Optimized the process parameter of resistance spot welding on High Strength Low Alloy Steel weldment

Vijay Bahadur
Research Scholar
Department of Mechanical Engineering
Bansal Institute of Engineering and Technology
Lucknow India
vk032126@gmail.com

Mr. Abdul Jabbar Ansari
Assistant Professor
Department of Mechanical Engineering
Bansal Institute Of Engineering and Technology
techno.abdul@gmail.com

Abstract: Resistance spot welding (RSW) is broadly used for piece metal joining of two dissimilar worksheet structure in the vehicle manufacturing. Key constraints, such as weld current, electrode force and weld time, is elaborate in the RSW method. Suitable welding parameters are vital for producing good welds; otherwise, undersized weld and expulsion are likely to be caused. The current situation study targets to evolving the necessary information of plastic distortion and fracture performances of high strength steel resistance spot welding. As per a resistance spot welding includes extremely in consistent microstructure, the whole research methodology are created on reviewing the native mechanical properties for specific areas in weld along with their relations using weld geometry on the deformation behavior. The previous research studies the data response throughout resistance spot weld arrangements in-line and founds a relationship among emitted characteristics besides the finishing quality of a spot weld. The two features examined to separate out weld quality are: the electrical sin wave design and the acoustic sin wave design formed throughout the welding arrangement. Both features was learned to has a straight relationship to the finishing feature of weld when cured. By computing and equating these features at the source, prospect are obtainable to reduction time and possible defects through checking the quality of every weld method and at work space.

KEYWORDS: ELECTRODE FORCE, ULTRASONIC TEST, SPOT WELDING, SHEAR TEST WELD QUALITY, WELDING CURRENT, RESISTANCE, WELDING TIME

1. INTRODUCTION

Resistance spot welding is accomplishment major importance in Automobiles, railway bodies and over bridges etc. by reason of automatic and fast procedure. The most important features monitoring this procedure are current, time, electrode force, contact resistance, property of electrode material, sheet materials, surface condition etc. the quality is best judged by nugget size and joint strength. Defects, improve product quality, increase flexibility, reduce time and cost, and achieve higher productivity.

An overall presentation for rule, working and boundaries of spot welding is given beneath. Resistant Spot Welding (RSW) is among the most seasoned of the electric welding strategy that utilized in the business and it is helpful and acknowledged technique in joining metal.

Spot welding is broadly utilized in welding carbon steel since they have higher electrical opposition and lower warm conductivity than the anode that produced using copper. The Spot welding is usually being utilized in car industry, where it is utilized to weld the sheet metal framing a vehicle. A normal RSW cycle can be isolated into four phases: pressing, welding, hold and cooling.

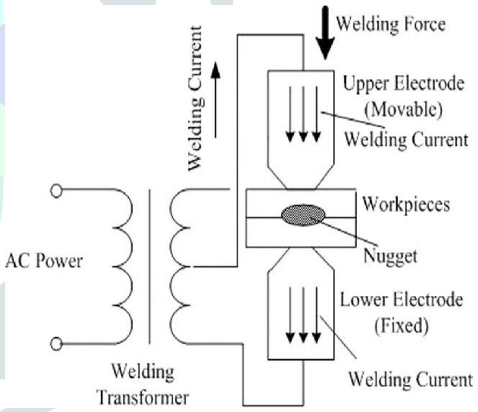

Fig. 1 Systematic RSW welding

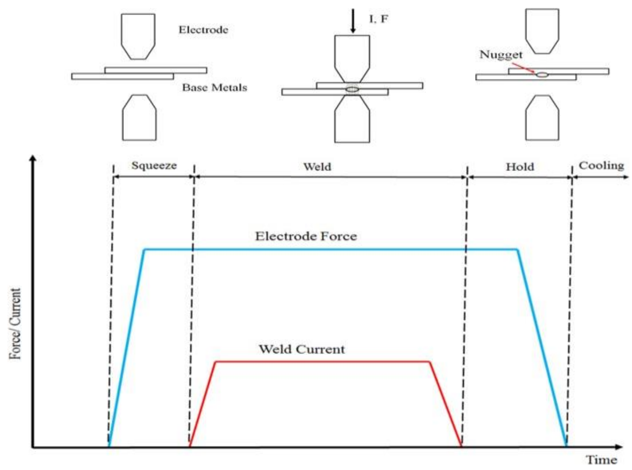

Fig 1.2 Typical RSW welding schedule

In the squeezing stage, the electrodes approach each other and the base metals (BM) are clamped by a constant electrode force. The welding stage follows the squeezing stage. In the hold stage, the welding current is cut off, and the electrodes remain clamped for complete cooling of the molten liquid. Then, a nugget is formed.

In a joint amongst two different metals, the metallurgy of both base metals and the weld metal should be considered, on the grounds that the weld metal is a composite of the melded base metals of three unique metals and may really be engaged with these joints. It is frequently simpler to make good joints between unique metals by opposite welding than by arc welding, since the issue of fluxing or arrangement of an idle air doesn't emerge, and the method accessible frequently limit the risk of the development of weak intermetallic compounds inside the joint.

Steels with low carbon content, normally up to 0.13% C, are great welding prepares, yet they are not awesome for fast production welding. Prepares with low carbon content are more ductile and simpler to shape than higher carbon prepares. They are utilized for applications requiring extensive cold framing, for example, stepping or rolled or framed shapes.

A gathering of low amalgam prepares that are designed to give better mechanical properties and at times more prominent protection from air erosion than regular carbon prepares are known as HSLA prepares. They are not viewed a alloys prepares in the typical sense since they are intended to meet explicit mechanical properties designed of a compound piece. Carbon content of HSLA prepares steels rarely 0.28% and is normally somewhere in the range of 0.15% and 0.22%

1.2 Objectives

The main objective of this research paper is to forecast the performance of resistance spot welded low carbon steel in conservative and intricate stack-ups. To be capable to make reliable estimates a detailed sympathetic of the hot-stamped boron steel metallurgy, material constitutive performances and joint performance is needed. The work presented in this research papers are considered preliminary and must be continued to complete the primary goal. The specific research tasks are Process Optimization and Characterization. Weldment Mechanical Testing. And Weldment Computational Modeling

This research seek out to inspect the gaps amongst the current resistance spot weld value validation procedures and their shortcomings with concern to manufactured goods excellence and proficiency.

1.3 Scope

The scope of this paper is to create novel facts for efficient and better procedure formation of RSW in engineering applications. The purpose are stated through two research inquiries aiming the problems of procedure dissimilarities in addition prospective of mathematical methods of a RSW method. The research interrogations are stated in expressions of weld size, and these are the main importance in RSW method development.

1.4 Materials in resistance spot welding

1. Material Properties

Usually properties of materials varies with variation in temperature. Resistivity of material, heat capacity and thermal conductivity of the material interrupts the heat generation throughout welding method. Hardness of the material as well as affects the contact resistance by weld surface. Solider materials source higher contact resistance for identical weld force. For that reason material collection is established on the beyond parameters.

2. Base metal

There are many different classifications for automotive steels that consider strength and metallurgical differences. In a broad sense, most steels fall into one of the following categories: low strength steels, high strength steels (HSS)Steel has been widely used in the automobile industry, due to its good weldability and mechanical properties. An acceptable nugget is produced with moderate welding current and electrode force. Zinc coating has been added to render good corrosion resistance of steel.

Spot welding of stainless steel has also been investigated, due to its superior mechanical strength and corrosion resistance. High electrical resistance renders it easy to join by RSW. The compositions of stainless steel play crucial roles in the final nugget performance. Two phases in austenitic stainless steel, austenite and ferrite, have been found to affect the strength in heat affected zone (HAZ) and nugget and in fatigue strength. Resistance spot welding of ferritic stainless steel is involved in phase transformation in the HAZ and nugget zone.

3. Electrode material

During the study, different electrode shapes and different compositions of electrodes were used. The design of the tip morphology notably affects the temperature distribution, force distribution, contact condition, resistance against expulsion and the degradation of the electrodes. On the other hand, the electrode composition determines the alloying reaction with base metals. Cu-Cr and Cu-Cr-Zr are the most commonly used electrodes in steel welding, Cu-Al_2O_3 electrodes have also been investigated for preventing electrode wear.

The choice of electrode was made using the following "Equation

$$D = 5\sqrt{t}$$

D: The diameter of the active face of the electrode (mm)

t: Sheet thickness of weld.

1.5 WELD QUALITY ATTRIBUTES

The quality of a weld is usually expressed by its measurable features, such as the physical attributes and the various strengths, when inspected in either a destructive or nondestructive manner. A weld's quality can be depicted in three ways: by its physical or mathematical elements, its strength or performance, or the cycle attributes during welding. The mathematical elements are either straightforwardly apparent after a weldment is made or uncovered through damaging tests, for example, stripping or cross-segment or seeing the microstructures, or nondestructive tests utilizing, for instance, ultrasonic or x-beam appliances.

- Nugget/badge size
- Infiltration
- Indentation
- Blows (surface and internal)
- Permeability/cavities
- Sheet parting
- Surface appearance

Among these weld nods, weld size, as far as nuggets width or weld button breadth, is the most often estimated and most significant in deciding a weld's strength. When two sheets are joined by a weld at the nugget, its size determines the area of fusion and its load-bearing capability. However, the nugget/weld size alone is often insufficient in describing a weld‘s quality, in place of it does not certainly suggest the physical reliability of the weld. Additional topographies of a weld, for example penetration, may possibly balance the nugget size also provide valuable facts on the grade of linkage. Join and piece is well thought-out interchangeability by various, especially in verbal performances. Though faithfully connected, but, they are not the similar by classification or dimension. In fact, a weld are meant to cover all parts of a weldment, such as the heat-affected zone (HAZ), in adding to the nugget.

2: Literature Review

Many articles report that work have been done on different features of modeling, simulation, and method optimization in the RSW procedure. Many experiences and studies conducted to establish the effects of parameters on the quality, weld strength and productivity. The main target to select a welding parameters leading to an optimal process. Resistance spot welding (RSW) has been a predominant welding procedure in the locomotive industry ever since the 1930s .

According to last studies, the reduction of the electric intensity and the pressure force will increase the life of the machine and the tool. The goal of this optimization is to have a useful product quality without increasing the cost of its implementation. The study about optimizing welding conditions finds its position in the significant improvement plans and the optimization leads to be launched to bring gains to the automotive company.

There are numerous standards that exist from the company to world level that detail the common practices and procedures used for spot welding of various materials. The resistance spot welding process is developed around the resistance created when current is passed through a completed circuit. A current, either alternating (AC) or mid-frequency direct (MFDC), is passed through water-cooled electrodes at a low voltage resulting in heating of the clamped materials and fusion at the faying surfaces between the work pieces. A schematic showing the typical configuration for a two-sheet (2T) stack-up.

Makwana Brijesh “and all”. (2017) [6] used the austenitic stainless steel304 material for 2.0 mm of thickness to study the resistance spot welding behavior. He used Taguchi method to reduce the number to run for experimental work and find the optimum results, with total experiences 27. He finds that the pressure was observed less effective factor, and the significant parameter is the welding power and weld time increases whereas pressure is decreases. Also, the contributions of each parameter, pressure is contributing with 46,46%, weld time 9,10%

Yash Modi “and all”. (2017) [7] present an experimental work and approach to determine the effect of different procedure considerations on weld quality also tensile strength of the weld, by using mild steel with 3 mm of thickness. The experience showed that the welding parameters are the most significant features for the strength; also the good combination is mandatory to have a high level of the strength of joining weld. In his experience, the most important parameter is holding time and the parameter that influence less is the weld time.

A.G Thakur and V.M Nandedkar (2010) [8] use the stainless steel AISI 304 to determine the effect of pressure, weld time and current. According to his study, the result confirm that the percentage contribution of current was 31.18% and weld time was 17.77%, comparing to the contribution of pressure 2.89%, the current and weld time are more significant for tensile shear strength.

Arjun Kumar and Sanjeev Sharma (2017) [11], this experience was carried out to analyze the effect of weld current and weld time on the weld nugget diameter, the work piece used to conduct this study is materiel JSC270C sheet with 6 mm thick. In this experience the spot aesthetic quality decrease when the welding current is increasing and the weld time is reducing. As a result, the weld current 10KA and weld cycle 10 is the optimal parameter for 6 mm thick sheet.

Sahota et al. [7] conveyed the trial to concentrate on the meaning of the cycle boundaries for example current, anode power and weld cycles on opposition spot weld of austenitic SS 316 material, on the rate improvement in material hardness. They observed that an expansion in weld current, weld time and anode force brings about an expansion in weld piece breadth and width. Anode space likewise increments by the expansion in current, weld time and cathode force.

3. Resistance Spot Welding Parameters

In RSW method parameters have their own significance. A minor variation of one parameter will affect all the other parameters. These parameters will describe the class of the welds. The appropriate arrangement of the spot welding parameter will produce strong joining and good quality of welding. Spot welding parameters contain.

1. Weld current
2. Weld Voltage
3. Electric Resistance
4. Electrode geometry
5. Time Sequence of the Resistance Spot Welding Cycle.
6. Electrode Force
7. Diameter of the Electrode Interaction Surface.

3.1 Weld current

The welding current is the best and normal boundary to impact welding consequence of a given material setup. A too low current won't give adequate hotness to make a nugget while a too high current will bring about removal and even temperatures over the limit. Removal diminishes the piece size and may likewise desert encompassing gear and parts. Assuming the limit is reached, there is higher risk for porosity in the completed weld. One more aftereffect of too high flows is too huge spaces in the metal surface. The ongoing level likewise influences the distortion of the base metal and the size of the heat effected zone (HAZ). Normal welding current adequacy lie in the scope of 5kA - 10kA relying upon sheet setup, other cycle boundaries and weld necessities.

3.2 Electrode geometry

Underway, the shape and size of the electrodes affect the weld result. The main boundary in the anode math is the contact region between the cathode and the metal sheet. When in general the width of the electrode tip ought to be around equivalent to , where is the thickness of the sheet .The contact will influence both the contact pressure and the ongoing thickness of the weld. In optimization of weld boundaries, it could be ideal to utilize various electrodes on each side of the stack-up. The tip bend of the anode is an action against the debasement of the cathode tip.As the electrode destroys the preliminary curvature will deform into a flat surface. An initially flat surface would cause a concave tip after continuous welding. The most commonly used electrode geometries are described in standard ISO5821:2009.

3.3 Time Sequence of the Resistance Spot Welding Cycle:

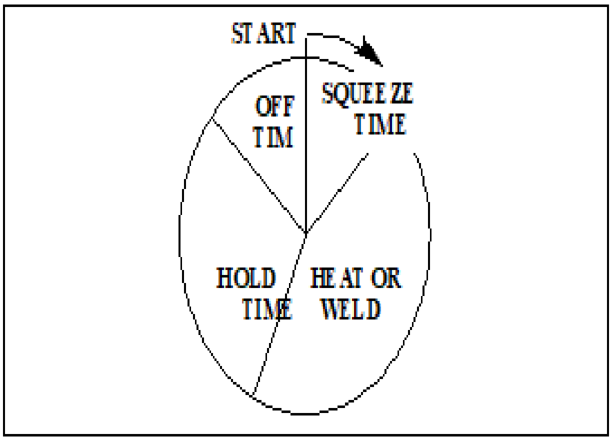

Fig. 3 Spot Welding Time Cycle

3.3.1 Spot Welding Time

As one of the essential components in Joule's law, welding time is considered an important factor in heat generation. The length of welding time is also influenced by the physical properties of the base metal. A long welding time is implemented for AHSS steel and stainless steel, whereas a short welding time is utilized for lightweight Al and 8 Mg alloys where the thermal conductivity is much greater. To achieve a good tensile shear strength of the joint, the welding time needs to be chosen wisely. A proper welding time can produce a joint that fails in pull-out mode; insufficient welding time delivers an undersized weld that fails in interfacial shear mode, which is not acceptable based on the industry.

3.3.2 Squeeze Time

Squeeze Time is the time interval between the initial application of the electrode force on the work and the first application of current. Squeeze time is necessary to delay the weld current until the electrode force has attained the desired level.

3.3.3 Weld Time

Weld time is the time during which welding current is applied to the metal sheets. The weld time is measured and adjusted in cycles of line voltage as are all timing functions. One cycle is 1/50 of a second in a 50 Hz power system. As the weld time is, more or less, related to what is required for the weld spot, it is difficult to give an exact value of the optimum weld time.

3.3.4 Hold time (Cooling-Time)

Hold time is the time, after the welding, when the electrodes are still applied to the sheet to chill the weld. Considered from a welding technical point of view, the hold time is the most interesting welding parameter. Hold time is necessary to allow the weld nugget to solidify before releasing the welded parts, but it must not be to long as this may cause the heat in the weld spot to spread to the electrode and heat it. The electrode will then get more exposed to wear. Further, if the hold time is too long and the carbon content of the material is high (more than 0.1%), there is a risk the weld will become brittle. When welding galvanized carbon steel a longer hold time is recommended

3.3.5 Electrode Force

In order to assure contact between the electrodes and the sheets during the entire weld process, the electrodes are clamped to the work piece. The force magnitude is another variable which will affect the outcome of the weld. If the force is too big, the electrical resistance will decrease at the contact surfaces and decreasing heat generation and not melting enough material. It may also cause conduction heat away from the weld area, which is undesirable for nugget formation. Furthermore, too high forces may cause damage to the work piece or excessive deformations. The surface deformations are especially important in areas where visual quality is of high importance. Examples of such areas may be outer sides of car bodies. On the other hand, a too low force will increase the risk of geometrical instability of the welding process and excessive heat generation. In other words, the risk for expulsion is increased with a lower force. Typical electrode forces in automotive manufacturing range between 3 - 6 kN depending on sheet material and thickness. Many conventional modern weld guns are capable of applying weld forces up to 5 kN, while higher forces may require stronger guns or custom modification of weld guns.

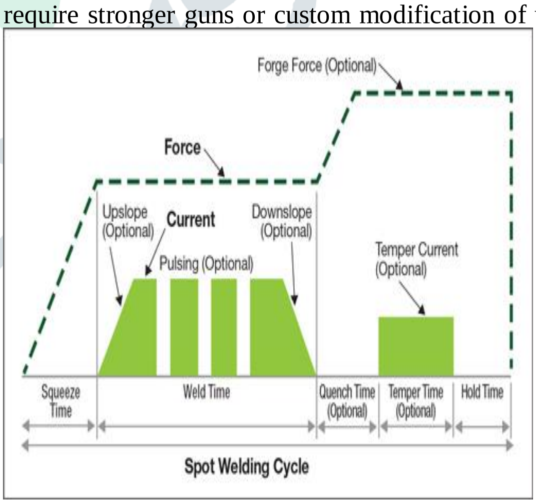

Fig. 4 Spot Welding process on low carbon steel

3.3.6 Diameter of the Electrode Contact Surface

One common principle of RSW are that the weld will has a nugget diameter of $D = 5\sqrt{t}$ Thus, a spot weld made in two sheets, each 0.88 mm in thickness, would produce a nugget 2.5 mm in diameter permitting to the 5 × t½-rules. Diameter of the electrode contact surface must be considerably larger as compare to the nugget diameter.

3.3.7 Electric Resistance

Resistance is the most significant features which belongings the weld ability in RSW .In the case of AC welding, resistance falls quickly at the preliminary stage for the reason decreased contact resistance as of the high current peak that are inattentive in DC. Extremely concentrated current generates great heat and brakes down the contact surface, destroying possible oxide phases on the edge that item as insulators.

3.3.8 Other parameters

After the experimentation it is establish that the parameters of the spot welding are very significant features for the mechanical strength test of the fusing joint. In this research it is establish that the electrode force, welding current, resistance, is the main parameter, which may possibly affect additional to the strength of a welding joint.

3.4 MATERIAL SELECTION

High speed low alloys steel sheets of thickness 0.88 mm is used for the experiment. High strength low alloys steel includes of major proportion of material welded with the RSW method. The carbon existent in the material may possibly disturb the properties of material when the welding; the joint might be become rigid and brittle.

3.5 Size of Sample

The dimension of the samples used for the experimentation are 125mm in length and 40 mm in width and the contact intersection is 40 mm as displayed in below fig.

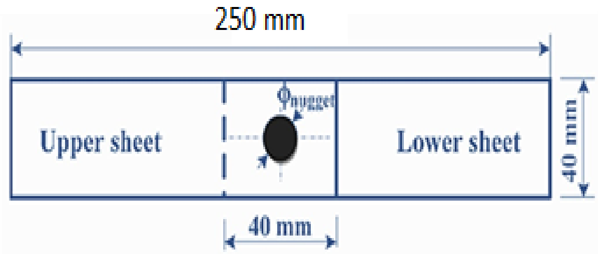

Figure 5: Arrangement and Dimensions of Sample

4.0 METHODOLOGY

4.1 CHEMICAL COMPOSITION

In the recent design of experimentation, samples of high speed low alloys steel composition are given in table 1,and base Ferrous was preferred. And these are Used in manufacturing of steel body of a mobile field vehicle, was subjected to severe field transportation condition. In the traditional process, metal sheets were joined by spot welding resulted in a fusion zone between the referred joining metal sheets with strength of the spot weld measured through diameter of the nugget.

Table 1. Chemical compositions of HSLA alloy sheets and other material.

Compositions %	Low carbon steel 0.75 mm	Low carbon steel 0.88 mm	HSLA Steel
C	.060	.0770	0.10
Si	.0160	0.151	0.61
Mn	0.25	0.45	1.889
P	0.088	0.019	0.025
Cr	0.032	0.0985	0.225
Mo	0.005	0.002	0.158
Ni	0.016	0.052	0.556
S	0.004	0.017	0.01
V	0.0041	0.0059	0.049
Fe	Bal.	Bal.	Bal.

The samples for tensile experiment have been arranged according to ASTM E-8 standard for thin sub size samples, see Fig. 9 and mechanical properties is table 2.
The broad parameters of welding process were finalized to attain maximum output of the assigned work and an approach based on determining tensile loads and micro structure analysis for optimized parameters for ideal spot welding process was adopted. High speed low alloy sheets samples were prepared through spot welding. The test samples were 250 mm in length and 40 mm in width with an overlap of 40 mm. A stationary spot welding machine with rated capacity of 85 KVA and electrode force of 0.5 Mpa was used. In the experimental set up Einstein – II TFT Ultrasonic Flaw detector machine in fig 8 , tensile loads were determined through universal testing machine .

Table 2. Mechanical properties of HSLA alloy sheet sheets and low carbon steel.

Metals	UTS (MPa)	Yield strength (MPa)
Low carbon steel 0.75 mm	255	155
Low carbon steel 0.88 mm	355	185
HSLA Steel	645	420

The results were recorded through Sintech UTS with load capacity of 50 KN at a speed of 3 mm/sec. Spot welding samples showing an overlap of 40 mm with .08 mm thickness are shown in Fig 10.

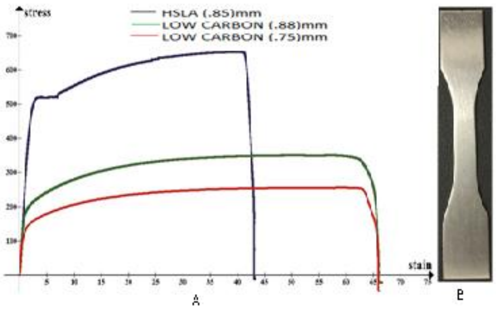

Fig 6. (a) Stress-strain tensile test; (b) tensile specimen.

4.2 Welding process

As manufacturing companies deal with the production of large quantities, larger or heavier machinery should be used. These pieces of equipment should be inspected regularly to avoid the downtime of the equipment. Manual testing of each machine in the manufacturing industry is not only time consuming but also costly and prone to errors. Therefore, practitioners traditionally rely solely on functional care. The idea was to repair the equipment only after it was broken or damaged. However, replacing equipment using this concept can have negative impacts on employee productivity, production quality, and cost. The Wall Street Journal estimates that $ 50 billion is spent annually at random.

4.3 HEAT GENERATION IN RSW

Heat generation in resistance spot welding is based on the Ohm's law. The amount of heat generated in an electrically conductive work piece depends on mainly three parameters welding current, resistance of work piece and time of current flow. The heat generated by resistance is expressed as below

$Q = k.(R1+R2).I^2 .r^{-4}$

Here R1 is the contact resistance of two metal sheets, R2 the metal's electrical resistance,

I = weld current, s is the weld time and r the contact diameter of two sheets

If manufacturing companies had the opportunity to anticipate the state of the operating system and take corrective measures to avoid possible deterioration? By incorporating that amazing approach, manufacturers can not only reduce cases of mechanical failure but also improve the productivity of their employees and improve cost savings. Machine viewing systems can effectively perform these functions and ensure minimal downtime

4.4 Experimentation

4.4.1 Ultrasonic testing

On behalf of planning of experiment sample, the resistance spot welding device is VS-10 model are used.
The experiment sample size such as length, width and connection is stated in Table 3.

Table 3 Test Specimen Size

Sr.No.	Parameters	Size (mm)
1	Length	250
2	Width	40
3	Overlap	40

Established on this size here we has in use into concern the Welding Current and Cycle time value using L_9 arrangement as exposed in Table 4

Sr.No.	Welding Current(kA)	Weld Cycle Time
Sample 1	3	20
Sample 2	2	21
Sample 3	3	21
Sample 4	2	16
Sample 5	4	22
Sample 6	3	20
Sample 7	2.5	21
Sample 8	3	19

Now, experiment samples are organized as per table 3 as well as their spitting image is displayed in Fig. 7 as below.

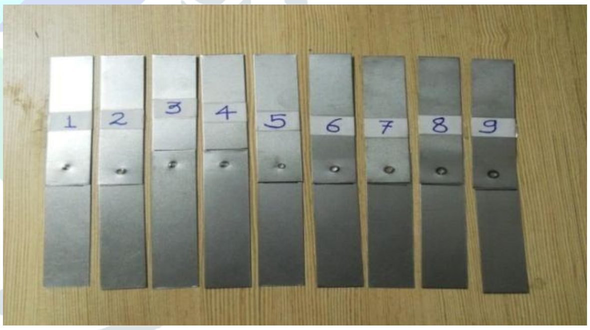

Fig 7 Test Sample when spot welding for Ultrasonic tests.

Einstein – II TFT Ultrasonic Flaw detector machine is used forcarrying out the test is as shown in Fig.8.

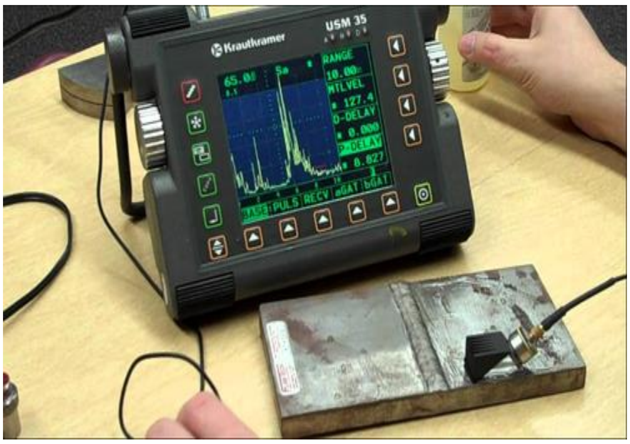

Fig 8. Einstein II TFT Ultrasonic Flaw detector machine

4.4.2 TENSILE SHEAR TEST

Once accomplishment of ultrasonic testing, then there are additional test was done, and the test is well-known as a tensile test are agreed out on the experiment samples. The Universal Testing Machine is used for tensile shear testing is presented in Fig 9.

The tensile–shear strength have been designated to describe the mechanical properties of spot weld. The tensile and shear stresses are performance a important role at the time of tension test. The sample was spot welded for every single of the 7 welding situations declared in table 5. In direction to rise the precision and the assurance level, the experimentation interrelated to every single parameters arrangements was effected for double spells and the normal values has been related. The tensile–shear tests was accepted out at a crosshead of 10 mm/min with UTM tensile machine. Throughout the tensile tests, three types of failure mode were observed in the used steels; interfacial, limited interfacial, and pullout. These methods are common in welded joints see Fig. 9.

Fig 9. Universal Testing Machine

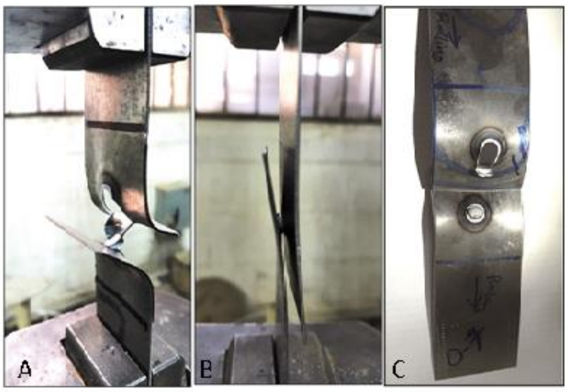

Fig. 10. (a) enclosure failure mode, 0.88 mm thickness; (b) interfacial for HSLA 0.8 mm; (c) partial interfacial, 0.75 mm thickness.

The results which we achieved during tensile testing of the experiment samples are utilized for conclusion out the optimal value of the welding current and cycle time to optimize the weld tensile strength and reducing the current rejection level. The result related to tensile testing for specimens are shown in Table 5.

Table 5.

Sr. No.	Sample	Tensile Shear Strength (N/mm^2)
1	Sample 1	140.845
2	Sample 2	130.531
3	Sample 3	84.889
4	Sample 4	154.849
5	Sample 5	340.745
6	Sample 6	286.532

4.4.3 Corrosion test

Samples was decided from welds and allowing to the welding conditions designated beyond, they was attached, and a corrosion test have conducted in a DY2300 Series potentiostat, for the two illustrations that achieved the extreme and lowermost assessment of tensile-shear tests and the viewing area 1 cm^2 over expending potentiated and cyclic anodic polarization method allowing to ASTM G 5-9430 standard, to find the values of Iscor, Ector, Epitt and analyze the corrosion rate for every single Sample. The aqueous intermediate for the involvement was arranged with synthetic seawater (3.5% NaCl), and these are contains of 35 grams of sodium chloride salt using 1000 ml of purified water, and the degree of pH was measured and establish to be equal to 6.5. At that time the Scanning Electron Microscope (SEM) examination was operated to inspection the cross-section combined microstructure, to regulate the joint interface, and to detect the effect of corrosion at the nugget zone.

4.5 Results and Discussion

The most important factors that affect weld quality are surface appearance, strength and ductility, weld nugget size, weld penetration, sheet separation, and internal discontinuities. Surface appearance of the welded dissimilar materials Ductility is also one of the most important factors that effects the spot weld quality. The ductility of a resistance weld is determined by the composition of the base metal and the effect of high temperatures and subsequent rapid cooling on that composition.

4.5.1 Ultrasonic test

Once research of the experiment samples, these are reviewed through non-destructive testing called as ultrasonic testing every single sample is evaluated through via this mechanism. The test outcomes are shown in Table 6.

Table 6. Ultrasonic test results

Sr. No.	Specimen	Nugget Diameter (mm)	Internal Defect
1	Sample A	2.55	ZERO
2	Sample B	2.10	ZERO
3	Sample C	2.00	ZERO

During this reading, flat weld surface exterior is very nearly zero attained in the case of low carbon steel samples. Though, the weld surface form for HSLA is not as flat as compared to low carbon steel and interior imperfection are decreases.

4.4.2 Tensile-Shear test

The tensile strength results of a HSLA steel samples of, 0.88 mm thickness are given away in Fig. 12. The red curve shows the tensile results. It's occurs if the high current and high welding time are used. In this situation all miscarriage will be pullout mode. The yellow curve characterized the reasonable strength of spot welded samples. The investigational inspections show partial interfacial failure mode. The bottommost tensile strength outstanding to with minor welding current and small time is shown in grey curve. The cracked samples display an interfacial failure mode. The green curve characterized the optimal tensile strength that attained due to expending of the welding parameters from Design Expert.

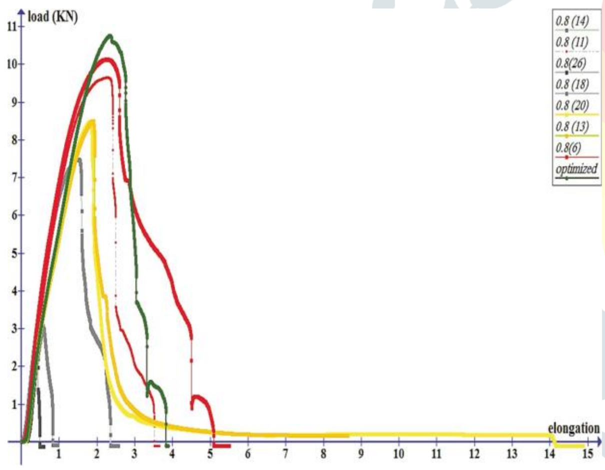

Fig 11. Results of tensile-shear force

Since Fig. 12, tensile shear load bearing capacity of low carbon steel are more as compare to HSLA steel, monitored through the mixture of composed materials. Thus that is comprehensible that the weld ability of HSLA steel is less as compared to low carbon steel, monitored through the arrangement of these materials.

Ductility is similarly most significant influences that special effects the spot weld quality. The ductility of a resistance weld is calculated through the arrangement of the parent metal as well as the effect of high temperatures and following quick cooling on that configuration. The adjacent things to ductility measurement are the hardness experiment since the hardness of metal is commonly an indication of its ductility Therefore; the hardness amount was achieved on the weld nugget.To decide weld nature of unique materials, the strength of weldment not set in strength. Structures it are normally intended to utilize spot welds. so the welds are stacked in shear when the parts are presented to stress or load loading. At times, the welds might be stacked in tension, where the course of loading is typical to the plane of the joint, or a mix of pressure and shear In this review, the impacts of pinnacle weld current, on the pliable shear load bearing limit of the unique materials welds are given in Table 2. Results are likewise shown graphically in Figures 6, 7, 8 and 9. It is observed that elastic shear load bearing limit of welded materials expanded with expanding top weld flows. The upgrade in pliable shearing load bearing limit of weldment with expanding of pinnacle current is basically ascribed to the growth of piece size [16, 17, 18].

From Figure 9,tensile e shear load bearing limit of low carbon steel is more than HSLA steel, trailed by the mix of the two materials. So it is reasonable that the weldability of low carbon steel is more than that of HSLA steel, trailed by the mix of these materials.

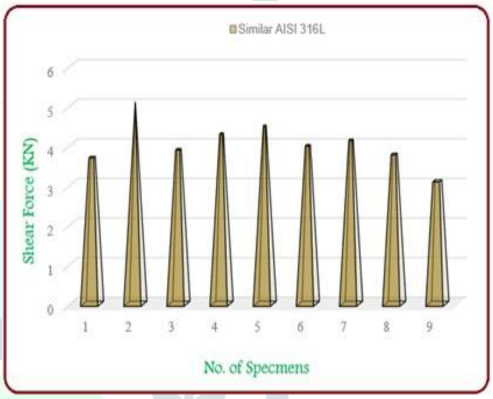

Fig.12 Tensile test result for spot welded HSLA with 0.88 mm

Ductility is likewise one of the main factors that impacts the spot weld quality. The Ductility of an opposition not set in stone by the piece of the base metal and the impact of high temperatures and ensuing fast cooling on that creation.

The closest thing to ductility estimation is the hardness test since the hardness of metal is normally a sign of its flexibility [5, 6]. Hence, the hardness estimation was performed on the weld nuggets. The impact of pinnacle current on the hardness across the not set in hard and the outcome is displayed in Fig.10.

As found in Figure 13, the addition in welding current outcomes in an increase in the hardness of the two materials. This increase in hardness esteem is mostly because of the increase in energy input, which causes more warming in examples, and stress solidifying takes.

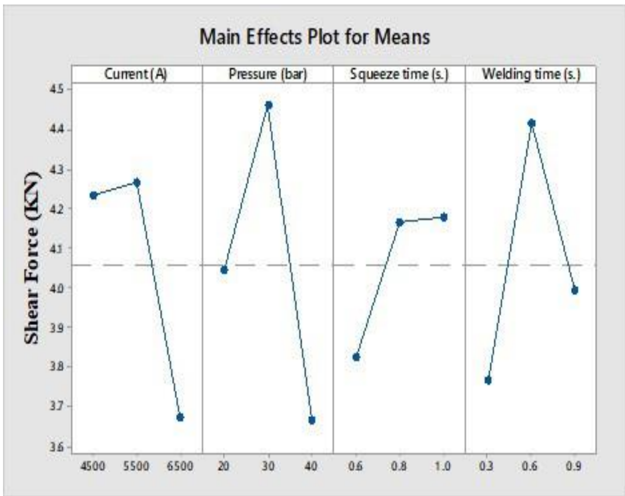

Fig 13. Effect design of the welding parameters on a tensile-shear force.

4.5.3 Corrosion test

When execution of corrosion tests through using potentiated method, two curves of a samples no.2 and no.9 was attained as exposed in Fig 14.

And there were other two curves for samples 2 and 9 when it tested by cyclic anodic polarization technique as plotted in Fig. 15. And through the help of the curves that looked in the beyond fig, the values of Icorr, Ecorr, Epitt and the corrosion rate of samples 2 and 9 were attained, as shown in the Table 4.

Subsequent to playing out the corrosion tests with the assistance of the great amplification SEM picture, the pitting locales that showed up in the two examples 2 and 9 and in the two the weld region and the regions near it were noticed, as displayed in Figure 16.

From the got values for the corrosion test, it was observed that the consumption rate of test no.9 is higher than it is in example 2 should be visible plainly in Figure 16 for the SEM. Also, the pitting corrosion esteem happened in the example surface of the weld region and its nearby regions, as displayed in Figure 16; it tends to be seen the example 2 has less pitting consumption.

This prompted the sample 2 get on the best ductile shear force from test 9.It is likewise known that St.St. can be helpless to seawater erosion. Since the welding states of test 9 as far as the welding current and anode pressure utilized for welding were higher and thus the warm burdens were higher than the example 2, so the pitting which showed up on a superficial level was more extreme and furthermore the erosion rate despite the fact that the openness time to the current was lower.

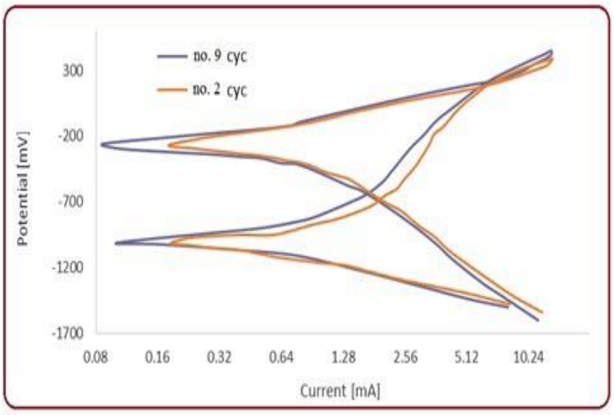

Fig. 14. The possible study for samples 2 and 9.

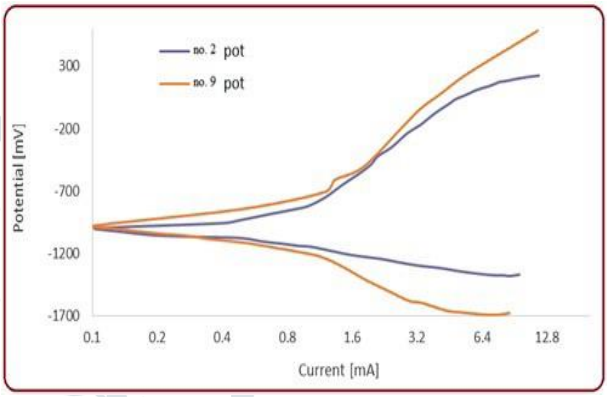

Fig 15. The cyclic test for two samples no.2 and no.9

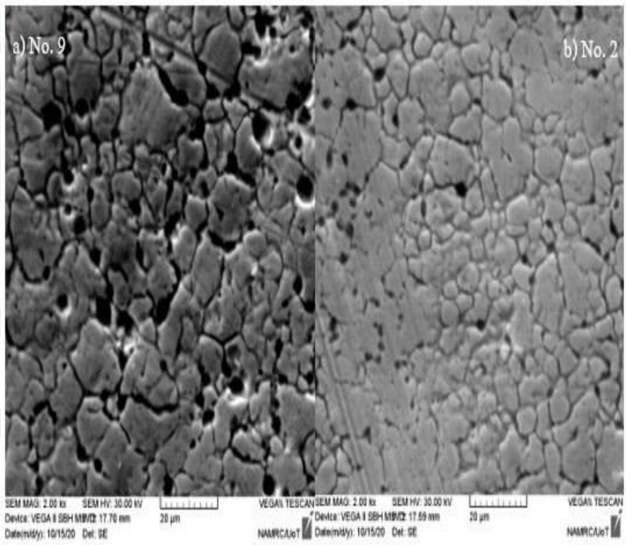

Fig 16. SEM of the two samples no.2 and no.9 after corrosion test.

5. Conclusion

Through evaluating the effects from several experiments, that work might be determined as follows:

The nugget size are increases when the input current value increase in resistant spot welding. Similarly nugget size of HSLA sheets of steel was establish to be better than the mild steel, for the reason that of, additional resistance at electrode and HSLA steel edge, as well outstanding to additional hardness of HSLA.

that was found the tensile shear load bearing capability

of welded materials rises with accumulative highest weld current due to the development of nugget size. Resistance spot weld ability of mild steel is more as compare to HSLA steel, monitored by weld ability of the arrangement of these constituents.
The failure of welded samples happened at the weld edge in every cases, and these are found due to high width of welded specimens.

For higher thickness material, used High welding current, bigger size diameter electrode, additional welding pressure and extra welding time give superior results.
When welding current increases, hardness of materials are also increases, due to high current, and heat generation is more due to welding is more, which is followed by increases in rapid cooling of material, thus, stress hardening take place.
In corrosion rate and pitting corrosion at sample 9 more as compare to sample 2.
When Increased welding current in RSW method leads to improved opposing as well as corrosion rate.

6. ACKNOWLEDGMENT

Author would like to thanks his professor and parents for the successful completion of this research work.

7. REFERENCES

1. K. Vignesh, A. Perumal and P. Velmurugan, Optimization of resistance spot welding process parameters and microstructural examination for dissimilar welding of AISI 316L austenitic stainless steel and 2205 duplex stainless steel, International Journal Advance Manufacturing Technology, 92, 2017, 1-11

2. Khanna O. P., Welding Technolo-gy, Dhanpat Rai Publications, 16th Edition, 2007.

3. Parmar R. S., Welding Engineering and Technology, Khanna Pub-lishers, 1 st Edition, 1997.

4. Marashi P., Pouranvari M., Amirabdollahian S., Abedi A. and Goodarzi M., Microstructure and Failure Behavior of Dissimilar Resistance Spot Welds between Low Carbon Galvanized and Austenitic Stainless Steels, Inter-national Journal of Materials Science and Engineering, Vol. 480, pp. 175-180, 2008.

5. Kaushal, S., & Indraj, S. (2017). Review on spot welding of steel sheets using different optimization methods. International Journal of Interdisciplinary Research.

6. Manoj, R., & Vishal, A. (2014). Optimization of spot-welding process parameters for maximum tensile strength. International Journal of Mechanical Engineering and Robotics Research, 3(4).

7. A. K. Pandey, M. I. Khan, K. M. Moeed “Optimization of resistance spot welding parameters using Taguchi method” A. K. Pandey et al. / International Journal of Engineering Science and Technology (IJEST), ISSN : 0975-5462 Vol. 5 No.02 February 2013.
A, 92, p.40499.

8. Zhou M., Zhang H. and Hu S. J., Relationships between Quality and Attributes of Spot Welds, Welding Journal, Vol. 77, pp. 72-77, 2003.

9. Mukhopadhyay G., Bhattacharya S. and Ray K. K., Strength Assess-ment of Spot-Welded Sheets of Interstitial Free Steels, International Journal of Materials Processing Technology, Article in press ELSEVIER. 2008.

10. Chao Y. J., Ultimate strength and failure mechanism of resistance spot weld subjected to tensile, shear, or combined tensile/shear loads. J Eng Mater Technol, pp. 125–32, 2003.

11. Chetan R Patel and Dhaval A Patel (2012), “Effect of Process Parameters on the Strength of Aluminium Alloy A5052 Sheets Joint Welded by Resistance Spot Welding with Cover Plates”, August

12. Pan, N., Sheppard, S. (2002). Spot welds fatigue life prediction with cyclic strain range. International Journal of Fatigue Volume 24, Issue 5, pp 499-602

13. Dai, W.L., Dickinson, D.W., Papritan, J.C., & Tsai, C.L. (1991) Analysis and Development of a Real-Time Control Methodology in Resistance Spot Welding. SAE Technical Paper, 14 pages

14. Arvinder Singh, Vanraj, Kant Suman, Suri N.M “Parameter optimization for tensile strength of spot welds for 316l stainless steel” International Journal of Scientific & Engineering Research, Volume 4, Issue 7, July-2013, ISSN 2229-5518.

15. Thakur A G, Rao T E, Mukhedkar M S and Nandedkar V M (2010), “Application of Taguchi Method for Resistance Spot Welding of Galvanized Steel”, November, ARPN Journal of Engineering and Applied Sciences.

16. Sahota D S, Ramandeep Singh, Rajesh Sharma and Harpreet Singh (2013), “Study of Effect of Parameters on Resistance Spot Weld of ASS316 Material”, March

17. R.K. Suresh “Parameter Optimization for Tensile Shear Strength during Spot Welding Of Corrugated Mild Steel Plates” VSRD International Journal of Mechanical, Civil, Automobile and Production Engineering, Vol. IV Issue VII July 2014 e-ISSN: 2249-8303, p-ISSN: 2319-2208 © VSRD International Journals.

18. A.S. Panchakshari and Dr. M.S. Kadam,”Optimization of the Process Parameters in Resistance Spot Welding Using Genetic Algorithm” International Journal Of Multidisciplinary Sciences And Engineering, Vol. 4, No. 3, March 2013)

19. Panchakshari A, Kadam M , Optimization of the process parameters in resistance spot welding using Genetic Algorithm, Journal of Multidisciplinary Science and Engineering Vol 4 No 3, March 2013

20. Pardeep M, Mahesh N, Hussain Raja, Process parameters optimization in resistance spot welding of dissimilar thickness materials, Journal of Mechanical, Aerospace, Industrial Engineering Vol 8 No 1, 2014