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Experimental Analysis of Bonding Strength of Ultrasonic Welding Joint

Surendra Kumar
Lecturer, Mechanical Engineering Department, MITRC, ALWAR
Alwar, Rajasthan, India
Ydewansh02@gmail.com

Abstract

In ultrasonic welding procedure, high frequency vibrations are shared with pressure to join two materials together speedily and firmly. Ultrasonic welding can join unlike metals in a split second, ultrasonic welding simplicities difficult assembly and this cost effective practice may be significant to mass producing fuel efficient. In this work outcome of various parameters on weld strength have been calculated. Welding of .5 mm aluminium plates were successfully welded by 20 kHz ultrasonic welding scheme. One dimensional vibration system for ultrasonic lap spot welding of metal plate of aluminium have calculated .The relations between weld strength and the variables of weld energy, period of weld cycle, have studied Experiment was carried out to determine the mechanism of aluminium-aluminium plate closeness. These experiment, including effect of amplitude and pat tern of bond formation. Experiment was carried to find out the optimal parameter for maximum strength.

Keywords: *Welding, Ultrasonic Metals.*

1. Introduction

Ultrasonic welding is an industrial tech-nique whereby two pieces of plastic or metal are fused together seamlessly through high-frequency acoustic pulsations. One component to be welded is positioned upon a fixed anvil, with the second component being placed on top. An extension ("horn") linked to a transducer is lowered down onto the top component, and a very quick (~20,000 Hz), low-amplitude acoustic pulsation is applied to a small welding zone. The acoustic energy is transformed into heat energy by friction, and the portions are welded together in less than a second.

2. Ultrasonic metals welding

The system that is used to brush the pieces together consists of four major components. The first of these is the anvil. This is simply a part of the machine, usually with a replaceable head, that grips one of the components still while the other is scrubbed against it. The "professional end" of the ultrasonic system consists of three major parts. The first of these is the ultrasonic transducer. This component takes an electrical indication from a power supply that is providing a 20 kHz AC indication and converts it to a mechanical motion at the same frequency as shown in fig. The vibration that results is at a frequency that is significantly above the range of human hearing, hence the name ultrasonic. There is a power supply which raises the frequency of the electrical current from the grid, then the transducer that transforms electrical into mechanical energy, then a booster that alters the shape and magnitude of vibrations an lastly the horn that vibrates the material to be welded, while it is compressed unto the stationary anvil.

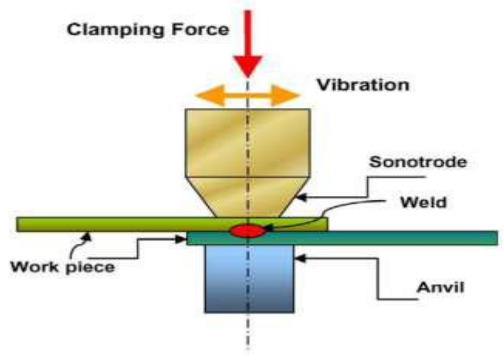

Fig 2.1 Ultrasonic metal welding

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3. Parameter control

1. Welding pressure or clamping pressure
2. Welding voltage
3. Welding current
4. Ultrasonic frequency
5. Welding time
6. Welding energy
7. Constant amplitude
8. Weld location

.

4. Welding in the energy mode

Welding in energy approach, i.e. with a constant energy setting, is known from ultrasonic plastics welding and can be used for ultrasonic metal welding. To attain a constant quality the welding time is automatically adjusted. Although this type of quality control is respectable with ultrasonic plastics welding, the method has to be more sensibly applied when it comes to ultrasonic metal welding.

Welding in energy mode

Energy: 2000 Ws
Weld position: at middle of lap
Amplitude: 75%
Pmax =300 w

Table 4.1 - Weld time and strength in energy mode

Sr.No.	Weld time in seconds (T2)	$\%P_{max.}$	$T2*\%P_{max.}$	Strength (weight) in Kg
1	2.8	54	151.2	8.5
2	4.8	41	196.8	9
3	3.2	63	201.6	9.5
4	3.64	62	225.7	11.5

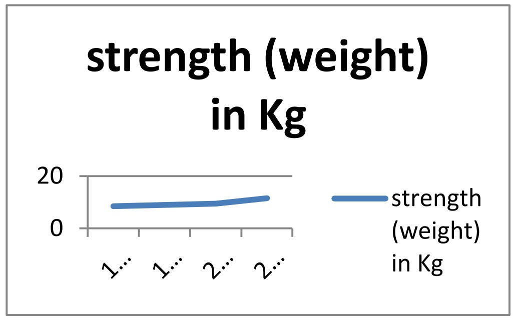

Fig 4.1. Relation between Weld time and Strength in Energy mode

5. Welding in the time mode

This is the most appropriate mode for ultrasonic metals welding. Welding energy and rate of compression is variable, but we only consider the variation in energy because rate of compression fixes minor effect on weld strength subject to the unconventionalities of the work piece. They should, however, stay within adequate limits. The welding process trimmings automatically as soon as the nominal time value is attained. The welding time is defined as the duration of ultra-Sonic's and can be both a constant parameter and a variable parameter familiar with the help of quality control devices for finest weld. Depending on the application the welding time can be between 0.1 and almost 4 seconds.

Welding in time mode

TIME: 2.5 s
Weld position: at middle of lap
Amplitude: 75%
Pmax =300 w

Table 5.1 weld energy and strength at 75% amplitude

Piece no	Weld energy in Ws	%Pmax	%Pmax* weld Energy.	Strength (Weight) in Kg
1	913	34	31042	3
2	1044	38	39672	4
3	1282	65	83330	10
4	1452	61	88572	10
5	1656	60	99360	11

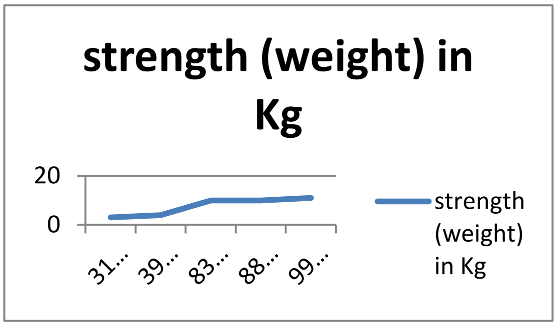

Fig. 5.1 Relation between weld energy and strength at 75% amplitude

Welding in time mode

TIME: 2.5 s
Weld position: at end edge of lap
Amplitude: 75%
Pmax =300w

Table 5.2- weld energy and strength at 75% amplitude at end

Piece no	Weld energy in Ws	%Pmax	%Pmax *weld Energy.	Strength (Weight) in Kg
1	672	46	30912	6.5
2	721	47	33887	6.5
3	880	45	39600	9
4	852	51	43452	9.5
5	965	52	50180	10

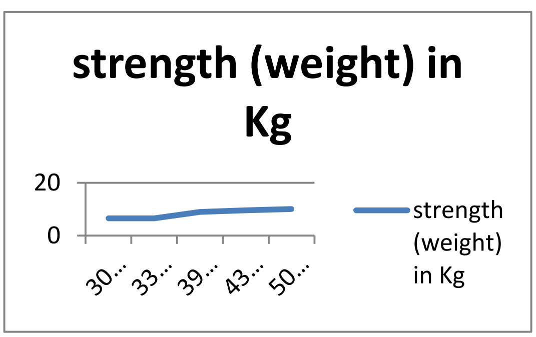

Fig 5.2. Relation between weld energy and strength at 75% amplitude at end

6. Evaluation among welding at the middle of the lap and at the edge of the lap-

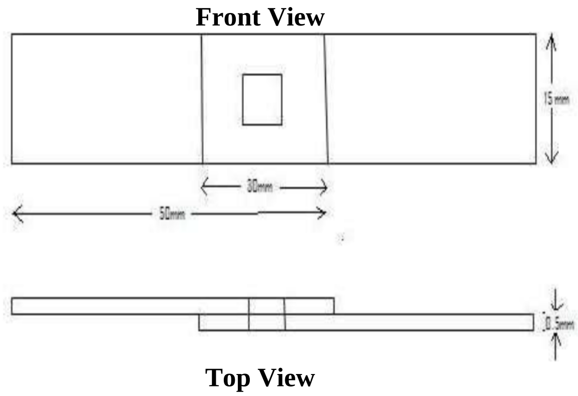

Fig 6.1 Welding at middle of lap

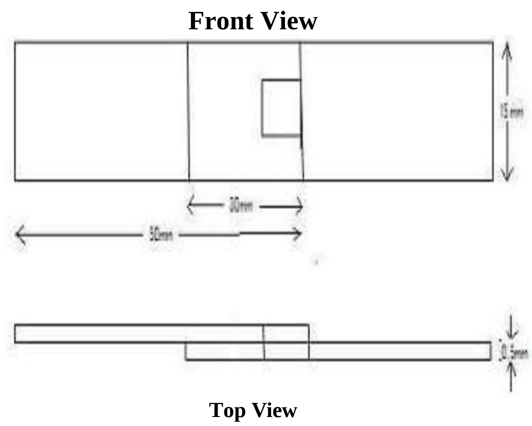

Fig 6.2 Welding at end edge of lap

TIME: 2.5 s
Amplitude: 75%
Pmax =300w

Table 6.1 Evaluation among welding at the middle of the lap and at the edge of the lap

Sr. No.	At the middle of the Lap		At the edge of the Lap	
	Energy (Ws)	Strength (Kg)	Energy (Ws)	Strength (Kg)
1	913	3	672	6.5
2	1044	4	721	6.5
3	1282	10	880	9
4	1452	10	852	9.5

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Exp. No.	Voltage (V)	Current (amp)	Pressure (Mpa)	Strength (Kg)
1	232	1.6	0.35	3.5
2	232	3.6	0.44	8.5
3	232	6.5	0.55	9
4	341	1.6	0.35	10.5
5	341	3.6	0.44	6.5
6	341	6.5	0.55	8
7	452	1.6	0.35	8.7
8	452	3.6	0.44	12.5
9	452	6.5	0.55	7.5
5	1656	11	965	10

Table 6.1 shows that in situation of welding at the edge of the lap the bonding strength is

Symbols	Process Parameter	Levels		
		Low	Medium	High
V	Voltage (Volt)	232	341	452
I	Current (amp)	1.6	3.6	6.5
P	Pressure (Mpa)	0.35	0.44	0.55

considerable more compare to welding at the middle of the lap. It also consumes less energy and gives superior strength. Because in case of welding at the edge of the lap the surrounding are mainly air Which have low thermal conductivity related to aluminium in case of welding at the middle of the lap. Because of high thermal conductivity of aluminium, the heat losses are more in case of welding at the middle of the lap associate to in case of welding at the edge of the lap. So the welding at the edge is favoured than welding at the middle.

7. Experimentation and data collection

Table 7.1:-parameters and their levels of experiment

7.1 Experimental results

Table 7.2:- Consolidated design of experiment

In this effort, the well-disciplined factors taken are Voltage (V), Current (I) and pressure (P). Since they disturb strength and welding operation and these factors are manageable in the ultrasonic welding process, they are considered as a controllable factor.

7.2Analysis of means and response graph for strength

Analysis of means

The analyses of each manageable factor are considered and the main outcome of the same is obtained in table. Main result of every factor at individual level i.e. at low, medium and high level is equal to the mean of strength of all experimentations with the factor at individual level.

(a) The main result of voltage on strength at various levels calculated as follows
L = (3.5+8.5+9)/3 =7.0 Kg
M = (10.5+6.5+8)/3 =8.33 Kg
H = (8.7+12.5+7.5)/3 =**9.57 Kg**
(b)The main result of current on strength at various levels calculated as follows
L = (3.5+10.5+8.7)/3 =7.57 Kg
M = (8.5+6.5+12.5)/3 =**9.17 Kg**
H = (9+8+7.5)/3 = 8.17 Kg
(c) The main result of pressure on strength at various levels calculated as follows
L = (3.5+6.5+7.5)/3 = 5.83 Kg
M = (8.5+8+8.7)/3 = 8.4 Kg
H = (9+10.5+12.5)/3 =**10.67 Kg**

Symbols	Manageable Factors	Strength (Kg)		
		Low	Medium	High
V	Voltage	7	8.33	9.57
I	Current	7.57	9.17	8.17

P	Pressure	5.83	8.4	10.67

Table 7.3 mean responses for strength

7.3 Response graph for means

The value obtained from the response table are plotted to visualize the effect of three parameters. From the means response graph observation finding are illustrated as follows-

(a) Level III for voltage (V3) =9.57 Kg indicated as the optimum situation in terms of strength.

(b) Level II for current (I2) =9.17 Kg indicated as the optimum situation in terms of strength.

(c) Level III for voltage (P3) =10.67 Kg indicated as the optimum situation in terms of strength.

Main effect plot for Strength Data means

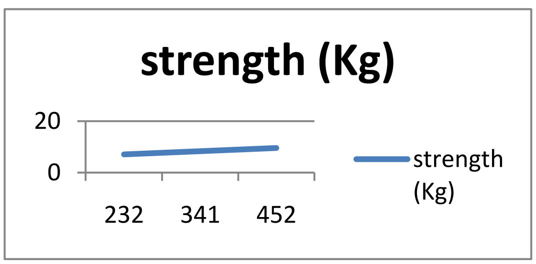

Fig 7.1(a) Strength v/s Voltage

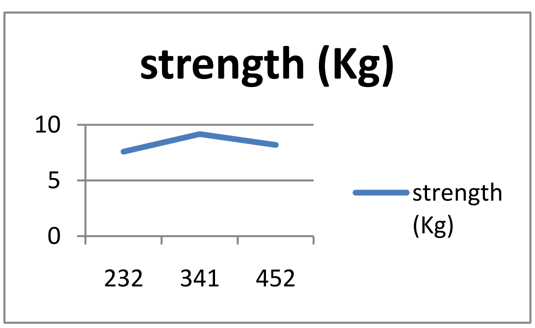

Fig 7.1(b) Strength v/s Current

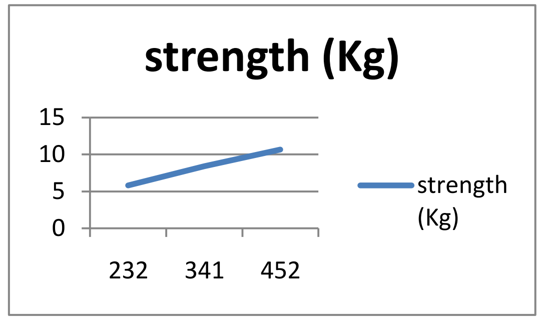

Fig 7.1(c) Strength v/s pressure

Fig 7.1 Mean response graph for strength

7.4 Confirmation of experiment

For maximum strength the combination of optimum parameters (V3, I2, and P3).It means high voltage, medium current and high pressure. For this combination **V3=452 v, I2=3.6** amp and **P3= .55 MPa, the** strength is **12.5** Kg.

8 Modeling of parameter

To generalize the outcome, the modeling of input parameters (Voltage, Current and Pressure) and output parameters (Strength) is done using REGRESSION MODELING and Mat lab software R2011b.

Now the Formula of strength in relations of voltage, Current, and Pressure

Strength (Kg) = (Voltage) 0.5514* (Current) 01431* (Pressure) 1.5115

9 Comparison of result

Strength (Kg)	
Experimental Result	Result from mathematical modeling
3.5	4.16
8.5	6.7
9	9.73
10.5	9.8
6.5	5.8
8	9

8.7	10.57
12.5	12.92
7.5	7.42

Table 9.1 - comparison of results

9.1 Evaluation of result for Maximum Strength

Result	Experimental result	Result from mathematical modelling
Level	V3-I2-P3	V3-I2-P3
Strength (Kg)	12.5	12.92

Table 9.2 - Evaluation of Results

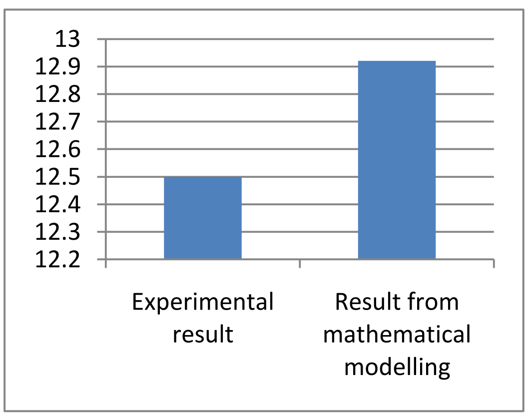

Fig. 9.1 Evaluation of Results

10. Conclusions

 the time mode is additional positive mode for ultrasonic metal welding.
 Weld position should be considered in ultrasonic lap joint welding, due to consequence of thermal conductivity of metals weld location also affect the welded quality. Welding at end edge of lap give relative good welded quality and the more efficiency of ultrasonic welding system.

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