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Experimental Investigation to Optimize Process Parameters for Spot Welding Process

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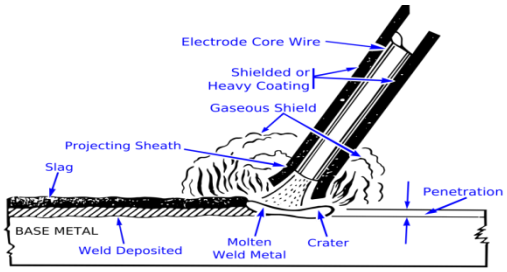
Abstract:
Resistance spot welding is a process which is widely used in the automotive industry to join steel parts of various thicknesses and types. The current practice in the automotive industry in determining the welding schedule, which will be used in the welding process, is based on welding table or experiences. This however may not be the optimum welding schedule that will give the best spot weld quality. In this thesis, number of experiments is conducted to join Aluminum alloy by spot welding process by varying the parameters welding current, weld time and voltage. The experimentation is carried out using a L9 orthogonal array with three factors with each factor having three levels. The weld characteristic optimized is weld strength. The welding current – 30Amps, 40Amps and 50Amps, Voltage – 200V, 210V and 220V, Weld Time – 40Secs, 50Secs, 60Secs are taken for experimentation. The optimization is carried out using Taguchi technique using Minitab Software. Static analysis is done to determine the stresses at the weld region. Modeling is done in Pro/Engineer and Analysis is done in Ansys.

Keywords: Spot welding, Alluminum alloy, Taguchi method, Minitab Software Pro/Engineer &Ansys.

1. Introduction:
Welding is fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is often added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that can be as strong, or even stronger, than the base material. Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Although less common, there are also solid state welding processes such as friction welding or shielded active gas welding in which metal does not melt.



TYPES OF WELDING:
Basically welding may be classified into three types:

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1. Plastic welding

In the plastic welding or pressure welding the pieces of metal to be joined are heated to a plastic state and then forced together by external pressure. This procedure is used in forge welding, resistance welding, thermit welding and gas welding.

2. Fusion welding:

In the fusion welding or no pressure welding, the material at the joint is heated to a molten state and allowed to solidify. This includes gas welding, arc welding etc.

3. Cold welding:

In this welding the joints are produced without the application of heat, but by applying pressure which results in undersurface molecular fusion of the parts to be joined. This process is mainly used for welding nonferrous sheet metal, particularly aluminum and its alloys.

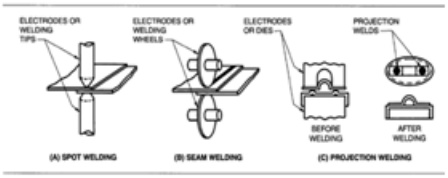
TYPES OF RESISTANCE WELDING

Butt welding

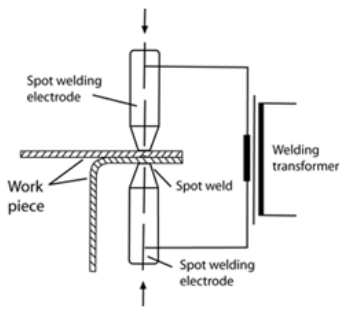
Seam welding

Projection welding

Spot welding



SPOT WELDING



Spot welding is a resistance welding method used to join two or more overlapping metal sheets, studs, projections, electrical wiring hangers, some heat exchanger fins, and some tubing. Usually power sources and welding equipment are sized to the specific thickness and material being welded together. The thickness is limited by the output of the welding power source and thus the equipment range due to the current required for each application. Usually two copper electrodes are simultaneously used to clamp the metal sheets together and to pass current through the sheets. When the current is passed through the electrodes to the sheets, heat is generated due to the higher electrical resistance where the surfaces contact each other. As the electrical resistance of the material causes a heat buildup in the work pieces between the copper electrodes, the rising temperature causes a rising resistance, and results in a molten pool contained most of the time between the electrodes.

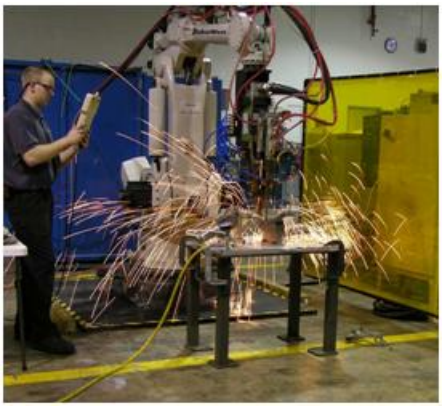


Fig: Spot welding robot

Basic Principles of Spot Welding

At first the job is cleaned and all types of contaminants like grease, oil, dirt , scale and paint are removed. The surface of the electrodes are also made very clean. For clamping the metal sheets together two copper electrodes are used at the same time. The current passes through electrodes and then into the metal sheets. Because of the resistance, heat is generated in the air gap within the contact points. Since copper is great conductor heat is dissipated to the metal so quickly.

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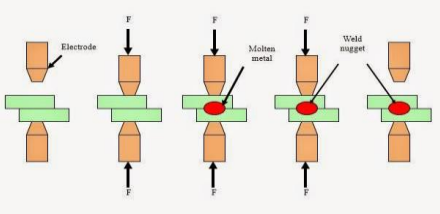
As the metal (workpiece) is a poor conductor of heat in comparison to the copper electrode the heat remains in the air gap. So the heat remains in the one place creating a strong effect and the metal is melted at that desired spot. The period of heat dissipation is very small and at this time metal gets melted and then become solid and thus the joint is formed.



2. LITERATURE SURVEY:
Technologies and resources

1] In the paper by **A. G. Thakur,** presented experimental investigation for optimization of Tensile Shear (T-S) strength of RSW for Galvanized steel by using Taguchi method. RSW of galvanized steel is always difficult due to tendency of zinc coating alloying with electrode. The experimental studies were conducted under varying welding current, welding time, electrode diameter and electrode force. Taguchi quality design concepts of L27 orthogonal array has been used to determine Strength to Noise(S/N ratio), Analysis of Variance (ANOVA) and F test value for determining most significant parameters affecting the spot weld performance. The experimental results confirmed the validity of used Taguchi method for enhancing welding performance and optimizing the welding parameter in RSW process. The confirmation test indicated that it is possible to increase tensile shear strength significantly.

2] In the paper by **B. S. Gawai,** focussed on response surface method to optimize the machining parameter of resistance spot welding that is (weld current, weld time, electrode force) which are responsible for Nugget diameter & strength of the weld. The experimental studies have been conducted under varying welding current & welding time, electrode force.

3] In the paper by **A. K. Pandey,** represents the optimization of various parameters of resistance spot welding. The experimental studies have been conducted under varying pressure, welding current, pressure, and welding time. In this investigation the quality characteristic (tensile strength) has been considered using Taguchi Method. The experimental studies have been carried out varying welding currents, weld and hold times for joining two sheets.

3. IMPLEMENTATION:
INTRODUCTION TO TAGUCHI METHOD

Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a method based on " ORTHOGONAL ARRAY " experiments which gives much reduced " variance " for the experiment with " optimum settings " of control parameters. Thus the marriage of Design of Experiments with optimization of control parameters to obtain BEST results is achieved in the Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal to Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

Static Problems:

Generally, a process to be optimized has several control factors which directly decide the target or desired value of the output. The optimization then involves determining the best control factor levels so that the output is at the the target value. Such a problem is called as a "STATIC PROBLEM".

Dynamic Problems

If the product to be optimized has a signal input that directly decides the output, the optimization involves determining the best control factor levels so that the "input signal / output" ratio is closest to the desired

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relationship. Such a problem is called as a "DYNAMIC PROBLEM".

4. RELATED WORK:

This system consists of brief introduction of different modules used in this project is discussed below:

STATIC PROBLEM (BATCH PROCESS OPTIMIZATION)

There are 3 Signal:to:Noise ratios of common interest for optimization of Static Problems;

SMALLER-THE-BETTER

n = :10 Log_{10} [mean of sum of squares of measured data] This is usually the chosen S/N ratio for all undesirable characteristics like " defects " etc. for which the ideal value is zero. Also, when an ideal value is finite and its maximum or minimum value is defined (like maximum purity is 100% or maximum Tc is 92K or minimum time for making a telephone connection is 1 sec) then the difference between measured data and ideal value is expected to be as small as possible. The generic form of S/N ratio then becomes,n = :10 Log_{10} [mean of sum of squares of {measured : ideal}]

LARGER-THE-BETTER

n = :10 Log_{10} [mean of sum squares of reciprocal of measured data]

This case has been converted to SMALLER:THE:BETTER by taking the reciprocals of measured data and then taking the S/N ratio as in the smaller:the:better case.

NOMINAL-THE-BEST

square of mean

n = 10 Log_{10} :::::::::::::::::: variance

This case arises when a specified value is MOST desired, meaning that neither a smaller nor a larger value is desirable.

EXPERIMENTAL INVESTIGATION:

Experimental investigation is done to determine the mechanical properties of Spot welding of pieces of Mild Steel by varying welding current, voltage and time. The property investigated is tensile strength of the welded pieces. The test samples are 100 mm in length and 40 mm in width and 10 mm in thickness. The electrodes which are used are RWMA Class II Cu-Cr alloy with tips of Ø6 mm diameter. Welding current, weld time and voltage have been used as the control factors with each having three levels

SPOT WELDING MACHINE

MACHINE SPECIFICATIONS:

The series of mobile spot welding machine, small size; light weight; welder, welding can get moving. The series spot welding machine, the main transformer silicon rails are cold copper imports, therefore, the main power transformer small, all types of small no-load current. The series spot welding machine thyristor main circuits are non-contact switch, the circuit turn-off time for fast, accurate and reliable. Welding time can be accurate from time to time adjustment, welding reproducible, and easy maintenance, high-quality welding can be achieved. The series spot welding

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machine can weld carbon steel, stainless steel, metal and many other black, non-ferrous, rare, precious metals and alloys. A wide range of steel furniture is better than the current,

Power distribution cabinets, the production of anti-theft doors, kitchen equipment and repair welding of steel wire mesh, such as tablets. Especially suitable for thin, medium and thick plate for welding and spot welding gap, and its reliability, stability, maintenance is simple, is the ideal choice for your welding equipment.

Experimentation photos

STRUCTURAL ANALYSIS

ALUMINUM

LOAD=3.9 KN

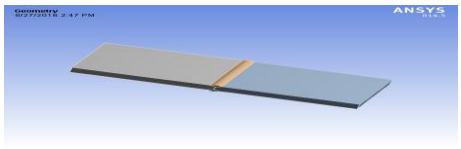
Save Pro-E Model as .iges format

→→Ansys → Workbench→ Select analysis system → static structural → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

→→ select mesh on work bench → right click →edit

Double click on geometry →select MSBR → edit material →



Material properties of Aluminum

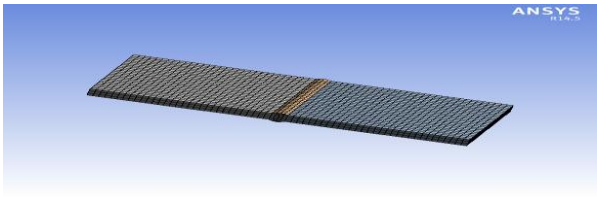
Density : 2770Kg/m^3

young's modulus : 71000 Mpa

passions ratio : 0.33

Select mesh on left side part tree → right click → generate mesh →

Meshed model



Select static structural right click → insert → select force and fixed support →

Select fixed support→ select required area → click on apply →

Select force→ select required area → click on apply → enter force value 3900N →

Select solution right click → solve→

Solution right click → insert → deformation → total → Solution right click → insert → strain → equivant (von-mises) →

Solution right click → insert → stress → equivant (von-mises) →Right click on deformation → evaluate all result

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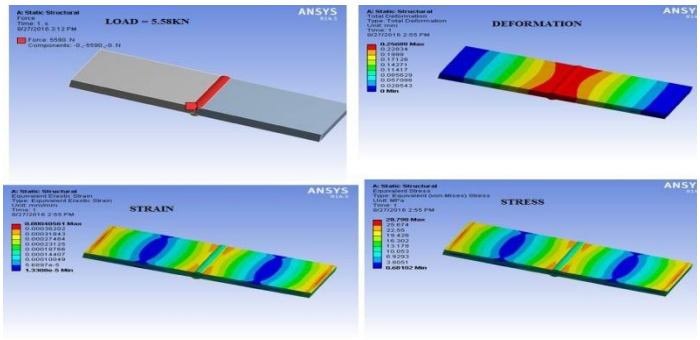
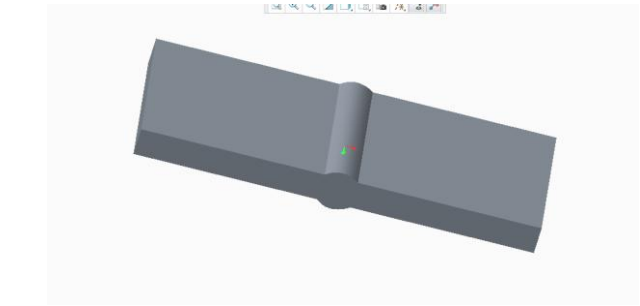
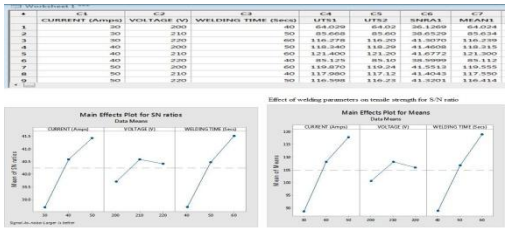


3D MODEL AND STRUCTURAL ANALYSIS OF SPOT WELDING PIECES



OPTIMIZATION OF PARAMTERS FOR TENSILE STRENGTH (N/mm^2)



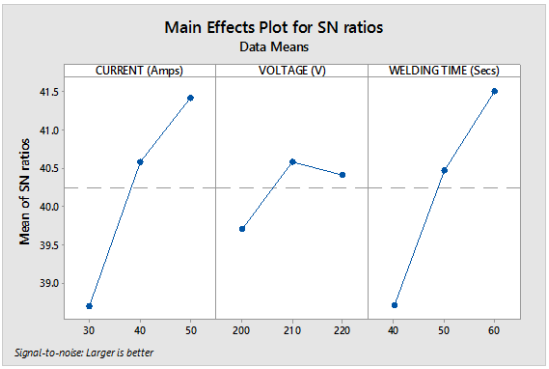
RESULTS

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The tensile strength is considered as the quality characteristic with the concept of "the larger-the-better". The S/N ratio for the larger-the-better is:

$$S/N = -10 * \log(\Sigma(Y^2)/n))$$

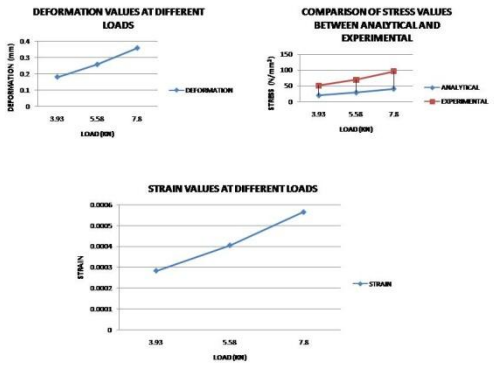
Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration above Eqn. with the help of software Minitab

The tensile strength measured from the experiments and their corresponding S/N ratio values are listed in Table



RESULTS TABLE

Load(KN)	Deformation(mm)	Stress(N/mm^2) Analytical	Stress(N/mm^2) Experimental	Strain
3.93	0.17922	20.092	51.066	0.00028298
5.58	0.25689	28.798	69.23	0.00040561
7.8	0.35845	40.183	95.975	0.00056596



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CONCLUSION:

In this thesis Spot welding is performed on the Aluminum pieces by varying the welding current, voltage and weld time at constant weld speed. The welding currents are 30amps, 40amps and 50 amps, Voltage – 200V, 210V, 220V, Welding Time – 40secs, 50secs and 60secs. Tensile tests are performed on the pieces. The strength of Aluminum alloy is 310MPa. By observing the tensile test results, the tensile strength is increasing by increase of current, and weld time but decreasing by increase of voltage. By observing the Taguchi method the following conclusions can be made: To get high tensile strength, the optimal parameters are current – 50amps, Voltage –210V and Welding Time – 60secs. Structural analysis is done at different loads. By observing the result, the stress values are less than the respective yield stress value of Aluminum alloy at both loads. The tensile strength values obtained from experimental are more than that of analytical stress values at respective loads.

4. ACKNOWLEDGEMENT

We would like to thank all the authors of different research papers referred during writing this paper. It was very knowledge gaining and helpful for the further research to be done in future.

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   Taguchi Approach By Mr. Nagsen D. Jadhav, Mr. Rahul A. Patil, Mr. Rajshekhar R. Patil,2015 IJEDR | Volume 3, Issue 4 | ISSN: 2321-9939