

e-ISSN: 2319-8753 | p-ISSN: 2320-6710

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International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 4, April 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**



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# Investigation of Surface Defects of TIG Welded Dissimilar Metals (En31 Steel and Mild Steel) Using NDT

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**ABSTRACT:** In the present work, the microstructure and effect of heat on hardness of base metal, hardness of weld zone and behavior of TIG welded joints of dissimilar materials were investigated using the plates of EN31 steel and mild steel. The mild steel plates were welded with EN31 steel plates by varying process parameters. Properties such as micro hardness and microstructure of welded joints were evaluated. (welding current, gas, flow rate, and filler material) as three input parameters each having three levels each (low, medium and high). In order to understand the micro structural changes occurring in the weld zone was investigated through the optical microscope. The hardness measurements were taken across the weld zone.

**KEYWORDS:** TIG welding, dissimilar welding, En31 steel, non destructive testing

## I. INTRODUCTION

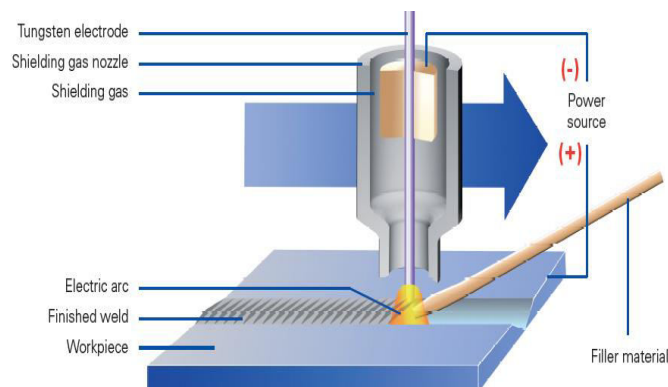
Dissimilar welding refers to the process of connecting materials with different alloy through welding. The filler material and both metals need to be evaluated before choosing the best way to connect the metals. While fusion welding is a popular method, it does not work well for some combinations of metals. Other methods may provide a more durable hold, especially for uses in high-stress environments. In fact, two metals with the same name can be welded together, but if they have different core properties, they are classed as dissimilar metals. For example, you can weld two austenitic steel metals together, but they may still be different enough to be considered dissimilar. The welding process itself leaves a strong and permanent joint between the two metals, essentially leaving behind one final product. We've covered more on the specific process itself in the section below. Dissimilar metal welding finds great use in the electronics industry such as the manufacturing of batteries, aerospace industry, automobile industry, in heat exchanger, boiler and liquid metal reactors.

EN-31 is very important metal from EN series. It is very most popular in manufacturing industries. It has good surface finishing and hardness. EN having following series like EN-8, EN-24 and EN-31 but it is very usefully in manufacturing. EN-31 has good machining properties. It is used for ball bearing shear blades, modeling die, industrial gauges, axles, and spindle and for high hardness components. EN-31 is an alloy steel that which is very popular in manufacturing field. Alloy steel is defined as steel alloyed with variety of elements in total amounts range from 1 to 50 %. Alloy steel classified into two class that is low alloy and high alloy.

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as “low carbon steel.” Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having carbon content from 0.30% to 2.0%. If any more carbon than that is added, the steel would be classified as cast iron. Mild steel is not an alloy steel and therefore does not contain large amounts of other elements besides iron; you will not find vast amounts of chromium, molybdenum, or other alloying elements in mild steel. Since its carbon and alloying element content are relatively low, there are several properties it has that differentiate it from higher carbon and alloy steels.

**PRINCIPLE OF TIG WELDING**

TIG welding is an electric arc welding process in which the fusion energy is produced by an electric arc burning between the work piece and the tungsten electrode. During the welding process the electrode arc and the weld pool are protected against the damaging effects of the atmospheric air by an inert shielding gas. By means of a gas nozzle, the shielding gas leads to the welding zone where, it replaces the atmospheric air. TIG welding differs from the other arc welding process by the fact that the electrode in the other processes such as metal inert gas (MIG) and manual metal arc welding (MMA). TIG welding is a welding process that uses the heat produced by an electric arc created between non-consumable tungsten electrode and the weld pool. This electric arc is produced by the passage of current through a conductive ionized inert gas that also provides shielding of the electrode, molten weld pool and solidifying weld metal from contamination by the atmosphere.

**Fig.1 Basic TIG welding process****II. RELATED WORK**

[1]. Mechanical properties and Analysis dissimilar metal welded joint between Alloy 617 and 12Cr steel by Hafiz Waqar Ahmer, Joeng Hi Hwang, Dong Hi Bae. Here dissimilar material welded joint mostly failed at the HAZ of 12Cr steel. There were no weld defect or oxidation on phenomenon the weld surface. [2] A Study of Microstructure and hardness in EN31 steel and Mild steel Welded Joints Using TIG welding by Ravinder Kumar, Jaswinder Singh, Amrinder Singh. Here the structural constituents and defect that influence the properties of material and the different base metals are used to achieve better result using Microstructure, Vickers hardness and Taguchi method. [3] InvesTIGATION of TIG welding on Dissimilar materials using NDT and Radiography Testing (Aluminium and Mild steel) by Sakthi. S, Azhagunambi .R. In Aluminium weld, AC source is used, where mild steel DC source is used, without any filler rod on pulsed DC power for obtained in TIG welding. Initially the welding is done by linear propagation of torch, but welding did not fuse completely, when torch was moved in curvilinear propagation. This welding we can observe satisfactory bonding for steels in using Analysis of mechanical properties. Higher strength and superior quality joints can be achieved using silicon bronze as filler metal. [4] The similar and dissimilar TIG welding of 316l and 321 austenitic stainless steel by Ozgur Cinar, Mehmet Yarali, Arif nihat, Golwoglu. No default issues will be obtained here only when the TIG is obtained. To provide more data the process should be observed using SEM and EDX attachment. [5] Feasibility of using TIG welding in Dissimilar metals between steel / Aluminium Alloy by Rattana Borisutthe, Muang, Nakhon -Ratahasimme, Sirirat Rattanachan. It is difficult to weld dissimilar metals joining between steel and aluminium alloy caused with brittle intermetallic reaction phase. By using self brazing technique to partial penetration weld steel sheet. This TIG welding resulted in thicker inter metallic reaction layer. The HAZ is the reason of lower of load resistance of aluminium alloy at heat affected zone.

From the literature review, we can observe that dissimilar metal weld done by TIG welding for most of the applications. The process is carried out with varying process parameter (current, voltage, welding speed, stand of gas flow rate), varying preheat temperature, by varying "V" groove angle in the butt joint, by varying filler rod.

**III. METHODOLOGY**

En31 steel and mild steel were joined using TIG (tungsten inert gas) welding process. Weld strength can be tested after joining is done by means of NDT (non-destructive testing) – to detect surface defects. Butt welding will be done for joining both metals by having a ‘v’ groove for 60° and a gap of 2 mm between the plates. Chemical polishing will be done after cutting process to make sure the surface is clean for TIG welding process. TIG welding process will be done by varying process parameters like voltage, welding speed and gas flow rate for three samples.

**Table 1 Process parameters for different samples**

Samples Vs Welding parameters	Sample 1	Sample 2	Sample 3
Current (A)	100	125	150
Welding speed (s)	300	350	380
Gas flow rate (L/min)	5	6	7

After welding is done for different samples, testing of the samples is carried out. TIG welding provides better strength. It provides more precise weld. It uses non- consumable tungsten electrode. It can be worked in any position. It produces high quality of weld. Because it can afford greater control during weld operation. In TIG welding narrow concentrated arc, provide a concentrated heating of the work piece. TIG weld has no splatter and complex areas can also welded.

**IV. EXPERIMENTAL RESULTS****Table 2 Ultrasonic Test results for different samples**

Sample No	Current	Filler Rod	Result
1	100	ER70S2 M.S	No Defect
2	125	ER70S2 M.S	No Defect
3	150	ER70S2 M.S	No Defect

**Table 3 Liquid Penetrant Test results for different samples**

Sample No	Current	Filler Rod	Result
1	100	ER70S2 M.S	Surface finish not proper.
2	125	ER70S2 M.S	No Defect
3	150	ER70S2 M.S	Defect Found



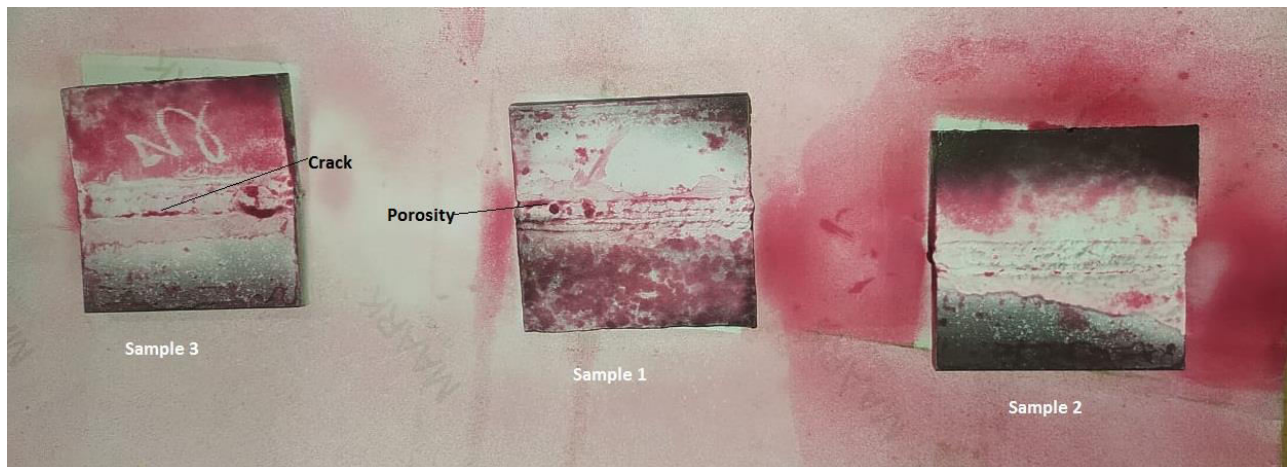


Fig 2 NDT tested samples with crack and porosity

#### V. CONCLUSION

The TIG welding is resulted in interior surface defects of the welds. A design of experiment technique, the penetrant test method has been used to identify the crack ability and TIG welding parameters (current, welding speed, gas flow rate). In Liquid penetrant Testing we are identify the No defect in Sample 2 (welded at 125amp current, welding speed 350 sec, Gas flow rate 6 L/min). Other samples “1” and “3” are identified as some defects like Toe cracks, and porosity. Ultrasonic Testing we are not find any defects in samples, so our samples provide better results

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