“Investigation of weld strength for different weld condition using design of experiment”

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ABSTRACT

Failure mode is a qualitative measure of resistance spot weld (RSW) performance. To ensure reliability of resistance spot welds during vehicle lifetime, process parameters should be adjusted so that the pullout failure mode is guaranteed. In this work, failure mode of resistance spot welds is to be studied under quasi-static tensile test. It is required to search for new weld quality criterion for resistance spot welded steels. An adhesive layer with appropriate thickness and elastic modulus is necessary to obtain reasonable distribution of stresses in the whole lap region of a weld-bonded joint.

In the first part of work spot weld information and failure causes will be discussed, along with it the adhesives and their applications in welding will also be discussed. DOE will be done using Minitab software for selection of combinations for experimentations. In later part of work analysis will be done using ANSYS and further validation of the results using UTM machine.

Keywords: Adhesive, Spot Welding, weld-bonded

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I. INTRODUCTION

Spot welds are provided for joining of two similar/dis-similar plates or structures. The spot welds number and locations is very important consideration in any object as the most possible leakage or brake chances are at this location only. So increase in the strength of the weld is desirable thing and if we are doing that with reducing the number of spots then it will add cost benefits as well as time benefits also, as we require less number of spots so less time to weld and less cost of welding.

Work-pieces are held together under pressure exerted by electrodes. Typically the sheets are in the 0.5 to 3 mm (0.020 to 0.118 in) thickness range. The process uses two shaped copper alloy electrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together. Forcing a large current through the spot will melt the metal and form the weld. The attractive feature of spot welding is that a lot of energy can be delivered to the spot in a very short time (approximately 10–100 milliseconds). That permits the welding to occur without excessive heating of the remainder of the sheet.

This strength improvement is to be studied under application of adhesives in spot welds. The adhesive will be added at spots and the comparative study of spot weld strength will be done and further for same strength (existing) the number of spots will get reduced with application of adhesives.

Resistive spot welding is a process in which contacting metal surfaces are joined by the heat obtained from resistance to electric current.

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The amount of heat (energy) delivered to the spot is determined by the resistance between the electrodes and the magnitude and duration of the current. The amount of energy is chosen to match the sheet's material properties, its thickness, and type of electrodes. Applying too little energy will not melt the metal or will make a poor weld. Applying too much energy will melt too much metal, eject molten material, and make a hole rather than a weld. Another feature of spot welding is that the energy delivered to the spot can be controlled to produce reliable welds.

Applications-Spot welding is typically used when welding particular types of sheet metal, welded wire mesh or wire mesh. Thicker stock is more difficult to spot weld because the heat flows into the surrounding metal more easily. Spot welding can be easily identified on many sheet metal goods, such as metal buckets. Aluminium alloys can be spot welded, but their much higher thermal conductivity and electrical conductivity requires higher welding currents. This requires larger, more powerful, and more expensive welding transformers.

2.BMW plant in Leipzig, Germany: Spot welding of BMW 3 series car bodies with KUKA industrial robots Perhaps the most common application of spot welding is in the automobile manufacturing industry, where it is used almost universally to weld the sheet metal to form a car. Spot welders can also be completely automated, and many of the industrial robots found on assembly lines are spot welders (the other major use for robots being painting).

3.Spot welding is also used in the orthodontist's clinic, where small-scale spot welding equipment is used when resizing metal "molar bands" used in orthodontics.

4.Another application is spot welding straps to nickel–cadmium or nickel–metal hydride cells to make batteries. The cells are joined by spot welding thin nickel straps to the battery terminals. Spot welding can keep the battery from getting too hot, as might happen if conventional soldering were done.

5.Good design practice must always allow for adequate accessibility. Connecting surfaces should be free of contaminants such as scale, oil, and dirt, to ensure quality welds. Metal thickness is generally not a factor in determining good welds.

II. OBJECTIVE

1. To study DOE (Software-Minitab) for finding weld bond strength estimation combinations.
2. Analysis of the combinations using ANSYS for finding best one.
3. Experimentation on final parameters for strength finding and validation.

III. METHODOLOGY

1. Study of DOE, using Minitab software for finding the Combination for experimental testing.
2. FEA analysis of combination found from Minitab, and further finding best out of them based on strength results. (Modelling using CATIA software and analysis using ANSYS)
3. Testing of Finalized combination by fabricating and testing using UTM machine for validation. (Tensile testing on UTM)

IV. DESIGN OF EXPERIMENT

1. DOE is a formal mathematical method for systematically planning and conducting scientific studies that change experimental variables together in order to determine their effect of a given response.
2. DOE makes controlled changes to input variables in order to gain maximum amounts of information on cause and effect relationships with a minimum sample size.
3. DOE is more efficient that a standard approach of changing “one variable at a time” in order to observe the variable’s impact on a given response.
4. DOE generates information on the effect various factors have on a response variable and in some cases may be able to determine optimal settings for those factors.
5. DOE encourages “brainstorming” activities associated with discussing key factors that may affect a given response and allows the experimenter to identify the “key” factors for future studies.
6. DOE is readily supported by numerous statistical software packages available on the market.
7. In an experiment, we deliberately change one or more process variables (or factors) in order to observe the effect the changes have on one or more response variables. The (statistical) design of experiments (*DOE*) is an efficient procedure for planning experiments so that the data obtained can be analyzed to yield valid and objective conclusions.
8. DOE begins with determining the objectives of an experiment and selecting the process factors for the study. An *Experimental Design* is the laying out of a detailed experimental plan in advance of doing the experiment. Well chosen experimental designs maximize the amount of "information" that can be obtained for a given amount of experimental effort.
9. The statistical theory underlying DOE generally begins with the concept of *process models*. Process Models for DOE.

Adhesive material	M1	M2	M3	M4
Lap length	10	20	30	40
Application of Adhesive	Y		N	

Taguchi Method:
Background

The technique of laying out the conditions of experiments [6] involving multiple factors was first proposed by the Englishman, Sir R.A.Fisher. The method is popularly known as the factorial design of experiments. A full factorial design will identify all possible combinations for a given set of factors. Since most industrial experiments usually involve a significant number of factors, a full factorial design results in a large number of experiments. To reduce the number of experiments to a practical level, only a small set from all the possibilities is selected. The method of selecting a limited number of experiments which produces the most information is known as a partial fraction experiment. Although this method is well known, there are no general guidelines for its application or the analysis of the results obtained by performing the experiments. Taguchi constructed a special set of general design guidelines for factorial experiments that cover many applications.

Sr. No.	**Material**	**Lap Length, mm**	**Adhesive**
1	M1	10	Y
2	M1	20	Y
3	M1	30	N
4	M1	40	N
5	M2	10	Y
6	M2	20	Y
7	M2	30	N
8	M2	40	N
9	M3	10	N
10	M3	20	N
11	M3	30	Y
12	M3	40	Y
13	M4	10	N
14	M4	20	N
15	M4	30	Y
16	M4	40	Y

V. EXPERIMENTAL TESTING

A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures

Sr No.	Material	Lap Length, mm	Adhesive	Deformation, mm	Breaking Load, N
1	M1	10	Y	1.86	7900
2	M1	20	Y	1.75	8430
3	M1	30	N	1.66	8510
4	M1	40	N	1.90	7860
5	M2	10	Y	2.10	7450
6	M2	20	Y	1.55	8600
7	M2	30	N	NA	
8	M2	40	N	NA	
9	M3	10	N	2.45	6700
10	M3	20	N	1.39	8900
11	**M3**	**30**	**Y**	**0.88**	**12480**
12	M3	40	Y	1.18	10050
13	M4	10	N	NA	
14	M4	20	N	NA	
15	M4	30	Y	1.0	11810
16	M4	40	Y	1.10	10760

In experiment, 4000 N load is applied on each specimen and corresponding value of displacement is noted and graphs are shown for optimum result.

For trial no 11

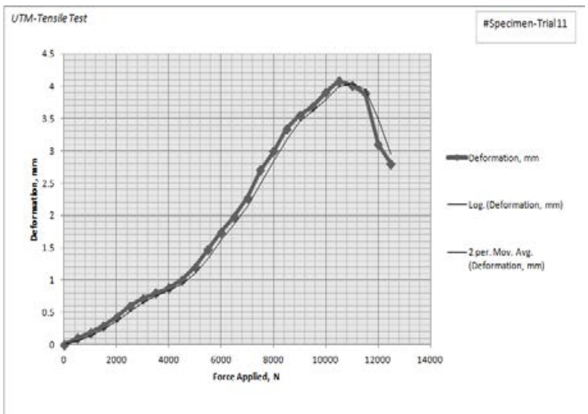

Fig.: Plot of Load vs. Displacement

In this case spot weld joint having lap length 30 mm and Adhesive is applied with material Epoxy resin and Phenalkamine hardener; the deformation is 0.88 mm for 4000 N load. It is shown in fig along with breaking load 12480 N.

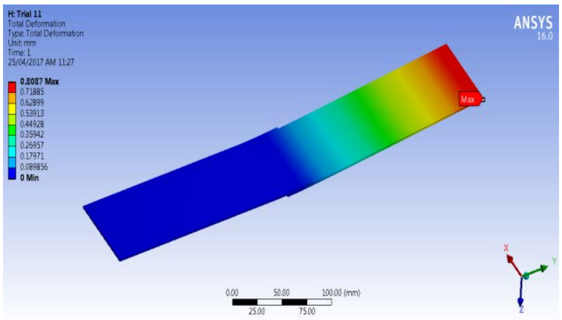

Fig: Stress generated in plate (at 4000N)

In Ansys 16 software, analysis of all specimens is made. Boundary conditions are used which was used in experimental analysis. One side of specimen is kept fixed at one end and load is applied from other end of specimenStresses are found through FEA only and are showing that at breaking load the stresses generated are all above S_{yt} of material i.e. it's failing/braking and same results we are getting experimentally.From all above results i.e. stresses and deformation we can see that trial 11 where spot weld joint having lap length 30 mm and Adhesive is applied with material Epoxy resin and Phenalkamine hardener; the experimental deformation is 0.88 mm for 4000 N load along with high breaking load 12480 N.

VI.CONCLUSION

1. Spot welds and adhesives are studied in detail.
2. It has been found that adhesive bonding with spot weld gives good strength and higher breaking loads than only spot welds.
3. In considered cases it has been found that the minimum braking load is 6700 N for trial 9 and maximum braking load is 12480 N for trial 11, i.e. overall 46.31 % more breaking load is possible for same operating conditions.
4. Lap length is also playing important factor and for lap length of 10, 20 mm getting more stresses and deformation compared to 30 mm. 40 mm lap length showing mix results

VII. ACKNOLEGEMENT

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