

# Design and Performance Analysis of Vacuum Arc Welding

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**ABSTRACT:** Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metal at the welding point. The welding region is usually protected by some type of shielding gas to prevent oxidation of the base metal. Another way of preventing oxidation is by conducting the welding process in the absence of air, i.e. in vacuum. In the present study, a new welding setup is so designed to conduct welding process inside a vacuum chamber. All the possible arc welding processes can be carried out inside this new setup with area of cross section of work materials up to 1 square meters. Vacuum is created inside a chamber made of stainless steel with top surface made of removable glass. The chamber has holes made on to it. One hole is made to attach a glove to hold the electrode and another one to attach vacuum gauge. Rest of the welding process is carried out in usual manner.

**KEYWORDS:** Welding, Arc welding, Vacuum welding, Strength analysis

## I. INTRODUCTION

Welding uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapour, or slag. Arc welding processes may be manual, semi-automatic, or fully automated. First developed in the late part of the 19th century, arc welding became commercially important in shipbuilding during the Second World War. Today it remains an important process for the fabrication of steel structures and vehicles.

One of the most common types of arc welding is shielded metal arc welding (SMAW), which is also known as manual metal arc welding (MMAW) or stick welding. An electric current is used to strike an arc between the base material and a consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapours that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination. The electrode core itself acts as filler material, making separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment.

## II. LITERATURE REVIEW

1. H. C. Miller "A Review of Anode Phenomena in Vacuum Arc;- Arc Melting is used for melting metals– typically to form alloys. Heating is via an electric arc struck between a tungsten electrode and metals placed in a depression (crucible) in the copper hearth. In vacuum arc melting the chamber is evacuated and then back filled with argon gas. Features: The metals can be heated to a temperature in excess of 2000°C. A batch of five alloys can be made in a single evacuation, as there are five crucibles in the hearth (four small and one large).
2. Vacuum Gauges by W.A. Tiller and J.W. Rutter:-BOURDON Vacuum Gauge The inside of a tube which is bent into a circular arc (the so-called Bourdon tube) is connected to the vacuum system. Due to the effect of the external atmospheric pressure, the end of the tube bends more or less during the evacuation process. This actuates the pointer

arrangement which is attached to this point. The corresponding pressure can be read off on a linear scale. With Bourdon gauges it is possible to roughly determine pressures between 10 mbar (7.5 Torr) and atmospheric pressure.

3. Tensile Testing By Stephan Favilla :- Tensile tests are fundamental for understanding properties of different materials, and how they will behave under load. This lab tested four different materials, including A-36 hot rolled steel, 6061-T6 Aluminium, polycarbonate, and polymethyl methacrylate (PMMA). Each material was tested three times using an In strong load frame and the Blue Hill data acquisition software.

4. Welding Metallurgy by George E. Linnert:- Welding in vacuum is a useful technique to assemble or to repair structures in space Electron-beam welding was developed, but it is dangerous for an astronaut to use because a high voltage power supply is required. An alternative method of arc welding in low pressure-in ecrets has been studied, while arc welding in vacuum has not yet been reported.

### III. OBJECTIVES

Welding industry is growing day by day with lots of new inventions and modifications. Main goals are increasing the strength of welded joint and its life time. In Arc welding decrease of strength in welded joints because of the surrounding gases. For a strong weld Atmosphere surrounding the welding process has to be stable.

#### The arc welding processes have following disadvantages

- Likely to be more costly to deposit a given quantity of metal
- Frequent stop/starts to change electrode
- Relatively high metal wastage
- Care required to preserve correct electrode alignment, as electrode Tip and weld pool are underneath solid flux cover
- Fume extraction may be required
- Atmosphere surrounding the welding process has to be stable (hence the shielding gasses), therefore this process is limited to draught free conditions
- Less efficient where high duty cycle requirements are necessary
- Radiation effects are more severe
- like slag inclusion or insufficient penetration happens

### IV. SOULTION METHODOLOGY

In arc welding process, the strength of welded regions reduced by the action of gases present in the atmosphere. To overcome this problem, It is going to introduce a new idea. In this project It is decided to apply arc welding in vacuum to avoid contact with gases. To create vacuum region by making a vacuum chamber.

#### Block diagram

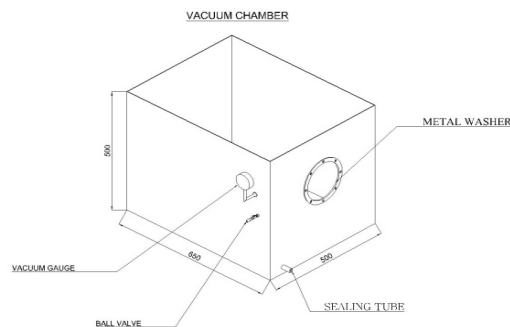


Fig. 1 Vacuum chamber

The main part of the experiment system is a vacuum chamber. The other parts attached to the vacuum chamber are the following

- Vacuum gauge
- Ball valve
- Brass fittings
- Welding cable and Holder
- Work table
- Work holding device
- Glass cover
- Welding machine

It is decided to use a metallic sheet 2 mm thickness as the material for vacuum chamber because of its strength, temperature withstanding capacity and it is very easy to transform into any other shapes. The top portion of chamber is covered by glass material for perfect view. To fix the glove, a hole is provided on the front side. Carbon fiber is selected for glove material due to its ability to withstand direct flame without melting, igniting or burning and it provides protection against molten metal and arc flash. Using a metallic washer and rivet, the glove is fitted on the chamber. A vacuum gauge is used to measure pressure inside the chamber. The chamber and Vacuum pump is connected using a Ball valve with Hose tap. It is used to regulate the air flow. A welding holder is placed in inside the chamber and its cable passes through the front wall of the chamber. A work table is fitted inside the chamber. The work table has a fixed jaw and a movable jaw. There is tightening mechanism provided on jaw.

It is preparing two welded joints with different atmospheric condition. One is welded in the normal atmospheric condition and the other one is welded inside the vacuum chamber. These two joints are subjected to tension test. Then compare the strength of two joints.

### Specifications of Parts

Table 1. Vacuum chamber

MATERIAL	GI
HEIGHT	50 CM
LENGTH	80 CM
WIDTH	45 CM
THICKNESS	2 MM

Table 2. Vacuum gauge

TYPE	COMPOUND TYPE
SHAPE	CIRCULAR
RANGE	0 TO -30 INCH OFF Hg
DIAMETER	45MM

Table 3. Welding equipment

SUPPLY	180-240V
FREQUENCY	50-60 Hz
PHASE	1Ph
CURRENT	50-200 A
AC / DC	AC

Table 4. Vacuum pump

POWER	0.5 HP
TYPE	ROTARY VANE PUMP
RPM	450
LUBRICATION STYLE	OIL-LESS
VACCUM PUMP STAGES	SINGLE
PUMPING SPEED	2-8 CFM

### V. RESULT AND DISCUSSION

It is preparing two welded joints with different atmospheric condition. One is welded in the normal atmospheric condition and the other one is welded inside the vacuum chamber. These two joints are subjected to tension test. Then compare the strength of two joints

Table 5. Results under atmospheric condition

Sl. No	Load (KN)	Area of cross section (mm <sup>2</sup> )	Stress (N/mm <sup>2</sup> )
1	5	161.29	31.00
2	10	161.29	62.00
3	15	161.29	93.00
4	17	161.29	105.40

Table 6. Test under Vacuum condition

Sl. No.	Load (KN)	Area of cross section ( mm <sup>2</sup> )	Stress (N/mm <sup>2</sup> )
1	5	161.29	31.00
2	10	161.29	62.00
3	15	161.29	93.00
4	17	161.29	105.40
5	19	161.29	117.80

As per the above observations we can prove that the specimen welded inside the vacuum chamber is stronger than the specimen welded in atmospheric condition

1. The maximum stress of specimen 1 = **117.80 N/mm<sup>2</sup>**  
(Welded inside chamber)
2. The maximum stress of specimen 2 = **105.40 N/mm<sup>2</sup>**  
(Welded outside chamber)

## VI. ADVANTAGES AND APPLICATIONS

Welding technology in space\vacuum is required to repair the space station. Arc welding in vacuum should be more conventional than electron beam welding because of low voltage operation. We can also make strong welded joints in vacuum arc welding process

- Welded region is more stronger than normal welding
- No dust particle inside the weld
- Smooth welding process
- Much better arc is produced
- Due to the absence of gases, less defects are happens in the region
- The welded region can withstand more tensile loading

### Scope of future work

- This project is basically about how to reduce the presence of gas particle while welding and analysis of its strength at vacuum condition and atmospheric condition
- We can also make a portable vacuum chamber so we can weld larger objects

## REFERENCES

- [1] H. C. Miller "A Review of Anode Phenomena in Vacuum Arcs". MEE Trans. On plasma Science, Xio1, PS- 13, No, S, pp. 242-252
- [2] W.A. Tiller and J.W. Rutter, Can. J. Phys., vacuum Gauges Vol 311, 1956, p 96
- [3] Welding Metallurgy by George E. Linnert GML Publications Hilton Head Island, South Carolina, USA
- [4] W.H. Sutton, in Proceedings of the Seventh International Vacuum Metallurgy Conference (Tokyo), the Iron and Steel Institute of Japan, 1982, p904-915