ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

Defect Reduction in an Arc Welding Process Using Cause and Effect Diagram

Muhammed Raazick[1]Noorshan[1], Rashid K[1], Rumaisa C M[1] Sanmishal P K[1], Jibi.R[2]
[1] Graduate Student, [2]Assistant Professor Department of Mechanical Engineering, AWH Engineering College Calicut, Kerala, India

Abstract— ***Demands are increasing on companies for high quality, reliable products. The increasing capabilities and functionality of many products are making it more difficult for manufacturers to maintain the quality and reliability. The challenge is to design in quality and reliability early in the development cycle. The quality management of manufactured products is one of the main aims in the production process. To make the process more objective rather than relying on the subjective opinion of people, automatic inspection and analysis techniques must be used. Although welding is a straightforward process, metal is a dynamic material, expect many twists and turns along the way. Welding defects can greatly affect weld performance and longevity. Non-Destructive Testing (NDT) techniques have been employed to test a material for surface or internal flaws without interfering in any way with its suitability for service. This paper discusses an effective method to analysis the welding defects using one of the seven quality tool, cause and effect diagram.***

Index Terms— **Defect detection, Pareto charts, Defect, Welding, analysis.**

I. INTRODUCTION

Welding is a process of joining of two piece of metal together to form one piece; a strong metallurgical bond is creating between the metals to be joined. Welding is distinguished from other forms of mechanical connections ,such as riveting or bolting which are formed by mechanical interlocking welding is a permanent joining of two piece of material. Welding process is used in large applications of mechanical engineering.Qualitymanagement of manufactured product is one of the main important things in manufacturing process. Welding defects can greatly affect weld performance and longevity. Non-Destructive Testing (NDT) techniques have been employed to test a welded joint for internal or external defects. Commonly using nondestructive testing methods are magnetic particle testing, die penetrant testing and ultrasonic testing in order to identify external or internal defect.

In the present work welded samples are under go nondestructive examination in order to identify the welded defects. Ultrasonic testing, die penetrant testing, magnetic particle inspection methods are used in this work to identify deects.identified defects are analyzed by using one of the seven quality tool cause and effect diagram. Cause and effect is used to conduct a root cause analysis. In Root Cause Analysis is the process of identifying causal factors using a

Structured approach with techniques designed to provide a focus for identifying and resolving problem. A Cause-and-Effect Diagram is a tool that helps identify, sort, and display possible causes of a specific problem or quality It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram"

Because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it looks.

II. LITERATURE REVIEW

- ***Defect in welding***

The defects in the weld can be defined as irregularities in the weld metal produced due to incorrect welding parameters or wrong welding procedures or wrong combination of filler metal and parent metal. Different types of welding defects are given below.

Crack: Crack may be microscopic scale or macroscopic scale and appear in the base metal, base metal weld metal boundary, or in the weld metal, weld surface or under the weld bead. The main causes of crack are poor ductility of base welding, fast arc travel speed, electrode with high H_2 content.

Distortion: During welding a good amount of temperature gradient at various points along the joint. Base metal under the arc melts, base metal ahead gets pre heated and base metal portion already welded starts cooling. This phenomena leads to distortion. The various factors leading to distortion are more number of passes with small diameter electrodes, slow arc travel speed and high residual stresses in plates to be welded

Incomplete penetration: penetration is the distance from base metal top surface to the maximum extends of the weld nugget.

Main reasons are too large root face, less arc current, faster arc travel, longer arc length etc.

Inclusions; inclusions may be in the form o slag or any other foreign material, which does not get a chance to float on the surface of the solidifying weld metal and thus gets trapped inside the same. Inclusions lower the strength of the joint and make it weaker. The main reasons are too high or too low arc current, long arcs, too large electrode diameter, too small included angle of joints.

Porosity: porosity is a group of small voids, They occur mainly due to the entrapped gases. The parent metal melted under the arc tends to absorb gases like hydrogen, carbon Monoxide, nitrogen and oxygen I they are present around the molten weld metal pool. These gases get spread through the molten metal pool. The solubility of the gases are in the molten metal reduces as it cools, and the dissolve gases escapes through numerous holes in the weld bead called porosity. Main reasons are incorrect welding technique, improper base metal composition etc.

Gas holes: Blow holes are large cavities present inside the weld bead, it is also known as gas pockets ,they are bigger isolated holes or cavities.it is due to gas trapped in the weld metal pool remain in there during solidification. After solidified the space is not filled with weld meal.

Spatter: spatter is small metal particles which are thrown out of the arc during welding and get deposited on the base metal around the weld bead along its length. Spatter may be due to excessive arc current, longer arc, electrode being coated with improper flux ingredients etc.

Under cutting: In under cutting a groove gets formed in the parent metal along the side of the weld bead. Groove reduces the thickness of the plate and thus the area of the bead, which in turn weakens the weld. The main cause of undercutting is too large electrode diameter, higher current, longer arc, faster arc travel speed.

Overlapping: An overlapping occur when the molten metal from electrode flows over the parent metal surface, and remain there without getting properly used and united with the same. Overlapping may occur due to lower arc current, slower arc travel speed, longer arc etc.

Poor fusion: the molten metal deposited by the electrodes does not fuse properly with the cold base metal the two do not unite properly and completely. The fusion may be lacking at the root, side, or between two runs in amulti-run weld.it is due to poor arc current, faster arc travel, improper weaving technique

- ***Non-destructive testing***

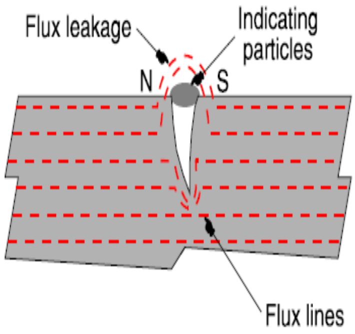
Non-destructive testing method used to identify internal and external defects are visual examination, vibration testing, pressure test, dye penetrant testing, radiographic examination, ultrasonic testing, magnetic particle testing, and eddy current testing.

Visual examinations: It consists of checking the surface of casting with eye magnifying lens or low power microscope etc.

Vibration test: This test is also known as sound test, percussion test and ring test.casting is swing freely and tapping with hammer to set up vibration and certain characteristic tone. Sound produced is listened electronically and compared that o sound of casting.

Pressure test: They are used to find out the presents o leak in casting. The casting is immersed in tank carrying water and air pressure is applied, if there is leak bubbles will form.

Magnetic particle testing: Magnetic particle inspection is used for alloy and steel, their alloy possessing magnetic property. The casting is first magnetized iron filing are sprinkled in the casting which align in the direction o line o force.deect are noticed iron filling jumble around the defect.



Fig; 1 Magnetic particle testing

Radiographic testing; Material with internal void is tested by placing the object between source of radiation and filim.the voids are shown by darkened area where more radiations has reached the filim. The part is placed between the radiation source and a piece of film. The part will stop some of the radiation. Thicker and denser area will stop more of the radiation. The film darkness (density) will vary with the amount of radiation reaching the film through the test object.

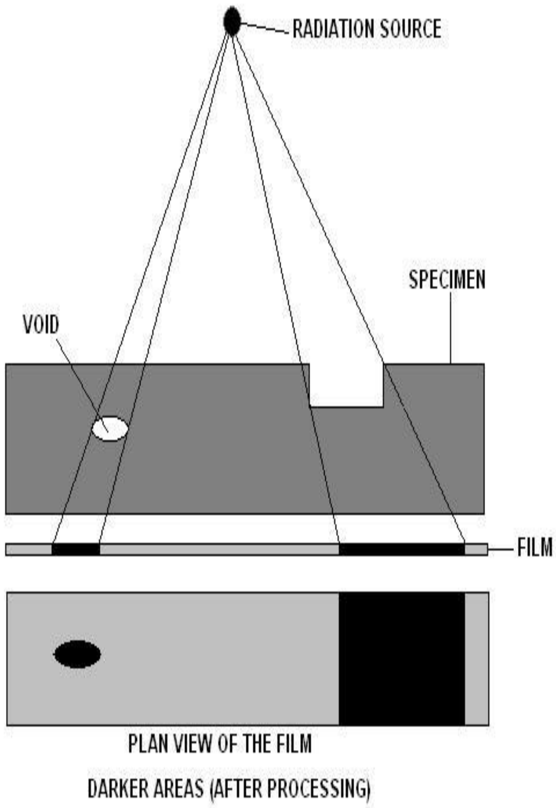


Fig 2:Radiographic testing

Dye penetrant testing: this method is requently used for detection o surace breaking flaws in non ferromagnetic material.The surace to be examined is irst chemically cleaned to remove foreign material.the de penetrant is applied.capillary action draws thw penetrant in to crack during this period.the surplus penetrant on the surace is then removed and thin coating of powdered chalk is applied.ater some time the chalk draws the dye out of cracklike a bottle paper provide visiual magnefied indication of the defect.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

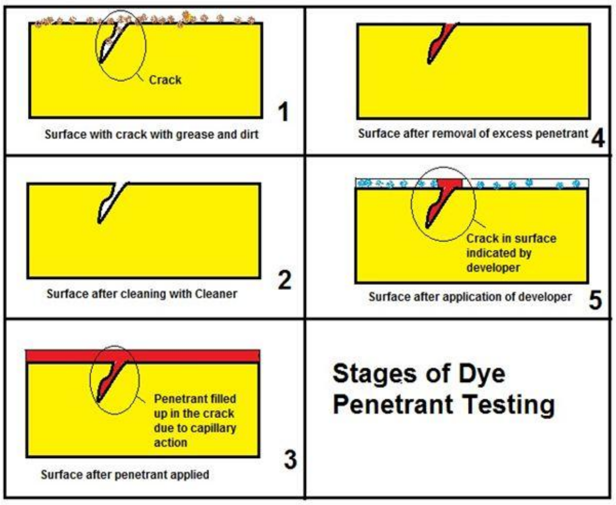


Fig 3: Dye penetrant testing

Ultrasonic testing: It is based on reflection of high frequency sound wave. If the section is homogeneous free rom defect.

The wave is reflected after travelling all section. If the casting contain any defect. The wave is reflected after travelling all section. If the casting contains any defect the wave is reflected from the surface of that defect and return in shorter period of time.an oscillograph is used to detect the length of time.

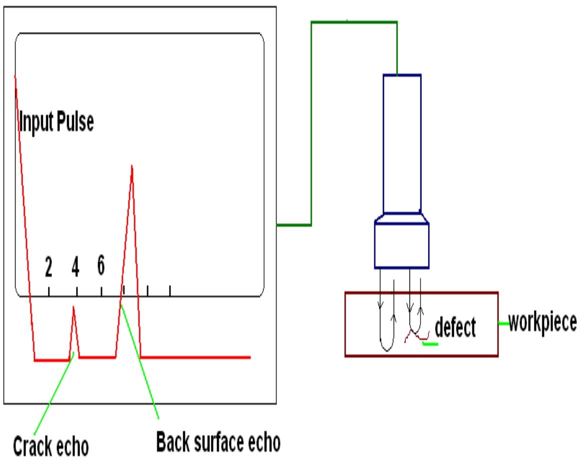


Fig 4: Ultrasonic testing

Eddy current testing: Eddy current testing is used to detect surface or subsurface flaws. Eddy current can be produced in any electrically conducting material that is subjected to alternating magnetic field. The magnitude of eddy current depends on the conductivity, permeability and geometry. Any change in material or geometry can be detected b change in coil impedance. When a crack occurs in a surface the eddy current must travel around the crack and this can be detected by the impedance change.

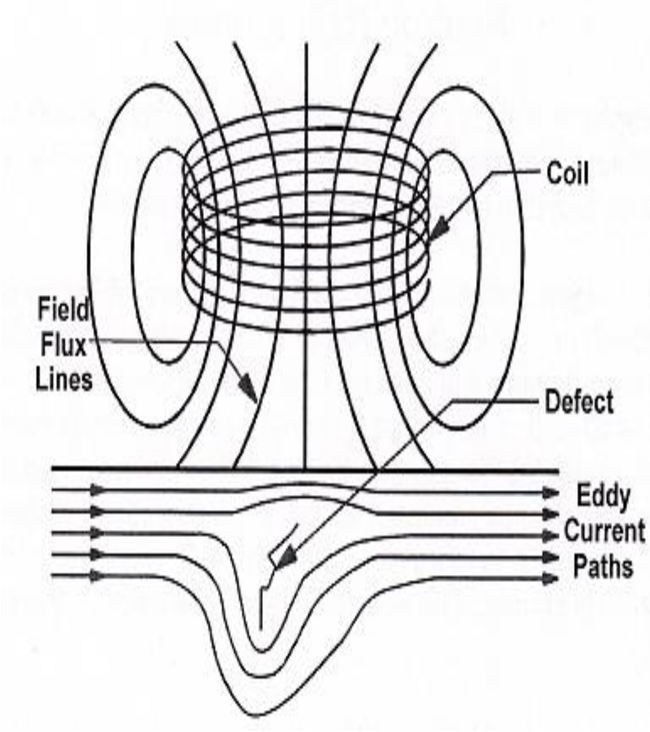


Fig 5: Eddy current testing

- ***Cause and effect diagram***

Cause and effect diagram is one of the seven quality tool. The Seven Basic Tools of Quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve majority of quality-related issues. The Seven Basic Tools of Quality includes:

1) Flowchart
2) Control chart
3) Scatter diagram
4) Histogram
5) Pareto chart
6) Check sheet
7) Cause and Effect Diagram (Ishikawa diagram)

A Cause-and-Effect Diagram is a tool that helps identify, sort, and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram “because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it looks.

A Cause-and-Effect Diagram is a tool that is useful for identifying and organizing the known or possible causes of quality, or the lack of it. The structure provided by the diagram helps team members think in a very systematic way. Some of the benefits of constructing a Cause-and-Effect Diagram are that it.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

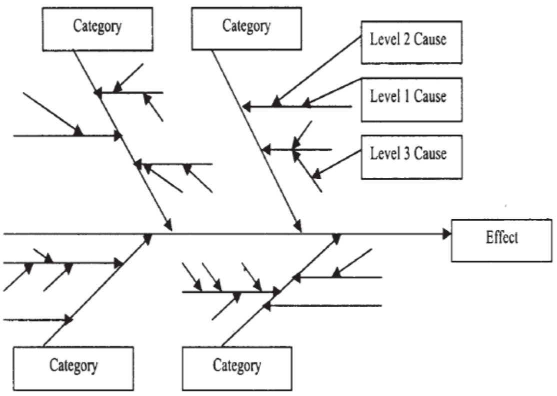


Fig 6: Cause and effect diagram

III. WORK DONE

1. Preparation of welded samples

Two types of samples are prepared. Sample no 1 have a 10 quantities and sample no 2 have 1quantity.sample no 2 undergo ultrasonic testing.

The figure below show the drawing of sample no: 1

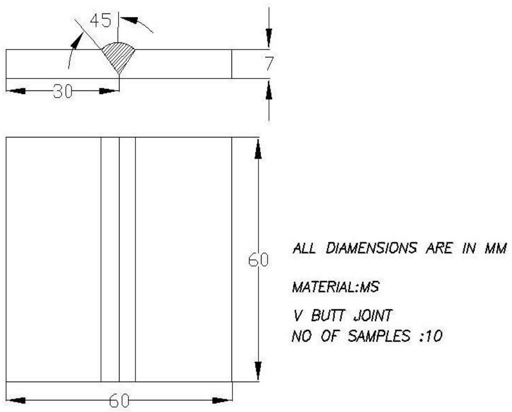


Fig 7: Cad drawing of sample No: 1

The figure below show the drawing of sample no: 2

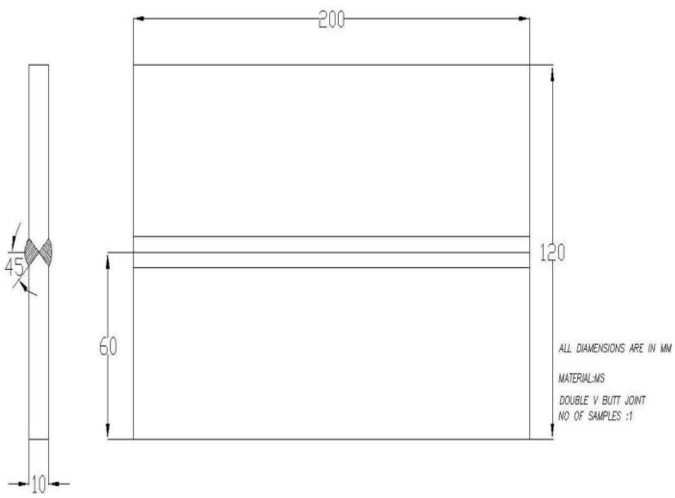


Fig 8: Cad drawing of sample No: 2

2. Welding Parameter

Welding type: Shielded Metal Arc Welding (SMAW)
Diameter of electrode: 3.15mm
Length of electrode: 350mm
Current required: 150amp DC/AC
Temperature produced: 6000-7000 Degree

3. Non -destructive testing of welded samples

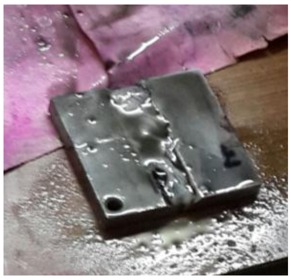
The following nondestructive testing is conducted on welded samples. Ultrasonic testing is only conducted sample no two.

Visual Inspection
Magnetic Particle Testing
Die Penetrant Testing
Ultrasonic Testing (conducted only in sample no: 2)

Magnetic particle testing conducted with magnetic ink INSTACHEK ML -72 B black oil base.

Step: 1

Step: 2

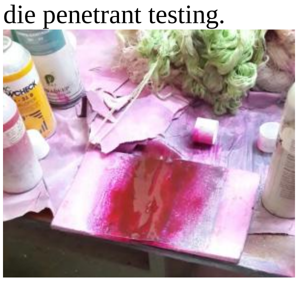


Step: 4

Step: 5

Fig 9: Magnetic particle inspection

In Die Penetrant Testing visible penetrant AMS2644/MIL-1-25135 is used .the figure below show die penetrant testing.



Step: 1

Step: 2

Step: 3

Fig 10: Die penetrant testing

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

Ultrasonic testing conducted in sample no 2.ultrasonic flaw detector used for identify defects. Ultrasonic flaw detector has Contact Angle Probe, beam angle 70 Degree is used for testing.

Minimum distance between center of weld bead and probe (calculation of SD)

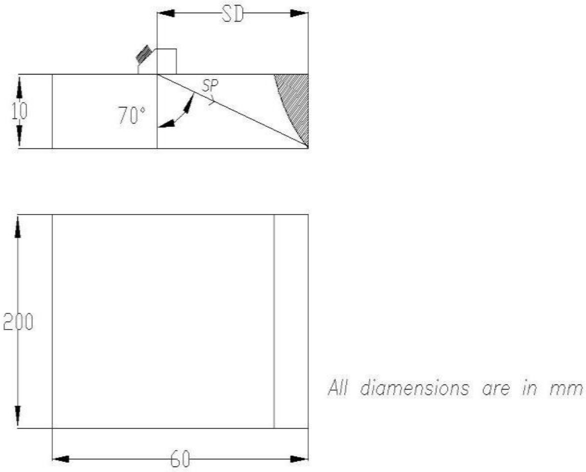


Fig 11: Calculation of SD value

SP=direction of sound wave travel.

SD=10*tan70

=27.47mm

Fig 12: Sample no: 2 SD value marked

Ultrasonic Testing: Case: 1

Probe placing 39.6mm form center of weld bead

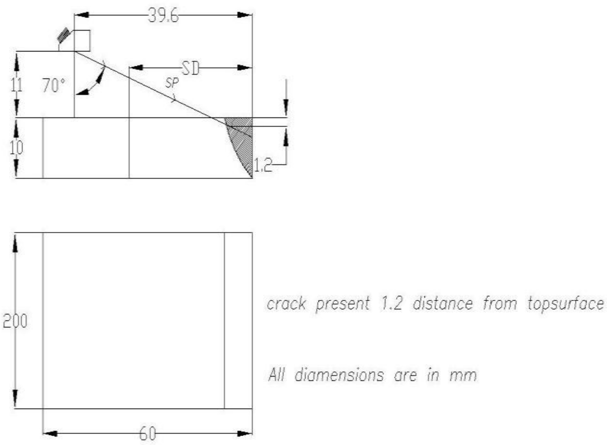


Fig13: Ultrasonic Testing: Case: 1

Fig14: Graph from ultrasonic flaw detector

Ultrasonic Testing: Case: 2

Probe placing 36.2mm form center of weld bead

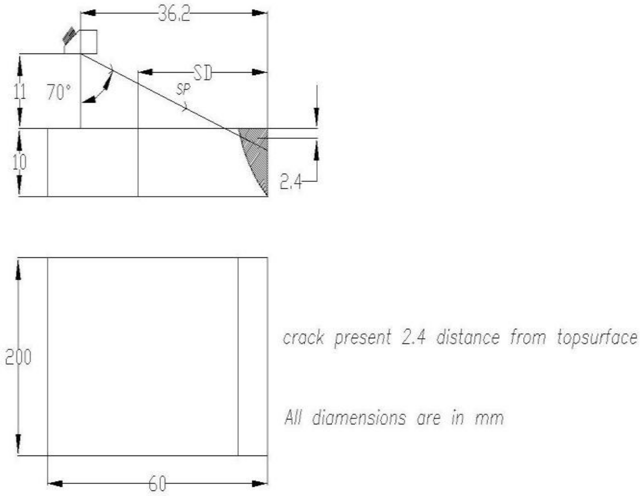


Fig 15: Ultrasonic Testing: Case: 2

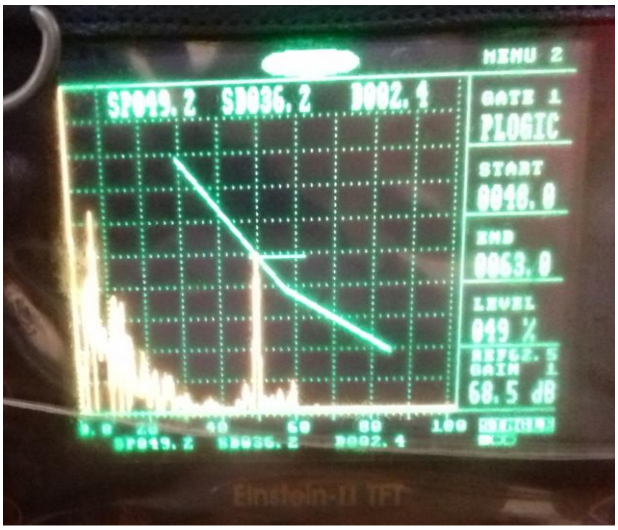


Fig 16: Graph from ultrasonic flaw detector

- Defects Identified In Samples

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

Sample	Porosity	Crack	Spatter	Excessive Penetration	Lack Penetration	Lack Of Fusion	Under Cut
Sample no:1.1	✓	✓	✓			✓	
Sample no:1.2		✓	✓	✓	✓	✓	
Sample no:1.3		✓	✓			✓	
Sample no:1.4			✓	✓	✓		
Sample no:1.5		✓	✓	✓	✓	✓	
Sample no:1.6	✓	✓	✓			✓	✓
Sample no:1.7		✓	✓		✓	✓	
Sample no:1.8	✓		✓				
Sample no:1.9	✓	✓	✓	✓			
Sample no: 1.10	✓	✓	✓	✓			
Sample no :2		✓				✓	

Table1: Defects Identified in Samples

- Percentage of welding defects

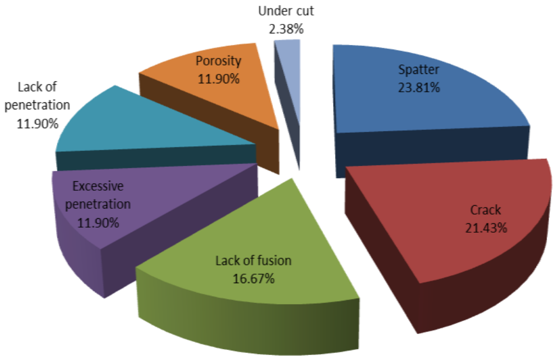


Fig 17: Types of welding defects

- Pareto Chart Analysis of Data

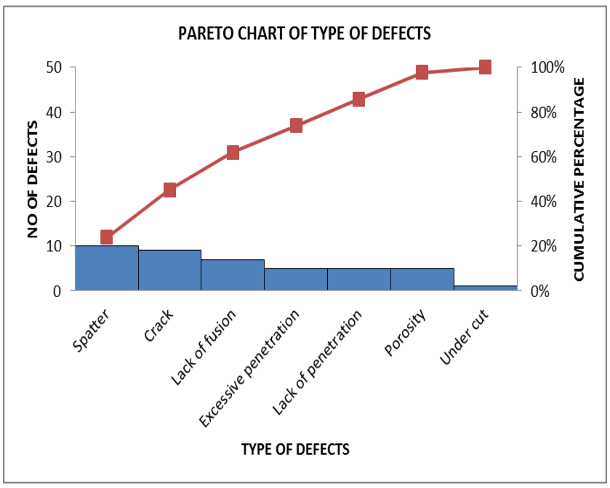


Fig18: Major constituents of welding defects

- Root Cause Analysis of Defect

Cause and effect diagram showing major causes for the welding defect

Spatter

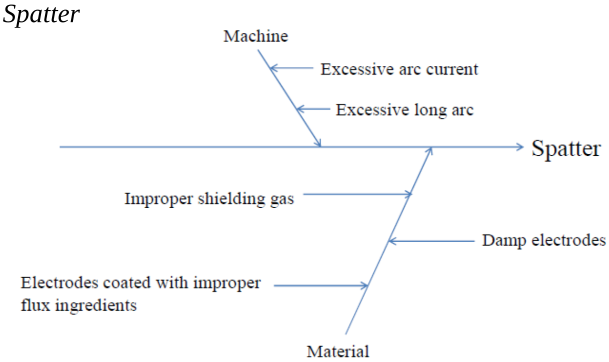


Fig: 19 Cause and effect diagram for "spatter"

Crack

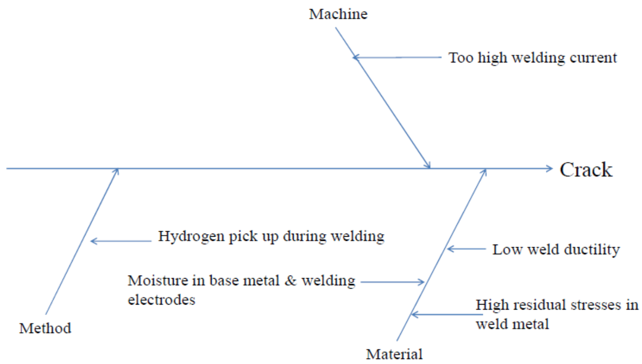


Fig: 20 Cause and effect diagram for "crack"

Lack of fusion

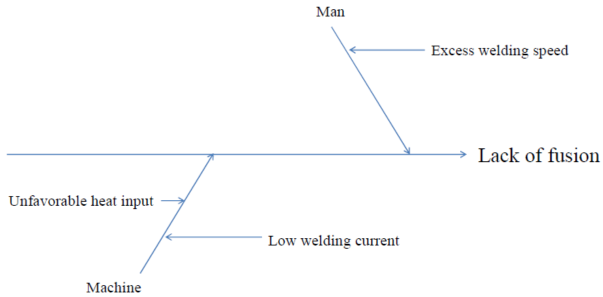


Fig: 21 Cause and effect diagram for "lack of fusion"

Excessive penetration

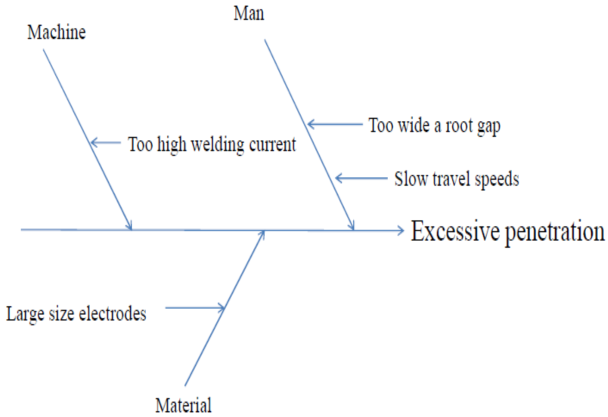


Fig: 22 Cause and effect diagram for "Excessive penetration"

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 5, Issue 11, May 2016

Lack of penetration

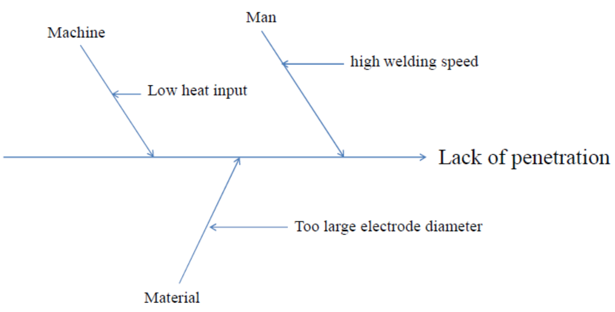


Fig: 23 Cause and effect diagram for "lack of penetration"

Under cut

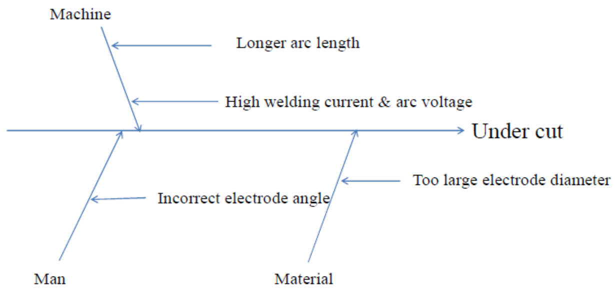


Fig: 24 Cause and effect diagram for "Under cut"

Porosity

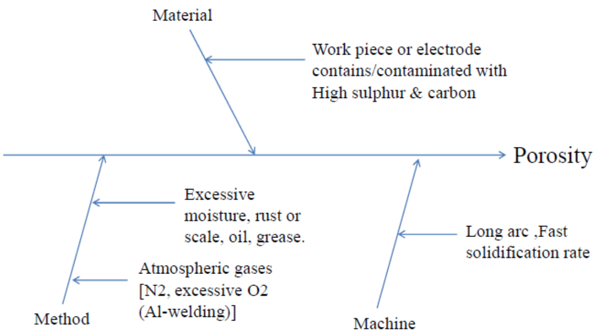


Fig: 25 Cause and effect diagram for "Porosity"

IV. CONCLUSION

The following conclusions are made:

- The major rate of defect is due to low skilled worker and no proper standards in production
- Pareto Chart states that spatter, lack of fusion and crack are the three major defects
- Process parameters play a vital role in eliminating the defects.
- From RCA, it is clearly visible that factors affecting defect rate

V. FUTURE WORK

Root cause analysis clearly shows the root causes of each defect ,take necessary actions prepare welded samples conduct NDT to check whether defects are reduced.

REFERENCES

[1] D. Rajenthirakumar, 2. T. Karthik, 3. V. Janarthanan, 4. S. Nanthakumar "Defect Reduction In Gas Tungsten Arc Welding Process Using Failure Mode Effects Analysis" ACTA TEHNICA CORVINIENSIS – Bulletin Of Engineering Tome VII [2014] Fascicule 4 [October – December] ISSN: 2067 – 3809.

[2] Wafaa Al-Hameed,Prof. Yahya Mayali and Prof. Phil Picton"Segmentation Of Radiographic Images Of Weld Defect" Journal of Global Research in Computer Science, Volume 4, No. 7, July 2013.

[3] Yousaf, F. and Ikramullah Butt, S. "Reduction in Repair rate of Welding Processes by Determination & Controlling of Critical KPIVs. " International Journal of Production Management and Engineering 2014.1609.

[4] Alireza Azari Moghaddam, Lalitha Rangarajan "A Method For Detection Welding Defects In Radiographic Images" International Journal of Machine Intelligence. ISSN: 0975–2927 & E-ISSN: 0975–9166, Volume 3, Issue 4, 2011.

[5] Ajay K Solanki, Mit Pandya, Dhananjay Bisht, Arpit Bhatiya, Asst. Prof. Manoj Pal"Lean manufacturing application on welding defects in cryogenic vessel"IJETAE Volume 4, Issue 10, October 2014.

[6] K. Kishore, P. V. Gopal Krishna, K. Veladri and Syed Qasim Ali"Analysis Of Defects In Gas Shielded Arc Welding Of Aisi1040 Steel Using Taguchi Method" ARPN Journal of Engineering and Applied SciencesVOL. 5, NO. 1, JANUARY 2010.

[7] Dalgobind Mahto; Anjani Kumar "Application of root cause analysis in improvement of product quality and productivity" JIEM, 2008 – 01(02):16-53 - ISSN: 2013-0953.

[8] R. W. Messler (Jr.), "Principles of Welding (Processes Physics, chemistry and Metallurgy), Wiley International, NY, 1999.

[9] ASM Metals HandBook Volume 17 - Nondestructive Evaluation and Quality Control.

[10] Bureau of Indian Standards IS 15431 (2003): Seven Basic Tools for Quality Management.