AN ANALYSIS OF WELDING TIP DURING SPOT WELDING APPLICATION IN THAKNA WELDING MACHINE WELDING USING ANSYS

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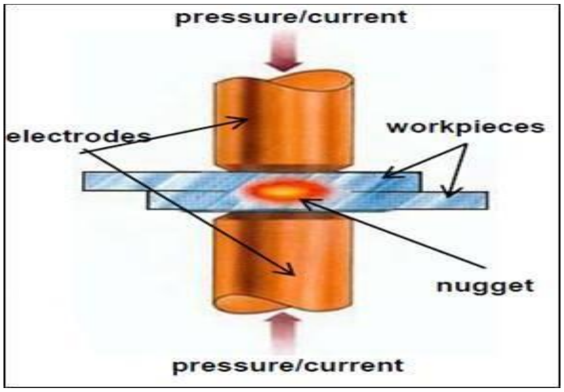
Abstract: Resistance Spot Welding (RSW) consists of mechanical-thermal-metallurgical-electrical phenomenon in which investigation of heat generation, current and resistance plays a key role. In this work, a review about material, nugget, and electrode has been carried out, which is the main point of concern in resistance spot welding. In industry, any small modification in the above concerned points may result in reduction of cost and time as well as increase in electrode life and strength of nugget.

Keywords: RSW, Electrodes, Time Cycle, Thermal Analysis, Nugget Formation, HAZ

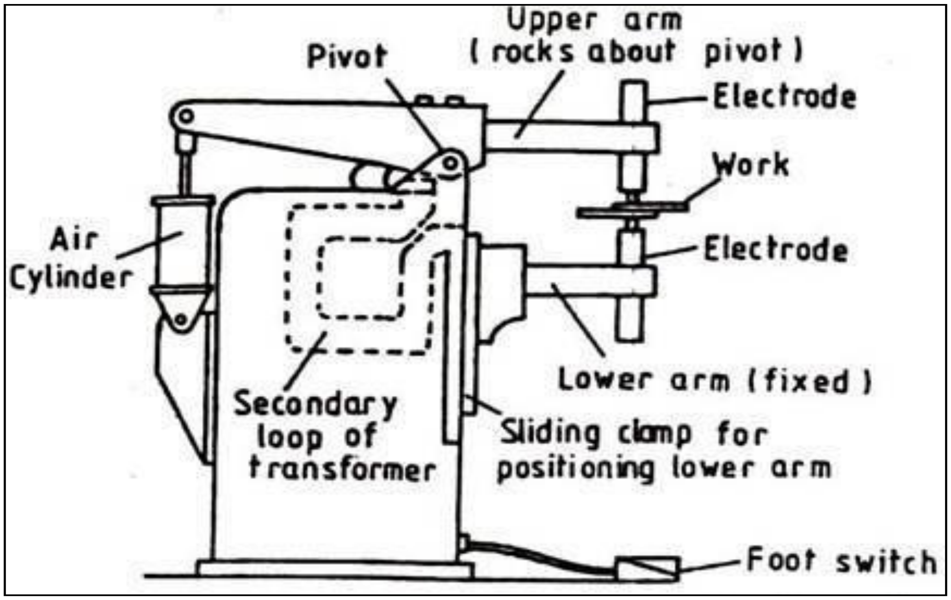
I. Introduction

Welding is a fabrication or sculptural process that joins materials by fusion. The different types of welding processes are Gas welding, Resistance welding, Arc welding and Solid State welding. Out of these, one of the oldest process used today is Resistance welding.

Resistance welding is the process of joining metal pieces together by increasing their temperature to fusion point and applying mechanical pressure to join them. In the context of commercial importance, the most widely used resistance welding processes are **Spot, Seam and Projection welding.** In this group, Resistance Spot Welding (RSW) is by far the predominant one.



Resistance spot welding is the process in which fusion of the faying surface of a lap joint is achieved when current is caused to flow through the electrode tips. The resistance of the base metal to the electrical current flow causes localized heating in the joint. In this, a strong electric current (A.C.) of high amperage and low voltage is passed through the pieces held together to be joined. A resistance is offered to the flow of current when it passes from one piece to the other resulting in raising of temperature of the two pieces till fusion at their junction. The tongs and the electrode tips (through which current flows) hold the parts together to impart pressure and make the weld in close and intimate contact before, during, and after the welding current time cycle.



The concept of heat generation can be stated by using a modification of Ohm's law i.e. when current passes through a conductor then the electrical resistance of the conductor will oppose the current flow and results in heat generation as

$$\mathbf{H = I^2R}$$

With the addition of time factor, the heat generation followsthe formula :- $\mathbf{H = I^2RTK}$

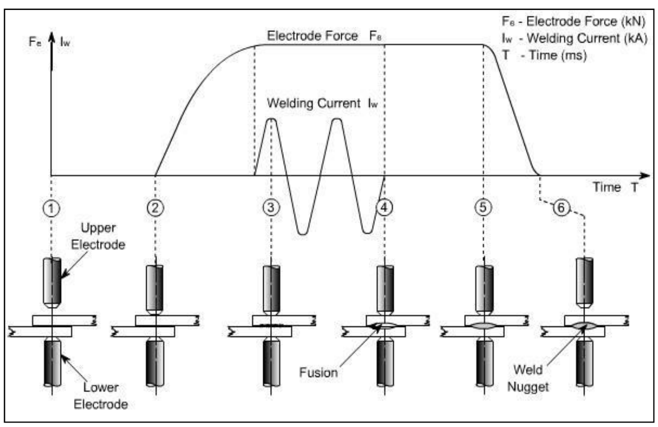
where , H = Heat , I^2 = Weld Current squared ,
R = Resistance , T = Weld time , K = Heat losses

This process is unique because the actual weld nugget is made internally in relation to the base metal surface. This process is mainly used to join in situations where an airtight assembly is not required such as sheet-metal parts of thickness 3 mm or less, using a series of spot welds. Other applications are in the mass production of automobiles, appliances, metal furniture and other products made of sheet metal, bars, tubes.

Successful application of resistance spot welding process is determined by the correct usage and proper control of the following parameters :

a) **Welding Current:** It is the electric current which is required to bring the metal to the molten state. It should be supplied enough as per demand by adjusting the current control device.
b) **Welding Pressure or Force :** In resistance spot welding, mechanical pressure is required at two stages – First, when the current flows across the pieces to hold them together (known as weld pressure) and Second, when the metals are getting melt to squeeze the pieces together for the formation of weld (known as forge pressure). It has a great effect on the weld current such as greater the pressure, lower the resistance which results in higher the welding current value.
c) **Time of application:** It is also termed as cycle time and is the sum total of different time periods allowed during different stages of welding. Different time periods are as follows:

- **WELD TIME,** The time period during which the current flows through the metal pieces to increase the temperature.
- **SQUEEZE OR FORGING TIME,** The time period during which forge pressure is applied to the metal pieces to squeeze them together to form a weld.
- **HOLD TIME,** The time period during which the weld solidifies. It is also referred as cooling time.
- **OFF TIME,** The time period between the release of electrodes and the start of next welding cycle.



The contact area of electrodes: contact area of the face of electrodes affects the weld size and shape which can be varied by varying the electrode tip.

Electrode plays a key role in resistance spot welding as they have to perform three major functions :- conduct electric current, hold the workpiece together and dissipate heat from the weld zone as quickly as possible. During welding, electrodes experience high compressive stresses at increased temperatures. For successful welding, electrode should withstand these stresses without much deformation. For this, electrode should have the characteristics like good electrical conductivity, good thermal conductivity, high mechanical strength, and hardness. To achieve these characteristics, electrodes are manufactured by using copper base alloys and refractory metal alloys. In copper base alloys, the principle alloying element is copper whereas Cu-tungsten mixture, pure tungsten, pure molybdenum, etc. are used as common refractory metal alloys. As Electrode tip decides the weld nugget shape and size, most common electrode shape is round shape but hexagonal, square, and other shapes can also be used. The resulting weld nugget, with a heat affected zone extending slightly beyond the nugget into the base metal, is 5 to 10 mm in diameter. Actually, electrode tip point should be slightly more than the weld nugget diameter. If the difference exceeds the limits then it may result either in small and weak weld nugget or developing voids and gas pockets due tooverheating the base metal.

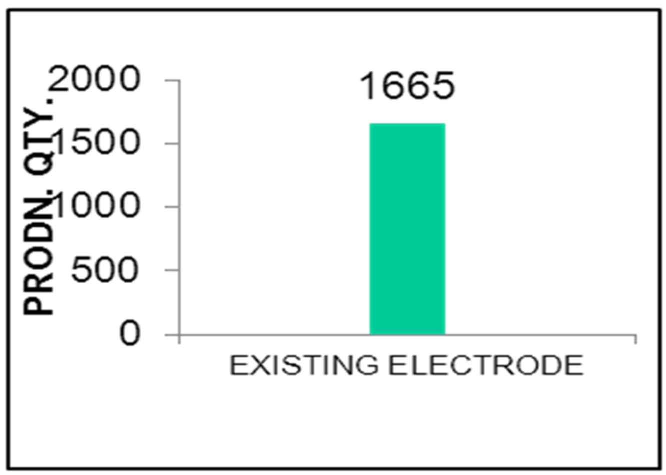
The equations of spot weld parameters for welding mild steel up to a thickness of 3.2 mm are as follows :

Electrode tip diameter = $2.54 + (t_1 + t_2)$ mm Weld time = $2.36 \times (t_1 + t_2)$ cycles
Weld current = $3937 \times (t_1 + t_2)$ AElectrode force = $876 \times (t_1 + t_2)$ N

Where , t_1 =thickness of first plate , mm
t_2 = thickness of second plate, mm

II. LITERATURE REVIEW

Resistance Spot Welding is the combination of electrical, thermal, mechanical and metallurgical science. The contact resistance between the electrode-workpiece interface and the faying surface is affected by the surface roughness of both workpiece and electrode. Therefore, the contact resistance of a lubricated sheet is lower as compared to an unlubricated sheet . In the study of aluminum alloys with homogenous distribution, nugget formation can be squeezed with a very high value of contact resistance or with a small weld force by increasing the local current density. A case study of Tip concluded that interfacial contact behavior plays a critical role in nugget formation while pressure and temperature observation offer understanding of electrode pitting. Also, weld quality is affected by weld residual stress and sheet deformation.

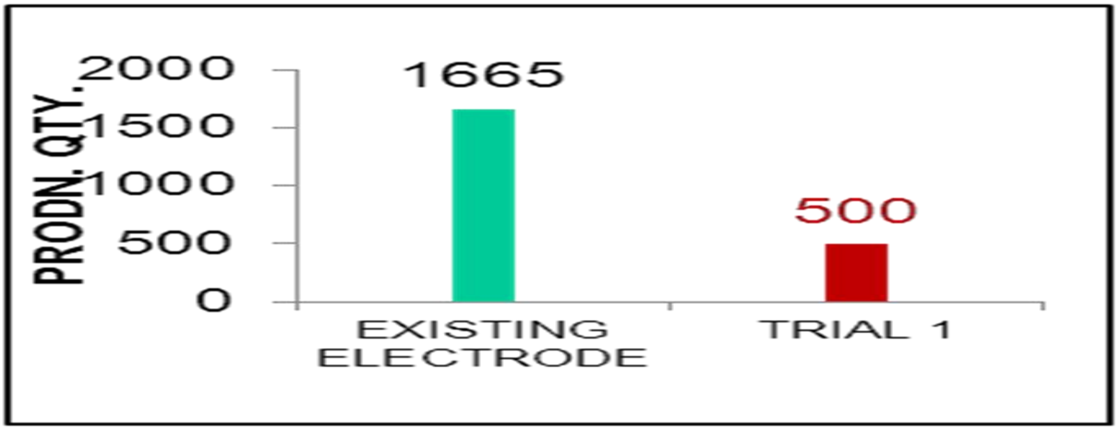


Tip: - Normal Tip shows in Figure.

An experimental study showing the Existing Electrode Analysis, In this study we found rid of the existing electrode to experiment it, that during production, many types of problem s arose in it like.

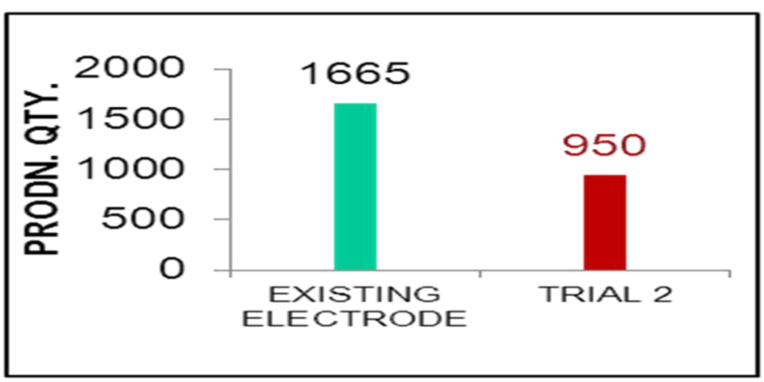
1. Shunting: - After some time spot welding Tip height damage approx 8.0 mm when shunting started of parts..
2. Tip Cost: - High Cost of Tip i.e. 142Rs each.
3. Wastage of Material is more

After Tip analysis we change the drawing of tip. This times we Tip manufactured two parts portion Shank & Tip. Now Tip dia.10 mm and Female Hollow Shank. When production time we find out the Tip bend after 500 Nos. This experiment was not effective as per requirement. Now we need large study.



Experiment: - 1 Shank & Tip shows in Figure.

After second time new Tip analysis we change the drawing of tip & Shank. This times we close the end of Shank (Blind Shank) & Tip dia 12.00 mm. During this experiment we found Tip not contact directly so electrode heat up with in short time. These cause Tip Finished small times. This experiment also was not effective as per requirement. Now we need very high study. This Tip shows in Figure.



Experiment: - 2 Shank & Tip shows in Figure.

After third time new Tip analysis we change the drawing of tip & Shank. This times we make open side of Shank dia.11.0 mm & Tip outer dia. down & inner dia. same with long height & deepness high. During this experiment we found Tip directly contact with water so no heat up & Cold Very festally. This time production very high without Tip damage. This Tip shows in Figure.

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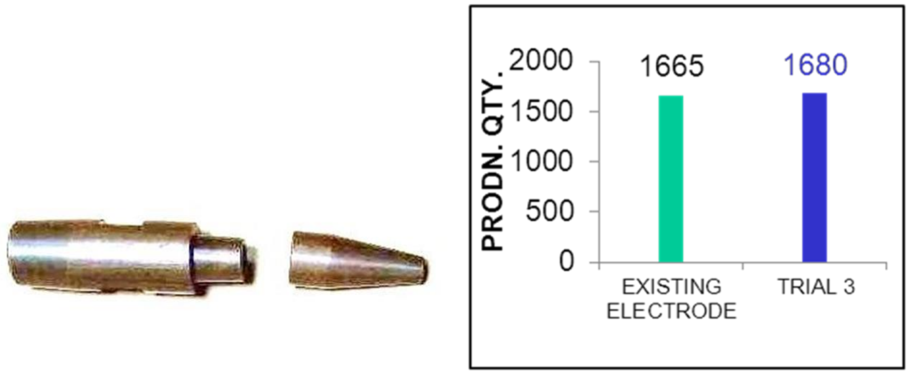
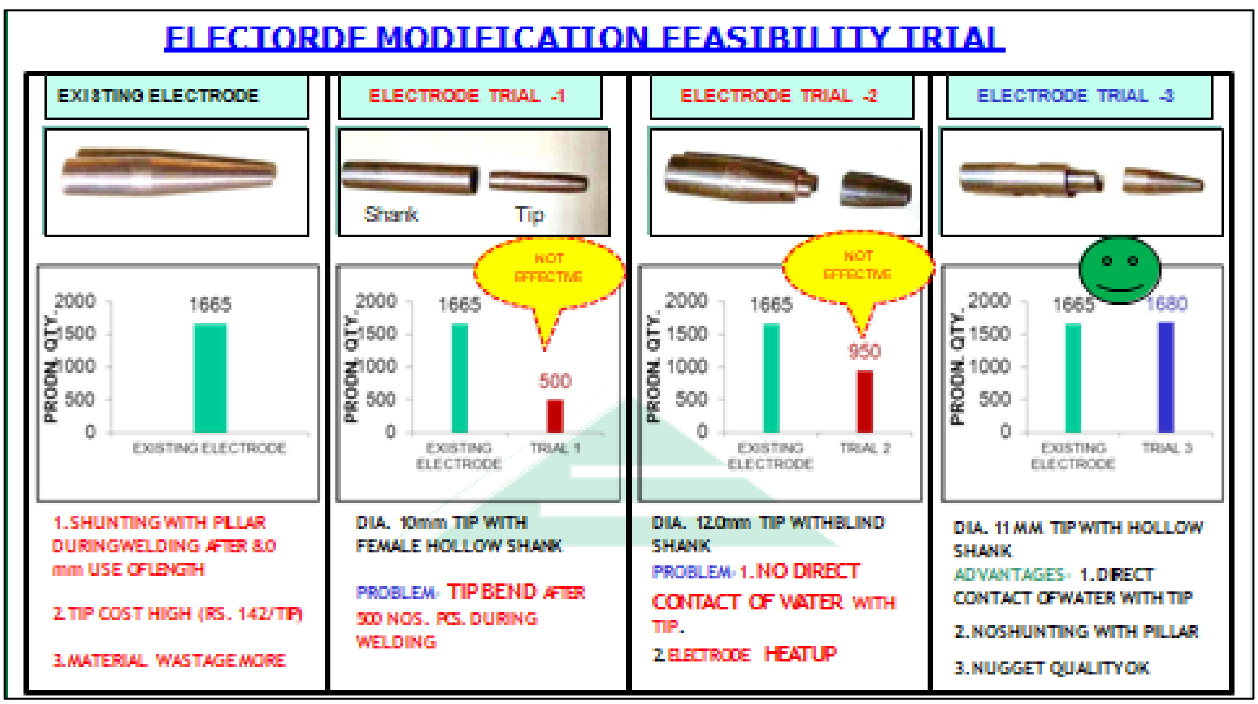
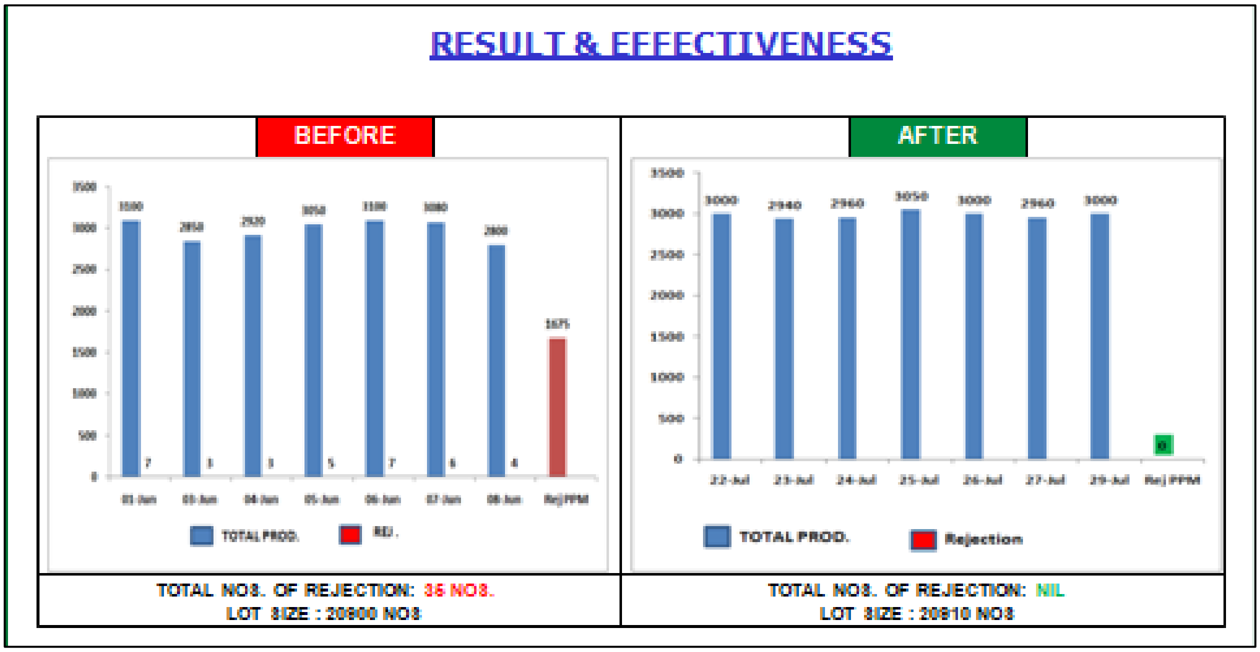
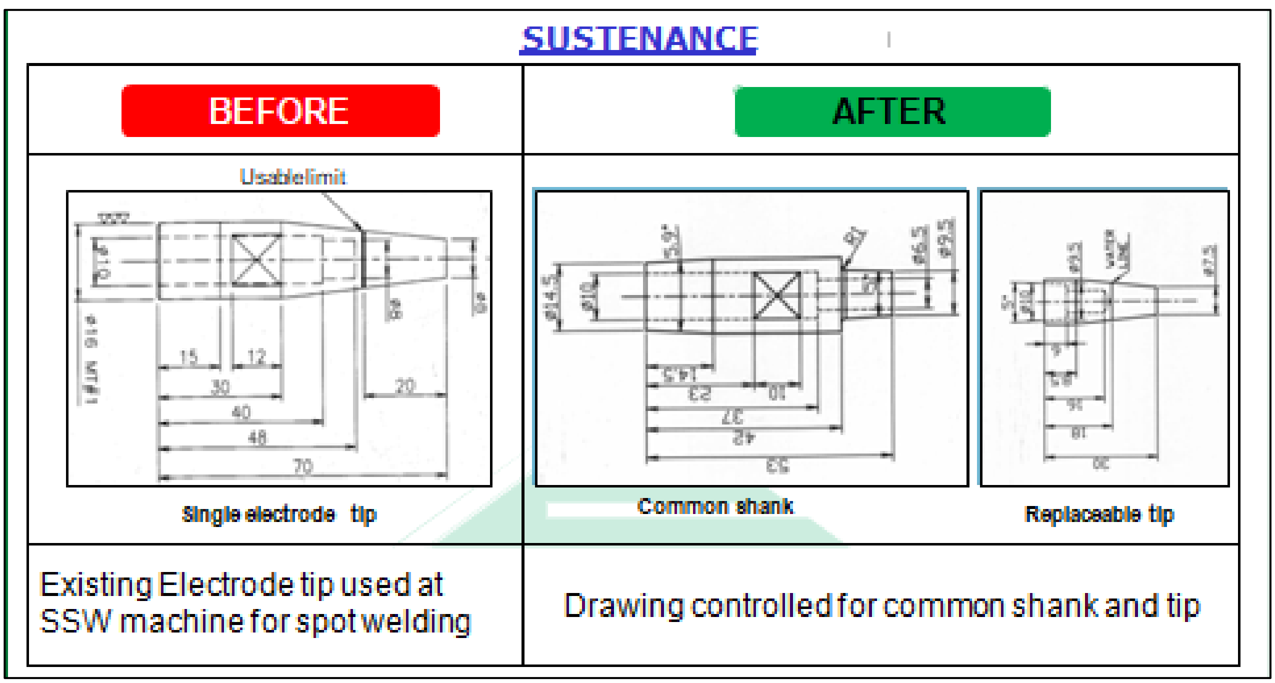


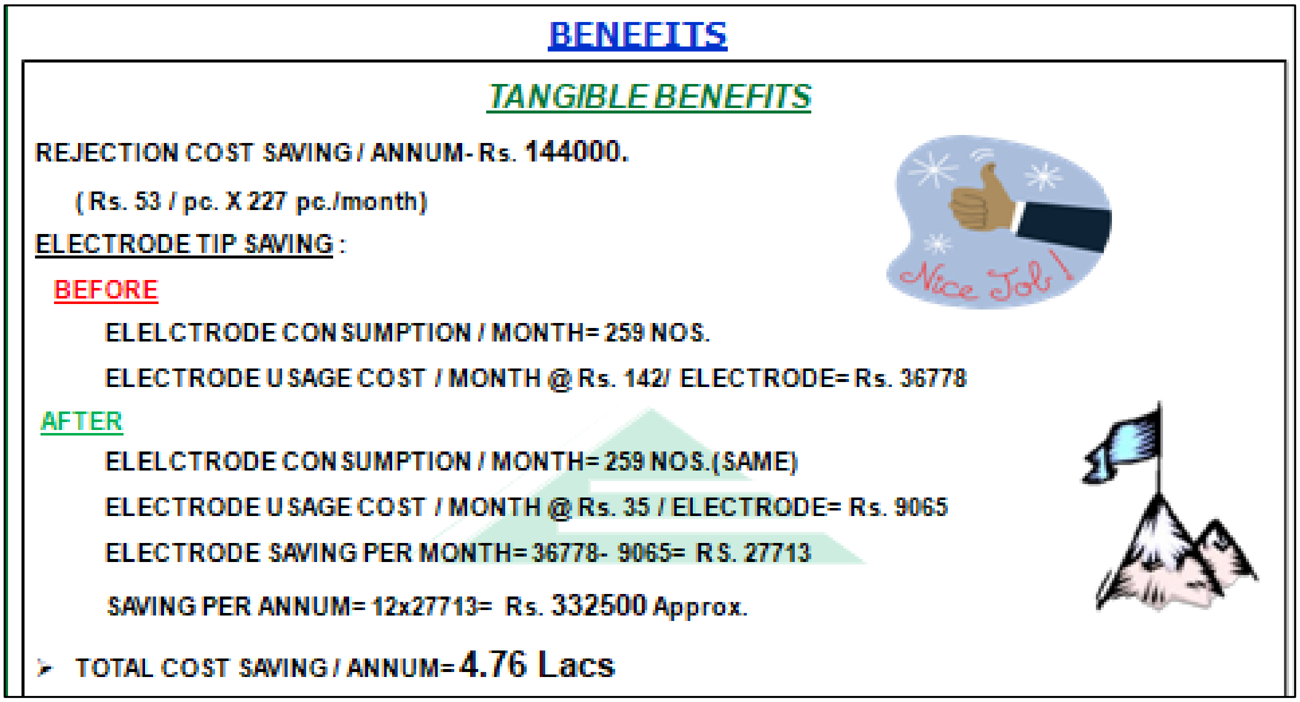
Experiment: - 2 Shank & Tip shows in Figure.

All Over Summary Of Tip & Shank Shown In Figure.




RESULT & EFFECTIVENESS
BEFORE
AFTER
TOTAL PROD.
REJ.
3500
3000
2500
2000
1500
1000
500
0
3000
2940
2960
3050
3000
2960
3000
22-Jul
23-Jul
24-Jul
25-Jul
26-Jul
27-Jul
29-Jul
Rej PPM
Rejection
TOTAL NOS. OF REJECTION: 35 NOS.
LOT SIZE : 20800 NOS
TOTAL NOS. OF REJECTION: NIL
LOT SIZE : 20810 NOS


SUSTENANCE
BEFORE
AFTER
Usable limit
15
12
30
40
48
70
20
Single electrode tip
Common shank
Replaceable tip
Existing Electrode tip used at SSW machine for spot welding
Drawing controlled for common shank and tip



III - RESEARCH GAP

Many experimental and theoretical works have been performed by different researchers in the field of resistance spot welding. Mainly, Steel, Aluminium and their alloys were used to depict the results. To perform the analysis of resistance spot welding process, researchers used different types of softwares such as MINITAB17, COMSOL Multiphysics, CFE using ABAQUS code, SORPAS, ANSYS, SYSWELD (FEM) etc.

Points which were absent or which had less content covered by the reference researchers were found out to be the research gaps in the resistance spot welding study. They are as follows:

- Deflection or bending of electrode due to current and pressure.
- Generally, copper and tungsten alloys were used as electrode material. There was no study based on silver electrode.
- There was limited analysis on workpiece material (mostly stainless steel and aluminium were used).
- More analysis was required in water flow rate and cap depth.
- More research work was needed in the case of HAZ around the elecrode tip during welding.
- Further analysis is to be done using CFD tool as it has huge scope in the future.

IV. Conclusion

RSW is one of the most widely used joining method in industry today. Since, it can be automated easily, it is a flexible and adaptive method of fabrication of components. Therefore, it is very important for researchers to keep modifying the parameters involved, to increase the weld quality and life of electrode. It should be noted that the welding method used also contributes to the overall manufacturing cost of the material. For this cost optimumisation, various engineers and scientists have used different tools for analysis and simulation of RSW. From these, two subjects that were studied exhaustively were :- Nugget Formation and Heat Affected Zones. These were verified experimentally. Besides FEM, other methods used were :- Graphical Lobe Curves, Weld Growth Curves and Statistical methods. Transient Response of RSW which was first measured using Thermovision and High Speed Cinematography, can now be analysed using CFD softwares like ANSYS-FLUENT. Therefore, we can conclude that with the advancement of technology, more and more efficient spot weld analysis will continue to happen, thus, improving the weld quality from time to time.

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