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Review of Finite Element Analysis for Spot Welds in A Structures

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ABSTRACT
In this Project we are going to analyze the BIW (Body In White) using ANSYS software under the static loading. The BIW consist mainly two part i.e. top hat and flat plate which are joint together by using resistance spot weld. Spot welds made by resistance spot welding are used extensively in automotive engineering. However, owing to increasing demands in the use of advanced and lightweight materials, resistance spot welding has become a popular alternative for producing spot welds. Because of the complexity and uncertainties of resistance spot welds and thus formed structures, the finite-element (FE) modeling of the welds for Dyanamics analysis is a research issue. In this project first outlines some of the existing modeling of top hat and analyzed by using ANSYS software for different materials and positions of spot welds. SOLID 185 (Tetrahedral 4 node 185) elements is used FE modeling. In this work by using ANSYS V 14.5 software we going to generate mesh BIW part and model generated by using CATIA V5 software.
Keywords: Resistance spot welding, Optimization, Non-destructive testing.

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I. INTRODUCTION

Resistance welding is the most commonly used method for joining steel sheets. No filler metal is needed and the heat required for the weld pool is created by means of resistance when a high welding current is directed through the welded work pieces. An electro-conductive contact surface is created between the work pieces by pressing them together. Contact is made using the shape of either the welded surfaces of the work pieces or the shape of the electrodes. Water-cooled electrodes made of alloyed copper are used in resistance welding. Electrodes convey a pressing force to the joint and direct the welding current to the joint in the appropriate manner. After welding, the electrodes rapidly cool down the welded joint .Work stages in resistance welding are very fast. The surfaces to be welded do not usually need to be cleaned before welding, in addition to which the weld does not usually require grinding or post heating. The Resistance welding process can be easily automated. Resistance welding is a highly efficient production method that is particularly well-suited for automated production lines and mass production.

Therefore there is scope for changing the position of spot weld in BIW part and Analyze static structural analysis in BIW part and to find out the suitable materials and best position of the spot weld in BIW part.

II. LITERATURE SURVEY

2.1 M.P.MALI & K.H.INAMDAR in the paper title Effect of spot weld position variation on quality of automobile sheet metal parts.

Reported in the International Journal of Applied Research in Mechanical Engineering (IJARME) ISSN: 2231 –5950, Vol-2, Iss-2, 2012

In this research have studied, Resistance spot welding is the most preferred and widely used method for joining metal sheets in automotive and many other industrial assembly operations. The body of a car is typically joined by thousands of spot welds. One of the many geometrical factors affecting the final geometrical outcome of the metal part assemblies is the welding process considering welding sequence used when the parts are welded together. The spot welds guarantee the strength of the car, but their positions also affect the geometrical quality of subassemblies and the final product. In practice, the positions of the weld points often deviate from nominal position. By analyzing industrial scanning data, deviations of spot weld positions are found to be of magnitudes up to 19 mm. In this paper, the influence of variation in position of spot welds is investigated with respect to geometrical quality, by simulating and analyzing the geometrical variation of an A-pillar assembly.

2.2 Rikard So¨derberg (2)*, Kristina Wa¨rmefjord, Lars Lindkvist, Rolf Berlin , in the paper title The influence of spot weld position variation on geometrical quality.

Reported in the journal Contents lists available at SciVerse Science Direct CIRP Annals - Manufacturing Technology 61(2012) 13-16 journal homepage: http://ees.elsevier.com/cirp/default.asp

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2.3 ShrutiNaik , Dr. M. Aruna Devi , Dr. C.P.S. Prakash, "a review on optimization of resistance spot welding of aluminum components used in automotive industry.

Reported in the journal International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Issue 04, Volume 4 (April 2017)

Resistance Spot welding (RSW) is one of the common welding processes used for sheet joining especially in the automobile and aerospace industry. It is used in a wide range of industries but notably for the assembly of sheet steel vehicle bodies. This is a type of resistance welding where the spot welds are made at regular intervals on overlapping sheets of metal. Spot welding is primarily used for joining parts that are normally up to 3 mm in thickness. The joint quality can be defined in terms of properties such as weld-bead geometry, mechanical properties and distortion.The objective of the research is to determine the optimum combination of parameters responsible for better quality of joints. The complicated behavior of the process must be analyzed to set the optimum parameters to get the optimum weld quality. The paper also presents the FEA simulation of the RSW process.

2.4 K. D. Hardikar, D.J.Nidgalkar, Dr. K.H. Inamdar in the paper title "Techniques to ensure minimum distortion of an assembly of metal parts induced due to the process of welding used for an assembly" .

Reported in the journal International Journal of Scientific & Engineering Research Volume 3, Issue 2, February-2012 1 ISSN 2229-5518

— In manufacturing industry there are hundreds of metal parts that ar e joined together by w elding process daily. Even a single typical automotive body has about 4000-5000 w eld spots in it w hich joins about 200 sheet metal parts together. During the joining process many factors affect the final geometrical quality. One of the many geometrical factors affecting the final geometrical outcome of the metal part assemblies is the w elding process considering w elding sequence used w hen the parts are w elded together. It is of course desirable to choose w elding parameters as w ell as w elding sequence that minimizes distortion i.e. both variation and deviation in critical dimensions of the final assembly. Reducing dimensional variation is of critical importance to improve the final product quality. In this pa per takes an overview of various techniques used to achieve minimum distortion w hile the metal parts are being assembled. Form the various techniques discussed, the technique w hich yields the minimum distortion is the technique for optimization of w elding process and leads t owards the quality manufacturing.

2.5 Jaime A. Camelio and S. Jack Hu**, In the paper title** Impact of Fixture Design on Sheet Metal Assembly Variation **.**

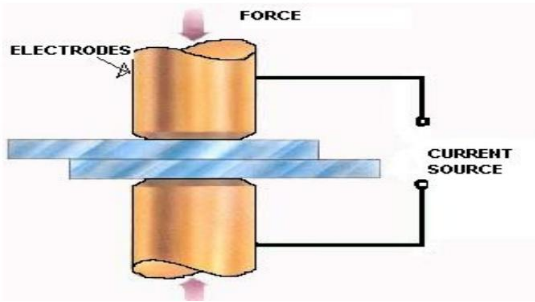
Reported in the journal Journal of Manufacturing Systems Vol. 23/No. 3 2004

In that research paper have studie a new fixture design methodology for sheet metal assembly processes. It focuses on the impact of fixture position on the dimensional quality of sheet metal parts after assembly by considering the effect of part variation, tooling variation and assembly springback. An optimization algorithm combines finite element analysis and nonlinear programming methods to determine the optimal fixture position such that assembly variation is minimized. The optimized fixture layout enables significant reduction in assembly variation due to part and tooling variation. A case study is presented to illustrate the optimization procedure.

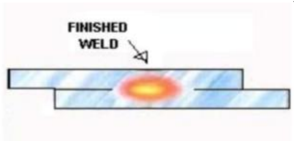
III. SPOT WELDING - A JOINING PROCESS

Spot welding is one form of resistance welding, which is a method of welding two or more metal sheets together without using any filler material by applying pressure and heat to the area to be welded. Spot welding is used in a wide range of industries but notably for the assembly of sheet steel vehicle bodies. This is a type of resistance welding where the spot welds are made at regular intervals on overlapping sheets of metal.

It is primarily used for joining parts that are normally up to 3 mm in thickness. The strength of the joint depends on the number and size of the welds. Spot-weld diameters range from 3 mm to 12.5 mm. A current is then passed between the electrodes, sufficient heat being generated at the interface by resistance to the flow of the current that melting occurs, a weld nugget is formed and an autogenous fusion weld is made between the plates. The heat generated depends upon the current, the time the current is passed and the resistance at the interface. The resistance is a function of the resistivity and surface condition of the parent material, the size, shape and material of the electrodes and the pressure applied by the electrodes.



In spot welding, two sharp copper alloy electrodes are used to cluster the welding current to a petite ‘spot’ as well as fasten the work pieces simultaneously. Inflicting a sizeable current via the two metal pieces eventually melt them a bit for welding. The best part of this procedure is that it occurs very quickly, in just 10 milliseconds and that too to a specific small spot to which the heat generated is not too much to result in warping.



Spot welding involves three stages; the first of which involves the electrodes being brought to the surface of the metal and applying a slight amount of pressure. The current from the electrodes is then applied briefly after which the current is removed but the electrodes remain in place for the material to cool. Weld times range from 0.01 sec to 0.63 sec depending on the thickness of the metal, the electrode force and the diameter of the electrodes themselves.

IV. PROCESS OPTIMIZATION

Optimization is the discipline of adjusting a process so as to optimize some specified set of parameters without violating some constraint. The most common goals are minimizing cost and maximizing throughput and/or efficiency. This is one of the major quantitative tools used in industry for decision making. When optimizing a process, the goal is to maximize one or more of the process specifications, while keeping all others within their constraints. This can be done by using a process mining tool, discovering the critical activities and bottlenecks, and acting only on them. The spot welding process tends to harden the material, causing it to warp. This reduces the material's fatigue strength, and may stretch the material. The physical effects of spot welding include internal cracking, surface cracks and a bad appearance. The chemical properties affected include the metal's internal resistance and its corrosive properties. Optimization of RSW process parameters have traditionally been performed through empirical experimental testing in laboratory environments. Such physical testing is accurate and reliable but it also has its downsides. Physical testing always involves material supply, welding equipment and operator skills, all of which are costly and critical for the results. In many fields of research, numerical modeling has been used partly or fully as a replacement for experimental testing. Numerical models can be used as an effective tool in virtual process planning. The complicated behavior of the process must be analyzed to set the optimum values of parameters to get the optimum weld quality.

V. STUDY OF PARAMETERS

There are three main parameters which control thequality of resistance spot welding:

A. EFFECT OF WELDING CURRENT: Current controls the heat which generated accordingto the equation Q = I2Rt.this shows that the current has more influence on the amount of heat generated. Tensile shear strength increases rapidly with increasing current density. Excessive current density will cause molten metal expulsion (resulting in internal voids), weld cracking, and lower mechanical strength properties.

Typical variations in shear strength of spot welds as a function of current magnitude are shown in Figure 2. In the case of spot welding excessive current will overheat the base metal and result in deep indentations in the parts and, it will cause overheating and rapid deterioration of the electrodes.

B. EFFECT OF WELD TIME:

The rate of heat generation must be such that weldswith adequate strength will be produced without excessiveelectrode heating and rapid deterioration. The total heat developed is proportional to weld time. During a spot welding operation, some minimum time is required to reach melting temperature at some suitable current density,assuming all other conditions remain constant. To a certain extent, weld time and amperage may be complementary. The total heat may be changed by adjusting either the amperage or the weld time. Heat transfer is a function of time and the development of the proper nugget size requires a minimum length of time, regardless of amperage.

C. EFFECT OF WELDING PRESSURE Welding pressure is produced by the force exerted on the joint by the electrodes. Electrode force is considered to be the net dynamic force of the electrodes upon the work, and it is the resultant pressure produced by this force that affects the contact resistance. As the pressure increases, the contact resistance and the heat generated at the interface will decrease. To increase the heat to the previous level, amperage or weld time must be increased to compensate for the reduced resistance. Contact resistance will be high. As the pressure increases, the high spots are depressed and actual metal-to-metal contact area increases, thus decreasing the contact resistance.

VI. SPOT WELDING JOINTS- QUALITY ASSURANCE

NDT OF SPOT WELDS

Nondestructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used.Today modern nondestructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. Most NDT methods that are used for ordinary fusion welds can be used on spot-welds. The most common NDT-methods are visual inspection (VT), penetrant testing (PT), eddy current testing (ET), ultrasonic testing (UT), magnetic particle testing (MT) and X-ray testing (RT).

DEFECTS IN SPOT WELDS:

All discontinuities in spot-weld could be divided in two groups.
1) Non-Surface breaking discontinuities
2) Surface breaking discontinuities

Some of the NDT methods can only detect discontinuities in one of the two groups and some methods can detect discontinuities in both groups. The discontinuities that exist in spot welds are:
1. Weld with no or minimal fusion
2. Cold or stuck weld
3. Weld nugget size
4. Weld expulsion and indentation
5. Weld cracks

Spot welds can fail completely in two distinct modes namely nugget pull out failure and interfacial failure. Nugget pull out failure is caused by plastic collapse and interfacial failure is governed by crack. Failure of a spot weld occurs when at least the fracture criterion for one of the mechanisms is satisfied first.

VI. CONCLUSION

In the review, it was observed that the common input parameters affecting the strength of multiple spot-welded joints are spot welding pressure, current and weld time. The spot welds withstand much better shearing forces than normal forces. Also the spot weld can rupture in two modes. Nugget pullout failure which occurs in stronger joints and interfacial failure occurs in weaker joints. The survey clearly manifests that Aluminum material is much preferred for spot welding in automotive industries because of its higher thermal and electrical conductivity and a good tensile strength. Due to these properties, spot welding of aluminum requires much higher tip forces and higher welding current but takes one-third the weld time of steel.

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