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Nondefective Friction Stir Welding of AA6063 and AA7075 Confirmed through Ultrasonic and Radiographic Techniques

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Abstract

Friction stir welding (FSW) is a solid-state joining process that uses a non-consumable tool to join two facing work pieces without melting the work piece material.[1] Heat is generated by friction between the rotating tool and the work piece material, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay, or dough.[1] It is primarily used on wrought or extruded aluminium and particularly for structures which need very high weld strength. FSW is an eco-friendly process because there is no fumes production and no filler material. To get high quality of weld, then high heat should be generated. In this paper, AA6063 and AA7075 alloy material is welded by En8 tool with different parameters and quality of weld is examined by using a non-destructive testing method called Ultrasonic and Radiography inspections. FSW is also found in modern shipbuilding, trains, and aerospace applications

Keywords: - *Friction stir welding (FSW), Defects, Alloy material, Aluminium alloys, Plate*

INTRODUCTION

Aluminium is the most abundant metal available in the earth crust. Steel was the most used metal in 19th century but Aluminium has become a strong competitor for steel in engineering

applications. Aluminium has many attractive properties compared to steel as it is attractive and versatile to use. It is used extensively in aerospace, automobile and other industries. The most attractive properties of aluminium and its alloys which make them suitable for a wide variety of applications are their light weight, appearance, fabric ability, and strength and corrosion resistance.

The most important property of aluminum is its ability to change its properties in a very versatile manner, it is amazing how much the properties can change from the pure aluminum metal to its most complicate alloys. There are more than a couple of hundreds alloys of aluminum alloys and many are being modified from them internationally.

Aluminium alloys have very low density compared to steel. It has almost one thirds the density of steel. Properly treated alloys of aluminum can resist the oxidation process which steel cannot resist; it can also resist corrosion by water, salt and other factors. There are many different methods available for joining aluminum and its alloys.

The selection of the method depends on many factors such as geometry and the material of the parts to be joined, required strength of the joint, permanent or dismountable joint, number of parts to be joined, the aesthetic appeal of the joint and the service conditions such as moisture, temperature, inert atmosphere and corrosion. Most alloys of aluminum are easily weldable.

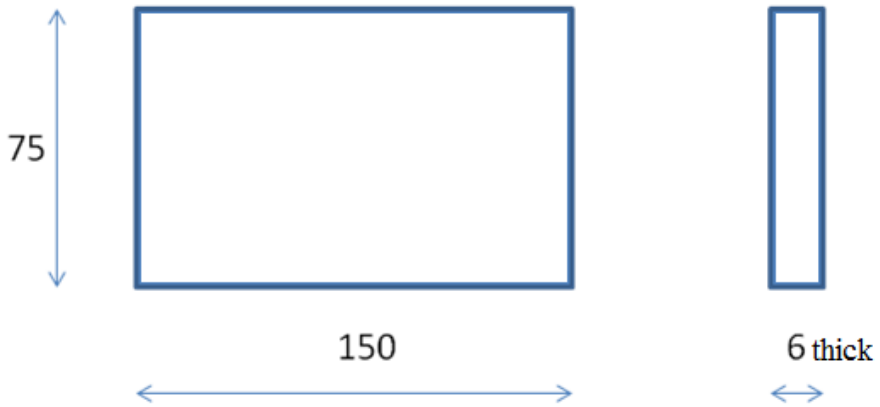
MIG and TIG are the welding processes which are used the most, but there are some problems associated with this welding process like porosity, lack of fusion due to oxide layers, incomplete penetration, cracks, inclusions and undercut, but they can be joined by other methods such as resistance welding, friction welding, and laser welding. Normal friction welding defects can be inspected by non-destructive testing method called radiography and Ultrasonic methods.

SELECTION OF MATERIALS

AA6063 alloy and AA7075 alloy is used extensively in aircraft primary structures. The friction-stir-welding (FSW) process is an emerging solid-state joining process in which the material that is being welded does not melt and recast.

DIMENSION OF THE PLATE

The dimension of the plate is given below



All dimensions in mm

SELECTION OF TOOL

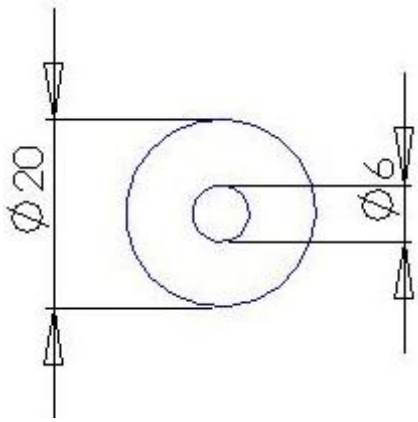


Fig. 6 EN-8 alloy steel circular tool

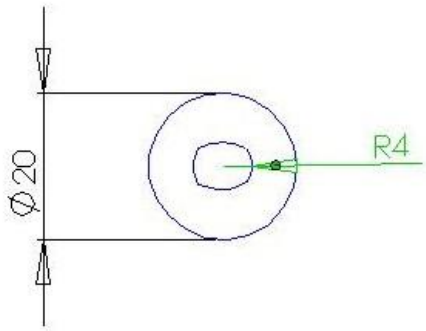


Fig. 7 EN-8 alloy steel THREAD Tool

The EN-8 alloy steel material is used in the friction stir welding process because the harness of the EN-8 alloy steel is more than the aluminium alloy plates. So we used the EN-8 alloy steel as the tool material in our friction stir welding process. The design of tool is a critical factor as a good tool can improve the both quality of the weld and maximum welding speed .It is desirable that the tool material is sufficiently strong, tough and hard wearing ,at the welding temperature. Further it should have a good oxidation resistance and low thermal conductivity to minimize heat loss and thermal damage to the machinery further up the drive train. Hot-worked tool steel such as EN-8 has proven perfectly acceptable for welding aluminium alloys within 0.5-50 mm but more advanced tool materials are necessary for more demanding applications such as highly abrasive or higher melding point materials such as mild steel or titanium. The tool was designed based on the chuck of the radial drilling machine then the tool was heat treatment applied to increase the hardness.

The pin diameter is increased from 6mm to 8mm and the shape of the pin also changed from circular into threaded shape. Because the flow of metal from retrieving side to advancing side is insufficient. So we changed the tool shape from circular into threaded shape. Due to this the gap between the tool pin and the aluminium plates is alternatively comes because of the threaded shape. The gap carries the metals so the flow metal from retrieving side to the advancing side is increases the enough flow makes the welding joint perfect.

SELECTION OF WELDING PARAMETERS

Table:-1

Sl.no	Tool profile	Feed(mm/min)	Spindle Speed(rpm)
1	cylindrical	40	710
2	cylindrical	30	900
3	cylindrical	20	1220
4	cylindrical	10	1400
5	threaded	10	710
6	threaded	20	900
7	threaded	30	1220
8	threaded	40	1400

EN8 Cylindrical and threaded Profile

FRICTION STIR WELDING PROCESS

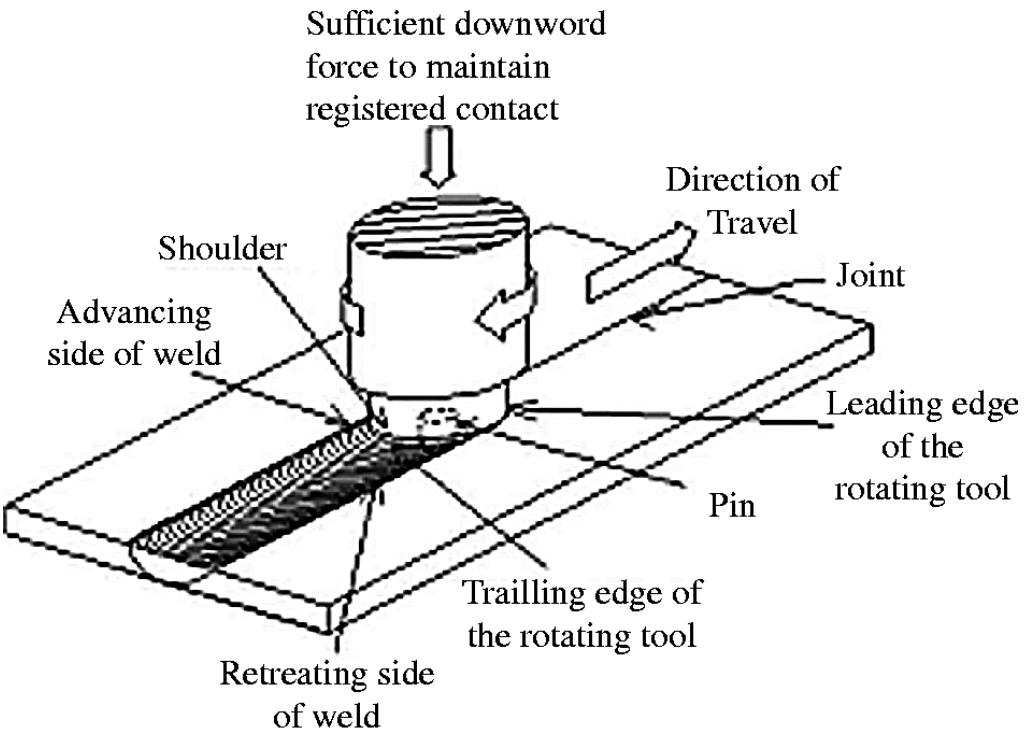
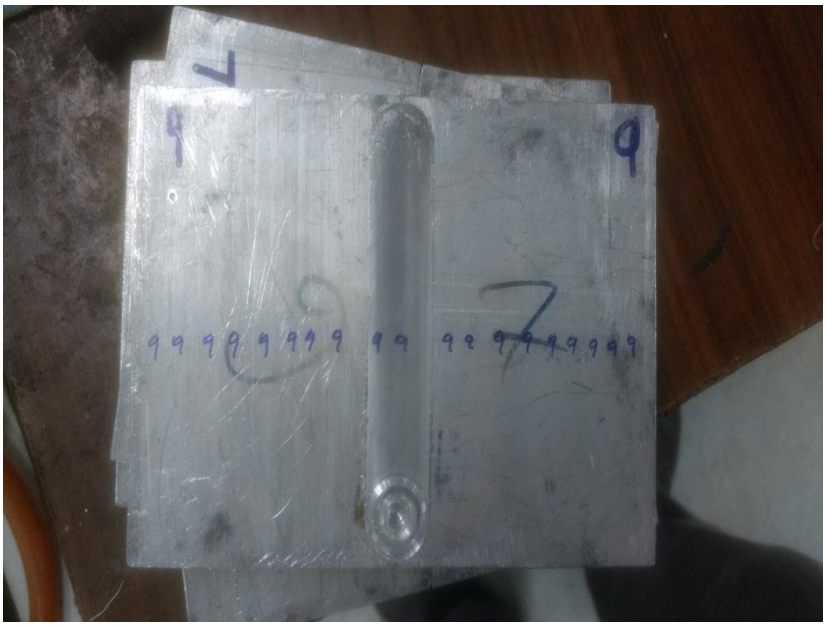


Fig. 9: Friction stir welding process

During friction stir welding process, the work piece is placed on a backup plate and clamped rigidly by an anvil along the far side to prevent lateral movement. A specially designed cylindrical tool with a pin protruding from the shoulder rotates with a speed of several hundred rpm and is slowly plunged into the work piece to start the process.



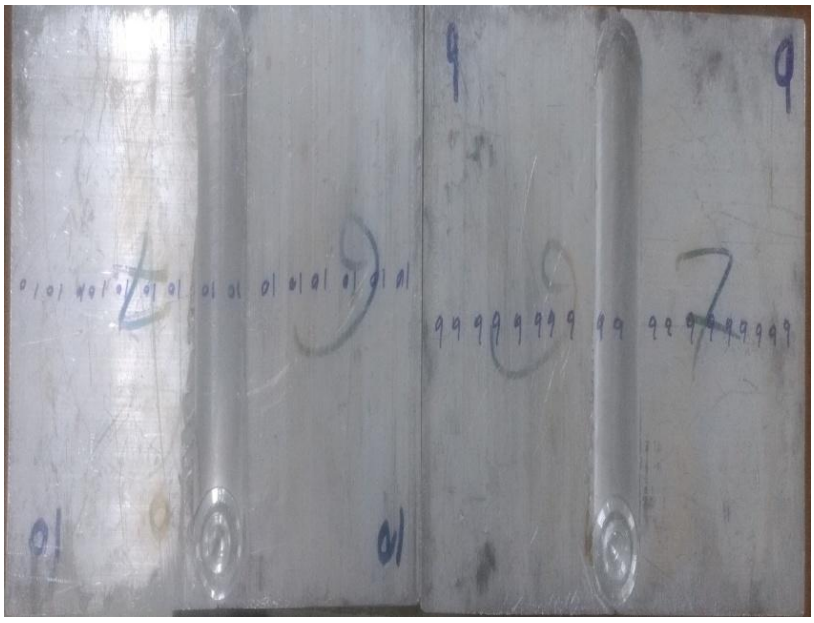


Fig.10 Welded Material

NON DESTRUCTIVE TESTING

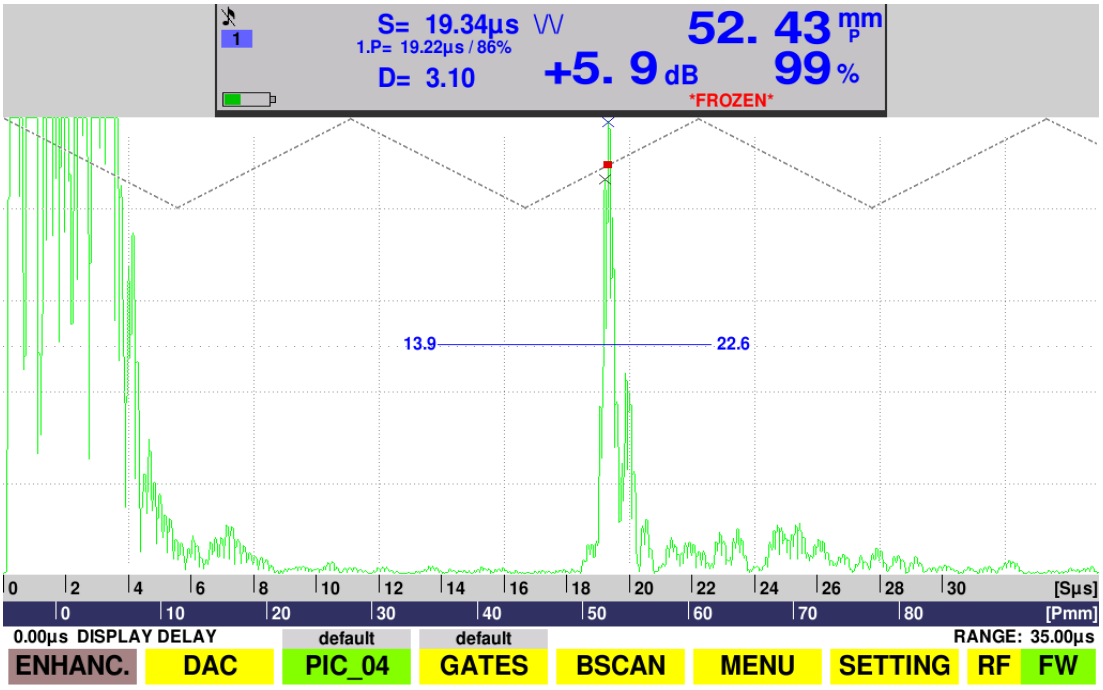
A component does not break in non –destructive testing and even after being tested so, it can be used for which it was made. Such a test is used to detect faulty components before assembly, to measure the thickness of metal or other materials, to determine level of liquid or solid content in opaque containers, to identify and sort materials, and to discover defects that may have developed during processing or use. Parts may also be examined in service, permitting their removal before failure occurs.

Nondestructive tests are used to make products more reliable, safe, and economical. Increased reliability improves the public image of the manufacture, which leads to greater sales and profits. In addition, manufactures use these tests to improve and control manufacturing processes.

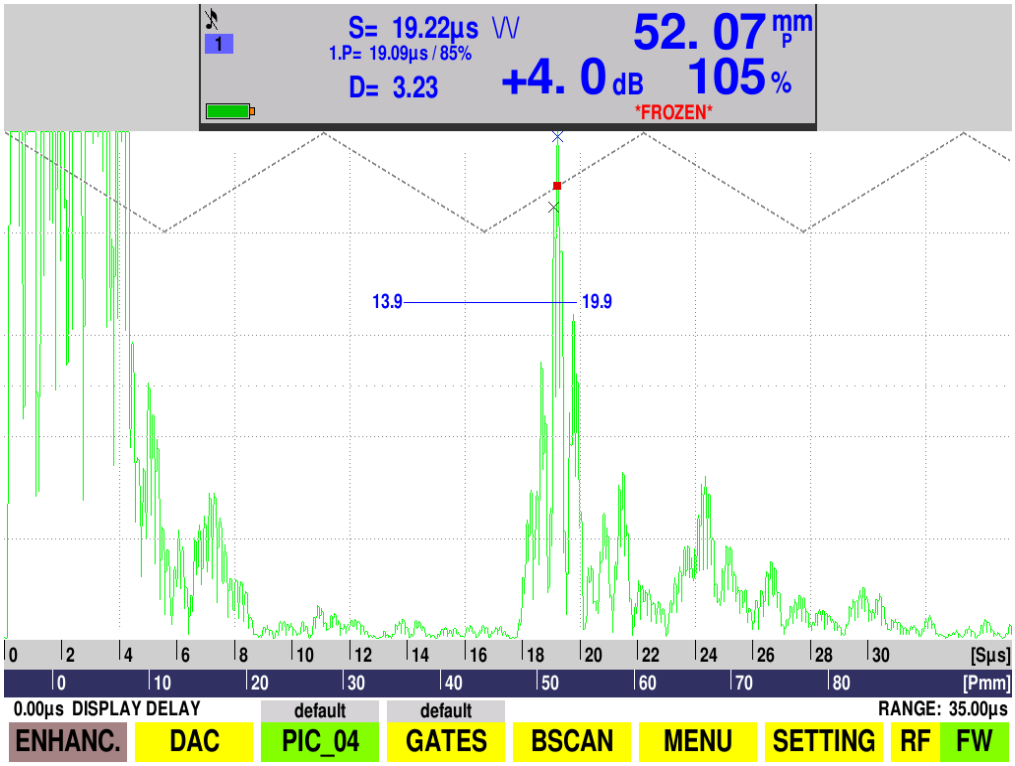
There are five basic elements in any non-destructive testing. n ultrasonic testing, an ultrasound transducer connected to a diagnostic machine is passed over the object being inspected. The transducer is typically separated from the test object by a couplant (such as oil) or by water, as in immersion testing. However, when ultrasonic testing is conducted with an Electromagnetic Acoustic Transducer (EMAT) the use of couplant is not required.

There are two methods of receiving the ultrasound waveform: reflection and attenuation. In reflection (or pulse-echo) mode, the transducer performs both the sending and the receiving of the pulsed waves as the "sound" is reflected back to the device. Reflected ultrasound comes from an interface, such as the back wall of the object or from an imperfection within the object. The diagnostic machine displays these results in the form of a signal with an amplitude representing the intensity of the reflection and the distance, representing the arrival time of the reflection. In attenuation (or through-transmission) mode, a transmitter sends ultrasound through one surface, and a separate receiver detects the amount that has reached it on another surface after traveling through the medium. Imperfections or other conditions in the space between the transmitter and receiver reduce the amount of sound transmitted, thus revealing their presence. Using the couplet increases the efficiency of the process by reducing the losses in the ultrasonic wave energy due to separation between the surfaces.

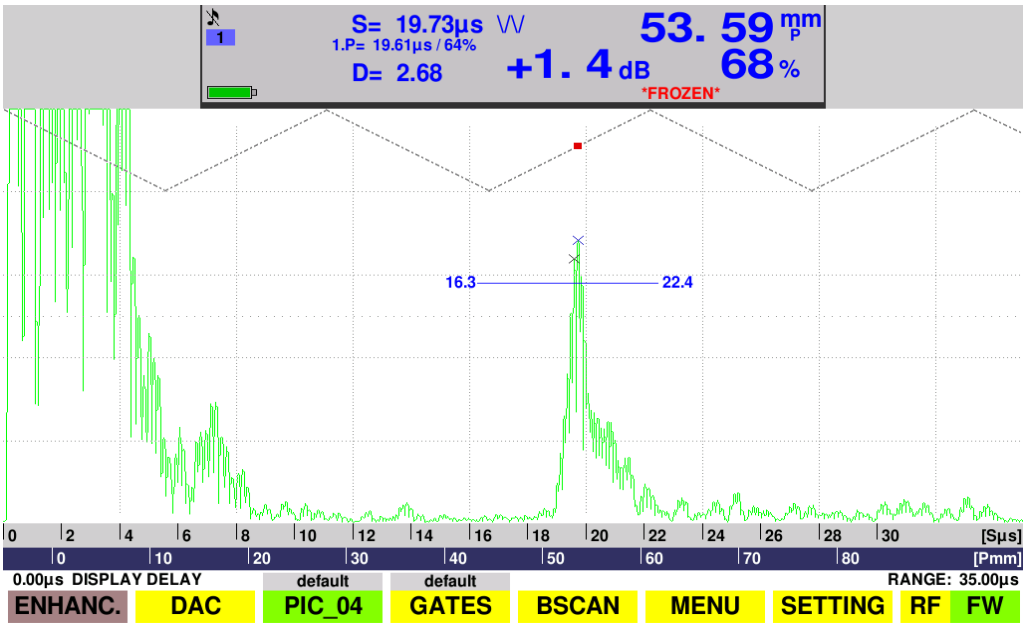
ULTRASONIC TEST



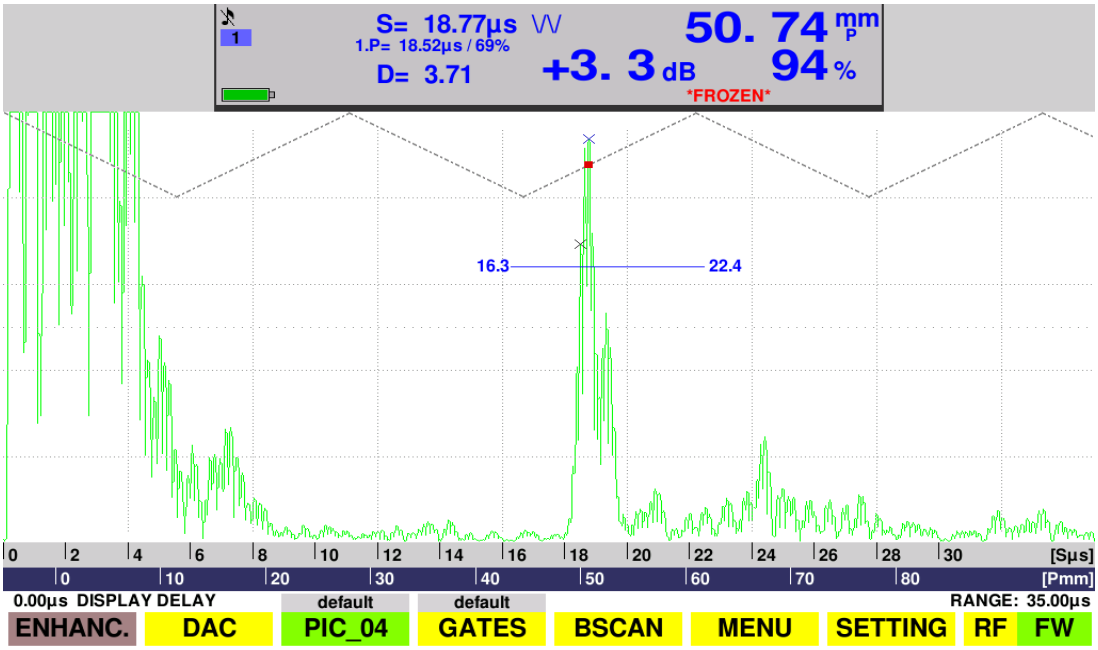
ULTRASONIC TEST AT 710rpm



ULTRASONIC TEST AT 900rpm



ULTRASONIC TEST AT 1220rpm



ULTRASONIC TEST AT 1400rpm

RADIOGRAPHY TEST

X-Rays and Gamma rays are widely used to detect internal defects in components of large size. This technique is also known as radiography.

This technique internal faults in forgings, casting, press workings, distributions of impurities and the mechanism of friction and wear in metals. Radiography techniques are finding more

extensive applications in the field of physical metallurgy and in the treatment of various diseases.

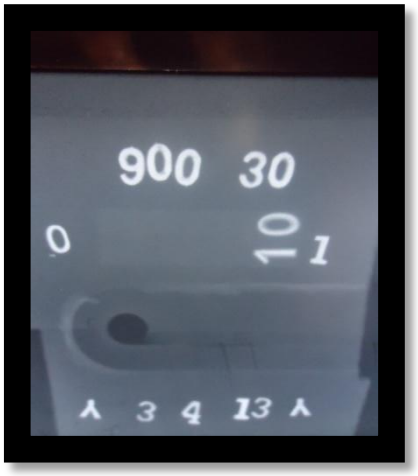
PRINCIPLES

Common radiography techniques are based on the use of X-rays, gamma rays and radioactive isotopes. The components to be tested are exposed to X-rays or gamma rays which can penetrate all substance to varying degrees. The rays, after passing through the components, show a picture on a fluorescent screen or on a photographic plate. The cracks, blow holes and cavities appear darker, whereas inclusion of impurities appear lighter than the components metals. The photograph film, after development, will show lighter and darker areas to represent the radiograph of defects in the component.

X-RAY RADIOGRAPHY WORKING METHODOLOGY

X-rays are produced when matter is bombarded by a rapidly moving stream of electrons when electrons are suddenly stopped by matter, a part of their kinetic energy is converted to energy of radiations, or X-rays. The portion of the casting where defects are suspected is exposed to X-rays emitted from the X-ray tube. X-rays after passing through the below hole in casting, will be absorbed to a lesser extent than X-rays which pass through sound mental. Fault can be detected by measuring the ray absorption.

Radiography Test AT 710rpm



Radiography Test AT 900rpm

Radiography Test AT 1120rpm

RADIOGRAPHY TEST AT 1400rpm

CONCLUSION

- The investigation of the defects in FSW is very much essential to obtain product quality.
- In ultra sonic testing, the Rotation speed 1400 rpm, Threaded profile and 40mm/min feed which gives fewer defects than other variables.
- In radiographic testing rotation speed 1400 rpm Threaded profile, feed 40mm/min which gives defect free welding.

REFERENCES

1. M.Tehyo, P. Muangjunburee, A. Binraheem, S. Chuchom and N. Utamarat, “Influence of friction stir welding parameters on metallurgical and mechanical properties of dissimilar joint between semi-solid metal 356-T6 and aluminum alloys 6061-T651”, Songklanakarin J SciTechnol ,34(4),pp. 415-421, 2012.
2. M.W. Mahoney, C.G. Rhodes, J.G. Flintoff, R.A Spurling and W.H. Bingel, “Properties of friction-stir-welded 7075-T651 aluminum, Metall Mater Trans A, 29A, pp.1955–1964, 1998.
3. N.S.Sundaram and N. Murugan, “Tensile behavior of dissimilar friction stir welded joints of aluminium alloys”, Mater Des, 31, pp.4184–4193, 2010.
4. P.Bahemmat, M.Haghpanahi, M.K.Besharati, S.Ahsanizadeh and H.Rezaeli, “Study on mechanical, micro and macrostructural characteristics of dissimilar friction stir welding of AA6061-T6 and AA7075-T6”, Proc IMechE Part B: J. EngManuf , 224, pp.1854-1865,2010.
5. P.Cavaliere, E.Cerri and A. Squillace, “Mechanical response of 2024–7075 aluminium alloys joined by friction stir welding”, J Mater Sci, 40, pp.3669–3676, 2005.
6. P. Cavaliere, R. Nobile, F.W. Panella, A. Squillace, "Mechanical and microstructural behaviour of 2024–7075 aluminium alloy sheets joined by friction stir welding"International Journal of Machine Tools & Manufacture 46 (2006) 588–594.
7. Alaknanda, R.S. Anand, Pradeep Kumar,” Flaw detection in radiographic weld images using morphological approach” NDT&E International, Volume 39, Issue 1, (January2006) 29-33.