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EXPERIMENTATION AND VALIDATION OF EFFECTS OF PROCESSINGPARAMETERS ON CORROSION PROPERTIES OF SIMILAR ROBOTIC SPOT WELDS OF MILD STEEL

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Abstract:Spot welding is extensively used for joining stiffened thin plate structures, particularly in car, railroad and plane structures, which contains hundreds and even a great many spot welds. There are different favourable circumstances of utilizing spot welding procedure, for example, there is no filler material is required and low warmth input suggests less danger of changing measurements during welding. The welding of similar metals is used widely in engineering over years. The importance of corrosion resistance is of top criteria at the weld joint, as the corrosion resistance leads to failure of the entire of the part.Subsequently in the present work, the different elements controlling the mechanical functioning of spot welds are considered. Here Robotic spot welding is considered in order tosimulate the exact types of welds which are done in the industry as well. The entire uprightness of a car structure is generally reliant on the mechanical execution and integrity of the spot welds.). The subsequent weld characteristics and Corrosion Properties of the welds created were tested and thus it is very crucial for the strength of the welds delivered. Here an effort has been made to join same metals of ASTM A36 Mild (Low-carbon) steel plates of 0.8mm. and 1mm thickness by the means of robotic arm spot welding technique. The welds were produced by varying the welding parameters (welding Current, welding time, tip force or welding force, holding time and thickness)studied.

Keywords: Robotic arm Spot Welding, Welding Parameters, Mechanical Strength and Corrosion behavior

I. INTRODUCTION.

Spot welding is the most seasoned welding forms in which heat was created at the interface of the parts which are joined by passing an electricity and flow through them at controlled time and under controlled pressure or (force). This was used in a broad range of automotive industries but especially in the assembly of steel sheets vehicle bodies.Spot welding was essentially used in joining the parts that are usually equivalent to 3 mm in thickness. The effectiveness of the joint depends on the number and sizes of the welds. The diameters of the spot welds range about 3.0 mm to 12. 50mm.Spot welding was a kind of Resistance welding, in which welding of at least 2 metal plates are welded without utilizing the filler material is finished by applying force and heat to the region to be welded. This procedure is chiefly utilized as a part of joining sheet materials and copper molded electrodes are utilized to apply force and to pass on the electric current to the workpieces. The parts are topically heated in a wide range of spot welding. The zone of the material in the middle of the anodes yields and is smashed together. Then melting takes place, destroying the interface among the parts.The flow of current is put off and the "nugget" of liquid materials hardens making the joint. Robotic welding procedures are being used by every industry, because there are many advantages in using robots by replacing with manpower. To meet the competition in the global market, many industries are using robots.There is a special demand for robot spot welding equipment because of its automation. In this regard robot must be special designed to meet the welding requirements. There are different sizes of welding robots with different specifications to meet the requirements. Classification of robots is done by using number of axes and different welding guns, which are required for applying pressure and current to the work pieces to be welded. Robotic spot welding is a broad range technology, which is specially used in various automotive industries in different applications like joining of different body parts of car. Using RSW, high precision is gained. This RSW does not use any additional filler material, which gives good welding joint and good surface finish is maintained. As car structures are joined by using welding techniques, there is a formation of corrosion on the weld joint, which leads to poor strength of the weld joint and causes damage to the car body parts, so watchful consideration is required while performing welding strategy.

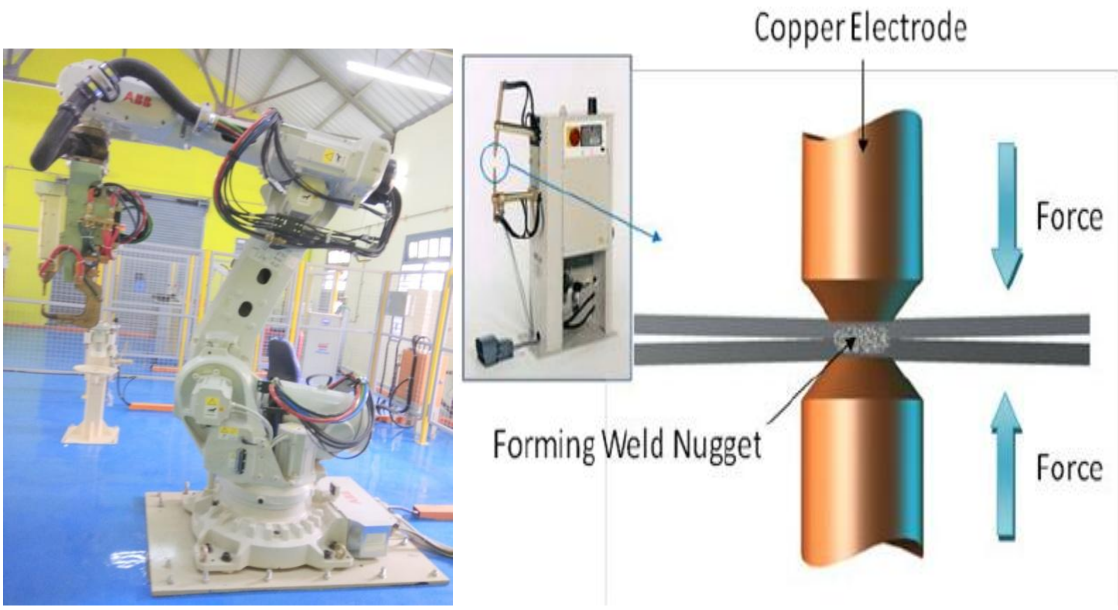


Fig 1 (a) representation of spot welding robot   Fig 1 (b) Schematic drawing of spot welding

II. LITERATURE REVIEW

Pasquale Russo, Stefano Rossi ID and Rudi [1], thinks about the Effects of Welding Parameters on Strength and Corrosion Behaviour of Dissimilar Galvanized Q&P and TRIP Spot Welds, Steel sheets have been welded with various current, clipping power, and weld time settings. The nature of the spot welds has been examined through lap-shear and salt shower consumption tests, likewise assessing the impacts of metal removal on quality and erosion obstruction of the joints. Be that as it may, cinching power has the essential impact on abstaining from blasting of liquid metal from the piece amid the joining procedure.**Aravinthan Arumugam, MohdAmiziNor** [2] contemplated the Spot Welding Parameter Optimization to Improve Weld Characteristics for Dissimilar Metals. This work focuses on the parameter advancement when spot welding steels with different thickness and sort utilizing Gray Based Taguchi Method. This experimentation in this work utilized a L9 symmetrical exhibit with three elements with each factor having three levels. These are the diverse welding parameters utilized: welding current, weld time and electrode force. **Rohan1, Dr. S. Chakradhar Goud** [3], have considered the Effect of welding on low carbon steel material on its properties, here in this investigation they have utilized circular segment welding strategy to join a metal of modern low carbon steel. That is the fundamental investigation of changes in the properties because of the warmth created and the warmth influenced zone amid the welding procedure. As the time taken is more than the change of the warmth will be more on the plate close to the weld metal, and which drags out the warmth influenced region.

III. OBJECTIVE

The main objectives of this are given below:

1. In the present work, the ASTM A36 mild steel sheets of 0.8mm and 1mm thickness are used for robot spot welding.
2. Finding the performance characteristics of each mild steel sheet, by varying the weld parameters like tip force, weld time, holding time and current flow.
3. In finding the performance characteristics of corrosion behaviour of post welded ASTM A36mild steel sheets with varying weld parameters.

IV. EXPERIMENTAL SETUP

4(A)EXPERIMENTAL SETUP FOR ROBOT SPOT WELDING:

Material selection:chemical composition of ASTM A36 mild steel

Chemical Composition

Element	Content
Carbon, C	0.25 - 0.290 %
Copper, Cu	0.20 %
Iron, Fe	98.0 %
Manganese, Mn	1.03 %
Phosphorous, P	0.040 %
Silicon, Si	0.280 %
Sulfur, S	0.050 %

Components of robot spot welding:

(a)**MCB** (Miniature Circuit Breaker) is a mechanically controlled electric switch, which is planned for protecting the electrical appliances like robots and human beings from electrical stuns and blames. MCB is must for the most part utilized as a part of low voltage electrical system than fuse.It acts as a main switch to the entire work cell

(b).**STABILIZER:** The main function of a stabilizer is to control the output voltage which is passed to the Robot equipment, connected to it as much as possible equal to the similar electric power supply, checking that there are no oscillations in electrical power,and its output is to maintain a constant value, preventing them from being experienced by equipment.

(c)**ROBOT GUN:** An electrical spot welding gun is capable in adjusting the position of electrode position. The control of the robot gun is done by separate robot gun controller, which is operated by teach pendant. The welding parameters like current flow, weld time and holding time are given to the robot gun by robot gun controller.

(d)**FLEXPENDANT:** The Flex Pendant (teach pendant unit) is a hand operated unit useful in performing different functions, which are useful in robot operation, program run, movement of robot and gun and changing the program. It has a touch screen operation, which is very user friendly.The flex Pendant demonstrates like a PC which contains equipment and programming. It is associated with the robot controller.

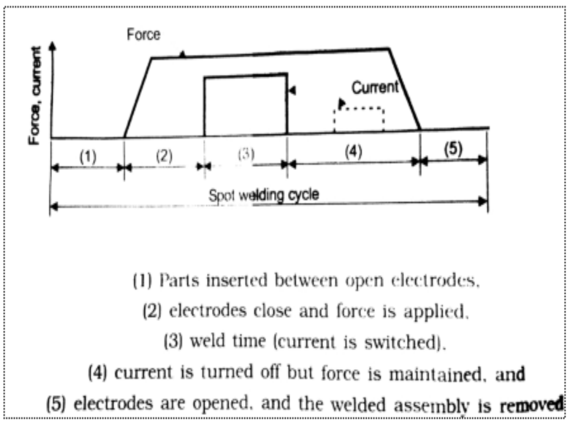


Fig 2 (a) step by step weld cycle

Fig 2 (b)alignment of robot gun to the weldinterface

Welding procedure: The weld sheet metal is cleaned together such that it is free from dirt, oxide, grease and oxides. The electrode tip is cleaned, therefore it should direct current; or else the electric opposition is created between work piece and electrode. Now turn on the MCB, stabilizer and Controllers of Robot and Gun. The electrodes should be in contact with both sides of the plate using fixtures. Presently, the current is sent through the electrode. The weld time use of time is taken. Now set the welding parameters such as current flow, weld time and hold time using the Gun teach pendant in Robot gun controller. At the weld time during the process force (1500 N to 4400N) to be maintained and weld current range of 2000A to 8000 A, (2 to 8 KA) and voltage speed of 331v should be passed to electrode at time of 0.1 to 0.5 sec. The current is passed starting with one electrode then onto the next electrode through the work piece, a little region of contact between the work pieces. The spot created is known as resistance spot. This whole process is done by using robot Flex pendant, inwhich the program is run.

S NO /PARAMETERS	1	2	3	4	5	6	7	8	9
WELD TIME (CYCLES)	8	25	70	8	80	8	8	25	70
CURRENT (%)	99	50	99	74	30	74	50	99	50
CURRENT(KA)	7.92	4	7.92	5.92	2.4	5.92	4	7.92	4
HOLDING TIME (CYCLES)	9	30	75	9	85	9	9	30	75
THICKNESS (mm)	2	2	2	2	2	1.6	1.6	1.6	1.6
TIP FORCE(KN)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	3	3	3	3	3	3	3	3	3
	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4

Table1. Process parameters

4 (B)EXPERIMENTAL SET UP FOR CORROSION TESTING:

Evaluation of pitting corrosion: In the laboratory, the pitting corrosion susceptibility of post welded or welded alloys is generally assessed by immersion and electrochemical corrosion testing (polarization and electrochemical impedance spectroscopy methods) in aggressive solutions. The electrochemical measurement provides useful information about the corrosion potential, passivity and pitting potential of the material.

Preparation of specimens: Corrosion specimens and microstructure specimens were manufactured by cutting a crossection from the RSW joints with the dimensions of 1cm*1cm*0.2cm**,** followed by mechanical polishing using 1/0, 2/0, 3/0 grade emery papers and the samples were polished using Al_2O_3 (3gm of aluminium powder and 100ml of water) on disc polishing machine and the samples obtained were shown in Fig-3

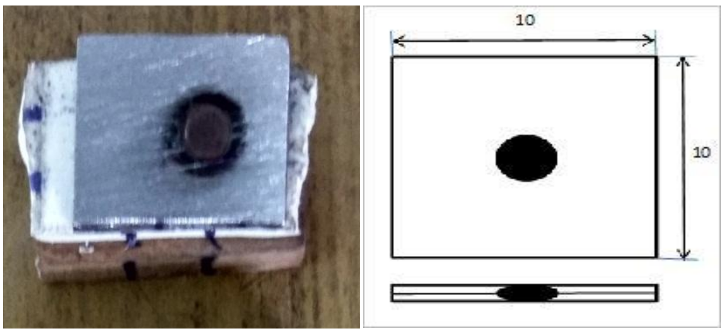


Fig 3 specimen for corrosion testing

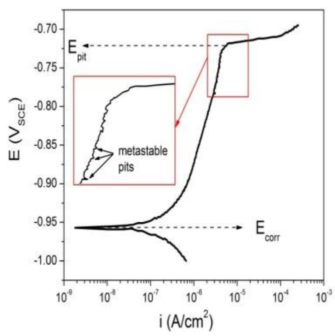


Fig 4model graph representing E_{CORR} and E_{PIT}.

Electro chemical corrosion testing:Software based Potentio-dynamic polarization (PAR), shown in Fig 5(a)Fundamental electrochemical framework was utilized for conducting Potentio-dynamic polarization tests to consider the pitting corrosion behavior of base metal. Saturated calomel electrode (SCE) and platinum electrode were utilized as reference and secondary terminals separately. Every one of the examinations were done in 3.5% NaCl solution. The potential sweep was done at 0.166 mV/sec with beginning capability of 0.25V (OC) SCE to final potential of pitting. The exposure area for these experiments was 0.6cm^2 of the weld surface.All the tests were conducted at room temperature (25±2) °C. The potential at which current increases drastically was considered as critical potential (Ecorr). Samples present comparatively high positive potential or low negative potential are advised with best corrosion resistant.Potentio-dynamic polarization estimations were done by fluctuating the current (mA/cm2) and the relating potential (mV) were obtained.

Fig. 5 (a) Equipment for corrosiontesting

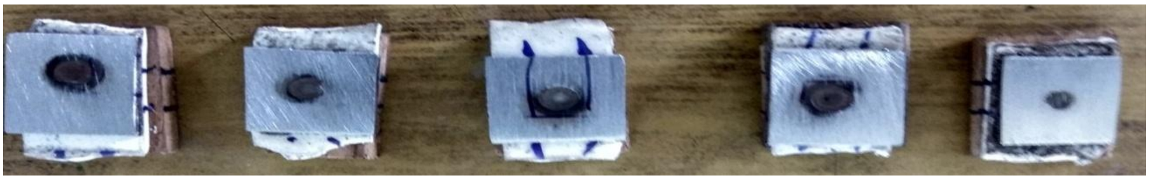


Fig 5different specimens for corrosion testing

V. RESULTS AND DISCUSSION

A. Influence of welding parameters on spot welds: When comparing the welding parameters of the MS samples varying tip force range 1500 to 4400 KN, current flow from 2 to 8 KA and corresponding weld time of sheets of thickness (1mm+1mm = 2mm) are shown below in fig 6. The current flow range of robot spot welding is 25% to 99%, where 100% is equal to 8KA, which is the maximum current flow provided with this robot spot welding. The tip force (clamping force) range is 1500 to 4400N or 1.5KN to 4. 4KN.The voltage applied is 331v.So by using these standards, spot welding is done by varying welding parameters such as weld time (cycles), current flow (% & KA) and tip force (KN).In plate (1) the current flow is 99%, which is approximately the maximum current flow and low weld time is taken for all values of tip forces depicts good weld with high tip force and with low tip force, there exists uneven spot weld that is with 1.5kn tip force. The zone of HAZ was very small or narrow. Therefore, plate 1 is thought to be great weld .In plate (2) the current flow is 50% and weld time is 25 cycles depicts good weld joints in all values of tip forces with more HAZ area compared to plate 1.In plate (3), the current flow is 99% and weld time 70 cycles, which means both current and weld time are taken high, depicts a poor-quality weld at 1.5kn tip force because of low tip force and high current and weld time and better weld at high tip force along with minimum HAZ zone. In plate (4), the current flow is 74% and weld time is 8 cycles, depicts very good weld joint with very less HAZ zone and all the weld spots are similar irrespective of different tip forces. In plate (5), the current flow is 30 % and weld time is 80 cycles, which means minimum current flow and maximum weld time depicts good weld joint, with very less HAZ zone and all the weld spots are similar irrespective of different tip forces .In plate (7), the current flow is 50% and weld time is 8 cycles depicts that there is more depth of spot weld with high tip force compared to others and more HAZ zone compared to others because the plate thickness is reduced to 0.8mm compared to 1mm.In plate (8) the current flow is 99% and weld time is 25 cycles with 0.8mm thickness, depicts a very large HAZ zone with less tip force and gradually as current flow is high .In plate (9) the current flow is 50% and weld time is 70 cycles with 0.8 mm thickness, depicts a deep spot weld and more HAZ with more tip force.

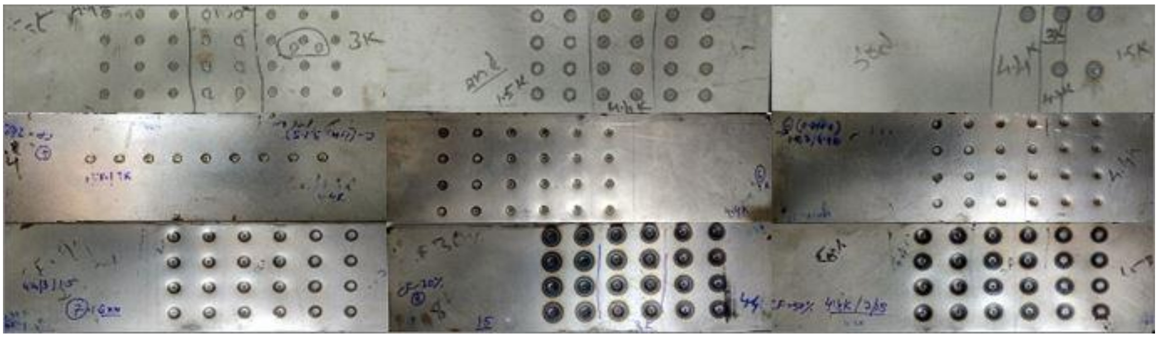
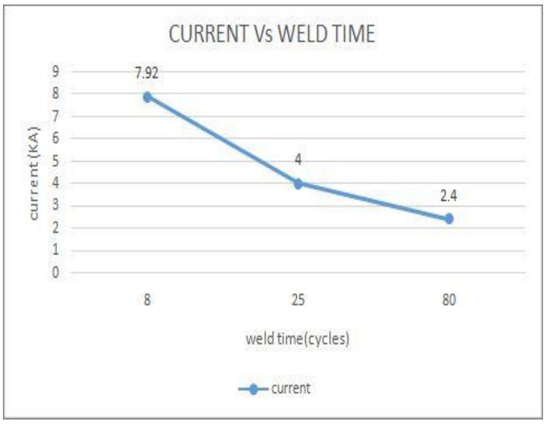


Fig.6. Surface appearances of Robot Spot Weld samples for various parameters (plate numbering starts from left)

The effects of the welding parameters on spot welds using Graphical representation: Figure 7a shows a graphical representation of current flow Vs weld time, in which weld time increases with decrease in current flow. Figure7b shows a graphical representation of tip force Vs weld time, in which tip force increases with increase in weld time.



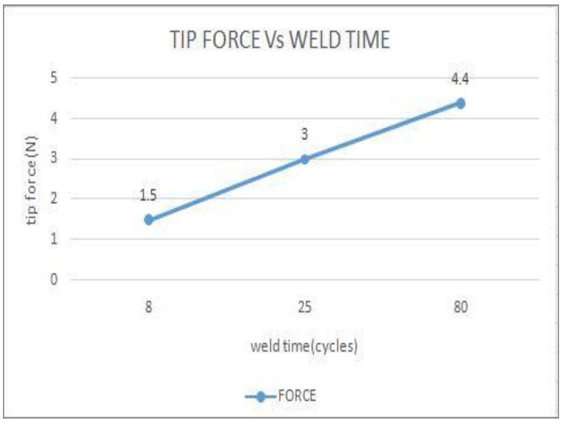


Fig7 (a) current Vs weld time

Fig7(b) tip force Vs weld time

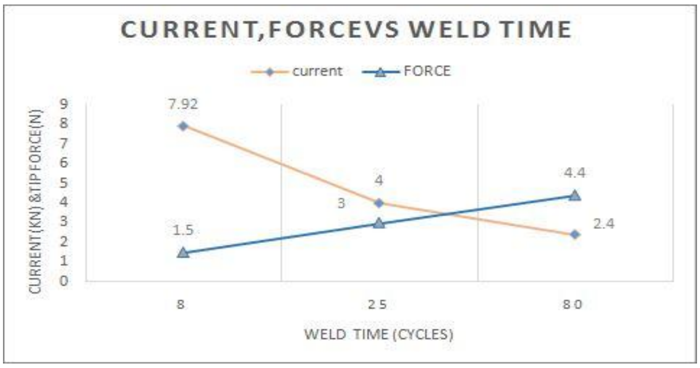
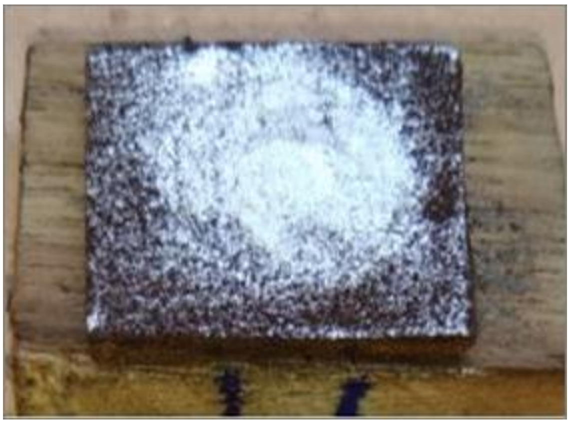


Fig 7 (c) Combined graph of current flow ,tip force and weld time

B .Electrochemical corrosion behaviour : Electrochemical corrosion behaviour of RSW surfaces of MS in 3.5 % Nacl solution are shown in Fig .8.All the specimens indicate similar corrosion polarization curves .At a particular potential, the current density of the samples first decreased as the applied potential was increased, indicationg the formation of corroded surface film on the surface samples ,and then the current density was increased sharply , which is due to the presence of concentration of corrosion in the samples.The corrosion potentials of the samples varies slightly from 541mv to 594mv.The current densities of the samples after the corrosion potential,increased sharply indicates the possibility of pitting corrosion occuring. Samples present comparatively high positive potential or low negative potential are advised with best corrosion resistant.The relatively low corrosion rate of surface samples produced at tip force 1500N , 50% current flow and with medium weld time having corrosion potential as 593.92mv , so it has great corrosion resistance.Corroded samples before and after corrosion are shown in Fig.9

S:NO	Tip force (N)	Current flow (KA)	Weld time(cycles)	Corrosion potential (mv)	Plate no
1	4400	7.92	8	566.21	1
2	3000	4	25	560.1	2
3	1500	4	25	593.92	2
4	1500	2.4	80	541.91	5

Table 2: Settings of welding parameters employed in corrosion tests

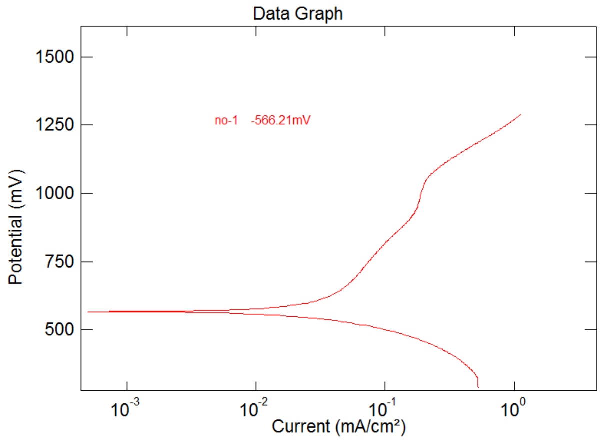


Before **After**

Fig.8.Corroded samples before and after corrosion

The corrosion rates of the samples were calculated and results are presented in table 2.It was observed that as tip force increased ,the corrosion rate was increased for the samples and if the tip force is reduced ,with medium current flow & weld time shows that corrosion rate was decreased ,showing that having better corrosion resistant at 1.5kn tip force ,50% current flow and 25 cycles Thus, the tip force has a direct relationship with the corrosion rate .In all instances, there is a significant reduction in the corrosion rate when the tip force was decreased from 4400N to 1500N . From graph with 1500N tip force, 50% current flow and medium weld time 25 cycles, it was observed that reduction in the corrosion rate was minimum compared with all the samples.. It is interesting to note that the highest corrosion rates were observed at a lowest tip force 1500N and 30% current flow and with increased weld time for most of the samples shown in Fig 9. Hence, in this regard, medium heat input into the welds results in excellent characteristics of the joint interface.

Higher corrosion rate was obtained at 1500N, 30% current flow and 80 cycles weld time and Optimum corrosion resistance was obtained for welds produced at 1500N, 50% current flow and 25cycles weld time.



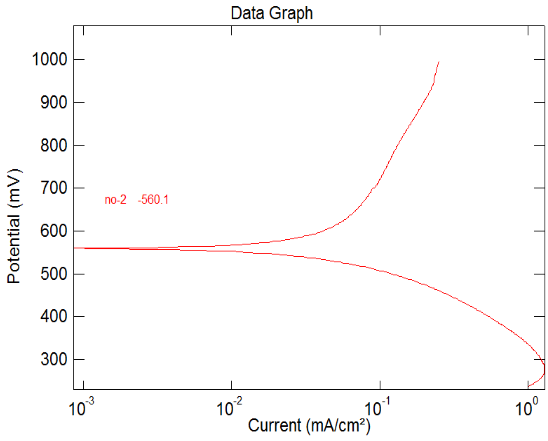
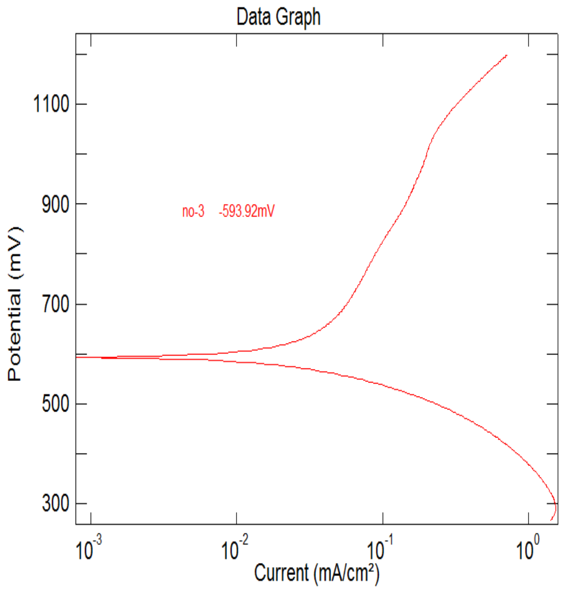


Fig (a) 4.4kn tf ,99% cf,8 cycles ,566.21mv Fig (b) 3kn tf ,50% cf,25 cycles ,560.1mv



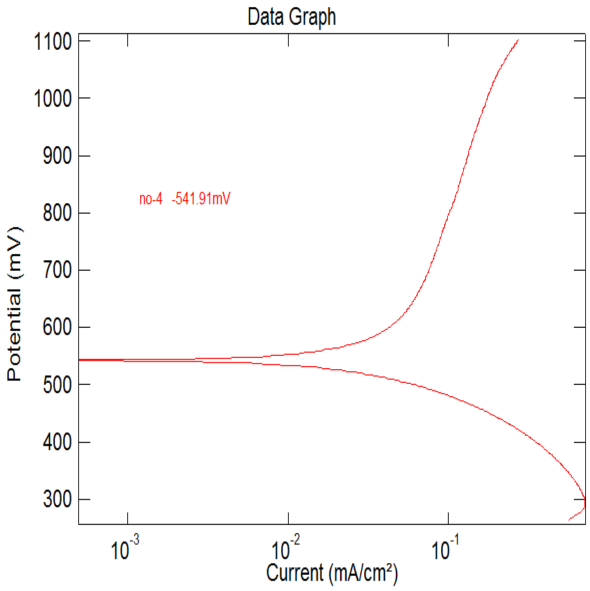


Fig (c) 1.5kn tf, 50% cf, 25 cycles ,593.92mv Fig (d) 1.5kn tf.30% cf, 80 cycles, 541.91mv

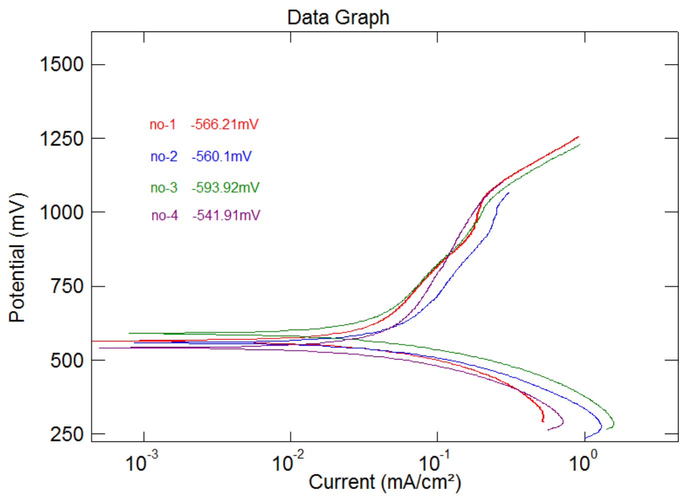


Fig (e) *Combined* graph *of all values*

Fig.9. (a) (b) (c) (d) (e): Graphs indicating polarization curves for corrosion potential

VI. CONCLUSIONS

The influence of the different weld parameters, such as tip force, current flow and weld time on corrosion behavior of similar Robotic Mild steel spot welds have been studied and investigated. Electrochemical behavior of Mild steel spot welds was obtained using Software based Potentio-dynamic polarization (PAR) Basic electrochemical system. The consequences of metal exclusion on strength of the spot weld and corrosion behavior was determined. Tip force with range (1500N TO 4400N), weld time (8 to 80 cycles) and current flow with range (25% to 100%) were varied to produce the welds and the corrosion behavior was studied.

The important results are summarized as follows:

- It was observed that as tip force increased, the corrosion rate was increased for the samples
- If the tip force is reduced, with medium current flow & weld time shows that corrosion rate was decreased, showing that having better corrosion resistant at 1.5kn tip force ,50% current flow and 25 cycles having high positive corrosion potential 593. 92mv.Thus, the tip force has a direct relationship with the corrosion rate.
- In all instances, there is a significant reduction in the corrosion rate when the tip force was decreased from 4400N to 1500N.
- From graph with 1500N tip force, 50% current flow and medium weld time 25 cycles, it was observed that reduction in the corrosion rate was minimum compared with all the samples.
- It is interesting to note that the highest corrosion rates were observed at a lowest tip force 1500N and 30% current flow and with increased weld time. Thus, in such manner, medium heat is contributed to the welds brings about great qualities of the joint interface.
- As automobile industries are using Mild steel for car body structures. New grades of MS are coming into existence, so many welding procedures are to be done in industries to find out the optimal condition to have high strength and high corrosion resistance, which requires a lot of time and leads to material wastage. So, to avoid these, the optimal solution is found out which will benefit the automotive industries.
- Hence, in this regard, medium heat input, current flow and medium weld time into the welds results in excellent characteristics of the weld joint interface.

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