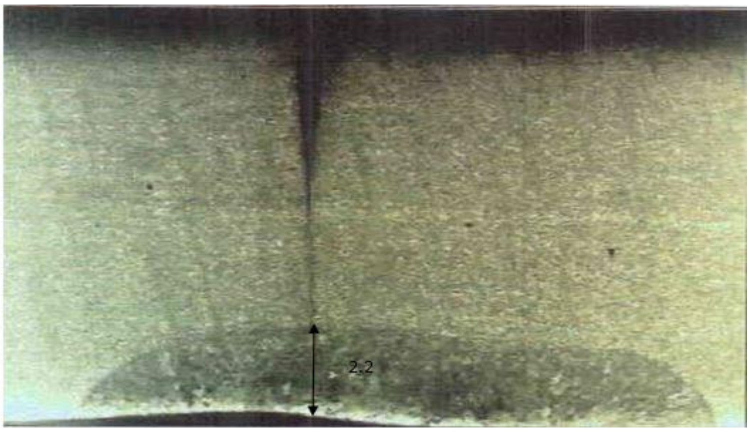
Current:	210 amps
The depth of penetration:	2.4 mm
Tensile stress (Mpa):	168.2
Ultimate Load (N):	35610
Vickers hardness test: At,	
Weld:	146
HAZ:	162
Parent:	147

b



Current:	230 amps
The depth of penetration:	2.9 mm
Tensile stress (Mpa):	188.5
Ultimate Load (N):	35610
Vickers hardness test: At,	
Weld:	158
HAZ:	172
Parent:	160

c



Current:	250 amps
The depth of penetration:	2.2 mm
Tensile stress (Mpa):	202.2
Ultimate Load (N):	37320
Vickers hardness test: At,	
Weld:	146
HAZ:	158
Parent:	152

C. Vickers hardness test:

Specimen were prepared for HV measurement. Readings at the Weld, HAZ, and Parent were taken for each work specimen. The hardness profile by using silicon dioxide is represented in Fig.2. The hardness profile by using titanium dioxide flux is represented in Fig.3. The hardness profile of conventional (without Flux) welding is represented in Fig.4. The hardness test (SiO_2) indicated that there was not much variation amongst the fusion zones. While variation in weld and parent zones are seen at TiO_2 Flux and without flux welding. Variation in the hardness of weld is shown in Fig-(2) (3) and (4).

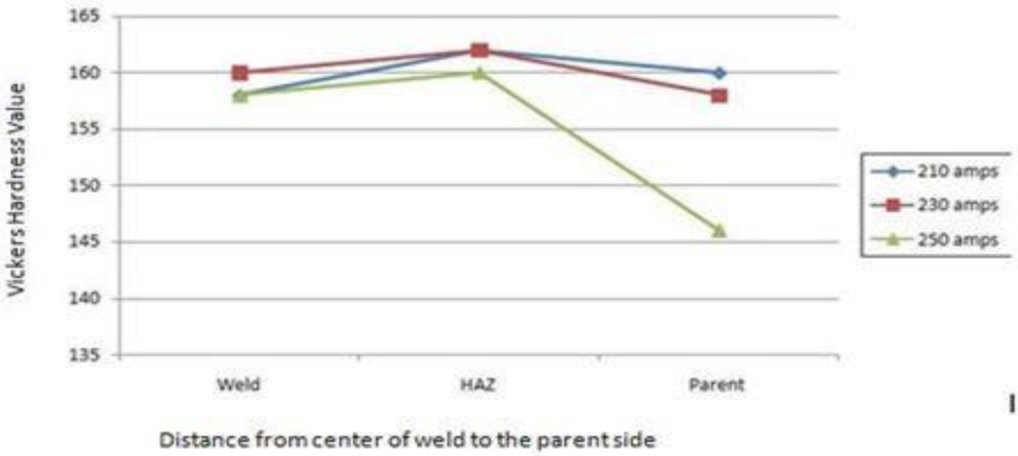


Fig.2. Vickers Hardness Value obtained with SiO_2 Flux

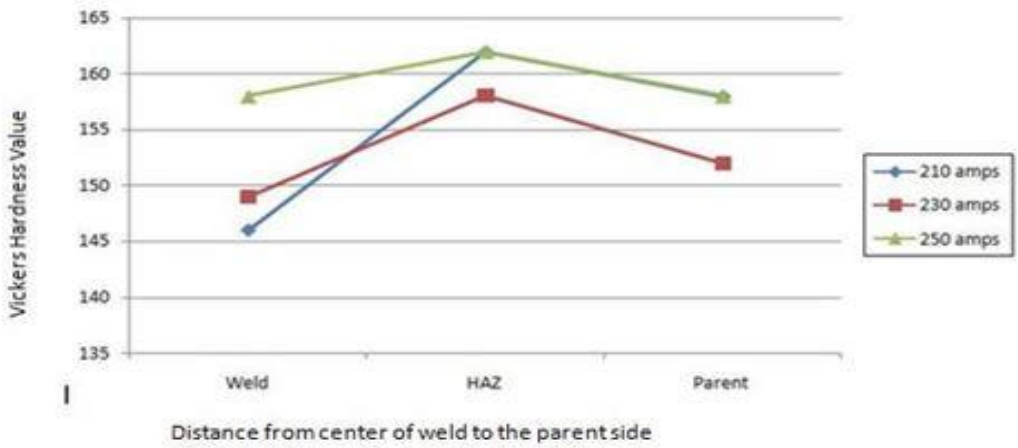


Fig.3. Vickers Hardness Value obtained with TiO_2 Flux

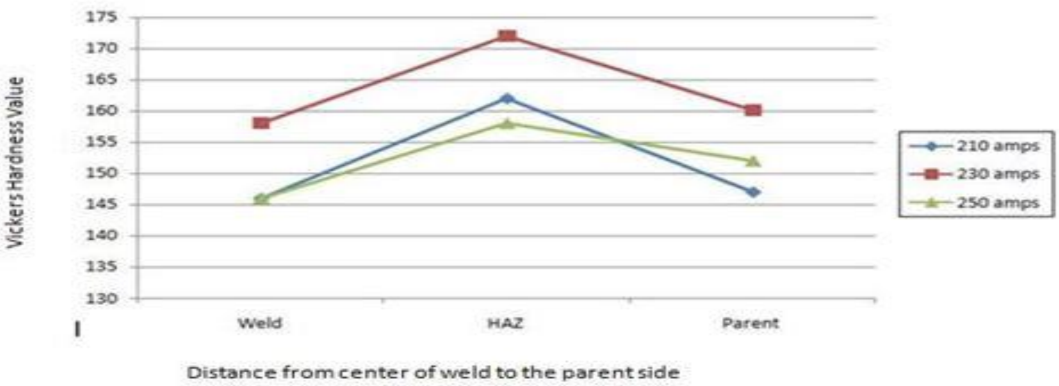


Fig.4. Vickers Hardness Value obtained without using Flux

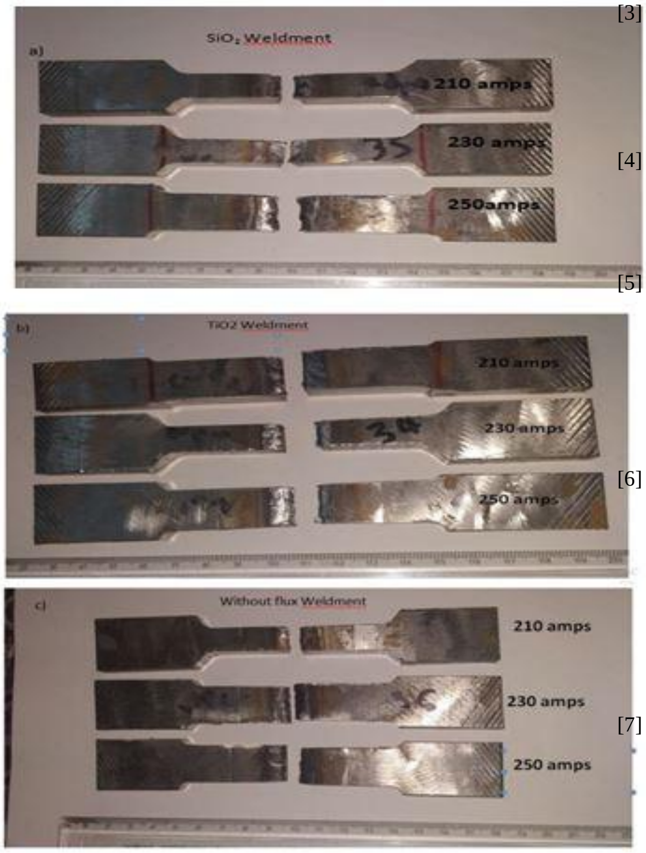


Fig.1. Tensile photographs represent the fracture at the weld zone for the A-TIG weldments of Stainless steel (UNS S30400) employing (a) SiO_2 (b) TiO_2 and (c) Without Flux, respectively.

IV. CONCLUSION

The Activated TIG is capable of increasing productivity by using Titanium dioxide flux and Silicon dioxide flux. The results show that the SiO_2 Flux is capable of increasing the maximum weld penetration. The hardness of the weld is greater compared to the parent metal.

The best result achieved in the study was With SiO_2 as Flux, 7.1mm DOP with 250A current, 2.9mm DOP on 230A current without Flux, With TiO_2 as Flux, 3.3mm DOP with 230A current. The best weld penetration we achieved was on SiO_2 Flux.

REFERENCES

[1] Akhilesh Kumar Singh, Vidyut Dey, Ram Naresh Rai, *"Techniques to improve weld penetration in TIG welding,"* 5th International Conference of Materials Processing and Characterization (ICMPC 2016), Proceedings 4 (2017) 1252–1259.

[2] P.Vasantharaja, M.Vasudevan, "*Studies on A-TIG welding of Low Activation Ferritic/Martensitic (LAFM) steel, Advanced Welding Processes, Monitoring and Modeling Programme,"* Materials Technology Division, Indira Gandhi Centre for Atomic Research, Kalpakkam 603 102, India, Journal of Nuclear Materials 421 (2012) 117–123.

[3] Yangchuan Cai, Zhen Luo, Zunyue Huang, Yida Zeng, "*Effect of cerium oxide flux on active flux TIG welding of 800 MPasuper steel, School of Materials Science and Engineering*", Tianjin University, Tianjin 300072, China, Journal of Materials Processing Technology 230 (2016) 80–87.

[4] Fang, YueXiao, Liu, ZuMing, Cui, ShuangLin, Zhang, Yu, Qiu, JiaYu, Luo, Zhen, "*Improving Q345 weld microstructure and mechanical properties with a high-frequency current arc in keyhole mode TIG welding*". Journal of Materials Processing Technology.

[5] Sanjay G. Nayeea, Vishvesh J. Badhekab, *"Effect of oxide-based fluxes on mechanical and metallurgical properties of Dissimilar Activating Flux Assisted-Tungsten Inert Gas Welds, an L.D.R.P.-I.T.R., Gandhinagar, Gujarat, India b"* Department of Mechanical Engineering, SOT, Pandit Deendayal Petroleum University, Gandhinagar-7, Gujarat, India, Journal of Manufacturing Processes 16 (2014) 137–143.

[6] Chandan Pandeya, Manas Mohan Mahapatra, Pradeep Kumara, Nitin Saini, "*Dissimilar joining of CFEF steels using autogenous tungsten-inert gas welding and gas tungsten arc welding and their effect on -ferrite evolution and mechanical properties*," a Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee, Uttrakhand 247667, India School of Mechanical Sciences, Indian Institute of Technology, Bhubaneswar, Odisha 751013, India, Journal of Manufacturing Processes 31 (2018) 247–259.

[7] K. Devendranath Ramkumar, Aditya Chandrasekhara, Aditya Kumar Singha, Sharang Ahujaa, Anurag Agarwala, N. Arivazhagana, Arul Maximus Rebelb, "*Comparative studies on the weldability, microstructure and tensile properties of autogenous TIG-welded AISI 430 ferritic stainless steel with and without flux"*, a School of Mechanical & Building Sciences, VIT University, Vellore 632014, India Centre for Nanoscience and Nanotechnology, Sathyabama University, Chennai, India, Journal of Manufacturing Processes (2015).

[8] K.DevendranathRamkumarn, Ramanand, AjmalAmeer, K.AghilSimon, N.Arivazhagan, "*Effect of post-weld heat treatment on the microstructure and tensile properties of activated flux TIGweldsofInconelX750*", School of Mechanical Engineering, VIT University, Vellore 632014, India, Materials Science&EngineeringA658(2016)326–338

[9] K. Devendranath Ramkumar, P. Siva Goutham, V. Sai Radhakrishna, Ambuj Tiwari, S. Anirudh, "*Studies on the structure-property relationships and corrosion behavior of the activated flux TIG welding of UNS S32750, School of Mechanical Engineering*", VIT University, Vellore 632014, India, Journal of Manufacturing Processes (2016).

[10] B. Arivazhagan, M. Vasudevan, Studies on A-TIG welding of 2.25Cr-1Mo (P22) steel, *"Advanced Welding Processes and Modeling Section,"* Materials Technology Division, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, Tamil Nadu, India, Journal of Manufacturing Processes 18 (2015) 55–59.

[11] K. Devendranath Ramkumar, B. Manoj Kumar, M. Gokul Krishnan, Sidarth Dev, Aman Jayesh Bhalodi, N. Arivazhagan, and S. Narayanan, "*Studies on the weldability, microstructure and mechanical properties of activated flux TIG weldments of Inconel 718*", Materials Science & Engineering A.