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Experimental Investigation of Ultrasonic Welding on Thermoplastic Material – A Review

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***Abstract*— Rapid performance and the absence of filler material in Ultrasonic welding has established itself as one the most effective techniques in manufacturing industry for fusing plastic assemblies. Faster joining and reliable process for developing plastic utility has increased in past decade. In Ultrasonic welding, by applying high-frequency vibratory energy and pressure, thermoplastics materials are joined without melting. Because of high-quality joints and low cost of Ultrasonic welding of Thermoplastic materials has become a popular process in the industry. In this research, experimental data of tensile strength of acrylonitrile butadiene styrene (ABS) and Polycarbonate (PC) of material for ultrasonic welding on welding parameters like Amplitude, Weld time and Welding Pressure has been studied. Analysis of Variation (ANOVA) and Full Factorial method are used to determine the critical states and effects of the welding parameters.**

Keywords*— *Ultrasonic Welding, Thermoplastic Material, Process Parameters, Tensile Strength, Full Factorial Method, ANOVA.

I. INTRODUCTION

In Ultrasonic Welding technique a high-frequency ultrasonic acoustic vibrations are passed on to work pieces being clamped together under pressure to create a solid-state weld.

It is generally used for plastics and metals, and mainly for joining dissimilar materials. In ultrasonic welding technique, there are no connective nails, soldering materials, adhesive, or bolts, necessary to bind the materials together.

The ultrasonic welding method is characterized by short welding times (<1 s for spot welds of glass, ceramics, and metals, and<4 s for spot welds of Carbon Fiber Reinforced Polymer and Glass Fiber Reinforced Polymer with metal) and as a result by a low-energy input. Because of no flames, fumes or spars, the ultrasonic welding process is environmentally friendly and clean. One of the advantages of ultrasonic welding technology is the automation capacity of the process and integrability of the ultrasonic welding into production line. Also, the electronic data storage and statistical evaluation of welding parameters is the other advantage of ultrasonic welding technology.

A Schematic diagram of Ultrasonic Welding apparatus is shown in Fig 1

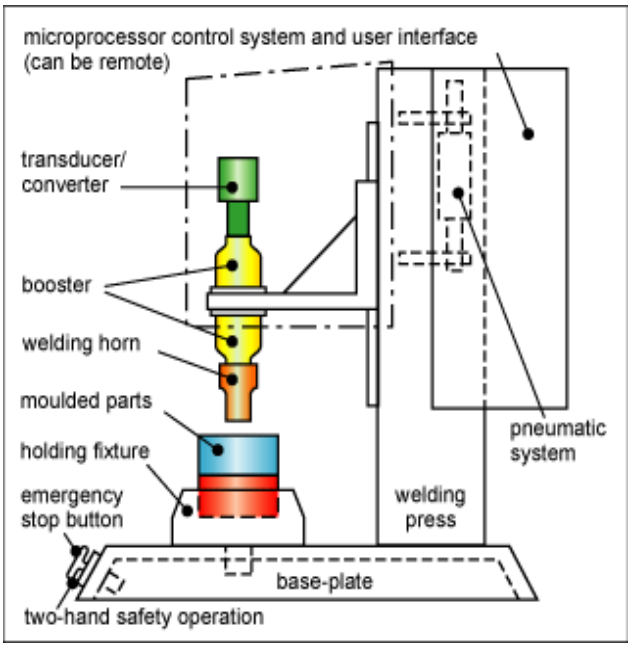

Figure 1: Ultrasonic Welding Schematic Diagram

To oscillate the components, the machine moves the tip of the sonotrode into very close contact of component. The component must be able to vibrate relatively freely and undamped within the predictable amplitude of oscillation.

Ultrasonic pulses are passed on and plasticizing takes place at the contact point of the part welded.

When the best possible plastification is achieved, a preselected intensified mechanical pressure is applied. After the ultrasonic impulse has stopped, the welding pressure is further increased but only to a nominal level. And after that cooling time begins. At the end of the process, machine sonotrode returns to its starting position and completes the welding process.

Based on the application and material the welding cycle time varies from 0.1 to 5 seconds.

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II. LITRATURE REVIEW

Umang Parmar and et. al[1] conducted an experiment on ABS to ABS using process parameters Amplitude, Welding Pressure and Weld time to influence effect on Welding Strength and Microstructure characteristics and analyzed experimental reading through ANOVA and Response surface methodology. They concluded that highly effective parameter is Amplitude and Weld Pressure.

Alejandro A and et. al[2] employed Tagauchi Robost design method and conducted an experiment on Thermoplastic Polyurethene using process parameters Weld time, Hold Time and Welding Pressure to influence effect on Welding Strength and Microstructure characteristics and analyzed experimental reading. They concluded that better weld quality and weld strength can be achieved by increasing weld time or the Ultrasonic wave amplitude.

D. Dehelean and et. al[3] used baseline for the experiment for Ultrasonic welding of Copper and nickel coated copper with Polyamid and Polypropelyn. They studied the effects on weld strength by varying process parameters Welding force, Welding Energy and Weld time and concluded that the Ultrasonic welding has an increased efficiency over conventional welding technology and there by higher productivity and saving in manpower and consumable.

Neda Stohr and et. al[4] studied the effect of the welding parameters and addition of plasticizers on weld strength and weld quality of ultrasonic welding of Polylactic acid films. They have used Welding force, Amplitude and Weld time as input parameter for their study. They concluded that addition of Plasticizers during ultrasonic welding of PLA films leads to improvement of weld factor and thereby to improvement in the weldability.

A. Levy and et.al[5] a multiphysics mathematical model and experimental validation on T300 Carbon Fiber reinforced polyetherimide was carried out. Studied the effects of welding parameters like Welding Force, Amplitude and Weld time for Dissipated power, Temperature prediction and adhesive evolution of welding joint. They concluded that mathematical model predicts the exact behavior of heat transfer problem and at the interface evolution of the adhesion.

W. Michaelia and et.al[6] conducted an experiment on Polycarbonate using process parameters Amplitude, Joining displacement and Welding Velocity to influence effect on breaking force and Microstructure characteristics and analyzed experimental reading through Response Surface Methodlogy. They concluded that for small joining displacements the influence of the amplitude is significantly higher than for joining displacement sw = 0.3 mm. At a joining displacement of sw = 0.1 µm the breaking force is decreased from Fb = 163 N down to Fb = 104 N when increasing the amplitude from â = 16.5 µm to â = 28 µm. At a joining displacement of sw = 0.3 mm the amplitude has no influence any more.

I Fernandez and et. al[7] employed Tagauchi Robost design method and conducted an experiment on Carbon Fiber reinforced Polyetherimide using process parameters Weld time, Hold Time, Amplitude and Welding Pressure to influence effect on Welding Strength and weld quality and influence of Energy directors and analyzed experimental reading. They concluded that multiple energy directors significantly reduce the disturbance of the fibers in the outermost layers of the welded parts. Transverse energy directors provide less scatter in the amount of welded area than parallel energy director configurations.

Rene Schulze and et.al[8] employed Central Composite Circumscribed design method and conducted an experiment on Aluminum 5083 & Carbon Fiber reinforced Thermoplastic using process parameters Energy, Amplitude and Joining force to influence effect on Welding Strength and weld quality and analyzed experimental reading. In this study they tried to evaluate the effect of various surface treatment on the quality of weld and weld strength. They concluded that achievable shear strength can be influenced by surface treatment. Laser micro structuring and thermal spray coatings helped in achieving higher tensile shear strengths.

Simona Jesvnik and et.al[9] conducted an experiment on Polyurethene to Polyamide using process parameters Frequency, Velocity and Pressure to influence effect on Bonding Strength and Weld Quality and analyzed experimental reading through Student T-Test. Statistical analysis showed that ultrasonic welding parameters, such as Velocity and welding frequency has high impact on the bending stiffness, thickness and bond strength of welded seams, but the obtained results were statistically insignificant.

Erol Sancakter and et.al[10] used baseline for the experiment for Ultrasonic welding of Polypropelyn with Fillers Mica, Calcium carbonate and Glass Fiber. They studied the effects on weld strength by varying process parameters Welding force, Amplitude, Trigger Force and Weld time and concluded that the weld time has the greatest effect on the weld strength of each of the filled compounds. High weld strength was observed at unfilled polypropylene which involves higher value of welding parameters. For each given filler, weld flash was highest at the highest loadings of filler.

III. CONCLUSION

1. From the literature review, it is concluded that work has been done on Ultrasonic Welding of different structural non metallic material like Thermoplastic Polyurethene, Polyamid, Polypropelyn, Polylactic acid, Carbon fiber reinforced Polyetherimide, Carbon fiber reinforced thermoplastics, Polyvinyle Chloride,
2. Based on the experiments, the effect of selected input parameters on the output responses like Microstructure, Quality of Weld and Tensile strength are studied.
3. Most influential process parameters are Amplitude, Weld Pressure and Weld Time.

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IV. GAP IDENTIFICATION

1. In case of non-Metallic Ultrasonic welding, it is found the studies, experiments and researches have been done on similar kind of thermoplastics, for example, ABS to ABS, Polyurethane Thin Film, PLA Films etc.

2. No research /study or experimental investigation was found for ultrasonic welding of pure ABS & pure Polycarbonate.

3. The effect of Amplitude, Weld Pressure and Weld time on Thermoplastic material like ABS and PC can be studied.

4. Optimization of parameters can be done by using ANOVA method.

V. FUTURE WORK

1. The effect of Ultrasonic Welding process parameters on welding of Acrylonitrile Butadiene Styrene (ABS) and Polycarbonate (PC) which is suitable for welded, bolted and riveted structures and for general engineering purposes.

2. The detailed experiments will be performed on using full factorial method and the parameters like Tensile Strength and Microstructure will be measured and studied by varying Amplitude, Weld Pressure and Weld Time.

3. The process performance parameter will be analyzed for various parameters using ANOVA and the optimum combination of process parameters will be obtained.

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