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INTEGRATING ISSUES OD FRICTION STIR WELDING OF STEELS IN CURRENT ENGINEERING PRACTICE OF SPECIAL TECHNIQUES

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Abstract: *In engineering practice there in the last decade a significant increase in labor productivity in proportion to the rising requirements for quality, economic efficiency and safety at work of the machining operations. The relatively new and modern methods to achieve a high level of these parameters, aspects, conditions and requirements, the integration of friction stir welding of steels in current engineering practice.*

Keywords: *friction stir welding, ferritic steels, research, welding, modern method, materials, temperature*

1. INTRODUCTION

Integration of friction stir welding of steel as an innovative method of joining materials in a real engineering environment was preceded by long and extensive research and development of the method. Research was conducted worldwide for materials with low melting point such as. copper, aluminum, zinc and lead. The final output of research in terms of concrete results of the welding of these materials in commercial-scale use. The research confirmed the proven benefits of friction stir welding of low-melting materials as compared with conventional hot melt welding methods, which led to considerable interest in the application of technology and examined for bonding materials with high melting temperature, such as. ferritic steel whose melting point is in the range above 1000 ° C. For further research, resulting in increased demands on the welding tool, the tool must be resistant to mechanical wear and thermal deformation at high temperatures accompanying the process of friction stir welding of ferritic steels. Based on studies demonstrated satisfactory welding tool joints forming the desired quality, made from PCBN material - polycrystalline boron nitride or WC - tungsten carbide. The Friction stir welding of steels provides for a significant number of benefits and innovation and the three basic problems encountered in the welding of ferritic steels with various uses.

2. THE PRINCIPLE TECHNOLOGY OF FRICTION STIR WELDING METHOD

The technology is based on the principle of rotating injection tool in the longitudinal direction of the contact plane of two joined materials (Fig. 1). Materials are to each other without join butt weld gaps, which are firmly clamped without movement of the supporting substrate. The bottom of the wear resistant welding tool is completed by a thorn, and the rotation of the rotating mandrel and contact with the material there is friction welded to generate heat, which will result in the creation of material welded joint plastification [1].

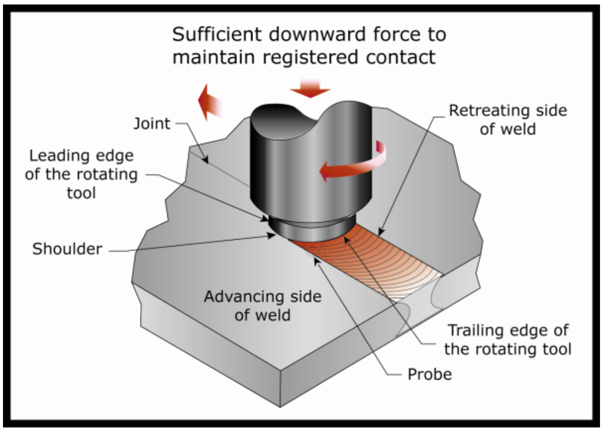


Fig. 1 Schematic representation of friction stir butt welding process [1]

Basic weld material can not be warmed by heat generated by friction of the melting point, but the value is reached temperatures high enough to plastificated basic material allows longitudinal movement of the welding tool to the line of contact of welded materials and created a permanent hole mandrel tool has been steadily filling. Fills the hole created back arm welding forging force generation tool joined plastificated material to the lower layers of the weld joint. The movement of material in the thickness direction of welded materials in combination with-flow around the rotating tool is incurred welded known viruses, which leads to mutual mixing of the two materials bonded together, and the creation of the weld. The area of the weld and the welding tool steels (welding tool is welded together with the material is heated at high temperature) is necessary to protect the supply of protective inert gas. This gas is fed through a welding nozzle to create the weld site. With the gradual moving the rotating tool along the contact surfaces of plasticized material flowing around the ends around the welding tool (punch), transferred from the capture (start of movement of material) to the end of the metal movement, which arises from the welding tool. Physical contact with the moving layers of metal heated base material and the plastic deformation of the joint significantly facilitates the process of capturing the course material and it is dynamic recrystallization, resulting in the formation of the weld joint [1].

3. THE WELDING TOOLS FOR FRICTION STIRRING WELDING

The rotating tool (Fig. 2) advancing the line of weld surface leaving behind touch whose dimensions are the dimensions of the mandrel (pin) tool. Wing area is roughly the shape of the annular diameter and the diameter of the mixed touch at the touch of welded plates. For this reason, that to achieve the highest strength and quality of service is necessary to optimize the welding process parameters so that at the smallest diameter mandrel (pin) to achieve the greatest diameter of the mixed. The main process parameters affecting the diameter of the mixed geometry of the working tool and especially the geometry of the mandrel. Tools are usually made from tool steel, whose mechanical properties are sufficient for most soft metals such as aluminum and its alloys, or. PCBN of unconventional materials - polycrystalline boron nitride or WC - tungsten carbide for welding of ferritic steels [2].

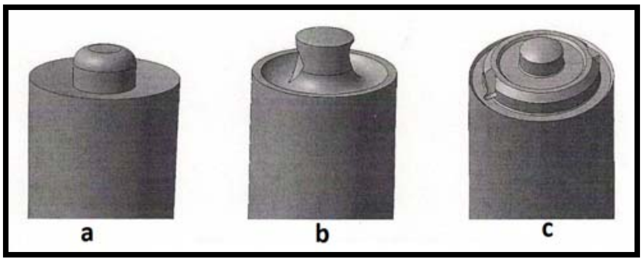


Fig. 2 Geometry of the working parts of the welding tools - a) Tool A, b) Tool B, c) Tool C [4]

In the case of instruments A and B (Fig. 2ab) is similar to the character of power injection. After initial contact with the tool material with heavy load strength gradually increases until it reaches a level at which the amount of heat generated is sufficient to cause reduction in strength and a significant increase in its plasticity. After overcoming the first local maximum begins to penetrate into the tool joint force constant, which is maintained through self-regulation process. If there is any increase in the resistance of material against the penetration of the tool, there is also the intense heat and the resultant increase in the plasticity and vice versa. In case of contact with the tool printed material on the front, there is a further increase in power injection up to a maximum value which is a thorn embedded in welded materials and tool face abuts the plate surface. In this position, the rotating tool remain after the set period of residence and ejected from the site [2].

4. EXAMPLES OF USING FRICTION STIR WELDING

Friction stir welding is mainly used for welding aluminum and magnesium (Fig. 3), but is also suitable for copper, titanium and steel. Allows you to connect a dissimilar materials, eg. aluminum alloy with magnesium. Commercially it is used mainly for welding aluminum alloys 2xxx series (Al-Cu), 6xxx (Al-Mg-Si), 7xxx (Al-Zn) and magnesium alloys AZ series. Quality links also arise when combining aluminum alloys that are difficult to weld by conventional fusion welding methods. Sheets and plates of aluminum and copper to a thickness of 30 mm can be welded to a transition to full penetration [3]. **This technology is welded:**

- Ship building: aluminum deck panels, boat hulls, masts and beams,

- In aerospace: the wings and fuselages, fuel tanks of aircraft and space shuttle and military rockets,

- In the railway industry: container and tank wagons, trams, subway cars and high-speed trains,

- Road transport: aluminum automotive frame structures, RV, motorcycle and bicycle frames, platform trucks, welding clips made of hydroformed aluminum tubes, extruded profiles welding automobile frames for casting,

- In construction: aluminum bridges, window frames, cladding panels and the like [3].

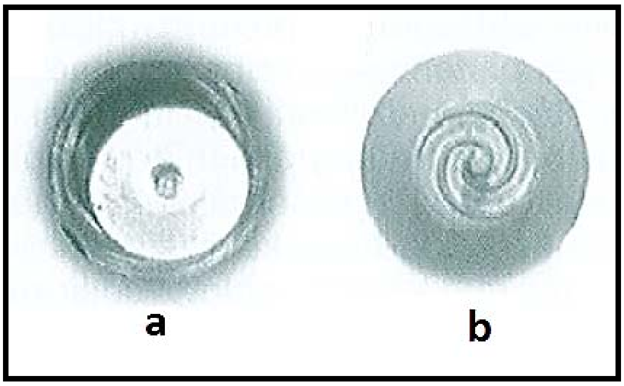
Friction stir welding is also applicable when making overlapped joints called. Pro-StirTM technique. Pro-StirTM the technology of production of welded joints in nearly final form of the structure using friction mixing overlapped joints. Technology is creating the final design iterations overlapped welded joints of thin or thick plates, followed by mechanical surface treatment on the final shape and size desired. This method allows - creating structures that would be using other conventional methods of production (fusion welding, machining, or. Fitting) imply a high loss of material required to produce the desired final design dimensions. The method also finds application in the production of complex structures, which can only be difficult, or they can not even construct appropriate method [3].

The advantages of friction stir welding [3]:

• do not result from changes in volume due to freezing (because there is no melting)
• residual stress and strain are minimal,
• at any time without weld porosity,
• The process is environmentally clean and highly energy efficient,
• can weld in all positions
• no need for any additional material or protective atmosphere,
• Requires no sanding and cleaning of welded areas.

Obr. 3 Transversal cross section of a weld [1]

Welding parameters for the instruments are usually chosen based on the results of previous optimization studies carried out in order to ensure flawless welds, creating high quality and good looks. The maximum temperature is concentrated in the weld areas directly related to the size of embedded energy in the resulting weld, parameters on the size and rotation speed of advancement of welding tool. It follows that the welds made with tools that are characterized by lower application rate of progression and increased rotational speed of the tool (Fig. 4a) can be considered hot welds. Welds made with instruments for which application is characterized by a greater progression rate and lower tool rotational speed (Fig. 4b) can be considered as cold welds [3].



Obr. 4 THE WELDING TOOLS FOR FRICTION STIRRING WELDING – a) with cavity conical shoulder, b) with scrolled shoulder [1]

For welding tools with tapered countersink tool shoulder is most commonly applied average welding mandrel (pin) 10 mm with a cone angle of 8 °, culminating in a cylindrical mandrel diameter of 3 mm in left-hand thread and a length of 0.9 mm. The axis of the tool is adjusted as needed with regard to the basic material. Tools with a spiral arm diameter 14 mm is usually set at zero angle, the pin is the same parameters as for instruments with a conical recess shoulders [3].

5. THERMAL REGIMES AND TECHNOLOGICAL PARAMETERS OF WELDING

Setting the optimal thermal welding is chosen based on results of examination of the impact of the main parameters affecting the amount of heat input for welding materials. Commonly used experimental methodology, based on the principle of the contact methods of temperature measurement, which ensures accuracy with variation not exceeding ± 15 ° C. The variable parameters of the friction stir welding is a welding tool rotation speed in the range 500 - 1400 rpm. / min, the average surface of the support shoulder tool - 8 to 12 mm and the welding speed from 80 to 210 mm / min. created by welding thermal cycles are directly subordinated to the theory of heat transfer laws. A necessary condition for the emergence of quality of welded joints in soft metals and their alloys to ensure the maximum temperature in the formation of weld greater than 390 ° C [2].

6. CONCLUSIONS & ACKNOWLEDGMENT

Friction stir welding appears in recent years as a highly efficient and reliable process for joining materials which are produced by high quality and precision welded joints of the required quality. Currently Extensive research into the wider application of this method in routine engineering practice, with very good results especially when combining metals and alloys of light materials (eg aluminum). However, application of friction stir welding is possible even during welding of ferritic steels.

When properly selected welding parameters and their continuous compliance during welding can ensure accuracy and continuity of the process.

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