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IMPLIMANTATION OF FEM TECHNIQUE IN THERMAL ANALYSIS OF FRICTION STIR WELDING

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Abstract: The aim of the study is to develop a three dimensional model of HDPE sheet by friction stir welding using finite element method for specific experimental cases & validate the data & results obtained by experimental techniques. The friction stir welding is to be simulated using FEM model with software tool ANSYS. The accurate 3D finite element simulation of the Friction Stir Welding (FSW) process requires a proper knowledge of both material and interface behaviours, but friction, the key phenomenon of this process, is quite difficult to model and identify. Friction stir welding is a relatively new welding process that has significant ad-vantages compared to the fusion process such as joining conventionally non-fusion wieldable alloys. Being a solid state joining process it produces weld with reduced distortion and improved mechanical properties. The HDPE sheet are widely used in different industrial applications such as ship building, aerospace and automobile industries due to their light weight, good mechanical strength and high corrosion resistance. A three dimensional finite element model is developed to study the thermal history in the butt welding of HDPE sheet using AN-SYS package. The heat source incorporated in the model involves the friction among the material, probe and shoulder. In this work, a moving co-ordinate has been introduced to model the three-dimensional heat transfer process because it reduces the difficulty of modeling the moving tool. In this model the main parameter considered is the heat input from the tool shoulder and tool pin. The temperature distributions of the weld at various welding speeds are obtained. The friction stir welding experiments are carried out at a transverse speed of tool 2970 rpm.

Keywords: HDPE sheet, Friction welding, FEM method, ANSYS

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INTRODUCTION

The use of the Finite Element Method (FEM) in product development is now well established. Its use in manufacturing processes is increasing and is part of the field of new applications in computational mechanics. The most important reason for this development is the industrial need to improve productivity and quality of products and to have better understanding of the influence of different process parameters. The modeled phenomena play an important role at various stages of the production of steel parts, such as welding, heat treatment and casting, among others.

The FSW technique was patented by The Welding Institute (TWI) UK, in 1991, introduced a new technique for metal joining & processing. It is a solid state joining technique which was originally developed & successfully applied for aluminium alloys. Recently, attempts have been made to adopt FSW technique to join the HDPE sheets. Friction stir Welding produces welds that are high in quality, strength & also inexpensive to make. The other main advantage is that it produces no fumes during process & is energy efficient. FSW does not need any filer material as required in conventional welding processes & is relatively easy to perform. However, the work-piece should be rigidly clamped & welding speeds are low in order to avoid defects like porosity. In the automotive industry, frictional stir spot welding (FSSW) was introduced in 2001 to replace resistance spot welding for aluminium sheets. Optimized process parameters & temperature variations during the process are important to engineers for an appropriate designing of weld layout. Both experimental techniques & simulations using finite element analysis are to be utilized to optimize the weld strength. The operating principle of FSW process is presented in figure 1.1.

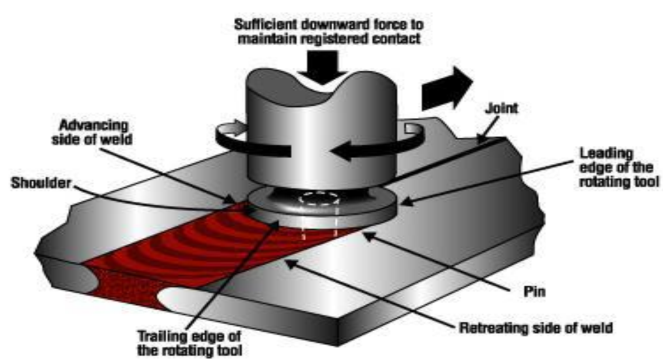

Figure No.1.1 Friction stir welding

OPERATION PRINCIPLE

1.2 Objectives

1. To Review the literature of Finite Analysis Approach for friction stir welding process.

2. To study thermal effects in a friction stir weld using Finite Element Analysis.

3. Various process parameters critical to the friction stir welding.

2 SYSTEM DEVELOPMENT

2.1 Experimental Model

2.1.1 Introduction

In this study use of the High Density Polyethylene (HDPE) Sheets for Specific experimental cases that in effect enhance the predictability of temperature evolution in joined work piece. The Friction Stir Welding (FSW) is a new type of manufacturing process in which the relative motion between the tool & work piece produces heat in the tool work piece interface makes two plastic sheets joined by plastic diffusion by virtue of frictional heat.

2.2 Detail of experimental setup

Friction Stir Welding (FSW) is an efficient solid states joining process that have numerous potential applications in many domains including aerospace, automotive and shipbuilding industries, as well as in the military. It combines frictional heating and stirring motion to soften and mix the interface between the two metal sheets, in order to produce fully consolidated welds. One of its main qualities lies in the possibility of joining materials previously difficult to weld, and to offer excellent mechanical properties.

FSW is based on strong couplings of thermo-mechanical phenomena. It induces very complex material motions and large shear forces. The material temperature is raised to about 80% of the melting temperature. Never the less the simulation of the process will be a further aim, as it is difficult to be numerically modelled due to the complex thermal and material flux occurring during the process, similar to Friction Stir Welding.

The conventional processes, working with molten phases are characterized by large heat input, which can change the microstructure of the diverse materials. This can provide mixed phases, which are very brittle and hardly formable, as well as hot cracks due to shrinkage during cooling or shape deviation. Contrary to melting joining techniques Friction Stir Welding is characterized as a solid phase welding. Technology, which was patented in 1991.The probe primary function is to mix the material under the tool shoulder, which can be enhanced by threads. FSW is actually performed in three steps. First, the probe is plunged into the joint formed by the two sheets to be welded, until the shoulder gets in contact. As the tool rotates at a high velocity, the sheets are heated up by plastic deformation and friction. Second, the tool keeps rotating without any translational motion, so the material heating due to friction increases. Finally, the tool moves along the joint line, heats the material further, moves it from the front of the tool, and deposits it behind its trailing edge, producing the weld. This process is illustrated in Fig. 1.

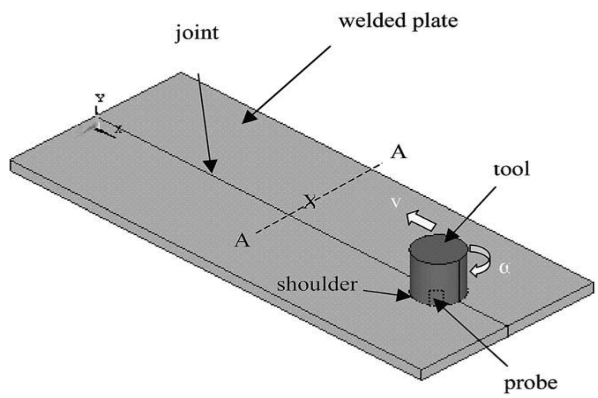

Figure No.2.1 A schematic representation of the Friction stirs welding process

Thermo-mechanical characterization of High Density Polyethylene (HDPE) Sheets has been the subject of various research works produced over a period of time. High Density Polyethylene (HDPE) Sheets present attractive properties with respect to their application in aircraft industries. These properties include medium to high strength, good corrosion resistance, improved weldability performance, good toughness as well as reduced residual stresses in large dimension plates and sheet products. These alloys have been investigated with respect to their mechanical properties, fatigue life, damage tolerance and corrosion resistance in. FEA can be used for thermal analyses to evaluate the temperature distribution, and stresses resulting from uneven heating or rapid temperature changes. Thermal analysis may include convection, conduction, radiation, steady-state, and transient analysis. The temperature dependent mechanical properties like the Young's modulus, tensile strength, true stress– strain. A three-dimensional rigid viscoplasticity model using computational fluid dynamics is carried out, that provides a parametric evaluation of the effect of tool speeds on the temperature field. The finite difference method and developed a three-dimensional heat flow model.

3. PERFORMANCE ANALYSIS

3.1 The study would consists of three parts which are:

The Theoretical Basis: The theoretical basis explores the information related

To friction stir welding and the factors related to utilize these theories.Friction stir welding is a relatively new solid state joining process.

Frictional heat is generated at the tool–work material interface by the tool under the action of a vertical load, thereby reducing the material flow stress.

Factors related friction stir welding,

Time, Speed, Strength, Depth of cut etc…

• Heat generation model & TEST RESULTS

By Fourlier's equation

$$Pc\,(dT/dt) = \text{div}(k\ \text{grad}\ T) + q$$

Material: HDPE Grade EN52009 Dimension: 400 mm X 75 mm, Thickness: 6 mm

Sr. No.	Tool Profile	Specimen No.	Tool No.	Speed (Rpm)	Force (Kg)	Temp (°C)	Dwell Time(sec)
1	Straight Cylindrical Tool with 0° Concavity and PD=10 mm	2	1	2970	8	162	40
2	Straight Cylindrical with 4° Concavity	4	2	2970	7	156	30
3	Taper Cylindrical with 4° Concavity	20	10	2970	12	131	25
4	Taper Cylindrical with 0° Concavity & PD=10 mm	12	6	2970	11	110	20
5	Taper Cylindrical Threaded with 6° Concavity	16	8	2970	11	77	40

Table No. 3.1 Experimental data (Friction Stir Welding)

Material: HDPE Grade EN52009 Dimension: 400 mm X 75 mm, Thickness: 6 mm

Sr. No.	Tool Profile	Specimen No.	Tool No.	Speed (Rpm)	Force (Kg)	Temp (°C)	Dwell Time(sec)
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4. RESULT AND DISCUSSION

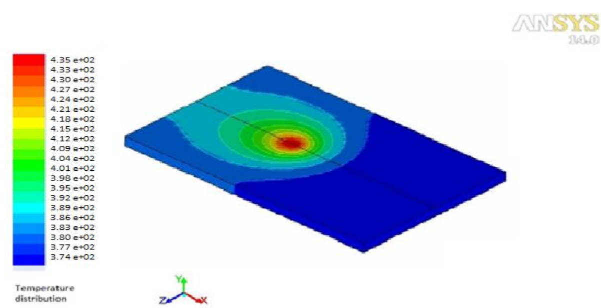
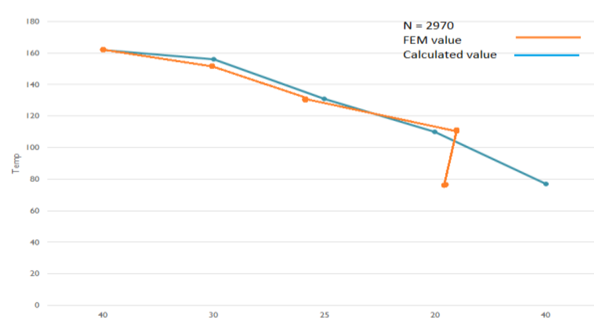
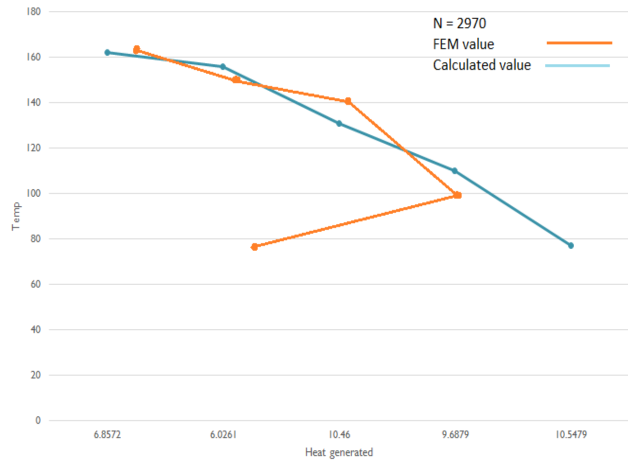


Figure No.4.1.HDPE sheet Temperature distribution in Ansys



Graph No. 4. 1 - A comparison of calculated and measured Temperature with Time



Graph No.4.2 - A comparison of calculated and measured Temperature with Heat generated

5 CONCLUSION

- From the comparison it shows that FE modelling and Experimental results gives nearly same values.
- From result temperature is decreases with decrease in time but at minimum temperature it increases.
- From result it concluded that FEM is best suitable for simulation of friction stir.
- Optimum value of tool rotational speed, tool plunge depth & dwell time must be used to obtain better weld strength as these process parameters governs the formation of weld nugget.
- In many cases, the quality of the joints was inadequate because of a non-satisfactory homogenization, which led to an embrittlement of the joint. Therefore, FSW of plastics is not a ripe technology yet, even if it seems a promising technique.

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