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Fatigue Life Prediction of Aluminum Alloy welding spot based on the workbench

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Abstract: The paper is mainly to make a fast fatigue life prediction for aluminum alloy 5754welding spot. A large number offatigue tests for aluminum alloy 5754 show that the fatigue failure of welding spot is mainly caused by the defects of welding process, so the welding spot defect have a big impact on the fatigue life prediction for welded parts.Based on the experimental data to match an S - N curve fitting of the aluminum alloy5754. Simulation analysis in the workbench—an finite element software can find the maximum stress, and predictthe minimum lifeof aluminum alloy material by using the S-N curve.At the same time, compared with the life of welding partswith the defects, getthe importance of welding defects for parts life influence.

Keywords: Aluminum alloy; Life prediction; S-N curve;defects

I. Introduction

Material fatigue and fracture have a high proportion in the failure of structure and components, and it is one of the most important forms of damage in engineering; In the fatigue failure position, welding spot is often weak links of the structure, and Stress concentration appears the surrounding area of the welding spot. So the fatigue failure first produced in this region. Fatigue prediction study mostly around the area, but little attention focused on the internal defects caused by the welding process that will have a great influence on fatigue life. This paper mainly studied the fatigue life of two welding parts with defects and without defects, and the importance of the impact of defects on fatigue life was verified , and provide the basis for the further study of spot welding fatigue.

II. The theoretical basis of fatigue life prediction

The current standard of life prediction algorithms are based on the principle Minner damage accumulation theory. The main assumptions of the theory is that under the effect of constant amplitude fatigue load spectrum, the damage caused by the increment of each cycle load is equal and independent additive. Under the effect of multi-step amplitude fatigue load spectrum, the damage at all levels of cyclic loading increment is independent additive; The critical damage of the material fatigue damage is a constant, only depends on the material properties, and has nothing to do with the load spectrum and the loading process.n_i is cycles number, N_i is total cycles in the stress range will lead to damage of the loop, the following formula is the critical of the fatigue damage.

$$D = \sum_i \frac{n_i}{N_i} = 1$$

In the IIW standard, damage ratio defined:

$$\frac{n_i}{N_i} = \begin{cases} \dfrac{n_i \left(\Delta\sigma_i\right)^m}{C_1} \left(\Delta\sigma_i > \Delta\sigma_1\right) \\ \dfrac{n_i \left(\Delta\sigma_i\right)^{m+2}}{C_2} \left(\Delta\sigma_1 \le \Delta\sigma_i \le \Delta\sigma_2\right) \end{cases}$$

$\Delta\sigma_1$、$\Delta\sigma_2$—Inflection point of S - N curve;C_1、 C_2 - constant.

The total mileage life follows:

$$L_f = \frac{1}{\sum_i \frac{n_i}{N_i}}$$

III. Fatigue life prediction model of aluminum alloy

3.1 Experimental materials and specimen form

The model use rolling sheet of the aluminum alloy 5754, its chemical composition and mechanical properties shown in table 1, respectively. Geometry size of the specimen used for fatigue test of tensile is shown in figure 1.

Table 1 AL5754 mechanics performance parameters of aluminum sheets

The yield strength σ_s （MPa）	Tensile strength σ_b （MPa）	Break elongation δ
100	**269**	23.46%

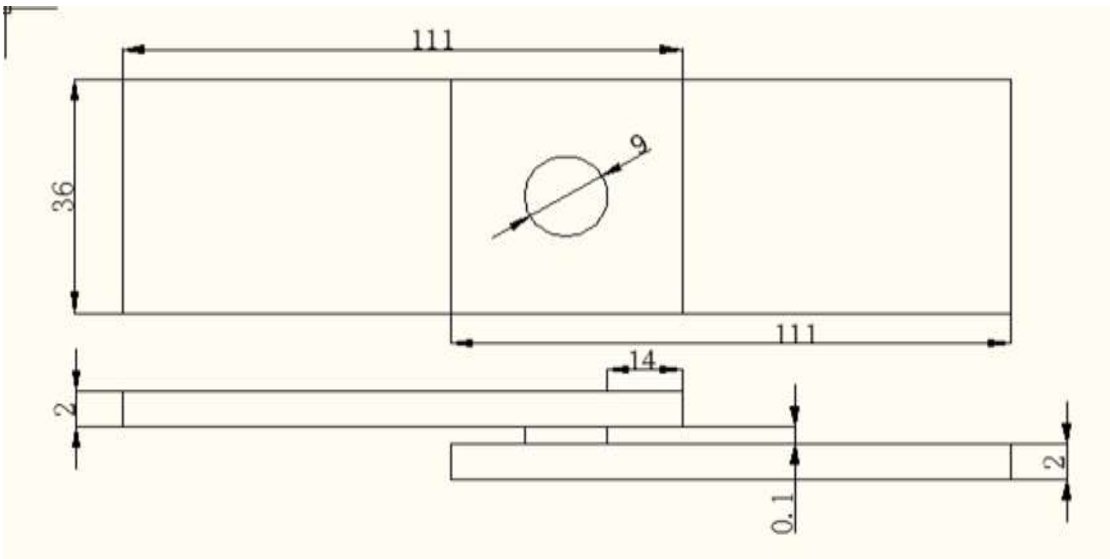

Figure 1tensile sample size of spot welding

3.2parameters of fatigue test

The whole experiment process used the load to control mode. Applying banner sine load, load ratio R is 0.1, load frequency is 20 Hz. Define the separation of the two aluminum plate specimen is fatigue damage, the peak load is 1000 N, young's modulus is 69 Gpa, poisson's ratio is 0.3,Figure 2 is the fatigue life of S - N curve.

Figure 2 fatigue life S - N curve

IV. The calculation results and discussion of the fatigue life

4.1 experiment results of static simulation

Figure 3, figure 4 is respectively static analysis results for complete specimens and the specimens with defects in the ansys workbench software. Figure 5 is Local amplification figure of the defects. By contrast, found that the position of stress concentration is arrounding molten nuclear edges of the spot welding, namely the place is the location of the fatigue failure under cyclic load, and the maximum stress of the stress concentration of defect specimen increased nearly three times than no defects specimen.

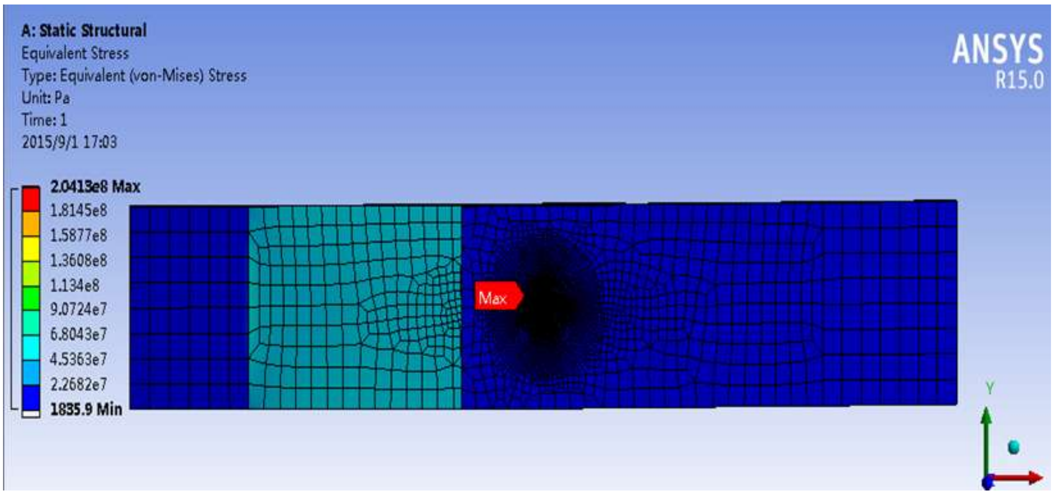

Figure 3 stress analysis results of welding specimen with no defects

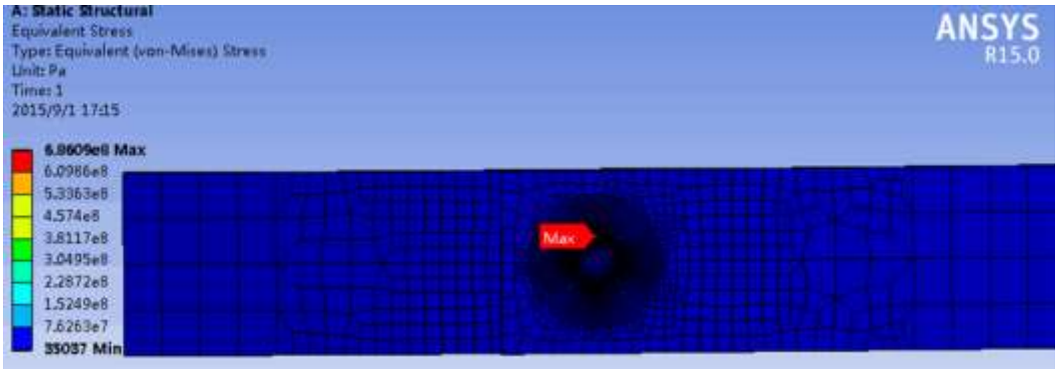

Figure 4.stress analysis results of welding specimen with defect

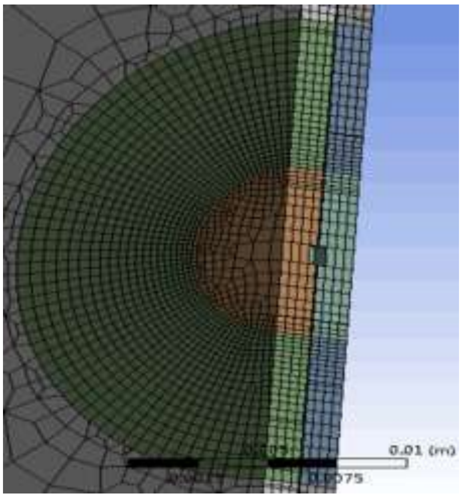

Figure 5 solder joint flaw local figure

4.2 prediction of the fatigue life

In this paper, fatigue tool module in workbench was used to calculate Fatigue life .Considering test conditions, set fatigue strength factor as 0.9, analysis type is the stress analysis, using Signed Von Mises stress as life calculation basis, according to actual load condition, selects the Goodman modification of mean stress correction theory (figure 6), finally calculated the life of two different specimen were 7557.5 cycles and 57.5 cycles. Result shows that defects of the welding spot is the real cause of the fatigue failure for welding parts, and the influence of the defect for the welding parts is quite large, so the optimization of welding process, control of welding spot defects is the key to improve product life.

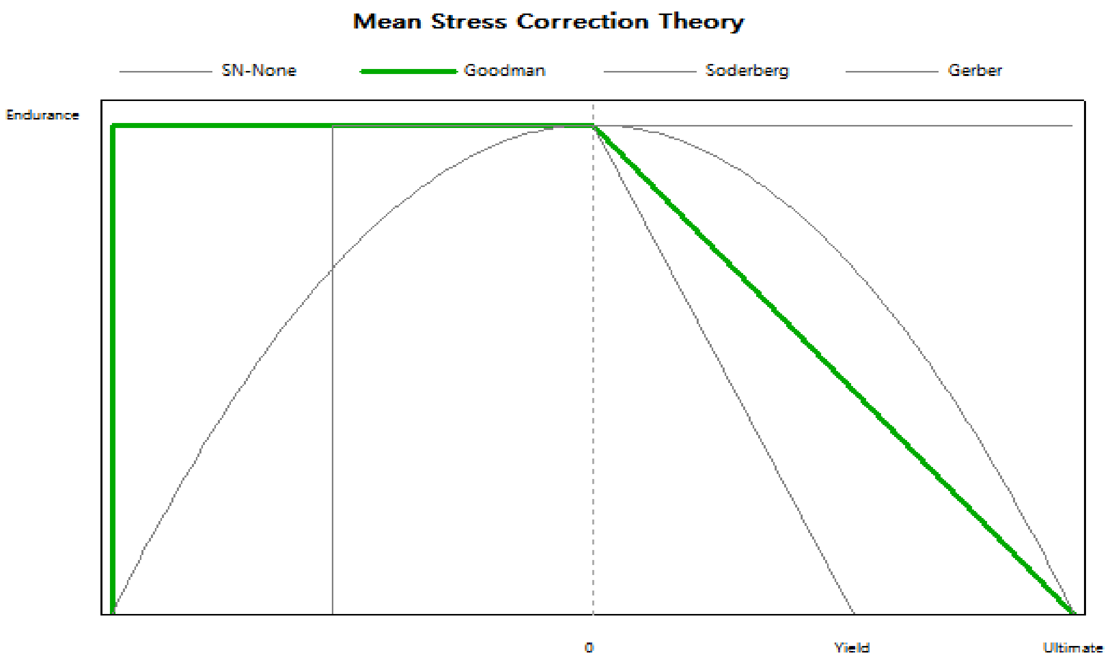

Figure 6 Goodman mean stress correction theory

V. Conclusion

In this paper, an S-N curve of fatigue life for aluminum alloy 5754 are obtained through experimental. Analysis of the failure mode of welding spot under the cyclic load, get the stress concentration location of welding parts, predict the fatigue life of two kinds of different welding parts, discuss the influence of defect for the fatigue life of welding parts. For further improving welding technology, it points out the direction ,and at the same time ,it laid the foundation for the next step research.

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