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Tensile and Fatigue Test Simulation Analysis for Al 2017 and Al 2024

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Abstract: Selecting a material aircraft component for the front leg seat requests a lot of investigation in their physical properties, such as strength, ductility, corrosion resistance which is also influenced by the material production process and part production process. There is various material that was used to manufacture aircraft front leg seats that is Aluminum alloys which Al 2017 and Al 2024. In this paper tensile testing and fatigue testing simulations of Al 2017 and Al 2024 had been conducted where the analysis was done in Ansys workbench at the same condition and load. These tests were completed by using two cylindrical dog-bone specimens by followed the geometry standard; which is ASTM E8-16a for tensile test simulation and ASTM E466-07 for fatigue test simulation. The tensile test and fatigue test simulations analysis is conducted with 100 kN force applied at one of the specimens ends and fixed support applies on another specimen ends. In this study, the result obtained from the tensile test simulation shows Al 2024 has the higher yield strength and tensile ultimate strength with 280 MPa and 895.67 Mpa respectively. Meanwhile, fatigue test simulation determines that Al 2017 and Al 2024 have the same value for fatigue life value which is 1x10^8. In terms of fatigue damage, Al 2024 has less fatigue damage with 4172.2 which means it has the lower safety factor which is 4.7198. Therefore, in this study, Al 2024 is more high strength and has excellent fatigue resistance.

Keywords: Tensile Simulation, Fatigue Simulation, Ansys Workbench, Aluminum 2024, Aluminum 2017

1. Introduction

As we know aircraft designers have been trying to attain the minimum weight since the first day of powered flight. The main priorities for material selection are absolute minimum weight and strength-to-weight ratios [1]. Aircraft applications have advanced significantly in which the only limiting factor is limits of material property due to high-performance requirements such higher performance

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requirements such as higher operating temperatures, high loading stress, and higher fatigue environments in which material is subjected [2]. For a certain service life, structural components in aircraft must be designed and therefore a detailed knowledge of their fatigue behavior is of great importance [3]. Due to the distinct properties that provide desirable features and thus a preferred choice over other metals, aluminum has always been highly sought after in aircraft applications [4]. Tensile test and fatigue test simulation analysis in this study is to know the mechanical behavior and fatigue failure for both Aluminum alloys.

Basically, all the testing are analysed using ANSYS software, in its explicit dynamic and static structural mechanical solver. First of all, a tensile testing had completed in this project by explicit dynamic and then the static structural solver is for fatigue.

1.1 Problem Statement

The more aircraft produces, the more the aircraft component requires. The characteristics of the component such as the aircraft's front leg are important to be met the requirements since it will be exposed to various conditions such as the mechanical and thermal influences that can lead to failures. Harmless doesn't mean it can be neglected. Turbulence also can lead to accidents. Based on the Federal Aviation Administration, approximately 58 fliers are [5]. Turbulence conditions with a load of passengers lead to repetitive loads injured by turbulence each year. A recent study, showed that the majority of service failures in aircraft components occur by fatigue and it amounts to about 60% of the total failures [6].

1.2 Objectives

The objectives of this study are:

i. To perform the simulation of tensile test and fatigue test for Aluminum alloys 2017 and Aluminum alloys 2024.
ii. To perform a comparison of analysis between Aluminum alloys 2017 and Aluminum alloys 2024.

1.3 Scope of Study

The scopes of this study are:

i. In this study, the material used is Aluminum alloys 2017 and Aluminum alloys 2024.
ii. The geometry of the specimen for the tensile test is ASTM E8-16a and for the fatigue, the specimen is ASTM E466-07.
iii. The tensile test and fatigue test will be carried out using Ansys Workbench software.

1.4 Significance of Study

This study is based on efforts to analyze the mechanical properties of Aluminum alloys. The knowledge of the material properties is necessary for the making of a used for application. Since the component matters are also included in the Act 1969, this study is significant as it can be considered in implying the guidelines of the front leg of aircraft front leg seat material fabrications. The prevention of environmental damage must be considered in the process of material selection at the same time to manage the cost required for materials expenses. Moreover, the safety issue is a must to be considered as the material chosen will be used for community uses products. Therefore, the result of simulation from this study might be important for the industry in the material chosen process for aircraft front leg seat manufacture. In this study, the tensile test and fatigue test simulation of different type of materials which is Aluminum alloys AI 2024 and AI 2017 will be done. The result of how the materials react towards the tensile test and fatigue test simulation will be known. The result obtained in this study may help in terms of aircraft front leg material selection in several parties. In addition, this study significant as basic knowledge and guidelines for Ansys Workbench beginners to simulate tensile and fatigue tests. This is because the FEM simulation needs many condition settings which complicated for beginners.

2. Methodology

The methodology describes all the necessary information that is required to obtain the results of the study.

2.1 Overall Flowchart

The flowchart of the methodology process of this study has been developed as shown in Figure 1 below to achieve the objectives of this study.

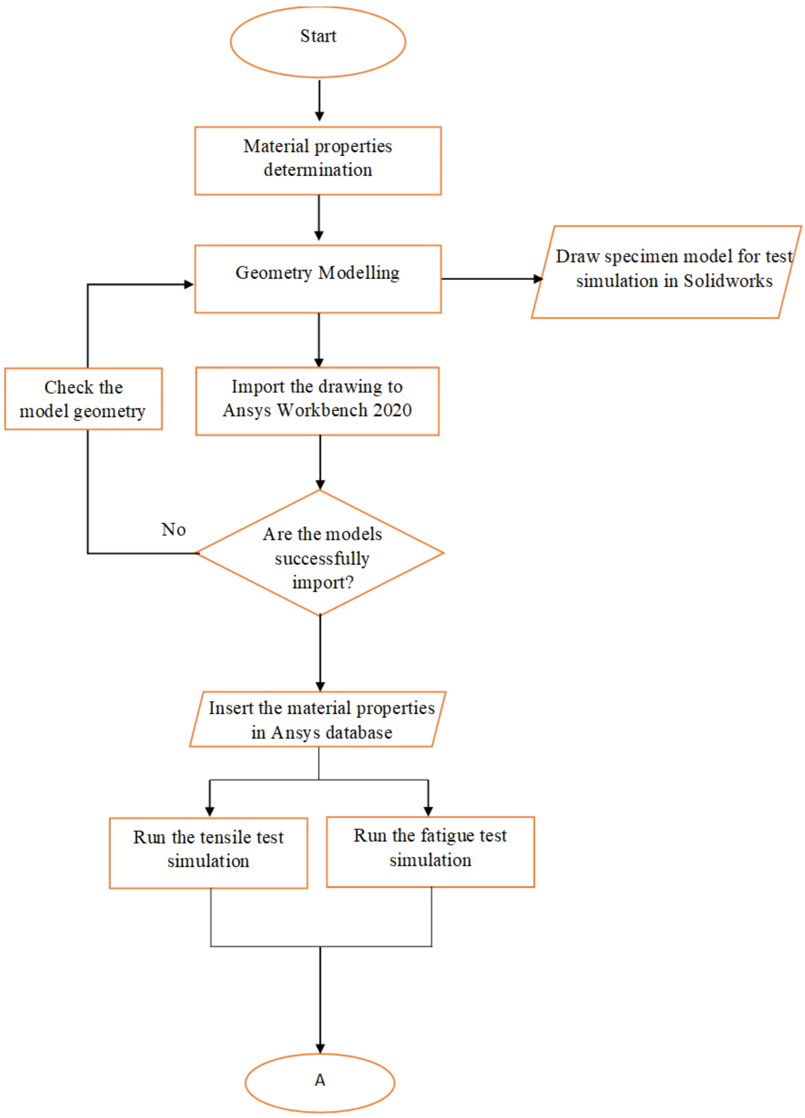


Figure 1: Methodology process flowchart (cont)

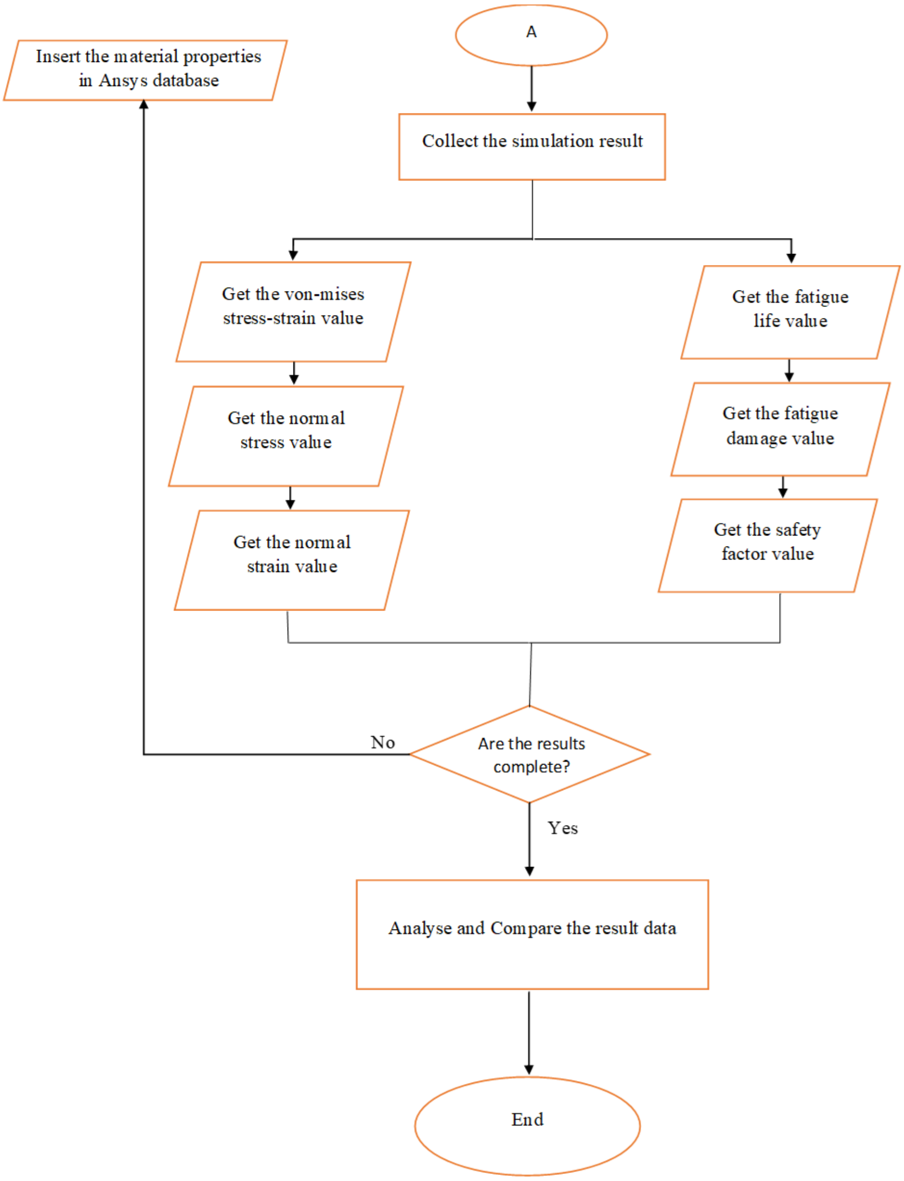


Figure 1: Methodology process flowchart

2.2 Tensile and Fatigue Simulation

In this study, the material used was Al 2017 and Al 2024. The material properties are given in Table 1 for Al 2017 and Table 2 for Al 2024.

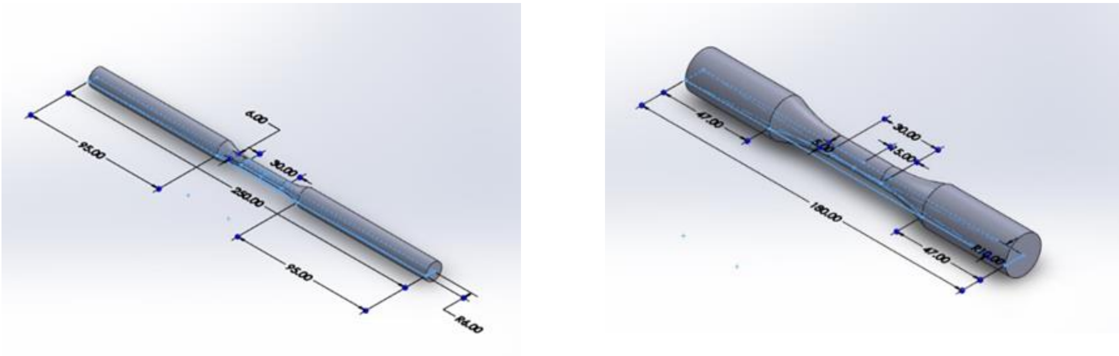
Table 1: Material properties of Al 2017

Property	Metric
Density	2.77 g/cc
Young's modulus	73 GPa
Poisons ratio	0.33
Shear modulus	28 GPa
Melting point	510 – 638 °C

Table 2: Material properties of Al 2024

Property	Metric
Density	2.79 g/cc
Young's modulus	72.4 GPa
Poison's ratio	0.33
Shear modulus	27 GPa
Melting point	513-641°C

Ansys Workbench is used in this study as a solver of finite element analysis for tensile and fatigue. To initiate the finite element analysis, a 3D CAD model of the specimen was drawn using SolidWorks software according to ASTM E8-16a for tensile test simulation specimen and ASTM E466-07 for fatigue test simulation, as shown in Figure 2. In Ansys Workbench, the required properties such as material properties applied loading, and constraint information was assigned.



(a) (b)

Figure 2: Specimen geometry: (a) ASTM E8-16a for tensile specimen, (b) E466-07 for fatigue specimen

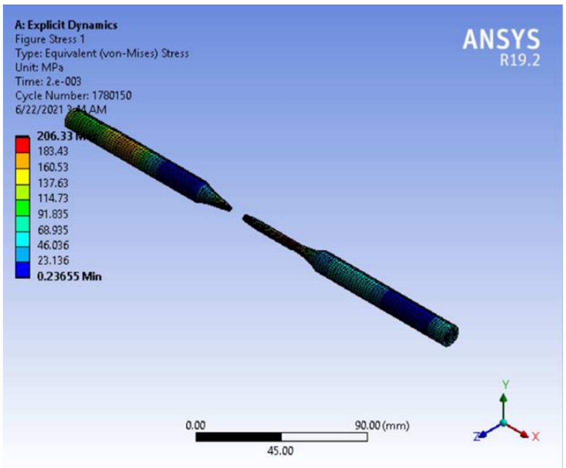
Fine meshing has been done on 2mm fine sizing meshing for the specimen. In the next stage, the load and boundary conditions were applied. The one end of the specimen was kept fixed and load 100 kN is applied in the opposite direction of the specimen. The tests were conducted using the same parameters.

3. Results and Discussion

The result from Ansys Workbench that has been used to make the analysis and comparison such as Von-mises stress, normal stress, and normal strain for tensile simulation. Also, fatigue life, fatigue damage, and fatigue safety factors were done by fatigue simulation. All the results contour plots of the analysis are taken from the analysis of Al 2017 and Al 2024.

3.1 Tensile Test

The following results are from Aluminum alloys 2017 and Aluminum alloys 2014 are shown in Figure 3 result for minimum and maximum value of Von-mises stress, normal stress, and normal strain for tensile simulation.



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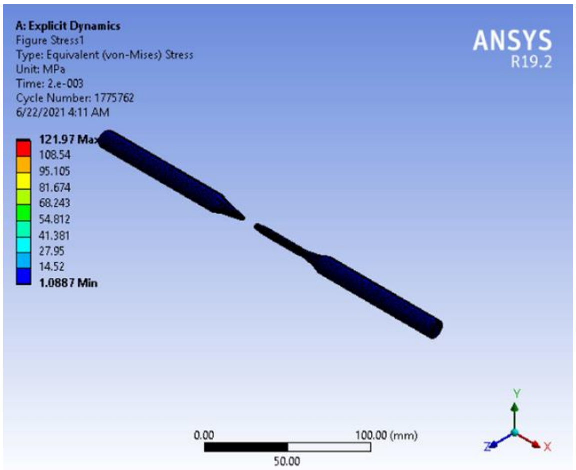

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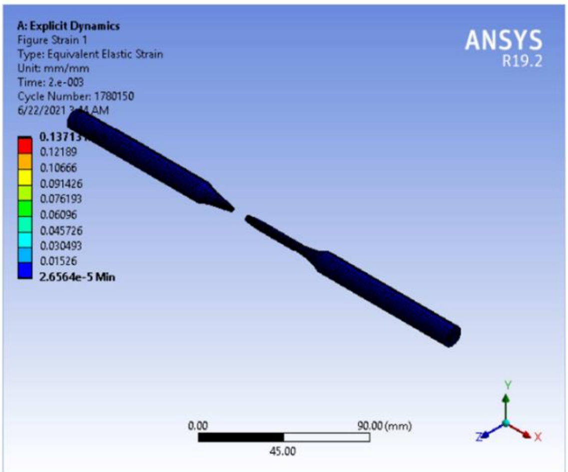

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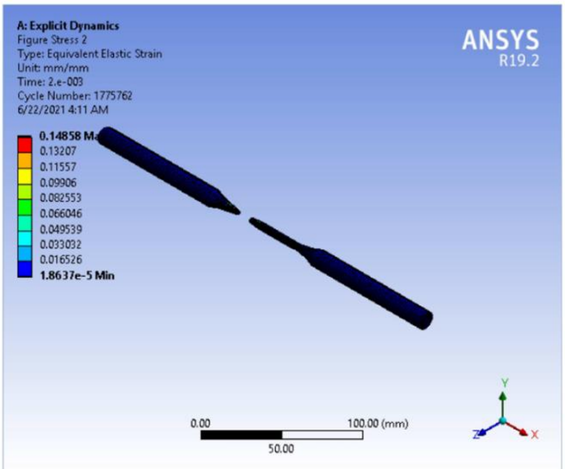

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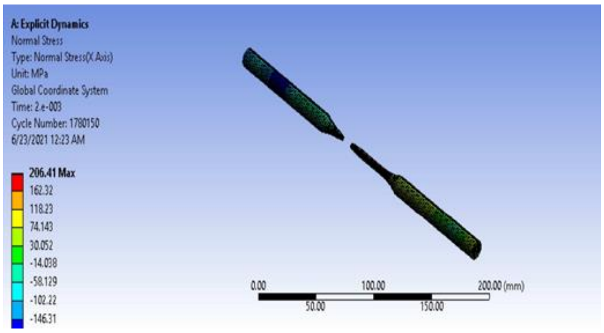

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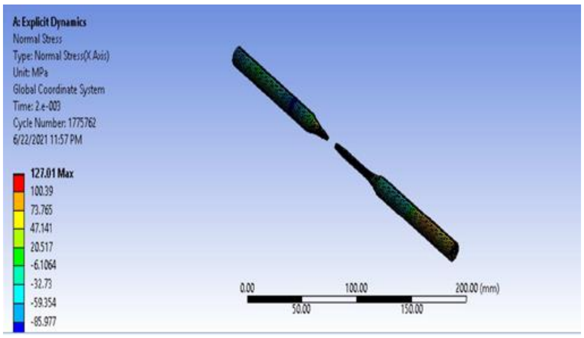


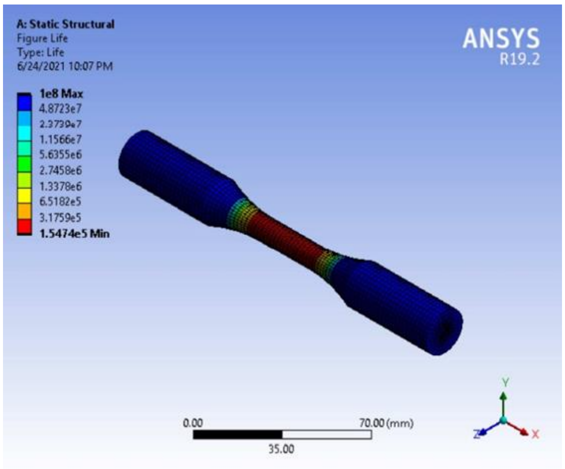
(f)

Figure 3: Tensile test result: (a) Von-mises stress Al 2017, (b) Von-mises stress Al 2024, (c) Normal Stress Al 2017, (d) Normal Stress Al 2024, (e) Normal strain Al 2017, (f) Normal strain Al 2024

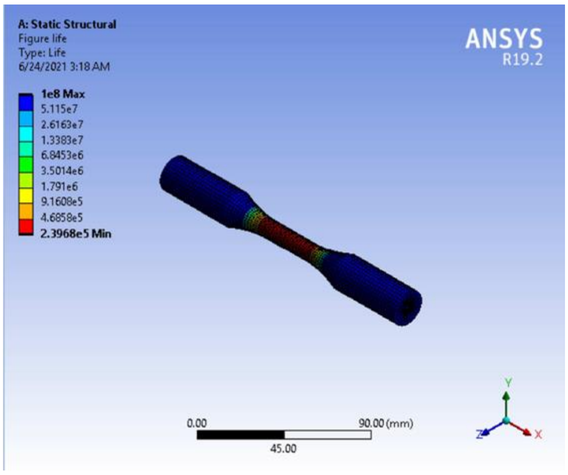
From the above figure 3 result was estimated to break at the highest value of von-misses stress. AI 2024 shows the maximum value of von-misses stress with 206.33 MPa and minimum at 0.23655 MPa. While Al 2024 maximum von-misses value at 121.97 MPa and minimum at 1.0887MPa. Between Al 2017 and AI 2024 in this study, Al 2024 shows a higher von-misses stress value which leads to high yield failure criteria than Al 2017.

3.2 Fatigue Test

The fatigue test simulation conducted in this study generated the result of fatigue life, fatigue damage, and safety factor for a dog-bone cylindrical fatigue specimen for Aluminum alloys 2017 and Aluminum alloys 2014 are shown in Figure 4.



(a)



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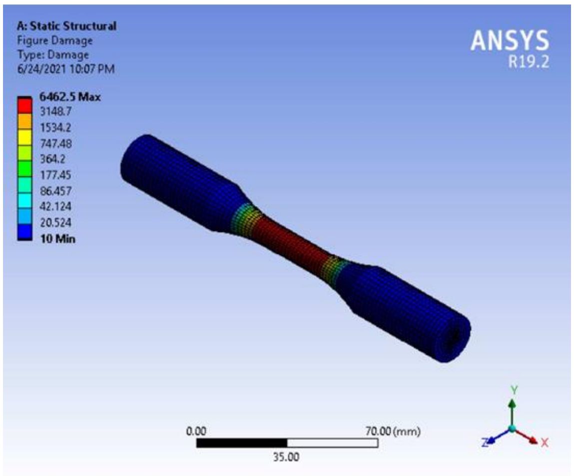

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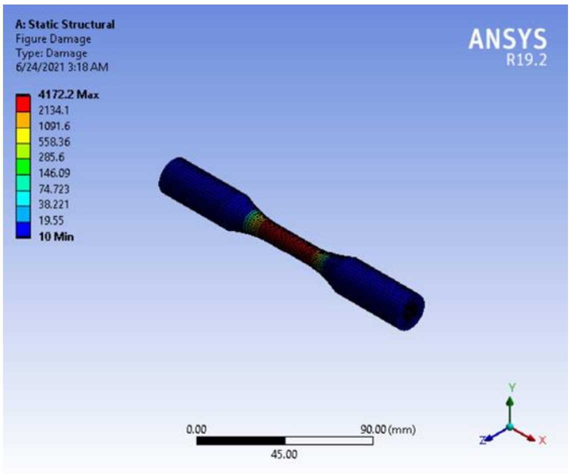

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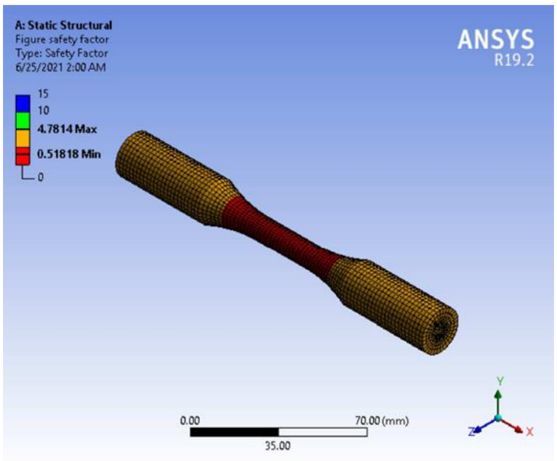

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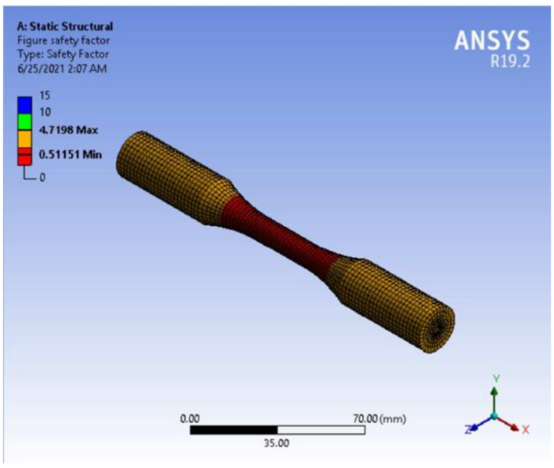

(f)

Figure 4: Fatigue test result: (a) Fatigue life Al 2017, (b) Fatigue life Al 2024, (c) Fatigue damage 2017, (d) Fatigue damage Al 2024, (e) Safety factor Al 2017, (f) Safety factor Al 2024

The result from figure 4 shows the maximum and minimum of both Aluminum alloys for the fatigue life, fatigue damage, and factor of safety The contour is red at the reduced section cylindrical dog-bone specimen at the middle section is critical that failure may occur.

4. Conclusion

Ansys Workbench was used to run both simulations, together with Ansys Modeler and SolidWorks for specimen design and dimensioning. Al 2017 and Al 2024 are the two types of Aluminum alloys employed in this investigation. The materials are subjected to the same circumstances in the tensile test and fatigue test simulation. In the tensile test and fatigue test simulation, a force of roughly 100 kN was applied with one fixed end. As a result, this study was effective in meeting all of its objectives. So, it is clear from the above results and conclusion that Aluminum alloy 2024 is best material to have a welding work on it. While Aluminum alloys 2017 has lowest mechanical properties among the all considered material but for this work it is a considerable for material selection and it is a light weight material.

Acknowledgement

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