Al 7075-T6 Cyclic Fatigue Testing at Elevated Temperatures

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Abstract

This report aims to highlight the progress of the thesis and to emphasise the key areas which will make up the majority of the research into the thesis. The aim of this research project is to determine the cyclic fatigue life trend of Al 7075-T6 at elevated temperatures. The motivations behind this research is to form a benchmark and a methodology to which nano-MMCs (Metal Matrix Composites) can be tested for fatigue properties. The method to which this will be done is by fixed amplitude cyclic tension-tension fatigue loading whilst controlling the surrounding temperature and mean stress applied to the specimen. The aim of this thesis is to develop the S-N curve for three temperatures in order to determine the effects of high temperature on aluminium and analyse the reasoning for this cause.

I. Introduction

Aluminium has always been highly sought after in aerospace applications because of the advantages it has over other metals. These properties include: a relatively high tensile, compression and shear strengths; a greater strength to density ratio; high corrosion resistance; tough; and the material is readily available and relatively easy to use\(^1\). Applications in aerospace have advanced significantly over the past few decades in which the only limiting factor is the material property limits due to high performance requirements such as higher operating temperatures, higher stresses, high loading and speed which bring with it many more constraints. This is not to say that there are no materials with these properties, however, weight and cost are two governing factors which make aluminium the material of choice. This has led to much research into aluminium alloys and methods in which to increase the structural properties of the metal.

There has been a lot of research and tabulated data done on 2000 series aluminium alloys due to its excellent strength at both cryogenic and elevated temperatures and creep resistance at elevated temperature however there is very limited research done into the fatigue testing of 7000 series aluminium alloys at elevated temperatures. This has been primarily driven by the fact that 7000 series aluminium is a specialised material and is difficult to manufacture metal matrix composites (MMCs) compared with 2000 series aluminium based composites hence it has not been utilised to the extent that 2000 series aluminium has been. MMCs increase several properties of monolithic aluminium such as stiffness, strength, reduction in density, increased creep resistance, higher wear resistance whilst maintaining the ease of manufacturing compared to other metals such as titanium\(^2\). As a result of this there has not been a requirement to test fatigue life at elevated temperatures to the extent of 2000 series aluminium alloys and 2000 series aluminium alloy based MMCs.

Unlike 2000 series aluminium MMCs which is used in many ground based applications, 7000 series aluminium alloys are preferred for use in aerospace applications because of its inherent properties. 7000 series aluminium alloys are made up of aluminium, copper, zinc and magnesium making it the strongest of all the aluminium wrought alloys\(^3\). The implications this has on aerospace applications means a reduction of weight for an equal amount of strength. Micrometric particulate reinforced MMCs has been trialed previously with minimal success, utilising 7000 series aluminium alloy, due to the particulates bring either too large to mesh with the alloy particles thereby increasing the slip when loads are applied or being unevenly distributed to be ineffective. With new research emerging into nanometric particulate reinforced MMCs with 7000 series aluminium alloy, this will potentially allow aluminium 7000 series nanometric MMCs to replace 2000 series MMCs and even several components which titanium facilitates at the present time such as gas turbine stator blades. It will also decrease the amount of material required in the application of hypersonic engines thereby reducing the weight of these aero-engines.
The current research into nanometric particulate reinforced MMCs utilises Al 7075-T6 aluminium alloy as the matrix for the composite. Because of the lack of research done on this particular alloy and temper, a benchmark and method by which the MMCs cyclic fatigue behaviour will be tested against must be determined and analysed.

II. Previous Research

Fatigue testing of 7000 series aluminium alloy has not been completely discarded. As early as the 1970s, fatigue life testing has been carried out on the 7000 series aluminium alloys under both strain and stress amplitude controlled experiments at ambient temperature\(^4\). Further research has been conducted in the late 1990s to evaluate the fatigue life of 7055 aluminium alloy at temperature up to 190 degrees Celsius\(^5\). This research was the closest research project found to this particular thesis objective. In the research conducted at the University of Cincinnati, the material utilised was machined from flat plate into rods for test specimens. The temperature limit of 190 degrees was determined by the aging temperature of the material. Thermocouples were used as temperature gauges and a servo-hydraulic automated system was used to apply compressive and tensile stresses in a cyclic loop.

Initial results proved that there was very little difference between transverse or longitudinal grain orientation for stress loading at room temperature but the transverse is notably more susceptible to fatigue at elevated temperatures however it is important to note that during applications, grain orientation with respect to stress loading will most likely to occur in the longitudinal plane because of the manufacturing processes of rods or sheet plate thereby the majority of the design of this research into 7075 aluminium will tend to focus on the longitudinal tests. The research carried out two methods of fatigue analysis experimentation. The first being stress amplitude-controlled testing and the second strain amplitude controlled testing.

Stress amplitude controlled testing involves either compression-tension testing or tension-tension testing. The method used in past research was the compression-tension method. This is done by loading the specimen cyclically with a set amount of force until failure. The purpose for this is to establish the influence of cyclic stress on fatigue life. The result is a stress versus cycles plot (S-N plot). Cyclic strain amplitude controlled fatigue testing varies the stress applied to a specimen during the life cycle to ensure that total fixed strain amplitude is maintained. This process is very technically challenging process and requires a lot of specialised equipment to perform. The result of this test is also an S-N curve however unlike the stress controlled test, which only plots the number of cycles until failure and the stress amplitude, the strain controlled plot depicts the variation of stress during the life of the specimen. This is useful if the purpose of the research if analysing the crack propagation and growth of aluminium however this thesis will only focus on the fatigue life of the alloy.

Although it is not the aim of this thesis research to investigate the fatigue crack growth of Al 7075, it is still important to mention the reasoning behind the process in order to gain a better understanding of the nature of Al 7075 and aid the explanation of the result of this thesis research. Al 7075-T6 is mostly used in aircraft airframes due to its strength however it is susceptible to stress corrosion. The corrosion causes pitting to occur and is a very extensive process to maintain and repair. The pitting can cause up to 3.5 times a reduction in life on Al 7075-T6\(^6\). In distilled water, where corrosion occurs at a faster rate, the S-N curve shifts 30-40% towards the lower stress levels which reinforces the affect that corrosion has on crack initiation and propagation of aluminium\(^7\). Cyclic stress loading will then assist in the crack growth exponentially as the effective area in which the stress is applied to decreases. Research has shown that the fatigue life is predominately determined by the number of cycles necessary to initiate and propagate the crack to approximately 100 µm\(^8\).

Another method in which to test for fatigue in aluminium other than an Instron machine is by ultrasound. This method allows specimens to be tested at very high cyclic rates which will reduce experiment time or allow cycles exceeding 10\(^8\). Although this method seems to be ideal, it is a very expensive method to employ and is affected by humidity at very small crack growth rates.
In more recent times, the monotonic fatigue experiment carried out on the first set of Al 7075-T6 AMC<sup>9</sup> is a good experiment to mention during the planning stages of this research thesis. The initial experiments were carried out utilising a rectangular test specimen in order to attach strain gauges. The experiment was conducted with an Instron servohydraulic mechanical machine at temperatures, ambient, 215 degrees Celsius and 350 degrees Celsius. This experiment took a lot of preparation time due to the technical challenges associated with attaching the heat resistant strain gauges. There were also complications with the manufacturing process hence there will be another round of tests carried out with a different design specification. To this fact, this thesis will aim to develop a better method of fatigue testing for this material.

### III. Trends and Predictions

From the past research, several predictions can be drawn by studying the trends of fatigue testing of other metals, such as titanium and even 2000 series aluminium alloy. By analysing the structure of aluminium gross predictions can be made as to the explanation of these trends and attempt to predict what will occur at elevated temperatures of Al 7075-T6.

When tested at ambient temperature and an elevated temperature of 190 degrees Celsius, aluminium tensile behaviour increases as the temperature increases. This is a trend common to most 7000 series aluminium alloys and their MMCs however it differs from ferrous metals and other face centred cubic metals in that the fatigue life increases as the cyclic stress decreases and has no definitive endurance limit<sup>10</sup>. The results of this research show that at an elevated temperature with a monotonic stress applied, the yield strength, tensile strength, and bulk modulus of elasticity decreased but the elongation percentage and the reduction in area both increased at increased temperatures. This creates a question as to if at even higher temperatures the tensile ductility will be great enough to stop the specimen from fracturing during cyclic loading.

At ambient temperature, fracture occurs in a brittle manner. The fine microscopic cracks progressively grow into multiple macroscopic cracks which propagate in the direction parallel to the stress axis. These cracks usually occur along the grain boundaries. It is suggested that localised regions of ductile failure is caused by the mutually interactive mechanisms of alternation slip and crack-tip blunting. At elevated temperatures, the fracture surface contains both transgranular and intergranular failure<sup>11</sup>. The initiation of the microscopic cracks which begin the fatigue of the aluminium with repeated cyclic loading can be attributed to the incremental accumulation of microplastic damage at the localised level. It begins randomly with favourably orientated grains and the spreads through out the matrix due to the cyclic loading. This is a result of the magnitude of the stress applied to the sample piece, the grain orientation and texture, the stress concentrations due to the build up of dislocations at the grain boundaries and at the interfaces of the incoherent particles in the microstructure, the presence of precipitate free zones and grain boundary triple junctions<sup>12</sup>. This implies that the quality of the alloy that is tested will determine the results obtained. The higher the quality of aluminium, the more evenly distributed the particles will be and a decrease in incoherent interfaces within the matrix. This will also result in a reduction of PFZs which is currently a problem with Al7075 AMCs.

One of the major reasons as to why the elevated temperatures the fatigue life decreases is that at ambient temperatures, the PFZ stress concentration is dispersed by the Al3Zr which form intense slip bands and dislocation pile ups and together with unrecrystallised regions in the matrix which encourages homogeneous deformation whilst reducing the influence of matrix strengthening. The coexistence of these two characteristics distributes the stresses into the dislocation pile up and is the reasoning behind the decrease in tensile ductility and the brittle fracture. At elevated temperatures, the microplastic deformation is aided by the increased number of grains favourably orientated for planar slip. Test temperatures as well as the quality of the metal play an important role in the formation of surface oxides which reduces the extent at which reversibility can occur. Since it is the irreversibility of the plastic deformation which is the root cause of the rapid growth of both microscopic and macroscopic cracks we can predict that an increase in test temperature will result in an increase in the crack initiation process. Ultimately the dominant failure process is due to the bimodal failure of both transgranular and intergranular failure in which is more susceptible at higher temperatures.
We can see from Figure 1 that the ultimate tensile strength decreases significantly with exposure to increased temperatures but the time of exposure also plays a part in the decrease in ultimate strength. This would indicate that the S-N curve that will be the result of this research project will decrease in magnitude as the test temperature increases. The decrease in magnitude will not be linear because the exposure time will accumulate with the life time. From this graph we can predict the ultimate tensile strength of Al 7075 at various elevated temperatures and derive our test results matrix from this. At a certain temperature the material will fail with minimal stress application.

Figure 2 shows the elongation of Al 7075 at increasing temperatures. This demonstrates the tensile ductility that Al 7075 adopts. The ductility throughout the intergranular region begins at the surface and over time normalises throughout the entire specimen to form a linear trend. However, over a short period of time the percentage elongation rate increases at more intense temperatures. Although the increase in temperature prolongs the rate of crack initiation, the ductility accelerates the fracture due to the elasticity. The prediction here is that the magnitude difference between the various temperatures at which Al 7075 is tested at will not be equal with temperature difference.

Titanium has similar properties to Al7075 and although the properties of titanium are significantly greater than aluminium, the trends are similar and will aid in the prediction of the effect of temperature on fatigue. Since Al 7075 AMCs will potentially replace many applications which currently utilise Titanium, it is of interest to compare the trends of Titanium against the trends of Aluminium which will potentially give a strong trend indication of its corresponding AMC.

In a research conducted to analyse the low cyclic fatigue behaviour of Titanium, the ductility of the alloy was seen to be considerably higher at an increased temperature. The stress-strain curve of the cyclic loading was found to be lower than the monotonic curve therefore it suggests that the intensity of the loading is exacerbated during each cycle compared to a continuous loading. This indicates that the S-N curve stress limits will be lower than the monotonic results.

Deformation in titanium at lower temperatures is confined to narrow slip bands similar to that of aluminium and at higher temperatures the deformation is more homogeneous. The effects of oxidation have a major role to play in the fatigue of titanium similar to aluminium. The loading applied to the specimen increased the oxidation layer as did the higher exposure temperature and time. At higher temperatures, above the aging temperature, phase changes can take place within the material. The phase change together with the bulk oxygen effect may be the cause of the matrix embrittlement.

An interesting fact of titanium is that although the tensile stress decreases as temperature increases, the crack growth rate decreases at higher temperatures. If the fatigue testing is conducted at a strain amplitude
controlled experiment then this will in fact result in an increase in fatigue life at higher temperatures. Titanium crack initiation is delayed at higher a temperature which differs from the properties of aluminium. The prediction for this is that the S-N curves for titanium, especially at higher temperatures will be the exaggerated trends compared to aluminium curves. (i.e. the aluminium curves will be more defined)

IV. Experiment Scope and Design

The aim of the experiment is to establish the effects of temperature on the cyclic fatigue of Al 7075-T6 and to determine the trend. The purpose for this experiment is to form a baseline fatigue life at elevated temperatures that Al 7075 AMCs can be benchmarked against as a basis for performance. The second purpose for conducting this experiment is to develop a method in which the AMCs can be tested both monolithic and cyclically with the instruments provided at the Australian Defence Force Academy. This experiment will form the foundation of further development in testing and other improvements. The final purpose for the experiment is to analyse the result of effects on Al 7075 and whether the properties can be explain similarly to that predicted earlier.

The test specimen will be manufactured from 12.5mm Al 7075-T6 rod. The rod, shown in figure 3 will be machined to 4±0.1mm diameter test section, a gauge length of 20.0±0.1mm, radius of the fillets of 10.0±0.1mm and grip section of 30.0±0.5mm with a diameter of 10.0±0.1mm. The selection of the specimen size was constrained with a few parameters. The first constraint was the jig that extended from the grips of the Instron machine was made to accommodate the previous monolithic stress testing of Al 7075 AMC therefore had a 10mm diameter female thread. The specimen has to conform to the ASTM E 8M – 04, which governs the standard test methods for tension testing of metallic materials. As the original test specimen had a rectangular test section, the effective cross sectional area was 18mm². A round test section was selected as there is now no requirement to attach strain gauges to the specimen thereby reducing any stress concentrations which may result form the square edges. This also implied that the effective cross sectional area is increased. Since the threaded grips were fixed, the only option was a 6mm or a 4mm diameter. A 6mm diameter would risk fatigue occurring within the grip section so a 4mm diameter was selected to ensure a 2:1 ratio minium between the thread and the test section.

The source of the material in which the specimen was to be machined from was of some concern. In many past experiments, specimens were machined from plate into rods. This is a long process and because the grain distribution is uneven between the plate walls and the centre of the plate, this will introduce microstructure differences between the specimens creating different results. Rod, however, is more even as it is extruded continuously and cut at the required length. This can only be purchased at a minimum diameter of 12.7mm. Due to the constraints of the jig, the entire rod will have to be machined to 10.0mm diameter to accommodate this. Furthermore, the ASTM requires the test section to be ground down to the required size due to the danger of introducing any prestresses with will be inherent of the lathing process. This is not possible due to the lack of equipment and laborious constraints of the project therefore, due to the delicate nature of the specimen; the NC lathe will be required to manufacture this specimen. The ASTM states that the test specimen can only be less than 6mm if the all parties agree to it. After discussions this was agreed upon by the workshop technicians.

Two elongation rates will be recorded with each data set (i.e. for a given stress amplitude and a given test temperature). Although measuring the crack propagation or the rate at which elongation occurs is not within the parameters of this research project, it is still valuable information which can be utilised in future research. A new method for measuring strain rates and elongation needed to be derived as strain gauges with previous experiments took a long time to prepare the specimens and was an expensive process to undertake. A laser
An extensometer was purchased to fulfil this task. As the laser has never been used in this manner, a calibration test was required to determine the effect of the oven glass on the readings.

The experiment was set up as shown in figure 4. A micrometer calibration stand was used to adjust the reflective strips to simulate elongation. The laser extensometer was then rested on a steady platform and directed at the micrometer at an angle. Increments of 20 µm was adjusted from 0 to a deflection of 400 µm, the readings on the laser extensometer were then recorded. This process was repeated three times to ensure a gross average of the results. A plot was graphed with readings versus adjustments as shown in figure 5. From the plot it can be shown that there are only minimal variations from the readings and the adjustments. During the experiment, slight disturbances of the bench would alter the readings of the laser extensometer therefore this would account for the variations. The conclusion from this test is that the oven glass does not hinder the readings in any way. However care must be taken not to disturb the laser extensometer during the experiments. Vibrations from the Instron machine may affect the readings as well.

![Experiment Setup](image)

**Fig 4 Laser Extensometer Calibration Test**

**Fig 5 Laser Extensometer Calibration Test**

**Results**

Figure 6 shows the general setup of the experiment. The Instron machine will be connected to the test specimens that will be arranged in a series configuration joint together with two collars. The experiment will take the form of a tension – tension cyclic fatigue test since a compression – tension test, which is the ideal test to conduct, requires programming and specialised computers to run, in which the university does not have. The
experiment will be a stress amplitude controlled experiment for the very same reason. Provided that the stress amplitudes remain constant for all the tests the result should produce an accurate trend plot. The purpose for aligning three specimens in series rather than testing one specimen at a time is that this method will reduce the testing time by three. In theory, each specimen will only be affected by the loading equally hence when one specimen fractures, it can be replaced by a stainless steel substitute and the cycle can continue. The specimens will be connected by stainless steel collars therefore fatigue will only occur in the aluminium test sections.

The laser will only measure the elongation of the central specimen due to the range of the scan. This is a compromise in order to save testing time however it is enough to establish the baseline trend for elongation properties. The data recorder will record the fatigue life of each specimen which will be analysed on a plot to obtain the trend line. The environment will be set at normal laboratory conditions in terms of oxygen and nitrogen saturation. When testing at elevated temperatures, the oven will be heated to the set temperature before the specimens are inserted and loaded. It is estimated that each run will range from 4 to 75 hours depending on the test conditions. Therefore a cut off of $10^6$ will be established to indicate that the material will not fracture to ensure that the experiment does not continue indefinitely.

The testing temperatures will be established from figure 1 and using the highest test temperature as the limiting stress amplitude value. A total of three temperatures will be analysed to cover the entire range that aluminium can operate at. These temperatures are ambient temperature, 190 degrees Celsius and 250 degrees Celsius. According to the military handbook, at 316 degrees Celsius, Al 7075-T6 will fatigue almost instantaneously with a small stress application. The value of 250 degrees was chosen because it was not desirable to pick a temperature too close to the upper temperature limit because this will limit the range of stress amplitudes we can test at therefore a value of 250 was high enough to be above the aging temperature but will still allow a selection range of stress amplitude to map the trend curve of the S-N at an increased temperature. The aging temperature of Al 7075 is approximately 190 degrees Celsius. A test point at this temperature will give an indication if a phase change will affect the behaviour of the alloy greatly or not. Past experiments on Al 7055 have been conducted at this temperature therefore it will also be a useful comparison.

An Instron Eurotherm 2408 oven, shown in figure 7, is used to control the test exposure temperature. Each specimen will be allowed 30 minutes before cyclic stress is applied in order for the heat to soak into the specimen. Due to the size of the oven, the Instron 8033 machine was chosen as the machine to accommodate the experiment. The stainless steel jigs from the previous monolithic stress analysis will be used to apply the load from the Instron clamps to the specimen.

After careful consideration, the highest test temperature curve was chosen to be the reference point for selection of the stress amplitudes. The purpose for this is that if the ambient temperature was used as the datum temperature for the stress amplitude range, the high end stress amplitude may lie beyond the ultimate tensile strength of the specimen at 250 degrees Celsius. It can be predicted from this that the lower end stress amplitude may take a significant amount of time to fracture at ambient temperature. Temperature datum points were chosen at 80%, 70%, 60% and 40%. These four points were chosen in order to cover the majority of the stress range which will result in fracture however will allow a significant amount of life cycles to normalise the results. At 250 degrees Celsius, the ultimate yield strength of aluminium has decreased to 71% of the strength at
ambient temperature. Since the ultimate yield strength of the specimen is based on the material and cross sectional area, a primary pilot test will need to be conducted to determine the ultimate yield strength for the specimen at ambient temperature. From this result we can derive the stress amplitudes based on the reasoning mentioned above.

Because of the nature of aluminium, there will be a lot of scatter within the results. This will lead to a major analysis of the results once the experiment is conducted however it is one of the reasons behind only selecting 4 datum points for stress to compare throughout the test temperature range. The second reason is that in order to manage the time given to complete this analysis a minimum of three stress datum points is required to produce a reasonable curve however four will produce a more accurate outcome. Should there be more time another datum point will be analysed. It is predicted that there will be a lot of overlap between the various results however this will be discussed in the next chapter. Most of the testing will occur at over 50% of the yield strength of the specimen. The purpose for this is to create a more accurate curve with the amount of test specimens and time allocated. We know that from trends that the steepest gradient of life cycles will occur at higher stress amplitudes. Because aluminium does not have a well defined fracture limit, the results of the lower end stress amplitudes will have little if any difference. Hence most of the effort will be spent on the higher end stress amplitudes to define the S-N curve.

High cyclic fatigue testing is a method which reflects the normal loading on a sheet of aluminium during operational use therefore will give a more accurate indication of what occurs in reality. This method also allows the crack to propagate evenly throughout the test section thereby eliminating a large brittle fracture and promoting ductility in order to get a larger difference between the various datum points. A value of a 10 Hz is chosen to be the cyclic frequency in which the specimen will be loaded at. The reasoning behind this value is that in past high cyclic fatigue (HCF) testing values of 5 Hz to 20 Hz have been chosen arbitrarily. There is no set value as to which value to select therefore a value to which the machine is capable of will be chosen. Depending on the capability of the Instron 8033, this value of 10 Hz may be increased to 20 Hz. The frequency is independent to the crack propagation since the life cycle is not time dependant rather a cyclic load dependency. However to eliminate variables the frequency will be kept constant for all test runs.

As most cyclic fatigue test are conducted as a tension - compression test where the cyclic amplitude is the selected stress loading, a challenge arose as to what values to cyclically load the specimens to. Tension – tension cyclic fatigue testing is usually limited to laminates and ceramic composites which are designed for tensile strength opposed to compressive rigidity. However since the apparatus available only allows for a tension – tension experiment a review was conducted on the methodology of tension – tension testing of ceramic composites. According to the ASTM outlining the standard testing methods for polymer matrix composites\textsuperscript{16} the cycles are sinusoidal and governed by the stress ratio $R = \frac{\sigma_{\text{min}}}{\sigma_{\text{max}}} = 0.1$. This ratio will be adopted in the experiments on the aluminium specimens. The mean stress amplitude will be the set datum point.

In order to acquire an initial gauge of the trends, the experiment will test 18 samples (6 in each temperature range) at the highest stress amplitude from the highest temperature and only move to the next stress amplitude once the data set has been acquired from the previous set stress amplitude.

V. Result Matrix

The result that this thesis research project will achieve is in the form of three S-N curves for each of the datum temperatures; ambient, 190 degrees Celsius and 250 degrees Celsius. From this plot it is the objective to identify the trend which aluminium 7075-T6 wrought alloy has at elevated temperatures. It will also identify the extent to which cyclic life is affect by the increase in temperature. An S-N curve is an effective way in engineering to determine the fatigue behaviour of a material for design processes. Between 1852 and 1870 Wöhler conducted the first systemic fatigue investigations. As a result of this, S-N fatigue tests in which constant-amplitude stress cycles with a specific mean stress level applied to the test specimens are called Wöhler tests\textsuperscript{17}.
A total of 72 test specimens will be analysed to form the data set. The three temperature exposure datum points will each test four sets of stress datum points utilising the stresses which will be calculated as mentioned in the previous chapter. As there are 24 results for each temperature, it is anticipated that there will be a large amount of spread and overlap between some results. The widely scattered results are because of the inherent inhomogeneity within the microstructure in the material properties, differences in the surface and the errors resultant from the test conditions of each specimen. This becomes an important factor because the crack initiation is the critical phase in the fracture analysis. Since the crack initiation is left to the inherent defects in the materials, this becomes an uncontrollable factor and some improbability will result from this. However, the unnotched experiment will give a better understanding of the material properties in reality and as to how susceptible the material is to crack initiation at the various test conditions.

Guidelines for the generation of S-N curves are outlined in the ASTM. The recommended sample size for preliminary research and developmental test are 6 – 12 and 12 – 24 for design and reliability testing. The percentage replication (PR) is based on the formula: \( PR = 100 \left(1 - \frac{L}{n_s}\right) \). Where \( L \) is the stress levels and \( n_s \) is the sample size. For each temperature we have four stress levels and 24 samples, therefore the PR is 83.3. This falls within the highest bracketing reliability data tests therefore the S-N curve derived from the experiment will give a good indication of the trend of Al 7075-T6 at the given temperature.

Given time, more data points will be selected at the lower end of the percentage ultimate tensile strength to produce a more accurate indication of the fatigue properties of Al 7075-T6. However this is unlikely due to the time allocated for this research. The secondary objective to map the deformation trend of the specimens at each of the various conditions may give an indication to the strain properties and the nature of the crack propagation within the specimen. Given the appropriate equipment, this experiment can be used to produce a strain amplitude controlled test which will map the crack propagation giving an insight to the effects that the temperature has on the ductility and the microplastic behaviour of the specimen. Given this, should time allow the research will endeavour to examine the test specimens under an electron microscope to attempt to explain the results not just theoretically but visually.

The results of this experiment should give an accurate indication to the trend of Al 7075-T6 AMCs and should form the basis for fatigue testing of these materials in the near future. It should also form the baseline fatigue properties in which the Al 7075-T6 AMCs should be tested against for performance criteria.

VI. Summary

In summary, this initial thesis report outlines the background, scope and progress of the thesis project. It forms the introduction to the final thesis report and will be a reference in the development of Al 7075-T6 AMCs. This research topic and the methodology used in this project can be improved and upgraded by future research for other purposes. Dr. Andrew Neely, Mr. Alan Fein and Mr. Adnan Ahmed have assisted in the research and design processes for this project.

VII. References

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15 Correspondence with Mr Alan Fein


Appendices:

1. Management documents