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Optimization of Spot Weld in Steel Component using FEA Technique

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ABSTRACT
In this paper the Optimization of Number of Spot welds on Automobile Wheel Rim using Finite Element Analysis is studied. Spot welded rim must pass certain tests like Weld Strength Test (WST).In Weld Strength test a shear force is applied on the spot weld using Universal Testing Machine. We choose three parameters for optimization namely, Number of spots on rim, spot diameter and thickness of rim. Finite Element Analysis Models are developed for the tests mentioned. Experiments of three tests are carried out. FEA results and Experimental results are compared for best combinations of selected parameters
Keywords*: Rim, Weld Strength Test,,FEA,optimization.*

1. Introduction

In this paper the effects of weld arrangement on the fatigue behavior of the multi-spot welded joints have been investigated via experimental and multiaxial fatigue analysis. To do so, three sets of the spot welded specimens with different arrangements were prepared and fatigue tests were conducted under the various cyclic loads. Experimental tests revealed that the spot welded arrangement effect has a considerable role in fatigue strength of multi-spot welded joints. A nonlinear finite element code was used to obtain the stress and strain distributions near the roots of the nuggets for the three kinds of the specimens. Fatigue lives of the specimens were predicted by means of six different multiaxial fatigue criteria using the local stress and strain values obtained from the finite element simulations. It was found that the SWT and Crossland criteria have the best accuracy for all types of the specimens among the applied criteria.[1]
In order to ensure the integrity of the joint, one should therefore consider these factors. However, the present study focuses only on design optimization; optimum selection of processing parameters is out- side the scope of this study. [2]

2. Finite Element Analysis of Welded Joint

In the current study, the spot-weld arrangement effects on the fatigue behavior of the multi-spot welded joints have been investigated using the experimental and multiaxial fatigue analysis. To do so, three sets of the four-spot welded joint specimens with different arrangements were manufactured and then fatigue tests were conducted under various cyclic longitudinal load levels. A nonlinear finite element ANSYS code was used to obtain stress, and strain distribution near the roots of the nuggets due to longitudinal applied loads. Fatigue lives of specimens were estimated with six different multiaxial fatigue criteria using the local stress, and strain distributions obtained from the finite element analysis.[1]

3.Methodology

Before starting analysis it is important to understand current process. Literature review was carried out to understand past work carried out in field stress analysis of wheel rim. To validate the solution following methodology was adopted.

1. Finite Element Method
2. Experimental Method
3. Comparison of above two methods

Finite Element Weld Analysis

We will start Analysing the Rim for Weld strength at minimum thickness(T1=2.0 mm),Maximum diameter (D1 = 8.4 mm) and (Spots numbers=21).If this experiment combination fails all the remaining experiments for T1 will get fail because we are using maximum diameter and maximum number of spots so other combinations will be weaker than above used. So we will directly take next thickness of rim. If passed we will go for the next experiment combination.

Force: As in UTM a force of 237.5 kN is applied.(As specified by Manufacturer)

1.Experiment No.1.1: D1=8.4 mm; S1 = 21; T2=2.0 mm

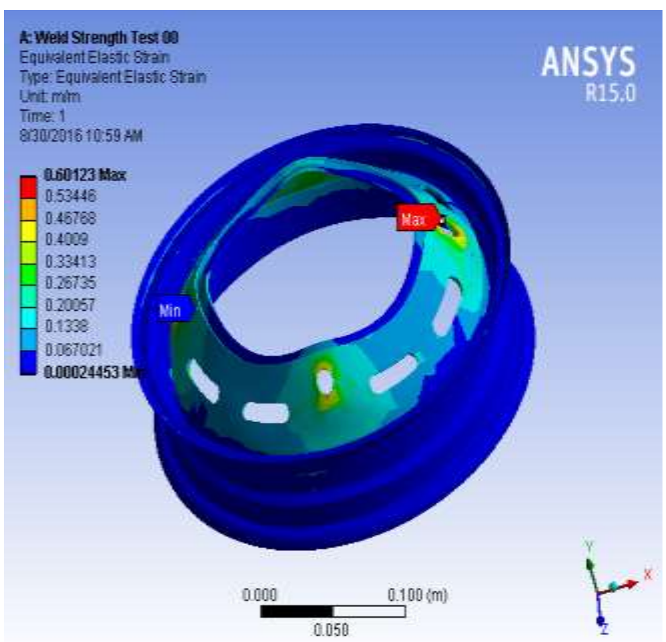

Fig.1.Equivalent Strain

From above plots Maximum strain is 0.60123 ;maximum equivalent stress is $1.1963X10^{11}$ N/mm^2 andMaximum shear stress is $2.96X10^{10}$ N/mm^2.

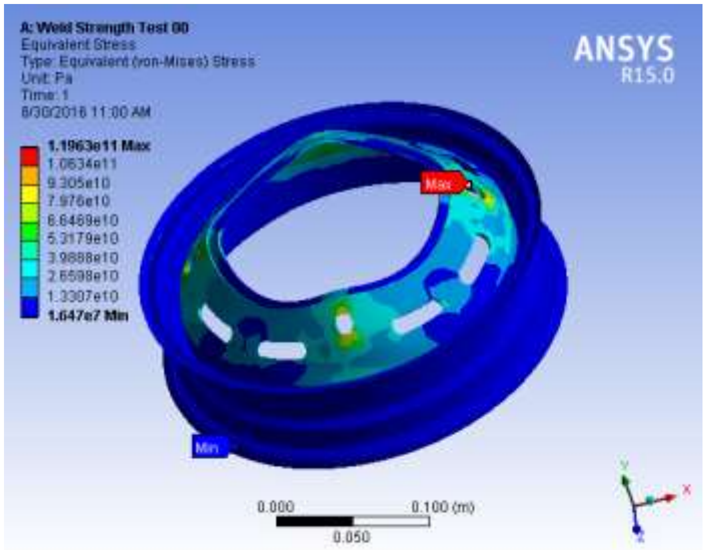

Fig 2.Maximum Equivalent Stress

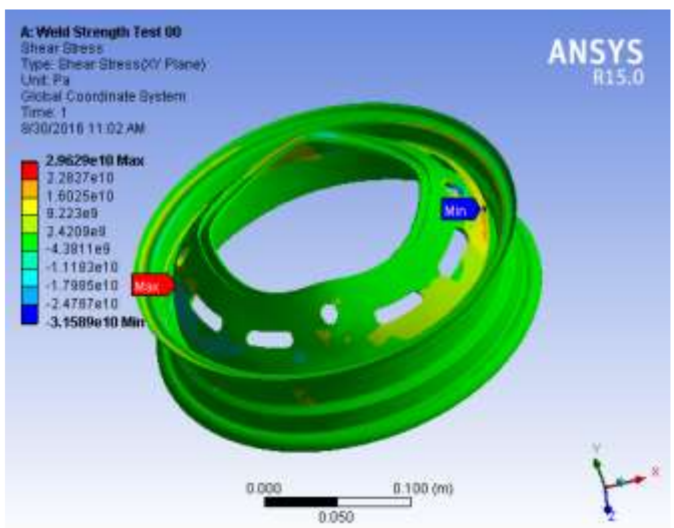

Fig.3. Max Shear Stress

This exceeds the limit indicating the failure of rim. As this is the best combination for the thickness selected all other combinations of number of spots and spot diameter will fail.
So we go for the next thickness of T2=2.3mm.

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The experiments for this thickness are as follows:

1	S1	D1	
2	S1	D2	
3	S1	D3	
4	S2	D1	
5	S2	D2	T2
6	S2	D3	
7	S3	D1	
8	S3	D2	
9	S3	D3	

Table:1.The Experiments for thickness T2=2.3 mm

Number of Spots (S):

S1 = 21	S2 =18	S3=15

Diameter of Spots (D):

D1=8.4	D2=7.7	D3=7.0

Now starting with Experiment No.1 for thickness T2=2.3 mm
The plots are as follows :

1.Experiment No.1.1: D1=8.4 mm; S1 = 21; T2=2.0 mm

From above plots Maximum strain is 0.60123 ;maximum equivalent stress is 1.1963X10^{11} N/mm^2 andMaximum shear stress is 2.96X10^{10} N/mm^2. This exceeds the limit indicating the failure of rim. As this is the best combination for the thickness selected all other combinations of number of spots and spot diameter will fail. So we go for the next thickness of T2=2.3mm.

Validation of Rim Weld Test

For validation Purpose of the wheel rim following is the experimentation:

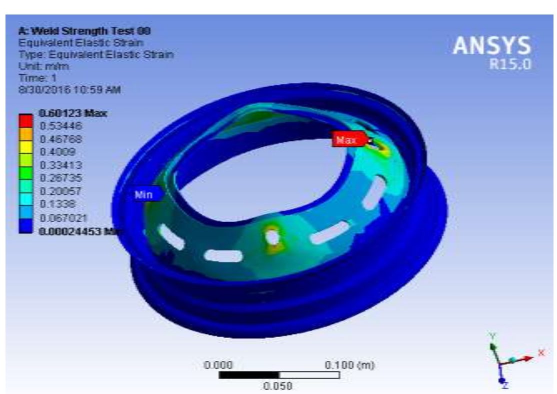

Fig:4. Equivalent Strain

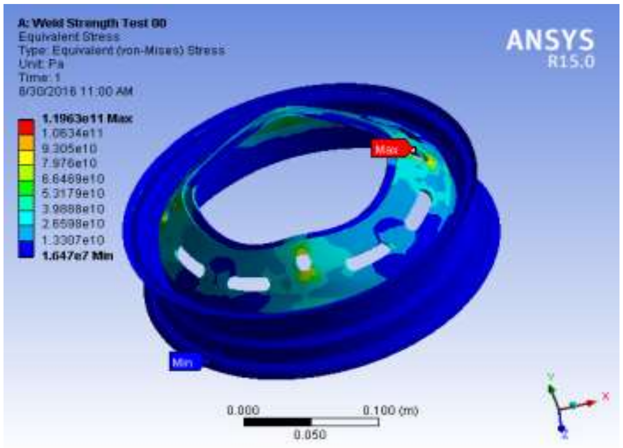

Fig.5. Maximum Equivalent Stress

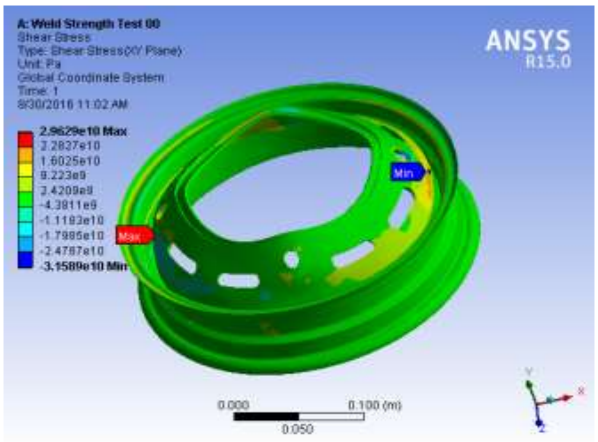

Fig.6.Max Shear Stress

Experimental Results Outcome:

From the comparison of Experimental Results and FEA Results it is clear that the FEA results confirms the optimiztion procedure. From the Weld Strength Test we see that the the rim at thickness T1=2.0 fails and for T2=2.3 mm following rims passed

Sr.No	Expt. No.	Spot No.	Spot Dia.	Rim Thk.
1.	1.1	S1	D1	T1
2.	2.1	S1	D1	T2
3.	2.2	S1	D2	
4.	2.3	S1	D3	
5.	2.4	S2	D1	
6.	2.5	S2	D2	
7.	2.7	S3	D1	

Table 2. Validation Experimentation

Exp	Spots	Dia.	Thk	Expt Res.	FEA Res.
1.1	S1=21	D1=8.4	T1	FAIL	FAIL
2.1	S1=21	D1=8.4	T2	**PASS**	**PASS**
2.2	S1=21	D2=7.7		**PASS**	**PASS**
2.3	S1=21	D3=7.0		FAIL	FAIL
2.4	S2=18	D1=8.4		**PASS**	**PASS**
2.5	S2=18	D2=7.7		**PASS**	**PASS**
2.7	S3=15	D1=8.4		FAIL	FAIL

Table 3: Comparison of Results

CONCLUSIONS

In this paper, the arrangement effects in the multi-spot welded joints on the fatigue behavior of the RSW joints have been investigated via experimental and multiaxial fatigue analyses. Based on the obtained results, the following conclusions can be drawn from the experimental and multiaxial fatigue analyses:

• It was revealed that the spot welded arrangement effect has a considerable role in fatigue strength of multi-spot welded joints.

• The results based on the employed multiaxial fatigue criteria have been compared with those obtained from experimental fatigue test. The results showed that there is a relatively good agreement among the employed multiaxial fatigue criteria predictions and experimental results.

• Among the applied criteria, the SWT criterion has the best accuracy for all types of the specimens.

• The VF's criterion shows rather inaccurate prediction of fatigue life among the employed multiaxial fatigue criteria for fatigue strength of multi-spot welded joints studied in this investigation.[1]

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