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"COMPARISON OF WELD STRENGTH OF DISSIMILAR MATERIAL USING FRICTION WELDING"

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ABSTRACT: *Prediction and study of the demand of joining dissimilar material in industry is largely in practice. Nowadays researchers worked to find the specimen with good mechanical properties, for this paper we undergone to find the AISI 430 ferritic stainless-steel material and copper with joining them with friction welding over the time. To understand the quantitative weld interface on the friction welded joint to evaluate the impact strength, torsion and tensile stress is discussed. Using the available data in the literature, input parameters of copper and AISI 430 ferritic stainless-steel material combinations were examined and analysed. Burn-off length, upset pressure, friction pressure and rotational speed are the parameters used to analyse the composition by using Taguchi's L9 orthogonal array for prepared sample. Also, samples weld joint analyses after testing through visual inspection for the better quality of products and strength of materials.*

1. INTRODUCTION

Fact about the engineering society, practiced in the industries for the quality manufacturing to reduce as the critical defect size. The assessment methods & tends practiced more than 100 years for the inspection during manufacturing. In different methods weld surface require lot of expertise and knowledge for the development of the industrial life. Since the choice of possible methods of joining of materials of the weld parts in the recent manufacturing, preservice and in-service.

After observation certain thing as data taken from experienced persons, I am trying to get the parameters properly for the major changes needed inside the thesis as per taken data. As usual, things are going inside industries, but right scenario needs to optimize the processes. Further details will attach in the final dissertation, as per experiment & results.

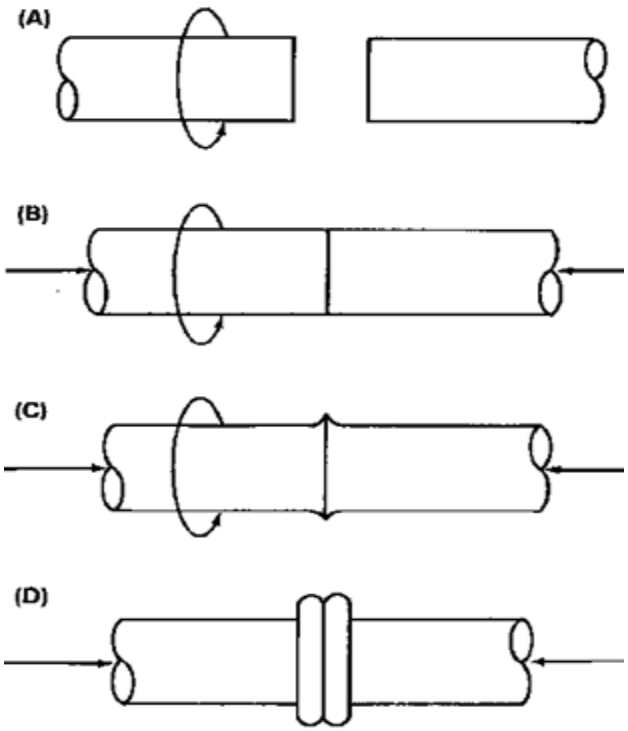

Fig 1: In the above figure steps involved for friction Welding

As discussed with their engineers and technician, major problems found inside the fiction welding are:

1. Current (Undercut formation)

2. Non-quantity (Current & voltage)
3. Thickness of Materials (SS, MS, Al)
4. Torch angle
5. Filler wire
6. Gas setting

In this study of friction welding, to improve & innovate the quality of manufactured products in the industry Taguchi methods are used as statistical methods. For the study of the dissimilar metals, here the optimal levels for various specimen, it is hard or impossible to control under uncontrollable conditions for the complete welding process that is, insensitive to noise factors in the continuous process

Enables joining dissimilar metals: It is essential that proper preparations and precautions should be taken for joining dissimilar metals. Recently, we used the bimetallic friction joints to join dissimilar metals. friction welding is that it can be used for the below metals in the recent research and their activity:

a) Titanium to Copper
b) Copper to Aluminium
c) Aluminium to steel
d) Nickel alloy to steel

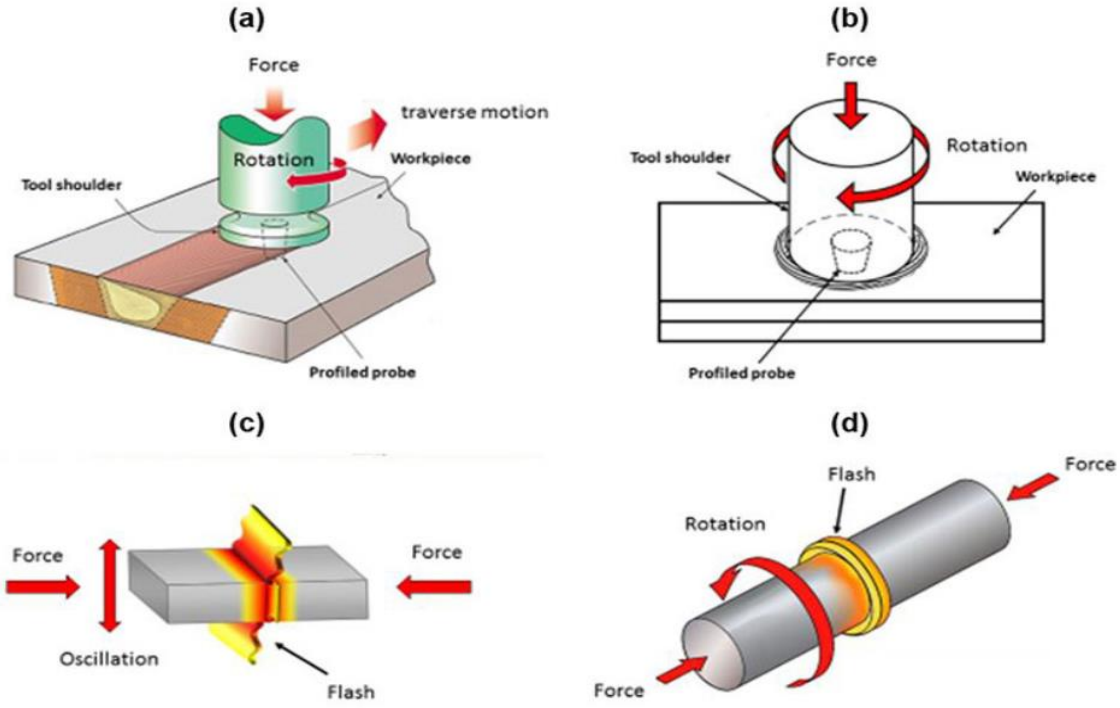

Fig 2: Friction welding above at various stages

To analyze the detail data of friction under the various stages of product creation, Minitab software used as problem solver of statistics data, with the reference of the several information.

2. OBJECTIVES OF RESEARCH WORK

I. Investigation of dissimilar material to access the development of solid-state conditions of Mild steel and Stainless steel using the friction between the two surfaces for detail conclusion.

II. Joining of dissimilar metals namely stainless steel and mild steel bars of same diameter to determine their optimal conditions. Under these conditions different parameters namely axial pressure, forge pressure, process speed and their comprehensive rotation force were studied.

III. Present study is for dissimilar metal (mild steel-stainless steel) investigated in the present work through the jaws over the machine by rotating at one end and other end is fixed for the applied torque to analyze the torsion & impact test through pendulum fall over the notch opposite ends. The tensile strength of the joints determined, using a conventional tensile test machine.

A gap is something that remains to be done or learned in an area of research; it's a gap in the knowledge of the scientist in the field of research of your study:

1. In the various research paper, I reported that the weld strength of several dissimilar material has been tasted on single scale i.e., UTM testing, Rockwell hardness testing, fatigue test.
2. Several dissimilar metal welding processes is carried out using the material having same diameter, we can also explore the welding as well as microstructure evolution using different diameter.
3. There was lot of parameters (Weld time, burn off length, RPM) which can be varied individually to see their individual effects rather than combining these parameters.
4. I also investigated that some sort of deflection occurred in several instrumental readings, the weld criteria and weld geometry as for the same RPM and for same welding dimension the test results vary.

3. Experimental Methods & Methodology

Specimen selection for friction welding

Experimental arrangement and their collection form the local and city markets with their complete information about material selection design factors. Conceptualization of the research and synthesis of new product analysis that will satisfy functional and economical specifications to the market, that is observed for the life of product is:

I. Parameter design

II. System design

III. Tolerance design

Dissimilar materials of copper and ferritic stainless steel friction welding are shown in Figure 1. In this work cylindrical rods of 25 mm diameter surface are well polished and cleans through the machining, samples diameter of cylindrical rods is 24 mm and 75 mm in length. Were purchased. Samples of the friction welded specimen is having the changes found in their chemical composition as detailed in Table 1 and 2. Testing machines used to find out the load test. Here, we used the tensile testing machine, with maximum load capacity of 75MPa to 135MPa. Dimension of 60 mm x 20 mm for tensile test was cut to test all the load conditions. Nozzle size and gas flow rate depends upon the specimen thickness (mm). Therefore, it is as per the thickness gas flow rate should be maintained.

Figure 3: Specimen visual inspection of welded portion

Specimen rotational speed sets by studying the literature review to 920 RPM. Levers are there inside the lathe machine to adjust the rotational speed over the specimen, the constant speed over the sample was achieved within a fraction of seconds. Before applying the axial pressure, specimen checked for their axial alignment subsequently. Axial pressures differed from paper to paper for present study under composition of alloy, also matter for the different weld joints between 75MPa to 135Mpa. Weld portion will come down at required cooling point after 5-8 minutes of wait after the welding joints formed.

Parameters for the specimen size to form the samples:

i. Sample size of 24mm x 75mm for their testing should be form.
ii. Dimension of Cylindrical rods (25 mm) of Día.

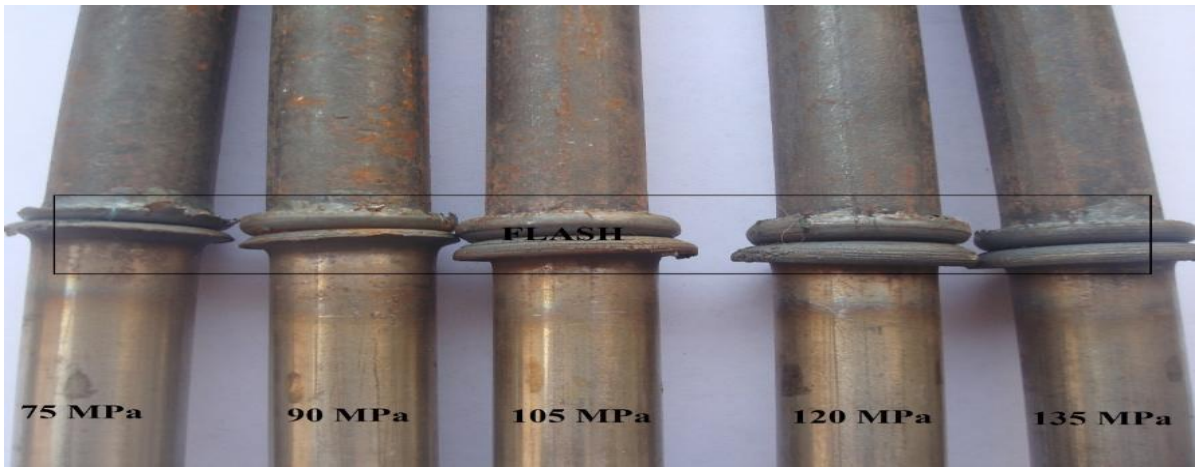

Figure 4: Specimen samples material (copper and ferritic stainless steel for friction welding at different pressure)

Dissimilar materials have taken inside this job. Experiments are conducted based on Taguchi's of 24 mm and 75 mm in length to a diameter. The chemical composition on L9 orthogonal array with three levels of copper and ferritic stainless steel made by friction welding are shown in table 1, 2 & 3. The friction welded samples of the dissimilar material is well polished and cleaned by using acetone.

Table 1: Shows the Ferritic stainless steel Chemical composition

Element	Si	Fe	S	P	Mn	C	Cr	Ni
%	0.551	81.58	0.016	0.023	0.689	0.076	16.52	0.19

Table 2: Shows the Copper Chemical composition

Element	Cu	Fe
%	99.99	<0.01

Table 3: Shows the Copper Chemical composition

Parameters	Level 1	Level 2	Level 3
Rotational speed (rpm)	500	1000	500
Burn-off length (mm)	1	2	3
Upset pressure (MPa)	65	87	108
Friction pressure (MPa)	22	33	43

All the parameters adapted for the friction welding of specimen taken for the readings is shown in below table 4. Nomenclature of rotation per minute is (RPM), materials friction pressure (Pressure P1), materials upset pressure (Pressure P2), No. of time t1 (friction time), No. of time t2 (upset time)- forging phase and - heating phase.

Table 4: Different parameters adapted for friction welding

Number of trials	Friction time (s)	Friction pressure (Mpa)	Rotational speed (RPM)	Upset Pressure (Mpa)	Upset time(s)
1	5	80	1500	150	5
2	5	80	1500	175	6
3	5	80	1500	200	7
4	5	80	1500	300	8

A material constitutes of several substances in their core shown in Table 1. Object is the mixture of materials and their substance. It can be their physical and chemical properties to their biological function and geological origin which retain it as their existence in pure or impure. This required their integrity to be retained during imaging. To achieve this prior to FIB preparation of samples.

Table 5: Different parameters adapted for friction welding

SAMPLE NO.	STANDOFF DISTANCE (inch)	OXYGEN FLOW RATE(m^3/min)	LPG FLOW RATE(m^3/min)	POWDER FEED RATE (gm/min)
1	7	180	70	14.09
2	7.7	265	64	14.09
3	8.5	35	58	14.09
4	7.7	180	58	15.94
5	8.5	265	70	15.94
6	7	350	64	15.94
7	8.5	180	64	17.80
8	7	265	58	17.80
9	8.5	350	70	17.80

Microstructures of the coating on substrate metal plate are

A. Micro-hardness of the coated material on stainless steel plates.
B. Porosity volume % fraction testing.
C. Scanning Electron Microscopy
D. Coating Thickness measurement.

There was lot of parameters (Weld time, burn off length, RPM) which can be varied individually to see their individual effects rather than combining these parameters.

4. RESULTS&DISCUSSIONS

As evaluated for the combinations of materials in the alloy with the visual examination like impact strength, micro hardness, and tensile strength through the machine to identify the conclusion for the product formed. It has been observed from the tensile test of the tested materials, by the specimen magnified images were captured samples to know their strength in tension at the fractured locations taken at 1,500 X magnification.

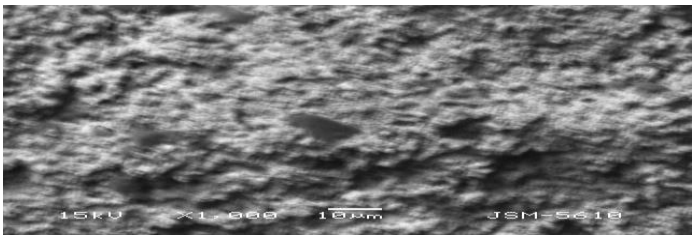

Fig 5: SEM of the coating at X1000 of particle size 10 μm.

4.1 Tensile Testing

For every specimen tensile test were subjected and recorded for different specimen load applied until it fractures and gets distorted from inside. Universal Testing Machine (UTM) used to perform the tensile test over the specimen and here machine used is having the capacity of 600 KN. Samples prepared through the ASTM standard and specimen gauge lengths were maintained for every sample as detailed in ASTM A370-12 to keep the gauge length in center of the weld interface. Samples one by one tested and result for tension, axial tensile stress, fracture recorded at the variations of load. Tensile stress Vs strain graph plotted after the result analysis, and it shows the increase in stress for every change or increase in strain.

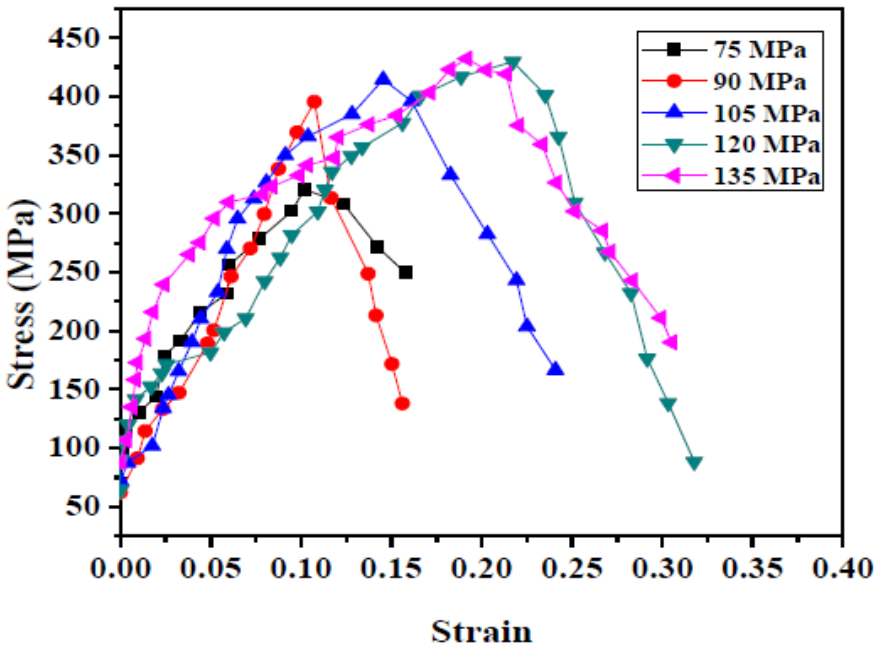

Figure 6: Relationship of Strain vs Stress (Mpa) at pressure exerted at axial point

4.2 Torsion Test Analysis

Analysis through scientific instruments performed for torsion test of the samples. Torsion test for the specimen applied till sample gets fractured. Every sample fitted to machine, machine have two jaws in which one side it was kept fixed, and the other side of jaw will rotate at applied torque. So, over the machine it gets twisted over the applied torque, degree of twist of the specimen called angle of twist and measured angle of twist said to be application of torque. During measured application of twisting moment all specimen starts twisting for the change formed at angle and the specimen angle of twist for every sample in terms of degrees varied from 70 to 160 and sample for maximum torsion strength for the tests varied from 11.82 Nm to 21.10 Nm. For every sample at interval of 5 min, we change the torque by increasing it and it change the angle of twist. Also, increase in axial pressure from the experiment noted that angle of twist increases for the sample.

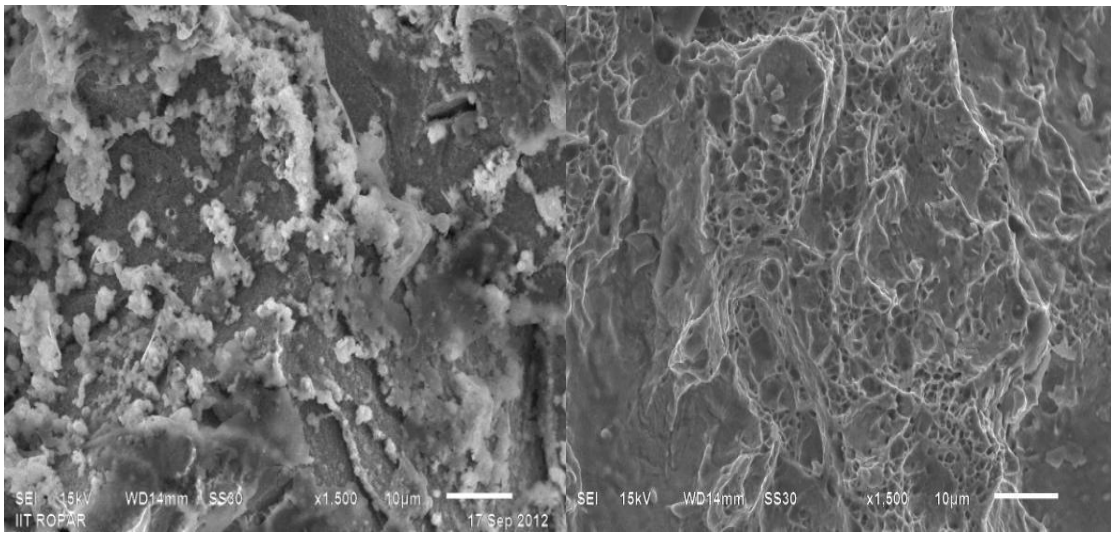

Fig 7. Specimen SEM image at 75 & 90 MPa axial pressure

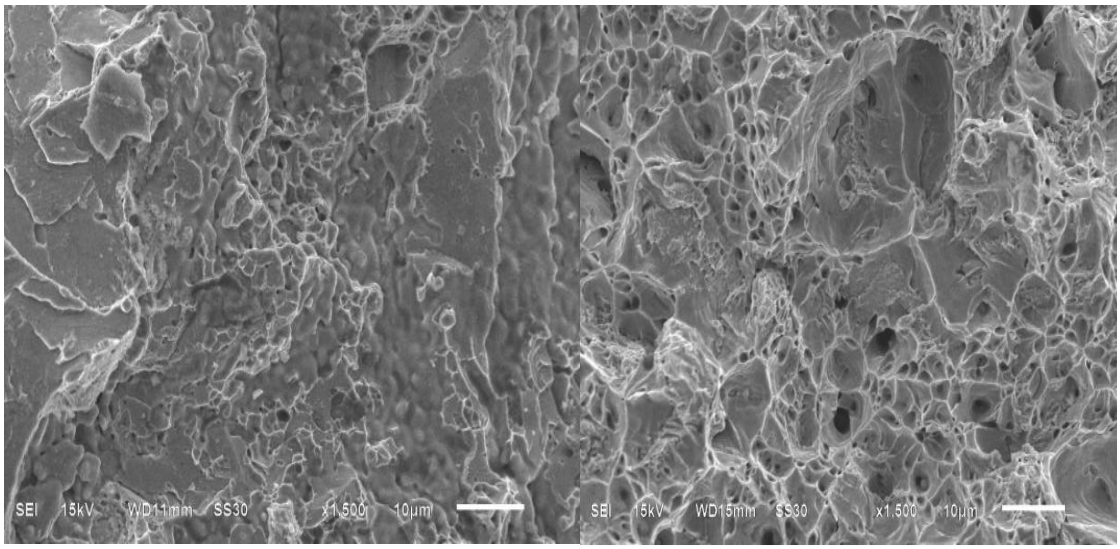

Figure 8: SEM image at 105 & 120 MPa axial pressure

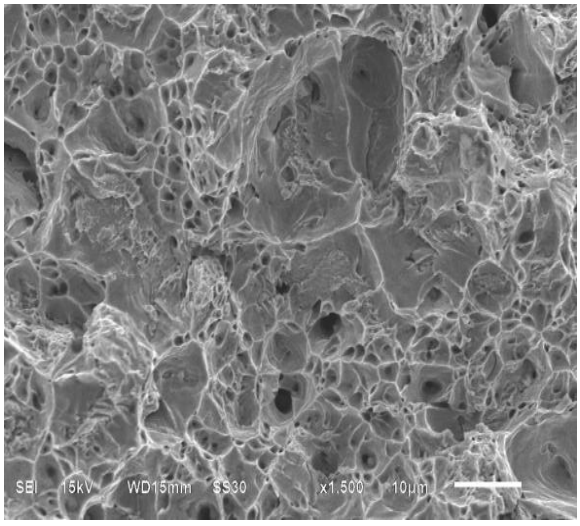

Figure 9: SEM image at 135 MPa axial pressure

Using impact testing machine with the method of pendulum type single blow test was carried out for Charpy impact test. ASTM standards set for the sample preparation to form the notch at the center of sample weld interface. at both ends specimens were supported and it was check by broking the sample opposite side of notch by dropping the pendulum. So, for every drop there will be test noted and shown in table for their relative change of impact around the samples.

Table 6: Samples with their impact strength relation

Sample No	Charpy Impact (J)	Izod Impact (J)	Axial Pressure (Mpa)	Fracture Location
S1	25	20	75	weld interface
S2	25	20	90	weld interface
S3	24	19	105	weld interface
S4	23	19	120	weld interface
S5	21	19	135	weld interface

4.3 Micro hardness testing

In this test we apply the load along the axis at the intervals of 1 mm which is constant on the alloy combination of materials by using the Vickers hardness testing machine. A potentiodynamic polarization curves obtained as shown in figure 10 through the test on the parent materials for the applied load of 500 gf. Affect of heat as indentations for the parent material to find the hardness and their variations tested, based pyramid type diamond analysis of micro hardness testing of materials achieve the length of the hardness required for the combination of materials.

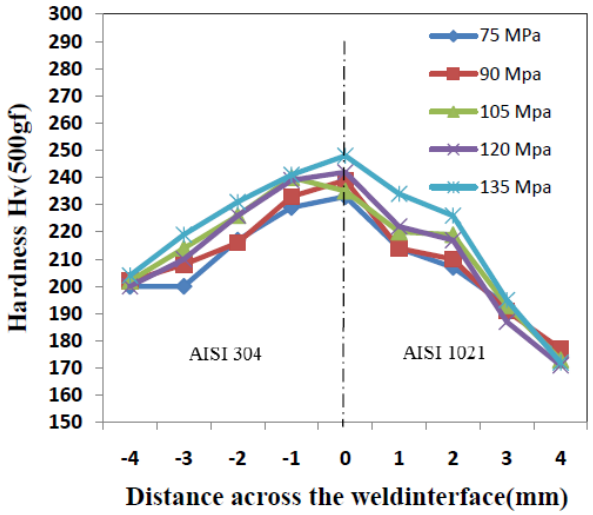

Figure 10: Shown the material Weld interface vs Hardness variations distance

At the weld interface all the materials used to form the alloy combinations is having indentations of higher values and on both weld faces, also interface was probably place during friction welding. In addition to hardness oxidation process which takes at the increase in hardness variations. Once the details for whole collected data through testing analyzed the following results obtained from Minitab software for the testing.

ANALYSIS

Probability Plot of Current (I), Voltage (V)

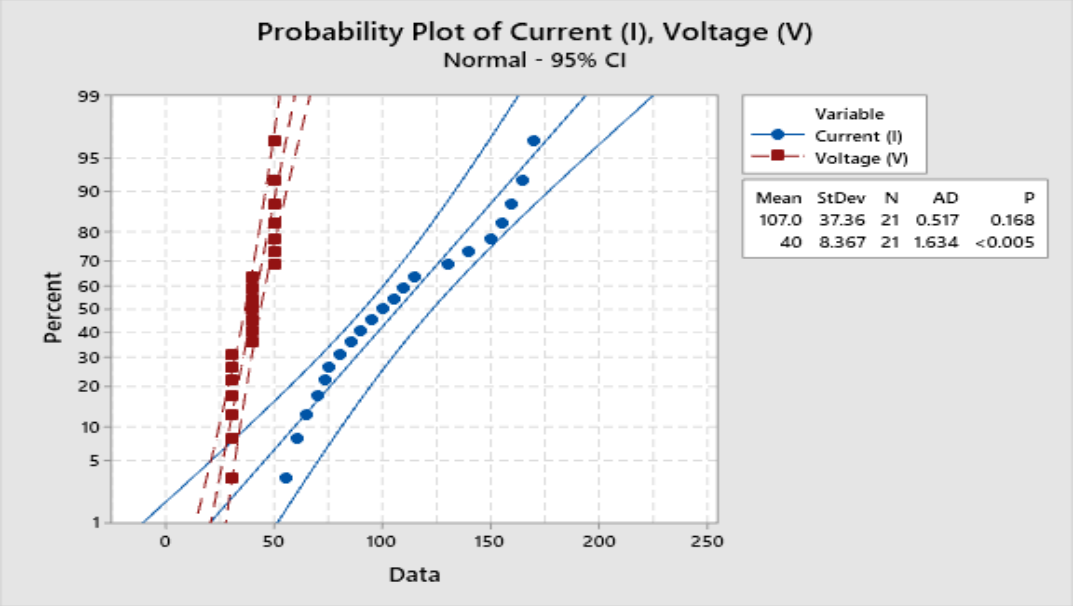

Fig 11: Minitab graph welding current 100,110, 120, 130 and 170 are used over the welded specimen and their welded sample

To reduce temperature length graph and the heat input variations inside the slope curve for the theoretical basis is the same. It increases with the root gap and decreases cracks the slope curve with the root gap spaces affected by the temperature gradients. Time is considered for the fraction welding inside the zone for maximum and minimum as found which. is easier to time curve.

4.4 *OPTIMISATION*

Temperature of the heat generated and the sample results at the time interval. Results are shown in below figure no. 12 for the applied eddy current and infrared image of the system was in the high temperature regions. Temperature gradients will increase gradually and these gradients from the thermal image have of cracks have more bright area of 2s around the crack across the sample taken, which have bright areas of the image was taken.

ANALYSIS

Pareto Chart of Current (I) by Welding Speed (S)

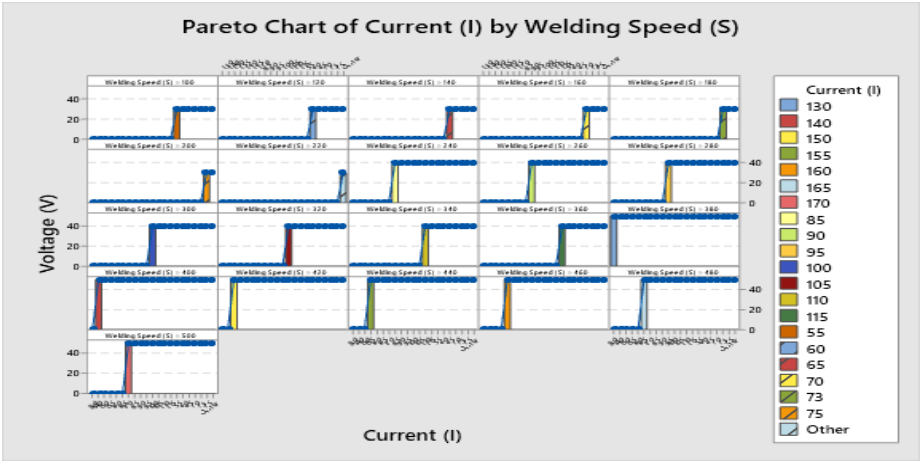

Fig 12: Minitab graph pareto chart fraction welded specimen and their welded sample

5. CONCLUSIONS

This model can be applicable for all properties of defined materials for the thickness of the ferritic stainless steel. The porous coating was found to be low compared to other thermal spraying coatings. which is a necessary condition for obtaining sound joint. All the materials with dissimilar nature evaluated for their material properties as tested and analysis have some conclusion based on their results as obtained.

i. The impact toughness values for ferritic stainless steel and copper obtained in which Friction welding for both materials joined successfully. Also, material joints have been different as compared with their points.
ii. In friction-welded joint this low upset pressure decreases in impact toughness when burn-off length is higher. Also, quality and the strength of the bond for both materials joined also varied with each other.
iii. Friction welded joint for increase in toughness of welded joint with the result of 14 J/cm2 with low burn-off and high upset pressure shows with 46 J/cm2.
iv. In this test due to temperature rise, impact toughness of the welded joint will result in poor accumulation of alloying elements. Also, presence of intermetallic layers has joined their elements at their weld interface with sustainable surface layer.
v. Impact tested sample with Fracture analysis result in ductile mode of fracture in the different magnifications was made with dimple formation.

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