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STUDY OF CRACK PROPAGATION DURING ROCKWELL HARDNESS AND CHARPY IMPACT TOUGHNESS TEST OF GAS WELDING WITH BRASS FILLED JOINT OF DUPLEX STAINLESS STEEL-2205 SPECIMEN

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Abstract - *The main aim of my present work is to study about crack propagation and investigate the Hardness and Charpy impact strength of gas welding of brass filled welded joint of Duplex Stainless steel-2205 specimen. The Hardness and impact strength is most important factor in considering the transport of gases & liquid fluids over a long distance which is mostly carried in pipe lines and making huge pipe without joints is impossible. So, there is possible of making joints in pipes so, we prefer to have strong joints in pipes in which there is no possible way in leakages and in this present work we choose TIG welding and calculate its hardness & impact strength.*

***Index terms* -** *gas welding, Charpy impact test, Rockwell Hardness*

***Nomenclature* -** *ASTM: American Society for Testing and Materials.*

1. INTRODUCTION

With the Modern Technological advancement, more structural materials are designed to carry heavier loads. Many structural parts need to be welded and the discontinuous parts of these structural materials need up to the mark of standard design to carry these loads. The hardness and impact strength are main determining factor to check whether material can withstand sudden loads. The Duplex Stainless steel-2205 is an austenite - ferrite alloy with the addition of Nickel, copper, chromium etc… It is designed to provide exceptional resistance to many corrosive environments. The nickel content is sufficient for resistance to chloride ion stress corrosion cracking.

Toughness of material in physical sense gives the energy a specimen can absorb when affected with sudden load until failure. Charpy Impact Testing is an ASTM standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample. The specimen either breaks (or) the weight rests on the specimen. From the energy absorbed by the sample, its impact energy is determined which indirectly determines the toughness of specimen.

2. METHODOLOGY FOLLOWED IN PRESENT WORK

- Two Duplex Stainless steel Specimen of 55*55 mm were prepared for gas (oxy-acetylene) welding
- Gas welding was carried out at 3600^{0}C. The specimen is welded with gas flame which acts as electrode to make it more effective than arc welding.
- The filling of Specimen was carried out with proper joining and removing impurities on the welded surface.
- After getting the required welded specimen, the notch was prepared of 2mm depth by means of shaper machine.
- The testing of welded joints first carried out in Rockwell Hardness Testing Machine and second it is carried out in Charpy Impact testing machine.

3. EXPERIMENTAL APPARATUS

A .Gas (Oxy-Acetylene) Welding

Although the oxy-acetylene process has been introduced long time ago it is still applied for its flexibility and mobility. Oxy-fuel welding, commonly referred to as oxy welding or gas welding is a process of joining metals by application of heat created by gas flame. The fuel gas commonly acetylene, when mixed with proper proportion of oxygen in a mixing chamber of welding torch, produces a very hot flame of about 5700-5800°F.

Principle of gas welding

The combination of oxygen and acetylene in near equal proportions produces a flame that has the intense heat (3000 °C) required to melt most metals. The oxy-acetylene gas combination is the only oxygen-fuel gas combination that burns completely to produce a non-reactive secondary flame or envelope suitable for fusion welds. This secondary flame does not influence the weld pool and also acts as a neutral shield that protects the weld and weld area from the effects of atmospheric gases. If the adjacent edges of two compatible materials are melted, then the edges may fuse together. A suitable filler may or may not be required. Other fuel gases such as LPG or propane produce a reactive secondary flame that interferes with the molten metal.

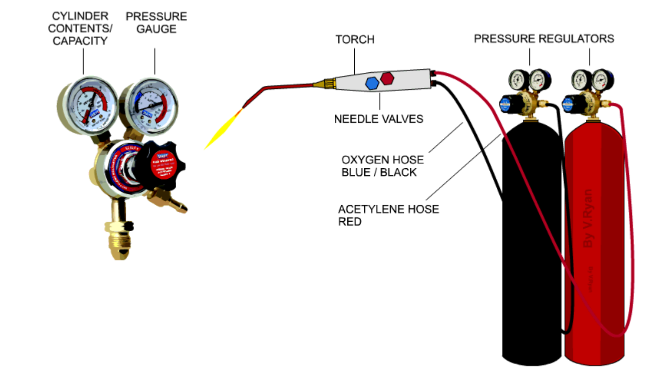


Fig .1 A VIEW OF GAS (OXY-ACETYLENE) WELDING

Equipment Details

Oxy-fuel apparatus consists of two cylinders (one oxygen and one acetylene) equipped with two regulators, pressure gauges, two lengths of hose, and a blow torch. The regulators are attached to cylinders and are used to reduce and maintain a uniform pressure of gases at the torch. The gases at reduced pressure are conveyed to the torch by the hoses. The regulators include high pressure and low pressure gauges to indicate the contents of the cylinder and the working-pressure on each hose. When the gases reach the torch they are there mixed and combustion takes place at the welding tip fitted to the torch.

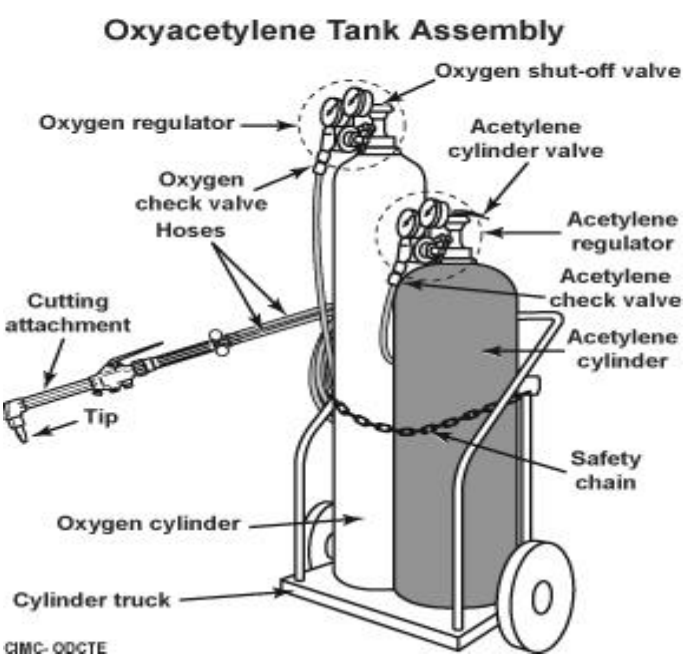


Fig .2 ASSEMBLY/PARTS OF GAS (OXY-ACETYLENE) WELDING

The basic exponents used to carry out gas welding are:

1) Oxygen gas cylinder (green)
2) Acetylene gas cylinder (maroon/red)
3) Oxygen pressure regulator
4) Acetylene pressure regulator
5) Oxygen gas hose (blue)
6) Acetylene gas hose (Red)
7) Welding torch or blow pipe with a set of nozzles and gas lighter
8) Trolleys for the transportation of oxygen and acetylene cylinders
9) Set of keys and spanners
10) Filler rods and fluxes
11) Protective clothing for the welder (e.g., asbestos apron, gloves, goggles, etc.)

Characteristics of the oxy-acetylene welding process include

- The use dual oxygen and acetylene gases stored under pressure in steel cylinders.
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip.
- The high temperature the gas mixture attains (~5800°F).
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks.
- The use of double line rubber hoses to conduct the gas from the tanks to the torch.
- Melting the materials to be welded together.
- The ability to regulate temperature by adjusting gas flow.

Applications

- Flux free fusion welding of plain carbon steel
- Fusion welds of pure aluminum and some alloys (flux required)
- Fusion welds of some stainless steels (flux required)
- Fusion welds of copper and copper based alloys (flux required)
- Fusion welds of other metals (requires great skill)
- General repairs

Advantages

- Equipment set-up simple
- Equipment is readily available and portable
- Wide range of applications
- Cheap consumables

Limitations

- Large heat affected zone (distortion)
- Slow output
- More suitable processes are available

Types of Welding Flames

In oxyacetylene welding, flame is the most important tool. All the welding equipment simply serves to maintain and control the flame. The flame must be of the proper size, shape and condition in order to operate with maximum efficiency. Three distinct types of flames are possible on adjusting the proportions of acetylene and oxygen:

1) Neutral Flame (Acetylene oxygen in equal proportions)
2) Oxidizing Flame (Excess of oxygen)
3) Reducing Flame (Excess of acetylene)

The acetylene and oxygen values are necessary to maintain the correct flame. The actual adjustment of the flame depends on the type of material to be welded. ***The below table shows the flame adjustment for different materials for better/best output.***

Metal	Flame
Mild Steel	Neutral
High Carbon Steel	Reducing
Aluminum, Nickel Alloy	Slightly Carburizing
Brass	Slightly oxidizing
Lead, Alloy Steel	Neutral
Copper, Bronze, Grey Cast-iron	Neutral, Slightly oxidizing

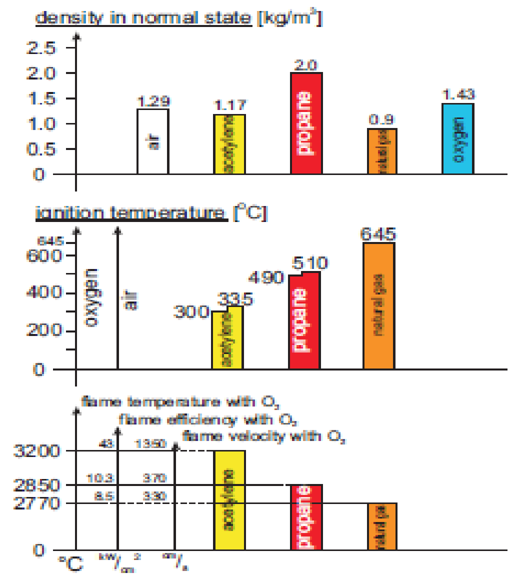
Test Images after Welding Process

Fig .3A

Fig .3B

Fig.3A & 3B Specimen images after Welding

Properties of fuel in-combination with oxygen



B. ROCKWELL HARDNESS TEST

Stanley P. Rockwell invented the Rockwell hardness test. This Hardness test uses a direct reading instrument based on the principle of differential depth measurement. He was a metallurgist for a large ball bearing company and he wanted a fast non-destructive way to determine if the heat treatment process they were doing on the bearing races was successful. The only hardness tests he had available at time were Vickers, Brinell and Scleroscope. Here we measure Hardness at Scale B (Steel Ball Indentor)

Principle of Rockwell Hardness Test

- Position the surface area to be measured close to the indenter.
- Apply the minor load and a zero reference position is established.
- The major load is applied for a specified time period (dwell time) beyond zero.
- The major load is released leaving the minor load applied
- The dial contains 100 divisions, each division representing a penetration of 0.002mm

Fig. 4 Rockwell Hardness Testing

TABLE 1

Various types of Rockwell Scale & Indentor

Rockwell Scale	Hardness Symbol	Indentor	Load(Kg)
A	HRA	Diamond Cone	60
B	HRB	1.6 mm Steel ball	100
C	HRC	Diamond Cone	150

Advantages

- Easy & quick to test the material
- It is suitable for testing large product series.

C. CHARPY IMPACT TEST

In simple words impact test can be said as Material which can resist sudden loads and heavier loading condition. A metal may be very hard (and therefore very string and yet be unsuitable for applications in which it is subjected to sudden loads in service. Materials behave quite differently when they are loaded suddenly than when they are loaded more slowly as in tensile testing. Because of this fact, impact test is considered to be one of the basic mechanical tests (especially for ferrous metals).

The term brittle fracture is used to describe rapid propagation of cracks without any excessive plastic deformation at a stress level below the yield stress of the material. Metals that show ductile behavior usually can, under certain circumstances, behave in a brittle fashion. The stress needed to cause yield rises as the temperature falls. At very low temperatures, fracture occurs before yielding

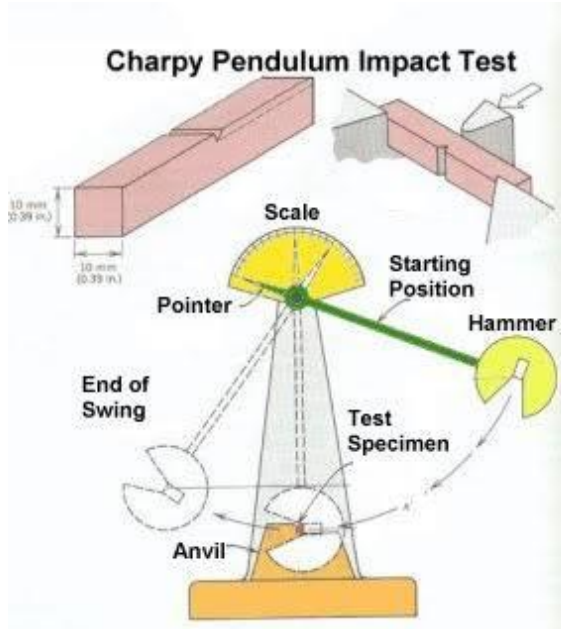


Fig. 5 Charpy Impact Pendulum Test

Test Image of Material after Testing in Charpy Pendulum Impact Test

4. RESULTS

A .ROCKWELL HARDNESS VALUES

The below two tables shows the Hardness values at two different conditions for welded joint and work piece specimen

AT 3-0 initial condition

APPLIED LOAD (kg-f)	HARDNESS VALUE AT WELDED JOINT	HARDNESS VALUE OF SPECIMEN
60	45	18
100	42	18
150	4	15
187.5	80	11
250	27	7

AT 4-0 initial condition

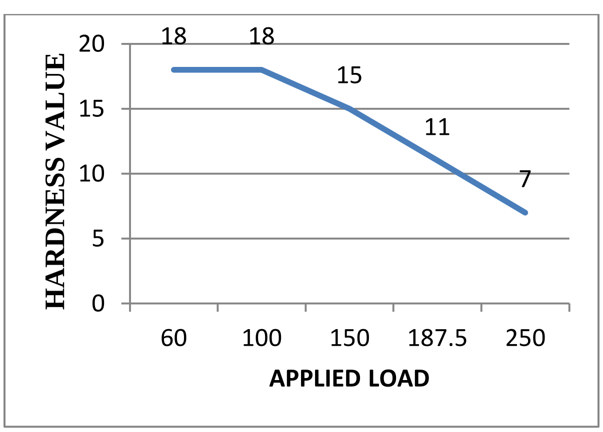
APPLIED LOAD (kg-f)	HARDNESS VALUE AT WELDED JOINT	HARDNESS VALUE OF SPECIMEN
250	92	92

B .CHARPY IMPACT TEST

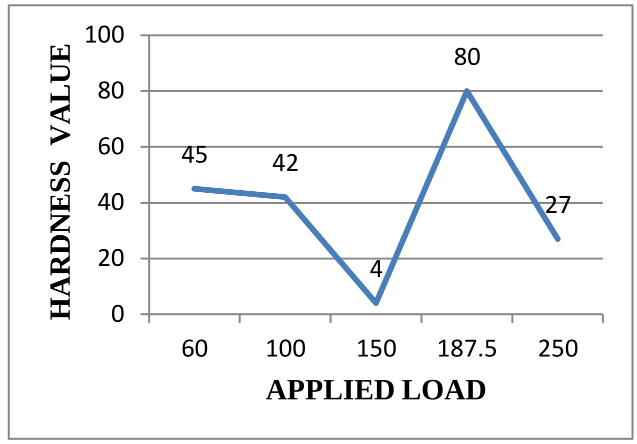
INITIAL ENERGY BEFORE FRACTURE (E1) Joule	ABSORBED ENERGY AFTER FRACTURE (E2) Joule	ABSORBED ENERGY OF SPECIMEN (E2-E1)
146	146	63 Joule

GRAPHS

For duplex stainless steel Material



For Brass (Oxy-Acetylene) Welded Specimen



5. OBSERVATION

- Gas welding has been successfully executed in joining two specimens.
- Charpy impact testing machine is used in calculating the impact strength of specimen.
- Rockwell Testing Machine is used in calculating Hardness of Specimen.
- From Rockwell Hardness Testing it is clear that hardness value at welded joint is nearly equal and greater to that of specimen
- From Charpy impact test it is clear that Material undergoes brittle fracture and can withstand applied heavier loads.

6. CONCLUSIONS

From the Values obtained from both Rockwell Hardness and Charpy Impact testing we can conclude that

- Welding can been Perfectly achieved with proper filling of specimen joints and removing impurities as which is important factor in achieving proper welding. As perfect welding can withstand heavy loads.
- From Rockwell Hardness testing it is clear that hardness of our material and welded joints are up to our required mark.
- From Charpy Impact test it is clear that 62 Joule is the absorbed energy when hammer is made hitted by the specimen but oxy-gas welded joint is weak as it undergone brittle (break) fracture. So, it is clear that it can be used in light weight carrying pipe lines etc…and can be said to be weak joint.

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