Numerical Modelling and Experimental Analysis of Cracking Properties of Aluminium alloy

G.Srinivasrao¹, and J.Jayaprakash²
¹,²Department of mechanical engineering, Saveethaschool of engineering, Saveetha institute of medical and technical sciences, Chennai 602105, Tamilnadu, India.

Abstract. This paper describes the aluminium alloy mechanical properties during the impact loading. The full work focused on aluminium alloy AW 5005 process perforation and tensile test. The numerical analysis and experimental investigations are carried out on the aluminium alloy AW 5005. From this, the aluminium Aw 5005 ballistic properties of the structure are find out. This experiment is done by the help of conical shape projectile. The wide range strain rates are calculated by the experimental and numerical investigation. It is known as failure criteria of the aluminium alloy Aw 5005. The failure criteria is find out by the optimization method functions. The both perforation test and tension results are from the numerical and experimental investigation are tabulated for comparison.

1. Introduction

In this paper, fully based on the investigation of the properties of an aluminium alloy AW 5005 it is known as experimental analysis. In the marine atmosphere, this material has good corrosion resistance and good weld ability. This property is get from the 0.8% ration of magnesium in the alloy. By comparing with the other alloys it has good thermal conductivity and lover density. This is commonly used type of aluminium in both plate and sheet form. Based on the dynamic loading the resistance and ballistic behavior of the aluminium is change. The material behavior is related to the ballistic behavior of the material. When the perforation process goes the interaction happened between the thin aluminium and projectile. From the study of different works gets many dynamic constitutive and expected curves.

2. Material and methodology

2.1. Tensile test

This test one the important test fined the mechanical behavior of the aluminium alloy AW 5005. The conventional hydraulic tensile machine is used to test the aluminium alloy AW 5005. The aluminium alloy AW 5005 is cut shape of dumbbells. The figure 1 shows the dimensions which are need test specimen. The loading displacement and loading force are noted.
During the quasi-static tension the aluminium alloy AW 5005 gets main failure mode of shear fraction. During quasi-static tensile tests, the specimen behaviours are noted by the camera. The results are given in the above diagram. During the tension load, the material local deformation values are recorded in the tension process. The specimen failure development is noted by the above figure. The left side image shows, the increasing of force with displacement and the initial stage of tensile process. By the combination of displacement and force measurements get by the camera which is in the hydraulic machine. The middle image shows the initial stage of plastic strain and maximum level of force. The formation of crack starts by the critical strain failure. And the same time the force comes to the Zero.

The tensile tests are done by 4 various rates of strain, 0.15, 0.1, 0.01, and 0.001 s⁻¹. By the result of tensile test the aluminium alloy AW 5005 not gets sensitive rate of strain. At the same time increasing of ductility is happened by the strain rate.
From the experiment the normal yield strength of the aluminium alloy AW 5005 is 148 Mpa. The above figure shows the stress and strain curves on four various rates

3. Perforation test

During the sudden loading aluminium alloy AW 5005 sheet gets different mechanical properties. Those properties values are recorded on this perforation test. The large range velocity of impact act on the specimen. The value of the impact is 40m/s to maximum 180 m/s. the 1mm thicken plate with 13 mm dia and 73 degree of angle in the projectile. The pneumatic gas gun is used to acceleration in perforation test. The tube gets initial velocity by the acceleration. Then the aluminium sheet is partially impacts projectile. Otherwise it was fully projectile by the maximum quantity of kinetic energy. The residual velocity is gets from the end of the operation. This velocity values are measured from the tested plates. During the perforation test, the initial velocity is measured by the laser and residual velocity measured by the laser barrier. The heat treated maraging steel is used to machine the projectile. The result is gets from difference between thr residual velocity and the initial velocity.

4. Numerical method

The numerical method made by the abaqus software. This software is user friendly than the other analysis software. For the numerical analysis four different strain rates are used to find the proper result. The four nodes and eight DOF shell element is used to analysis. The size of the shell element is shown in the figure. For the analysis, two different type thickness shell are used. They are 1.5mm thickness and 1.0 mm thickness.
5. Modelling tensile test

The main scope of the numerical tensile test to check the result value of experimental with numerical. For the experiment test parameters are used in the numerical test. The common values are reported in the table. There are 16590 nodes and 16646 elements are created by the meshing. The equal elastic strain value is distrusted on the specimen.

![Tensile test in numerical method](image)

**Figure 6.** Tensile test in numerical method

The figure shows the result of the tensile test by the numerical method. The blue color areas are safer area and the red colour area is broken point area. The maximum value is denoted by the red color tab in the right side of the figure. The two figures are same test but the strain value is different which means the left side image has 0.040 strain rate and the right side image has strain rate of 0.045.

6. Result and Discussion

The experimental analysis and numerical analysis test reports are compared with each other. The comparison results are shown below given figures. The best results are got from strain rate 0.1 s\(^{-1}\). The both numerical analysis result and experimental test results are similar for the tensile test. The ductile property of the aluminum alloy AW 5005 observed from the numerical method.

![Comparison results of numerical and experimental curves on failure](image)

**Figure 7.** Comparison results of numerical and experimental curves on failure
Figure 8. Comparison results of numerical and experimental curves on damage model

Figure 9. Comparison of perforation test results

Figure 10. Simulation and experiment curve for ballistic curve

7. Conclusion and Future works

The aluminium alloy AW 5005 is successfully analysed for mechanical properties in both experimental and numerical methods. The combinations of both experimental and numerical methods
are used to collect the correct results. Both perforation simulation and tensile test are helps to find the damage initiation criteria. The good results observed from the FEA simulation and the same time good experience to known about the both types analysis. After this made new sandwich shape aluminium alloy AW5005 and analysis it.

8. References

[1] Amiri F., Mill´an D., Shen Y., Rabczyk T., Arroyo M., 2014, Phase-field modeling of fracture in linear thin shells, Theoretical and Applied Fracture Mechanics, 69, 102-109.
[2] ABAQUS, Abaqus/Explicit User’s Manuals, version 6.11, 2011.
[3] Børvik T., Hopperstad O.S., Langseth M., Malo K.A., 2003, Effect of target thickness in blunt projectile penetration of Weldox 460E steel plates, International Journal of Impact Engineering, 28, 413-464.
[4] Bao Y., Wierzbicki T., 2004, On fracture locus in the equivalent strain and stress triaxiality space, International Journal of Mechanical Sciences, 46, 81-98.
[5] Kulekci M.K., 2014, Effect of the process parameters on tensile shear strength of friction stir spot welded aluminum alloy (EN AW5005), Archives of Metallurgy and Materials, 59, 221-224.
[6] Waleed Ali Badawi, "Underground pipeline water leakage monitoring based on IOT," International Journal of MC Square Scientific Research, vol. 11, no.3, 2019.