ISSN 2395-1621

A Study on Residual Stress of Resistance Spot Weld

[#1]Mr. Sourabh Babasaheb Shinde,[#2]Prof. Mr. S. R. Gavali

[1]sourabh311@gmail.com
[2]srgavali@coe.sveri.ac.in

[#1]Student M.E. Mech CAD/CAM Engg,Department of Mechanical Engineering
SVERI'S, COE, Pandharpur, Maharashtra, India.

[#2]Professor, Department of Mechanical Engineering
SVERI'S, COE, Pandharpur, Maharashtra, India.

.

ABSTRACT

Resistance spot welding with stainless steel sheets is a joining technique widely used in the rolling stock industries. Simulations of resistance spot welding processes have been studied and developed by numerous researchers.Tensile residual stress of resistance spot welded structures increases the maximum stress and tends to reduce fatigue strength. Accordingly, the welding process must be optimized to minimize the tensile residual stress. This paper presents residual stress obtained from electrical-thermal structural analysis and the parameters that affect residual stress. Finally, equations for residual stress are developed in terms of welding conditions and are used to find welding conditions that minimize residual stress.

ARTICLE INFO

Article History :

Received:2nd November 2015

Received in revised form:

4th November 2015

Accepted : 5th November 2015

Keywords:**Resistance spot welding, Residual stress, Stainless steel, Strength.**

I. INTRODUCTION

The finite element method was used to simulate the welding process and to determine the physical response of the joint material for various welding conditions. In the finite element analysis procedure, the temperature-dependent contact resistance and material properties were taken into account. Coupled finite element modelling procedures were used to simulate the electrical, thermal, metallurgical, and mechanical changes during resistance spot welding processes.

II. RESISTANCE SPOT WELD

Resistance spot welding (RSW) has been widely employed in sheet metal fabrication for several decades, in particular in automotive bodies and structures. It is easy to operate, perform automate control, and thus is an ideal joining technology for mass production [1]. Resistance spot welding with stainless steel sheets is a joining technique widely used in the rolling stock industries. Simulations of resistance spot welding processes have been studied and developed by numerous researchers.The resistance spot welded parts have various configurations of stress states in accordance with the enforced loading type and the geometry around the spot weld. Those loading types are generally classified into three groups: tensile-shear, tension, and coach peel. The most frequently generated loading type among those is the tensile-shear type [2].

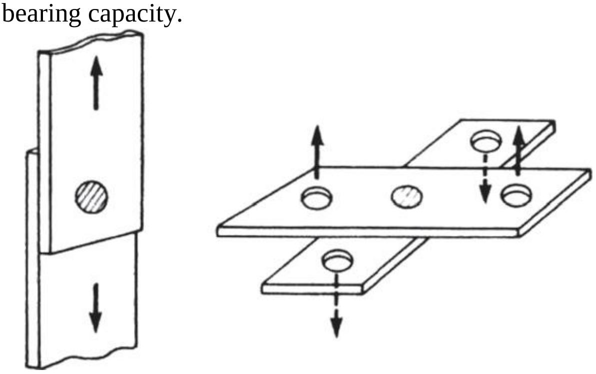
III.RESIDUAL STRESS

Regardless of the loading type on a resistance spot welded structure, tensile residual stress from the welding procedure deteriorates the fatigue strength and quality. It also tends to increase the maximum stress. Many researchers have simulated the resistance spot welding process. However, their concerns have been concentrated mainly on process control, nugget size, contact resistance, and so forth. Efforts to decrease the negative effects of tensile residual stress have seldom been undertaken by controlling the welding conditions. It is important to accurately predict the deformation behavior (elastic and plastic) of the joint over a range different loading conditions to avoid over loading or time-dependent deformation. For welded structures, the extent of the plastic deformation is dictated by the interaction between the geometry of the joint, the constitutive properties of the material, and the performance of the actual bond itself [4, 5]. In addition, detailed properties of each welded zone for different base material could also help to accurately predict the effect of some key design parameters, typically the nugget size and sheet thickness, on the structure properties and the selection of welding procedures and/or parameters. Finite element (FE) modelling has been widely used in modelling the spot-welding process and the mechanical deformation of spot-welded joints. In general, this would require ensuring that the correct constitutive properties of the adhered parts and any residual stresses are properly included in the finite element analysis. This is not always straightforward since the material properties of spot-welded joints can vary widely between the base metal, the heat affected zone, and the weld nugget itself [2, 5, 7]. For steel, the nuggets consist of martensite and bainitic phases, while the HAZ zone around the nugget, and have a mixed microstructure consisting of martensite, bainite, ferrite and pearlite.

These different microstructures could result in significantly different material behaviour. This mismatch may also affect the stress distribution and cause localized stress concentration. However, obtaining a sample of material from each of these regions large enough for tensile testing can be challenging, owing to the size of the heat-affected zone and nugget. Many investigations have used indentation tests (which require only a small volume of material) to characterise the gradient properties within the welded zone in particular the HAZ zone with some empirical relation being used to estimate the material parameters such as yield stress [3].

However it is difficult to directly estimate the full material constitutive laws from a single indentation test. Recent development in inverse modelling has opened up the possibility of predicting the full plastic behaviour using indentation data. However, the majority of published work on inverse modelling requires the use of a continuous depth sensing technique, which is not widely available; this has limited its application to a wider field. The work presented here used a more simple methodology to characterise the material properties using a standard hardness test machine. The strain hardening parameters of the three zones were inversely determined from conventional indentation test, with the HAZ divided into three sub-zones according to microstructure. The predicted stress–strain curve of the base material was compared to standard tensile test experimental results. A 3-D finite element model based on the predicted material properties coupled with a Gurson fracture model was developed to predict the deformation of spot-welded joints beyond the onset of initial yield under shear tensile test. This type of analysis is crucial to predict the load bearing limit and energy absorption of a welded structure. The deformation mode and force–displacement data showed a good agreement with experimental results. The effect of nugget size and the sheet thickness on the tensile-shear strength of spot-welded joints was further studied using a high performance computing system [6, 7].

It can be observed for example during quasi-static Cross Tension or Tensile Shear tests as shown in Fig. 1, the typical tests for the determination of weldability. As a consequence, understanding the diversity of failure situations appears necessary in an attempt to model the spot weld behaviour and its load bearing capacity.



Tensile shear Cross tension

Fig. 1.Sketch of the Cross Tension and Tensile Shear tests [4]

Numerous factors may be prone to influence the mechanical behaviour of spot welds. They can be classified into three categories:

(i) Geometrical factors (weld size, sheet thickness, specimen width, and distance between the machine grips),

(ii) Loading mode (dominated by shear, by normal loading or combined) and

(iii) Metallurgical factors related to the welding thermal cycles and the chemical composition of the steel (brittleness of the microstructures in the different Heat Affected Zones (HAZ), presence of inclusions or porosities, residual stresses) [9].

The weld is a heterogeneous material with significant microstructure gradients from the BM to the center of the weld nugget. This is related to the thermal history experienced during the welding process [8].

IV. CONCLUSION

The various properties of materials are considered dependent on temperature, and the contact resistance is given in the function of temperature. Many applications for spot-welded joints are in load bearing situations and their mechanical strength has a strong influence on the integrity of the whole structure. It is important to accurately predict the deformation behaviour (elastic and plastic) of the joint over a range different loading conditions to avoid over loading or time-dependent deformation. Consequently, the following conclusions are obtained. First, assuming bilinear isotropic material in elastoplasticity, the simulated residual stress has good agreements with the measured data when the hardening tangent is supposed to be 1% of the elastic modulus. That assumption implies that the difference between real and bilinear constitutive material can be reduced by the appropriate selection of hardening tangent.

Therefore, when a welding process being analyzed, the hardening tangent must be considered as an effective factor. Second, to minimize the tensile residual stress in the radial direction around a spot-welded nugget, the values of electrode force, weld current, and weld time within the weld lobe must be as large as possible. In the other welding processes, such as arc welding, as the quantity of heat input per unit area is increased, the tensile residual stress becomes large. However, to the contrary, it becomes small in the spot welding process.

REFRENCES

[1] B-W.Cha and S-J.Na, "A Study on the Relationship between Welding Conditions and Residual Stress of Resistance Spot Welded 304-Type Stainless Steels", Journal of Manufacturing Systems, Vol. 22/No. 31, 2003.

[2] X. Kong, Q. Yang, B. Li, G. Rothwell, R. English, X.J. Ren , "Numerical study of strengths of spot-welded joints of steel", Materials and Design 29 , 2008.

[3] S. Dancette, D. Fabregue, V. Massardier, J. Merlin, T. Dupuy, M. Bouzekri, "Experimental and modelling investigation of the failure resistance of Advanced High Strength Steels spot welds", Journal of Engineering Fracture Mechanics, 2011.

[4] C.L.Tsai, D.W. Dickinson, C.Y. Kim, and M. D. Garnett, "Mechanical Behaviours of Resistance Spot Welds During Pry-Checking Test," Supplement to welding journal, June2006.

[5] M. M. Rahman, Rosli A. Bakar, M. M. Noor, M. R. M. Rejab, M. S. M. Sani," Fatigue Life Prediction of Spot-Welded Structures: A Finite Element Analysis Approach," European Journal of Scientific Research, 2008.

[6] Xin Zhang, Bing Liu, "Strength Analysis and Simulation of Multiple Spot-Welded Joints," June 1-4, 2009.

[7] Ahmet H.Ertas, FazılO.Sonmez, "Design optimization of spot-welded plates for maximum fatigue life", August 27, 2009.

[8] Jacek Karlinski, Artur Kopczynski, Artur Iluk, "Dynamic studies of Top-Hat thin-walled elements joined by spot welding", Journal of KONES Powertrain and Transport, Vol. 17, No. 1 2010.

[9] China papers "Research on the Influence of Spot Pitch on the Static Strength and Fatigue Strength of Body Structure Member," July 28, 2010.

