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Modification of Inert Oxy-Acetylene Welding Nozzle

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Abstract:
In Continuation of the project cited as Ref-1. Our team has taken a step further in this direction for improving and optimizing the nozzle design and its parameters for achieving better results from "Inert Oxy-acetylene Welding ".The project discussed here tackles with the shortcomings of the previous nozzle design, the most important was hindrance of the shielding gas with oxy-acetylene flame.In Inert oxy-acetylene welding Air in the weld zone is displaced by the shielding gas, thus preventing the contamination of the molten weld puddle.This contamination is caused by nitrogen, oxygen and water vapors present in the atmosphere. The idea of introduction of shielding gas in oxy-acetylene welding is based upon its usage in MIG/TIG welding process.Argon has been used as shielding gas to avoid defects associated with the contamination of the weld pool. The modified nozzle design proposed in this paper, thus eliminates the limitations of previous nozzle design and helps in optimization of the overall welding process. Therefore, the main flame and the shielding gas are appropriately distanced from each other. Flame temperature rises significantly, resulting in deeper penetration, better hardness and strong welds.

Keywords: *inert oxy-acetylene welding, nozzle optimization, parameter optimization, argon, quality of weld, TIG, MIG.*

1. Introduction

Inert oxy-acetylene welding process uses a shielding gas such as argon for shielding the weld pool from the outer atmosphere. The idea behind this concept came from other welding processes which are commonly used in the industry (GMAW and GTAW, more popularly known as MIG and TIG, respectively).Before This process oxy-acetylene welding was originally developed to provide a means to produce acceptable weld quality on a variety of metal materials. The gases present in weld zone, (atmospheric or dissolved in liquid metal) affect the soundness of the weld joint. Gases such as oxygen, hydrogen, nitrogen etc. are commonly present in and around the liquid metal. These gases should escape out during the solidification; due to high solidification rate encountered in welding processes these gases may not come up to the surface of molten metal and may get trapped. This causes gaseous defects in the weld, like porosity, blowholes etc. Owing to these limitations, it led to the development of modification of oxy-acetylene welding into inert oxy-acetylene welding.

This project is based upon further improvement and increasing the efficacy of the inert oxy-acetylene welding process. The nozzle design presented certain constraints which were like gas flame and shielding gas disturbance resulting inan unstable flame and thus, reduced flame temperatures. The new modified nozzle design solves this major problem and helps to increase the viability of the whole welding process by proper parameter optimization this nozzle design increases weld strength and produced better quality welds.

Apart from nozzle design and its impact on welding, this paper also explains the impacts of inert oxy-acetylene welding on the environment and the human welder. The effect of pollutants on the welding and its solution is presented here in this paper in a brief manner.

2. Nozzle Design

According to the inert oxy-acetylene concept, argon gas is supplied at periphery of the torch tip surrounding the flame, which results in the improvement of the performance of gas welding. It involves the minimum constructional maintenance and running cost, this attempt is quite useful for industrial purpose. It is an innovative approach to increase the temperature of the flame and hence increases the strength of welding and also improves the chemical composition of welded structure.

2.1. Comparison of Previous Design and the Modified Design

NOZZLE design as per (Feasibility Study and Development of Inert Oxy-Acetylene Gas Welding) technical paper is as follows:

2.1.1. Previous Nozzle Design

The previous design prepared by our seniors had also two parts, one was for the main flame and the second was for supplying argon at the periphery of the main flame. But this design had a flaw and it generated some problems. The schematic diagram of the previous design is shown as follows-

Figure 1

Its construction is as follows. Grooved portion of the inner part was cut down to an appropriate length by holding it on the lathe machine and performing the cutting operation. Then the grooved part was welded at the tip of welding nozzle. The outer part is then drilled with a hole on its periphery at a larger cross-section. A Plane washer is then welded to the upper portion of the nozzle modified in the previous step and then inserted in the outer part of cutting nozzle in a manner that the washer touches the end of the outer part and the whole is welded.

The remaining portion of the inner part is then welded in line to the hole drilled in the outer part. It is welded for the supply of inert gas.

2.1.2. Flaw in This Design

As we can see in the picture shown above the inner part that supplies shielding gas (argon) is converging. Due to its construction/design it was found during testing that the argon is interfering with the main flame and thus, disturbing it thereby, reducing the required flame temperature for welding.

2.1.3. Modified Design of the Nozzle

The design we have prepared is as explained:

The welding nozzle is made in two parts which are screwed with each other.

The main welding flame passage is converging.

The outer part is cylindrical and extended to form the gas lens.

The shielding gas is fed to the outer jacket and it comes out through small holes near the main flame.

The shielding gas and welding flame are appropriately away from each other without interfering the main flame.

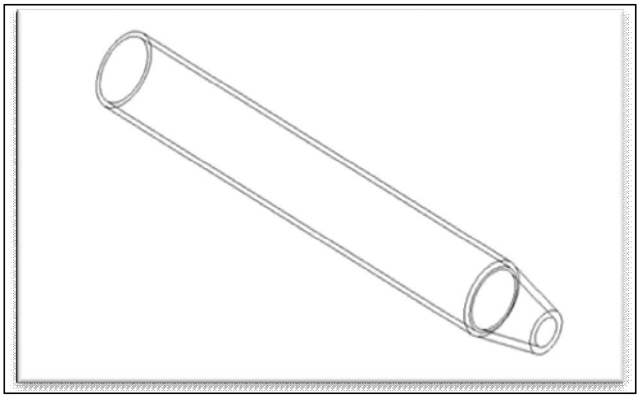


Figure 2: Main Flame Passage

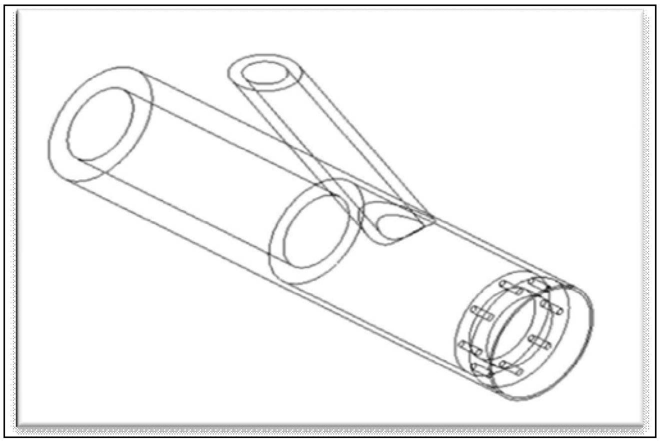


Figure 3: Outer Jacket for Shielding Gas Flow

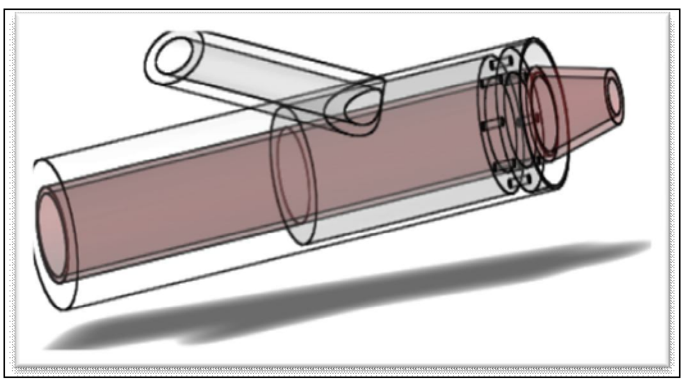


Figure 4: Complete Nozzle Assembly

3. Chemistry of the Flame

When acetylene is burned in air, the end products are carbon dioxide (carbon plus oxygen) and water vapor (hydrogen plus oxygen). A chemical equation covering complete combustion reads like this:

$2\ C_2H_2 + 5\ O_2 = 4\ CO_2 + 2\ H_2O$

The above chemical reaction is for the conventional oxy-acetylene welding. In this reaction if we divide it by 2 we get, 1 mole of C_2H_2 will react with 2.5 mole of O_2 will produce 2 mole of CO_2 and 1 mole of H_2O. Now, in case of 2.5 mole of O_2, we consume 1part of the oxygen from cylinder and 1.5 part of oxygen from atmosphere.

On contrary to this, in Modified inert oxy-acetylene welding nozzle, as we provide Shielding to the flame using inert gas, there is no oxygen available from atmosphere and we are consuming it from cylinder. But, the advantages of using this design are as follows:

- Faster welding speed.
- Slower Solidification of weld bead and hence better weld grain structure.
- No galvanic reaction of weld metal with other gases present atmosphere.
- Higher Strength.
- No fumes generation.

4. Eco- Friendly Initiative

It is evident that our atmosphere contains mainly of 78% Nitrogen (N_2), 21% Oxygen (O_2) {approximate values} and remaining 1% consists of CO_2, Helium (He), Methane (CH_4) Etc. and other gases by volume.

During these recent times the most important problem the world is facing right now is "POLLUTION".

Some of The factors leading to pollution are:

- Rapid industrialization.
- Increasing use of automobiles.
- Population growth.
- Globalization, et al.

Our main concern now-a-days is air pollution which affects surrounding air quality. The above factors discussed here produce emissions which ultimately pollutes the atmosphere.

The pollutants which are responsible for air pollution are as follows:

- NO_x (oxides of nitrogen),
- SO_x(oxides of sulphur),
- SPM(Suspended particulate matter ,PM 10 & PM 2.5) ,Ozone(O_3),
- Carbon mono oxide CO and CO_2,
- Benzene etc.

Not only the presence of these contaminants/pollutants prove deleterious for human health, but they also affect the weld quality which is further explained here in this project.

As an effort from our side, we tend to not only minimize air pollution by making the welding process more environment friendly, but also making it less hazardous for the welder.

The effect of pollutants/contaminants on the weldment and the environment are discussed as below:

4.1. Effect of (Nitrogen and its oxides)

NO_X decompose into nitrogen (N_2) and nascent oxygen (O) and this oxygen reacts further with O2 in the atmosphere to form deadly ozone (O_3) at high temperatures such as here at 3000 deg. Celsius.

An illustration:

Decomposition of NO_x at high temperatures

Reaction:$NO_2 \rightarrow NO + O$ (Nascent)

Now this nascent oxygen will combine with atmospheric oxygen O2 to form ozone.

Reaction:$O_2 + O \rightarrow O_3$

$2NO \rightarrow N_2 + O_2$

NO further reduces to form N2 and O2.

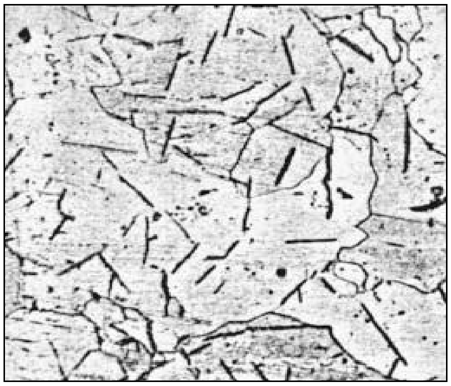


Figure 5: Nitrogen cracking

Thus we observe that the nitrogen released in the last reaction causes nitrogen cracking and forms needle like cracks on the weld surface and most importantly pollutes the environment by emitting ozone.

This scenario can be avoided by using a shielding gas during welding as an inert atmosphere will not allow the contaminants to leak into the weld zone.

Therefore, in the same manner if the SO_x (oxides of sulphur) are present in the welding environment, it would form sulphuric acid which corrodes the weld and it may form dangerous welding fumes.

4.2. Effect of Benzene on Weld

Benzene present in atmospheric air even in small quantity can affect the welding after reacting with oxygen at higher temperature through following reaction:

$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O$

The CO2 released gets trapped in the metal, causing porosity. In addition, excess oxygen can combine with other elements in steel and form compounds that produce inclusions in the weld metal.

4.3. Effect of Suspended Particulate Matter

short for SPM's which include minute dust particles and particulate matter(PM 10 and PM 2.5), inhalable particles, respirable particles, smoke, mist (generally in ppm) when present in the surrounding air while welding causes porosity in the welds which affects the strength of the weld ultimately.

Figure 6

FIG; Round holes in the weld bead are a sign of a defect called weld metal porosity.

Thus, we observe that by using a shielded atmosphere for welding the above defects can be minimized and the emission of the pollutants is reduced.

5. Effect of Inert Oxy-Acetylene Welding on Welder

As discussed above earlier, not only inert oxy-acetylene welding produces better welds than the conventional method, but it also minimizes the welding emissions such as CO2, CO and ozone etc.

Effect of CO: Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death.

Effect of nitrogen oxides: Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems.

Effect of ozone: Acute effects include fluid in the lungs and hemorrhaging. Very low concentrations (e.g., one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function.

These above effects can be avoided significantly by using inert oxy acetylene welding rather than the normal gas welding setup.

6. Advantages of Inert Oxy-Acetylene Welding

Following are the advantages of the modified nozzle design:

- Better quality welds as a result of shielding.
- Seasonal defects are minimized.
- Deeper penetration of flame due to increase in temperature of flame.
- Lesser emissions (More eco-friendly).
- Chemical composition of weld is improved.
- HAZ (Heat Affected Zone) microstructure is enhanced.
- The welding speed is increased and flame temperature increased by 400°C.

7. Result

The results produced are as follows:

- Hardness- Test Method: IS 1501(PART 1)-2013

Location	Observation	Test method
Weld	137-139	IS 1501(Part 1)-2013
HAZ	128-130	
Parent Metal	122-124	

Table 1: With Argon as Shielding Gas

Location	Observation	Test method
Weld	124-126	IS 1501(Part 1)-2013
HAZ	130-132	
Parent Metal	120-122	

Table 2: Without Shielding Gas

- Microstructure- Test Method: ASM-9, 2004 & IS 4748-2009

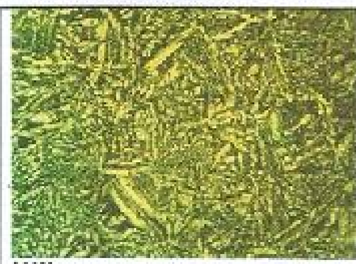
Observed Results	
WELD: The structure consists of grains of α and β phase.	 200X
PARENT: The structure consists of grains of ferrite. Grain Size - 7-8 100X	 200X
HAZ: The structure consists of grains of ferrite.	 200X

Figure 7: With Argon as Shielding Gas

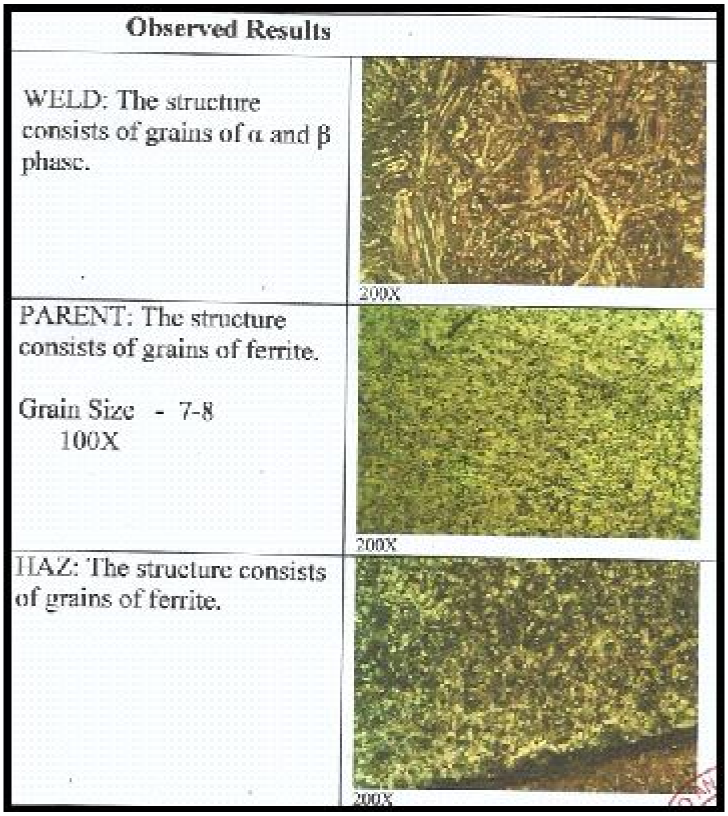


Figure 8: Without Shielding Gas

8. Conclusion

The new design of the welding nozzle prepared by our team thus, eliminates the problem of main flame disturbance due to shielding gas flow and the produced flame would be more intense. Argon flows at the outer periphery of the main flame and it follows a straight cylindrical path without interfering with the oxy-acetylene flame.

This design improves the penetration depth and the Grain structure of the welding improves as the weld pool will solidify slowly. We have finalized this design after designing it on a 3-D modelling software. The weld pool temperature increased by 400°C and also as per results produced, strength of welding is increased considerably. There is neither inclusion of slag nor blow holes produced. Thus better welding can be done by this method economically.

Limitations: Due to limited resources and the non-availability of certain tools which are exclusive to industry as they were not present in the various domestic markets we couldn’t manufacture the nozzle up to the desired level of accuracy and finishing. But with industry grade tools and resources this design can be easily produced to achieve improved results.

9. Acknowledgments

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