PAPER ON COMPARISION OF CONVENTIONAL WELDING METHODS WITH SOLID-STATE WELDING TECHNIQUES

[1]V. prasanna Associate Professor ,Department of Mechanical Engineering, NITS, Hyderabad

[2]S. Narsing Rao , DGM Midhani, Hyderabad

Abstract:-*The aim of the present study was to compare Friction Stir Welding (FSW) method which is an innovative solid-state welding technique with conventional welding methods. Nowadays, the technologies are toward eco-friendly system. The eco-friendly systems represent reduction the potential threat and waste to the earth. Friction Stir Welding (FSW) is a new kind of welding method that was invented by The Welding Institute (TWI). It is different from conventional welding methods and also different from other old solid welding process. The method utilizes rotating welding tools to generate friction heat for heating the parent metal until the metal merge. The process is called Solid-state joining process, which is the original metal characteristics have not changes.*

Keywords: Solid-state Welding, Friction Stir Welding, Conventional Welding, Solidification

1. INTRODUCTION TO WELDING

Welding is a process of joining two or more pieces of the same or dissimilar materials to achieve complete coalescence. This is the only method of developing monolithic structures and it is often accomplished by the use of heat and or pressure.

There are two groups of welding processes according to the state of the base material

- Liquid-state Welding (Fusion Welding) and
- Solid-state Welding

Fusion Welding

In fusion welding the base material is heat to melt. No filler metal is added in the fusion welding operation which is referred as autogenously weld. Fusion welding is far by more important category as.

- Oxy-fuel gas welding
- Arc welding and
- Resistance welding

Oxy-fuel gas welding (OFW)

It is the term used for cutting and to separate metal plates and other parts. A mixture of oxygen and acetylene and filler metal is used to produce a flame to melt the base material. It is economical, versatile process that is well suited to low-quantity production and repair jobs.

Arc welding (AW)

It is a fusion welding process in which heating of metals is accomplished by an electric arc. In most arc welding processes, filler metal is added during the operation to increase the volume and strength of the weld joint. As the electrode is moved along the joint, the molten weld pool solidifies in its wake.

Resistance Welding (RW)

It utilizes a combination of heat and pressure to accomplish coalescence. The heat required is generated by electrical resistance to current flow at the interface of two parts to be welded.

Solid-state welding

Joining takes place without fusion at the interface, when two surfaces brought together no liquid and molten phase present at the joint. The most broadly used welding processes are Solid-state welding category, which can be organized in to the following general groups.

- Diffusion welding
- Friction welding
- Ultrasonic welding

Diffusion welding

It is a solid-state welding process which produces coalescence of the faying surfaces by the application of pressure and elevated temperatures. Temperatures are well below the melting points of the metals and plastic deformation at the surfaces is minimal. The process is used quite extensively for joining dissimilar metals and used primarily by the aircraft and aerospace applications.

Friction welding

It is a process which produces coalescence of materials by the heat obtained from mechanically-induced sliding motion between rubbing surfaces. The work parts are held together under pressure. This process usually involves the rotating of one part against another to generate frictional heat at the junction. Then the parts are driven toward each other with sufficient force to form a metallurgical bond.

Ultrasonic welding

Is a process which produces coalescence by the local application of high-frequency vibratory energy as the work parts are held together under pressure. Welding occurs when the ultrasonic tip or electrode, the energy coupling device, is clamped against the work pieces and is made to oscillate in a plane parallel to the weld interface. Most ductile metals can be welded together and there are many combinations of dissimilar metals that can be welded.

2. Weld defects in conventional welding processes

Most defects encountered in welding are due to an improper welding procedure.
The major defects or discontinuities that effect weld quality are below.

- Porosity
- Slag Inclusion
- Incomplete Fusion Penetration
- Weld Profile
- Cracks and
- Surface Damage

The above listed defects are discussed briefly,

Porosity

Porosity is gas pores found in the solidified weld bead. These pores are generally distributed in a random manner. However it is possible that porosity can only be found at the weld centre. Pores can occur either under or on the weld surface. The most common causes of porosity are atmosphere contamination.

Slag Inclusion

Slag is normally seen as elongated lines either continuous or discontinuous along the length o the weld. Slag inclusions are usually associated with the flux processes. Inclusions: Welding conditions are important and with proper techniques the molten slag will float to the surface of the molten weld metal and not be entrapped.

Incomplete Penetration

Welding current has the greatest effect on penetration. Incomplete penetration is usually caused by the use of too low a welding current and can be eliminated by simply increasing the amperage. Other cause can be the use of too slow travel speed and an incorrect torch angle. Both will allow weld metal to roll in front of the arc,acting as a cushion to prevent penetration.

Weld Profile or Unacceptable weld Profile

Weld profile is important because it can indicate incomplete fusion or the presence of slag inclusions in multi-layer welds. Unacceptable profile can include any of the following: weld too small (not enough fill), weld to flat, excessive weld fill, uneven weld profile, excessive concavity or convexity, or excessive surface roughness.

Cracks

The type of cracks occurred are typically longitudinal, transverse, crater, toe cracks Fusion –line, root and under bead. This can occur due just to thermal shrinkage or due to a combination of strain accompanying phase change and thermal shrinkage. In the case of welded stiff frames, a combination of poor design and inappropriate procedure may result in high residual stresses and cracking.

Surface Damage

During welding, some of the metal may spatter and deposited as small droplets on adjacent surfaces. Example in arc welding, the electrode may inadvertently contact the parts being welded at places not in the weld zone. Such surface discontinuities may occur at the weld part. Under proper welding techniques and procedures is important in avoiding surface damage.

2.1 Drawbacks of Existing Conventional Welding

1. Fusion welding processes generates fumes, gases or smoke which may cause harmful effects on operators.
2. In fusion welding process, possibility of porosity and slag inclusions are more.
3. Less process efficiency with high energy consumption.
4. Welding of dissimilar alloys and complex shapes is difficult.
5. Heat affected zone is more.
6. Distortion of work pieces and spatter is the most common problem in fusion welding.

The defects and drawbacks in Conventional welding processes can be effectively overcome by adopting new solid state welding technique called friction stir welding.

3. FRICTION STIR WELDING

3.1 Introduction

Friction Stir Welding (FSW) is a new joining and Solid state welding process. It overcomes many of the problems associated with conventional methods. FSW basic concept creates extremely high-quality, high-strength joints with low distortion. It is different from

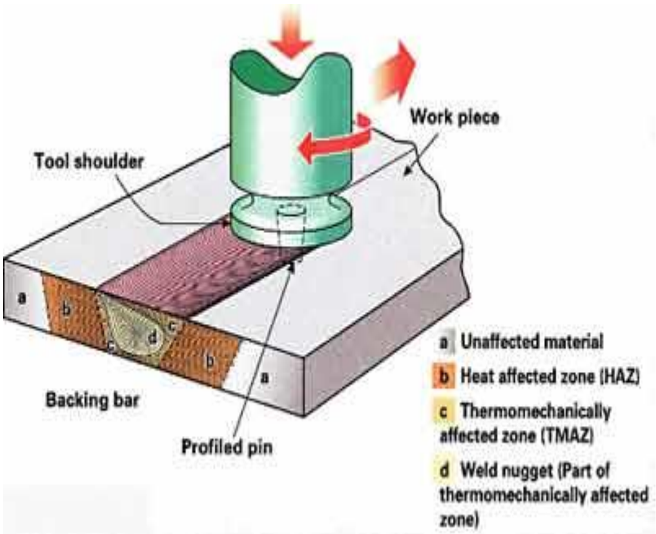

Fig: 1 Profile of Friction Stir Welding

A non consumable rotating tool with special pin and shoulder id inserted into abutting edges of sheets or plates. FSW produces welds of high quality in difficult-to-weld materials such as Aluminium and its alloys, copper, Brass, Magnesium, Titanium, Steel alloys, Stainless steel, Tool steel, Nickel and Lead.

FSW is considered to be the most significant development in metal joining in a decade. Recently, friction stir processing (FSP) was developed for micro structural modification of metallic materials.

3.2 Background of FSW

In 1991 a novel welding method (FSW) is invented by Wayne Thomas at The Welding Institute (TWI) Ltd at England. It is further developed New Friction Stir Technique for Welding Aluminium, in 1992 to study this technique. Since its invention the process has received world-wide attention, today FSW is used in research and production in many sectors, including aerospace, automotive, railway, shipbuilding, electronic housings, coolers, heat exchangers, and nuclear waste containers.

FSW has been proven to be an effective process for welding low and high melting temperatures like aluminium, brass, copper, magnesium, titanium, steels, carbon and nickel-based alloys, by developing tools that can withstand the low and high temperatures and pressures needed to effectively join these materials.

3.3 Working Principle of FSW

In friction stir welding a rotating pin emerging from a cylindrical shoulder is plunged between two edges of sheets to be joined and moved forward along the joint line. The material is heated by friction between the rotating shoulder and the work piece surface and simultaneously stirred by the profiled pin leaving a solid phase bond between the two pieces to be joined.

During friction stir welding, advancing and retreating side orientations require knowledge of the tool rotation and travel directions. As shown in the above fig.1, the FSW tool rotates in the clockwise direction and travels into left or right. The advancing side is on the left, where the tool rotation direction is the same as the tool travel direction (opposite the direction of metal flow). The retreating side is on the right, where the tool rotation is opposite the tool travel direction (parallel to the direction of metal flow).

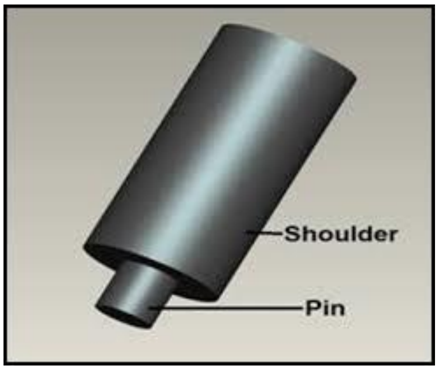

Fig: 2 Friction Stir Welding Tool

The tool shown in fig.2 serves three primary functions:

1. Heating of the work piece
2. Movement of the material to produce the joint, and
3. Containment of the hot metal beneath the tool shoulder

Heat is generated within the work piece both by friction between the rotating tool pin and shoulder and by severe plastic deformation of the work piece. The localized heating softens material around the pin and, combined with the tool rotation and translation, leads to movement of the material from the front to the back of the pin, thus filling the hole in the tool wake as the tool moves forward. The tool shoulder restricts metal flow to a level equivalent to the shoulder position, that is, approximately to the initial work piece top surface. As a result of the tool action and influence on the work piece, a solid-state joint is produced.

3.4 Advantages and Benefits of FSW

- Provides opportunities for new solutions to old joining problems
- Virtually defect-free welding
- Versatile applications by welding all joint geometries including complex contours
- Limitless panel length and width
- Superior mechanical characteristics
- Join dissimilar alloys and
- Green process

Other advantages

- Low distortion and shrinkage, even in long welds
- No arc or fumes
- No porosity
- No spatter
- Can operate in all positions
- Energy efficient
- One tool can typically be used for 1000m
- No filler wire required

- No grinding, brushing or pickling required in mass production
- Excellent mechanical properties in fatigue, tensile and bend tests

DISADVANTAGES OF FSW

- Work piece must be rigidly clamped, slower transverse rate than fusion welding.

APPLICATIONS OF FSW

Aerospace Industry
Railway Industry
Land Transportation and etc,

CONCLUSIONS

Welding categories and its types of defects are discussed in this paper. The major problem identified, FSW opens new welding areas, and Properties look good in most cases, Low distortion, no spatter, no fumes, welding will be done below the melting point of metals and alloys, creates high strength welds in hard to weld metals.

FUTURE SCOPE OF FSW

Welding on high temperature materials like titanium, steels and etc, and characterisations of the mechanical properties like residual stress tensile strength, hardness, microstructure with EDX, Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) and Fracture properties like fracture toughness, fatigue test and Impact test have good scope in future on FSW joint.

REFERENCES

[1] Mandeep Singh Sidhu, Sukhpal Singh Chatha "Friction Stir Welding – Process and its Variables: A Review" IJETAE Volume 2, issue 12, 2012

[2] M. Sivashanmugam, S. Ravikumar, T. Kumar, V. SeshagiriRao, D. Muruganandam, "A Review on Friction Stir Welding for Aluminium Alloys", 978-1-4244-9082-0/10/$26.00 ©2010 IEEE, pp. 216 – 221.

[3] W.M. Thomas, E.D. Nicholas S.D. Smith, "Friction Stir Welding – Tool Developments" Aluminium joining symposium, New Orleans USA, 2001.

[4] Thomas W. M , Nicholas E. D., 1997. Friction stirs welding for the transportation industries. Materials & Design 18(4-6): 269-273.

[5] Maggiolino S., Schmid C., 2008. Corrosion resistance in FSW and in MIG welding techniques of AA6000. Journal of Materials Processing Technology 197: 237– 240.

[6] Malarvizhia S., Balasubramanian V., 2011. Effects of welding processes and post-weld aging treatment on fatigue behaviour of AA2219 aluminium alloy joints. Journal of Materials Engineering and Performance 20(3): 359-367.

[7] Wang X., Wang K., Shen Y., Hu K., 2008. Comparison of fatigue property between friction stir and TIG welds. Journal of University of Science and Technology Beijing, Mineral, Metallurgy, Material 15: 280-284

[8] Cabello M., Ruckert G., Huneau S. B., Marya S., 2008. Comparison of TIG welded and friction stir welded Al– 4.5Mg–0.26Sc alloy. Journal of Materials Processing Technology 197 (1-3): 337-343.

[9] Elangovan K., Balasubramanian V., 2008. Influences of tool pin profile and tool shoulder diameter on the formation of friction stir processing zone in AA6061 aluminium alloy. Materials and Design 29: 362–373.

[10] Dawes C., Wayne T., "Friction stir joining of aluminium alloys", TWI Bulletin, No.6, 1995.