ANALYTICAL INVESTIGATIONS OF MECHANICAL PROPERTIES OF SEMI SOLID PROCESSED ALUMINIUM 7075 ALLOY

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Abstract

At present for industries it is a challenge to produce products of good quality and should have high durability. In this engineering world there is great a great need of various engineering materials to satisfy these engineering needs. The material usage mainly depends on the material strength and properties. Aluminum-7075 alloy is primarily used for transport applications, such as aerospace, maritime and automotive industries, thanks to its good mechanical properties and a low density. For the semi-solid formation of aluminium alloys, a homogenous equiased grain structure is required. The stress mediated melting mechanism is one of the approaches used to achieve such a microstructure.

The present work describes the synthesis of Al 7075 semi solid metal matrix composite reinforced with graphene and the characterization of their mechanical properties. Graphene is added to aluminium-7075 and samples are prepared both with stirring and without stirring at varying temperatures. The samples are prepared at 680^{0}c, 710^{0}c, 740^{0}c, 770^{0}c, 800^{0}c, 830^{0}c, 860^{0}c, 890^{0}c, 920^{0}c.

At these temperature the material is mostly semi-solid Aluminium 7075 and graphene is added to this semi-solid molten melt and stirred with stirrer. The specimens are prepared according to ASTM standards. The tests like hardness, tensile, impact and compression tests are performed and the values are compared. The tensile power, hardness, compression reduces as its temperature increases. The specimens are analysed using ANSYS software. The specimens with stirring has good mechanical properties than without stirring. Graphene has good mechanical characteristics such as strength and hardness.

Keywords: *Aluminum-7075, Graphene, Furnace, Die, Crucible, Tensile Strength, Mechanical Properties*

1. Introduction

A mixture of two or more distinct substances with a visible interface is a macroscopic material. A hybrid material Composite has a multi-phase material that has a considerable proportion of the properties of both component phases in order to achieve a greater balance of properties. This is called the combined action theorem. Due to its low specific gravity, a high weight/force ratio, high wear resistance, high reflectivity, excellent heat/electric conductance, a small melting point, insignificant gas solubility, excellent cast capacity and good corrosion resistance in the automotive, naval and aerospace industries, aluminium alloys have a wide range of applications. In general, aluminium alloys can be categorised as forged alloys and casting alloys. Aluminum casting alloys are a category

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of cast materials second to ferrous casts in terms of tonnage. [1] This is because aluminium cast alloys are amongst the most flexible cast alloys. In addition, many aluminium alloys are relatively free of heat and tearing tendencies and have a fine as a cast surface finish with little to no defects. [2] Fine homogeneous equiaxed spheroidal grain structures required for the forming of aluminium alloys with no semi-solid condition due to the resistance to fluidity of the dendritic system[13] and the mechanical characteristics of the spheroidal structure to dendritic microstructure. SIMA (Strain Inducted Melt Activated) process is one of the methods used to achieve this microstructure. This alloy is ideal for applications of semi-solid formation with a wide freezing range from 7075 alloy, between 477 and 635 ◦C . The evolution of the fluid volume fraction of 7075 alloy with rising temperature is demonstrated according to Fu et al. [16].

Casting alloys are characterised by their chemical composition and by the main alloys in the alloy. Alloying materials and impurities in a cooling alloy determines the precipitation of the components. This main alloy elements are added to improve aluminium casting alloy strength and properties.

2. Literature Survey

Review of the Properties of Al7075 Matrix Composites by K. Krishnamoorthi, P. Balasubramanian, et al. Journal of Material Science and Mechanical Engineering (JMSME) [1]. This paper reviews the theoretical and experimental results obtained. In this different techniques of casting are discussed. The physical properties like density and mechanical properties like tensile strength, hardness of AMC's are discussed. It states that the density of Al7075 decreases due to reinforcement and hardness of Al7075 increased as the reinforcement contents increases. The rate of wear increases as the load is applied. It was observed that tensile strength of this is high than the base material.

B. Ravi et.al Development of Al7075-SiC-TiC Composites International Journal of Engineering Science Invention ISSN, Hybrid Metal Matrix [2]. In this paper different samples of specimen are prepared with 5%TiC, 5%SiC and 5%TiC+5%SiC. The hardness of TiC+5% SiC MMCs as cast Al7075-5 was found to be 39% higher than that of the Al7075 base alloy. Al7075- 5 percent TiC+5 percent SiC MMCs with an as-cast Al7075 basis alloy were 129and 155 MPa. This indicates that the basic alloy as Cast Al7075 has improved by 32 percent. With strengthening material, the tensile strength, the output strength and the compressive strength increase by 5% TiC enhancement and decrease by 5% for SiC strengthening.

ALUMINIUM-7075 Metal Matrix Composites International Journal of Mechanical Engineering and Technology(IJMET)[3], Lokesh KS, Chetan IC, and alDetriment Of Compressive Strength Of Graphene Reinforced. In this paper different samples has been prepared with 0.5%, 1%, 1.5%, and 2% wt. %. Graphene added to Al7075. It was found that the sample with 0.5 wt% graphene shows good mechanical properties. It was found that 0.5% graphene records compression strain of 0.60025 with a maximum breaking load of 222KN which is better than other samples.

V. Balaji, N. Satish, M. Manzoor Hussain, et al. and others, Manufacture of Aluminum Metal Matrix by Stir Casting, 4th International Conference on Materials Processing and Characterization [4]. In this paper different samples has been prepared with SiC as reinforcement material density of the matrix is found increasing. The hardness of the material is observed to improve as the filler content is increased. it was 10% increase in hardness. Tensile strength is also higher for Al7075-SiC than the base material.

Al Characterization Al-7075 Metal Matrix Composites: A Review Journal of Material Research and Technology (jmr&t)[5].

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Mohammed Imran, A. R. Anwar Khan, and others. The aim of this paper is to look at how aluminium metal matrix is made, with an emphasis on the mechanical properties and corrosion behaviour of Al7075. Different samples are prepared with addition of silicon carbide, alumina, and barium chloride addition of these increases the tensile strength, hardness whereas addition of graphite as reinforcement material increases tensile strength but decreases hardness.

Sahin.Y The MMCs manufacturing setup has been created. The system has a lower tapping machine. Three methods for the combination of strengthening were tested and the particles were distributed completely and homogenously in the matrix alloy.. But the set-up cannot adjust the location of the impeller in the melt. This could further improve the efficiency of the manufactured MMCs if examined. During the method of blending, the molten liquid is removed from the bottom of the crucible.

WitthayaEidhed During their study on solution treatment period impact on the Al-12Si-1.3Cu-1.1Ni microstructure hardness developed by permanent mould casting, a high microstructural hardness was observed between 4 and 6 hr at short solution time. The chosen solution was 520o C with 0.5, 1, 1,5, 2, 4, 6, 8 and 10hr hold periods. Water quenching and ageing is pursued for 15 hours at 175oC.

M. N. Mazlee*, J. B. Shamsul, H. Kamarudin Studied the effect and dynamic mechanic properties of A357 alloys on superheat treatment. Superheat treatment The large Si-particles and larger α-Al-dendrites of the non-superheated alloy A357 than superheated alloy were observed in optical microscopic experiments. Strong damping potential of superheated A357 has shown dynamic mechanical properties.

Erhard Ogris He researched new ductile alloys from the semi-solid metal Al-Si-Mg in his PhD thesis. The theoretical and experimental description was given of silicon spheroidisation and its effect on mechanical properties. Modeling and laboratory studies of silicon spheroidisation have shown that eutectic silicon can spheroidise between 500°C and 540°C within minutes of swimming time. The application of the SST treatment for thixo-formed components led to the high elongation values (up to 18%) at a good yield intensity (~230MPa). This treatment has been carried out in a thixo-formed setting. Even components that have particularly variable wall thicknesses, FEM simulations of fast high temperature thermal treatment show that effective SST is short.

M.WESSÉN, et.al In their research, the microstructure and tensile properties of a thick-walled segment of arheocast portion (approximately 45 mm × 43 mm) were investigated. Long solidification can result in rough eutectic Al-Si. The eutetic sodium has been used as a modificator to minimise coarseness. They made a 1) as cast tensile testing specimen, 2) a modified cast na and 3) a modified cast melt 30 minutes after Na added. The content has been tested as cast and in T6. The findings indicate that Na adds a polished al-Si eutectic even after a 30-minute deterioration. However, no change decreased the return intensity by over 30%.

M. Hitchcock, et.al Studied Al–7Si–0,6Mg slurry and rheo die casting effect on microstructure Studied. The aerospace aluminium alloy in 2017 was distinguished by metallographic research. For the precipitation of the 2017 alloy, solutions were reinforced with processes of 550oC and ageing heat treatment. The microstructures of thermal samples showed uniform distribution θ’ particles in the aluminium alloy alloy α-matrix, which allowed the aluminium alloy to be used for aeronautical applications for the 2017 aluminium alloy precipitation enhancing and ageing heating processes.

M.A. Bayoumi Studies were carried out on semi-solid extruded as cast alloy A356. Picked

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extrusion temperatures were 560°C, 570°C, 580°C and 3 isothermal keep periods 5 min 30 min and 60 min. The selected extrusion decrease ratios were 5.3 and 17. Changing the stiffness and strength of force, wear resistance and tiredness of the metal, relative to standard cast alloys. The tensile specimen is fragmented with SEM.

G.T. Abdel-Jaber1, et.al The solidification behaviour of Al Si alloy (Si3-15 percent) and mechanical performance in various moulding conditions have been investigated. The effects of alloying element contents and conditions on wear resistance and alloy friction are assessed by micro-structural tests and wear studies performed using a disc-trribometer screw. The findings revealed that the durability of the solidification improved by a 12 percent increase in silicon content. The improvement in the silicon content therefore results in both the ultimate tensile strength and the hardness. Wear rate decreased and friction coefficient improved as the silicone material increased.

S.Tahamtan, A. Fadavi Boostani Studied thixoformed A356 alloy's corrosive behaviour, contrasted with gravity-dipped A356 alloy, at varying heating temperatures. He noted that silicon particles were present at the interface of the Al-Si matrix. Results indicate that thixoformed sample resistance to pitting corrosion was higher at 590 °C than the samples at 600 ^{0}C, rheocast resistance and gravity-cast resistances.

From the available literature it was noticed most of the Al-Graphene alloy castings were produced by sand casting method and rheo-casting technique. Melt treatment was carried out in electric arc furnace. Effect of modification and age hardening on mechanical properties, wear and corrosion characteristics were Studied. Based on literature survey, AL-7075 was selected for the present study. The research was especially directed on the effects, mechanical properties, and different characteristics of alloy.

The present work aims to analyse the effects of the maintenance temperature and length in the mechanical properties of a semisolid 7075 alloy during the reheating process. In order to achieve the equalised good mechanical properties with the appropriate solid-liquid ratio for thixoforging applications it is possible to present optimised heat treatment parameters for the extruded 7075 alloy.

3. METHODOLOGY

a) Modelling

The specimens are then modelled using ANSYS software to do the virtual tests such as tensile tests, impact tests and compression tests at different temperatures to determine the behaviour of the casted specimen. The analysis results are displayed in the results & discussions page. The modelled specimen is shown in the below figure.

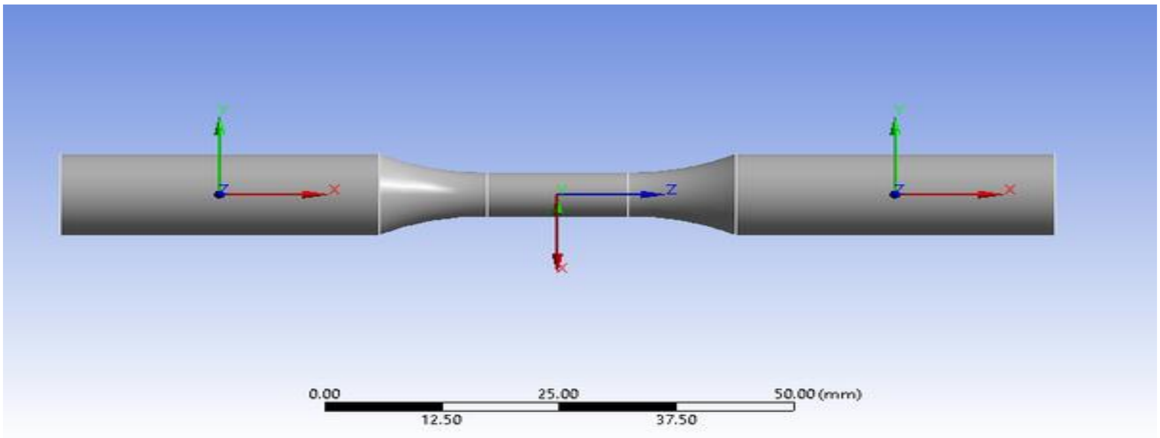

Fig 3.1 Modelled Specimen in ANSYS

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b) Meshing

Meshing is an important part of a simulation method where complex geometries are separated into basic elements which can be used to approximate the bigger domain locally. The mesh affects the precision of the simulation, convergence and speed. Since meshing usually takes a large part of the time it takes to obtain simulation results, the quicker and more reliable the solution is easier and more automated.

To do transient structural finite element analysis to a cylindrical shape specimen to do tensile and compressive tests. Here the geometry generated in DM and the analysis settings have been established, as you can see in the fields of Geometrics, Coordinate, Mesh, Initial Terms, analysis, loads in the previous image(Displacement) and restrictions(Fixed support).

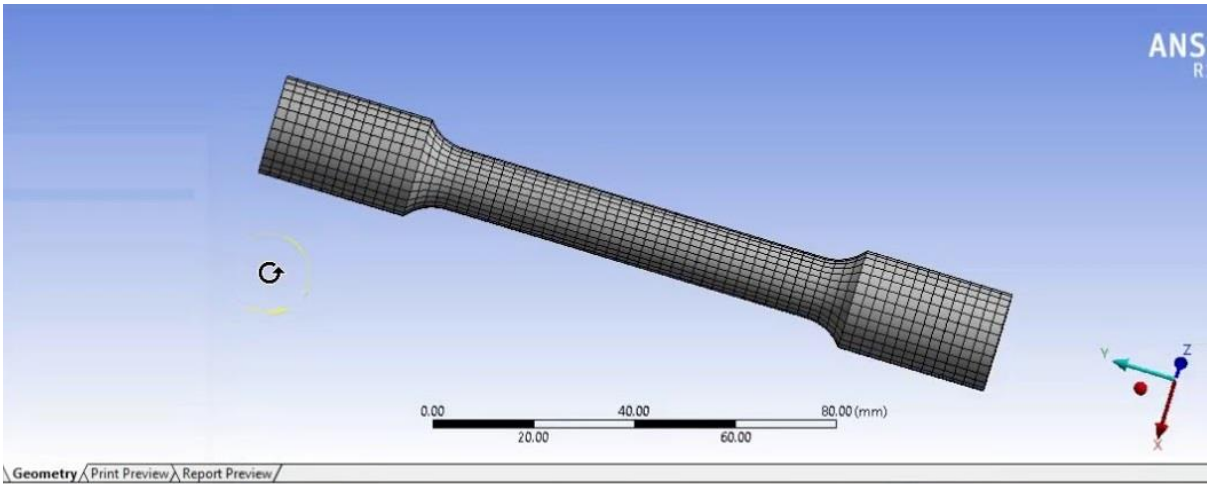

Fig 3.2 Meshed Model

4. Results & Discussions

a) Analysis of Tensile Test Specimens

The tensile test specimen is being analysed using ANSYS software. The tensile test specimen of required dimensions according to ASTM standards is modelled in the design software and is being generated into the ANSYS workbench and material is given to the model. The tensile test specimen is analysed using ANSYS software, different loads of tensile test are given. The stress concentration of various specimens at different loads are shown in above figures. The maximum tensile strength values are observed and compared with the experimental values. Similarly the compression test analysis are done using ANSYS and compression load is applied and stress distribution is being analysed and these values are compared with the experimental values and they found to be approximately similar with experimental values.

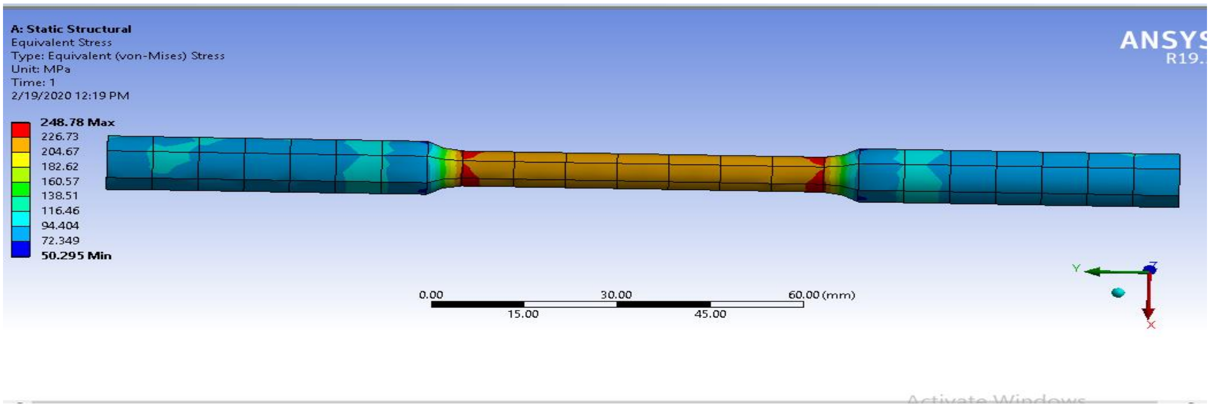

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Fig 4.1 Tensile test analysis for 680^{0}C

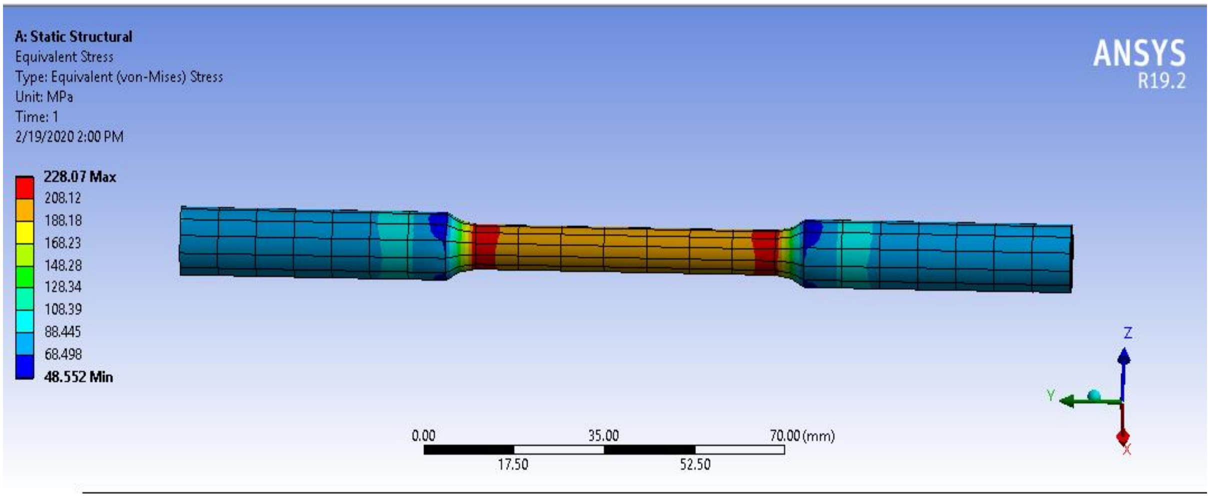

Fig 4.2Tensile test analysis for 710^{0}C

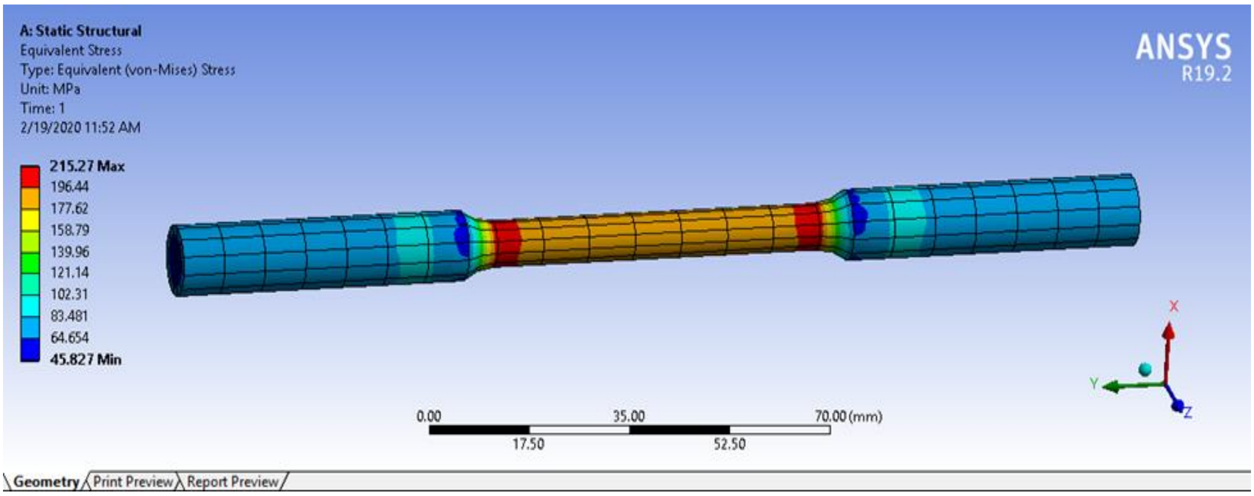

Fig 4.3 Tensile test analysis for 740^{0}C

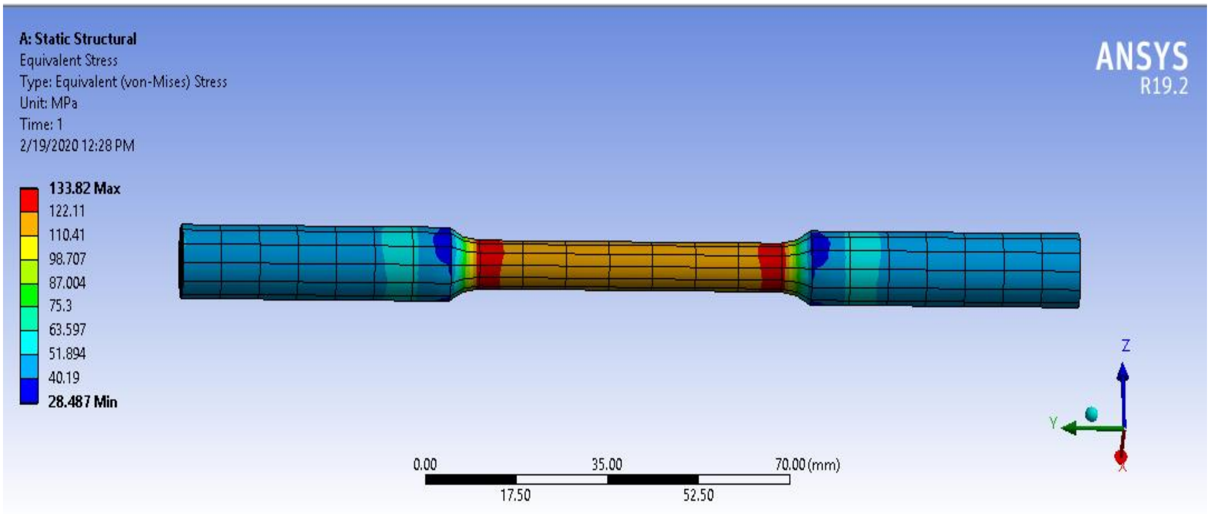

Fig 4.4 Tensile test analysis for 770^{0}C

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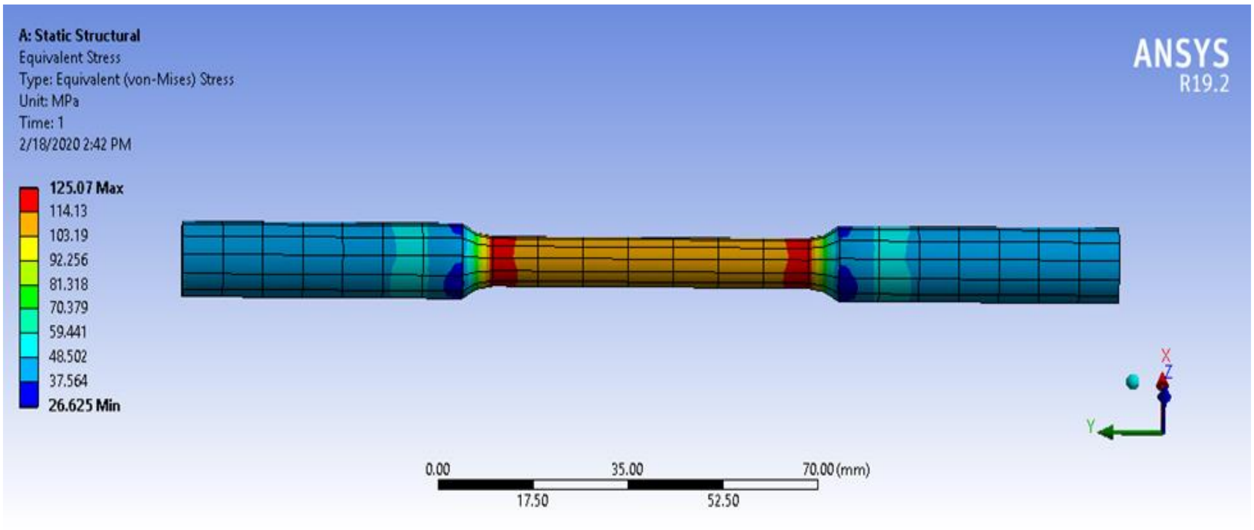

Fig 4.5 Tensile test analysis for 800^{0}C

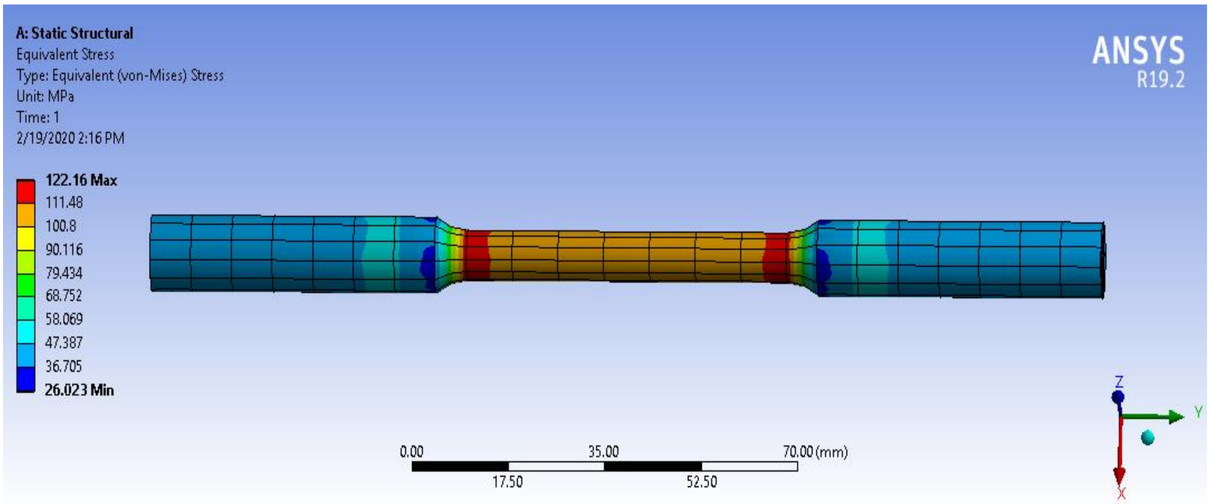

Fig 4.6 Tensile test analysis for 830^{0}C

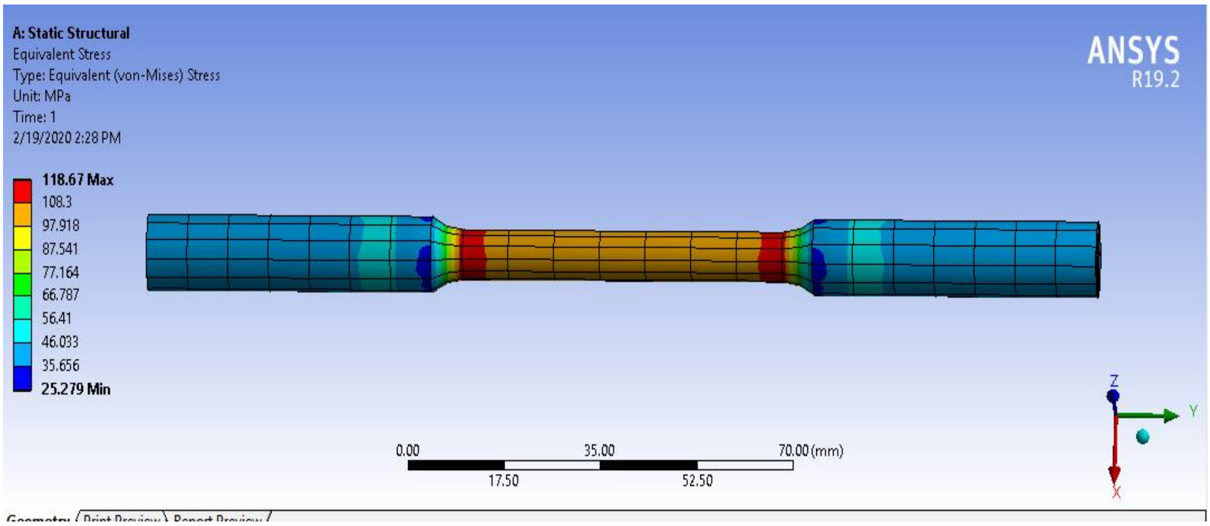

Fig 4.7 Tensile test analysis for 860^{0}C

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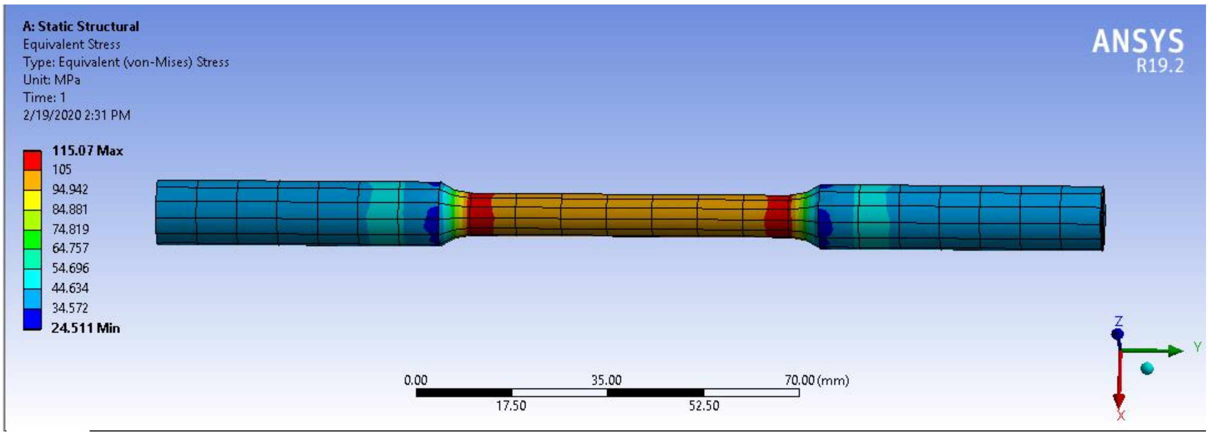

Fig 4.8 Tensile test analysis for 890^0C

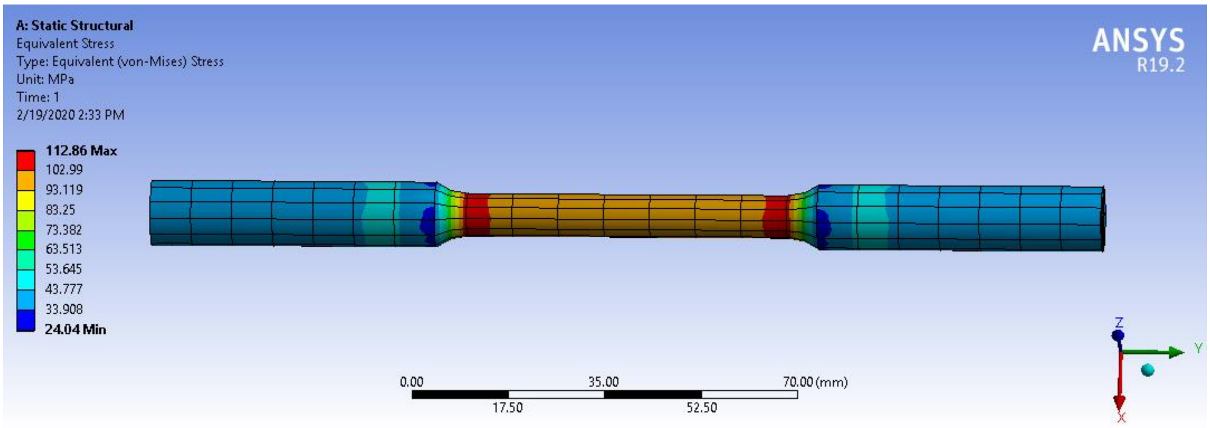

Fig 4.9 Tensile test analysis for 920^0C

Table 1.1Tensile Test Readings through ANSYS

S.No	Temperature (°C)	Without stirring (Tensile Strength) MPa	With stirring(Tensile Strength)MPa
1	680	165.21	248.78
2	710	160.56	228.07
3	740	145.43	215.27
4	770	126.82	133.82
5	800	121	125.07
6	830	114.02	122.16
7	860	112.86	118.63
8	890	109.95	115.07
9	920	109.36	112.86

b) Analysis of Compression Test specimen

The compression test sample is being analysed using ANSYS software. The sample has to be prepared according to dimensions and is modelled in design

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software. The modelled sample is generated into workbench and required material is given. The required load condition is being applied to the specimen and stress distribution is observed. The below figures shows the various stress distribution of different samples at various load conditions.

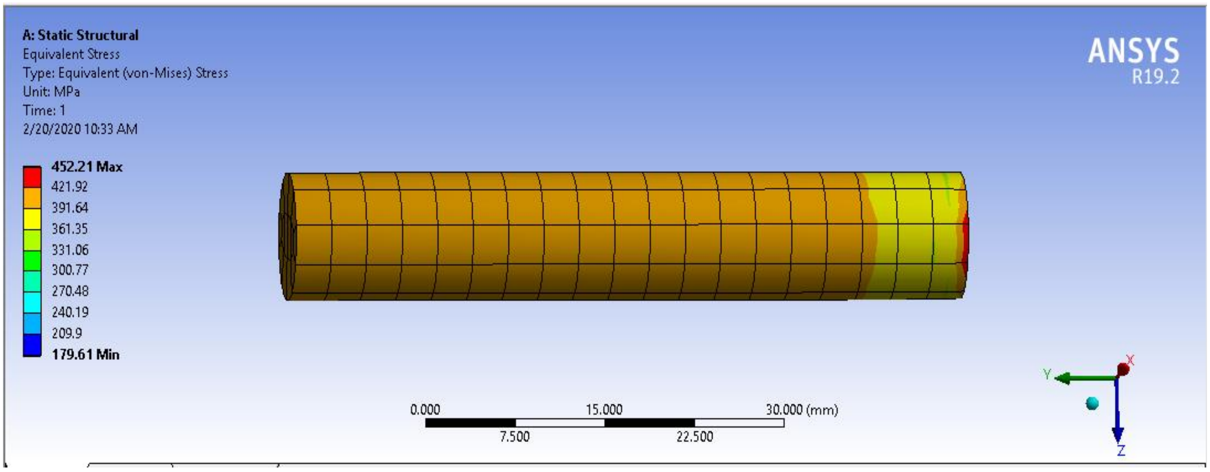

Fig 4.10 Compression test analysis for 680^{0}c

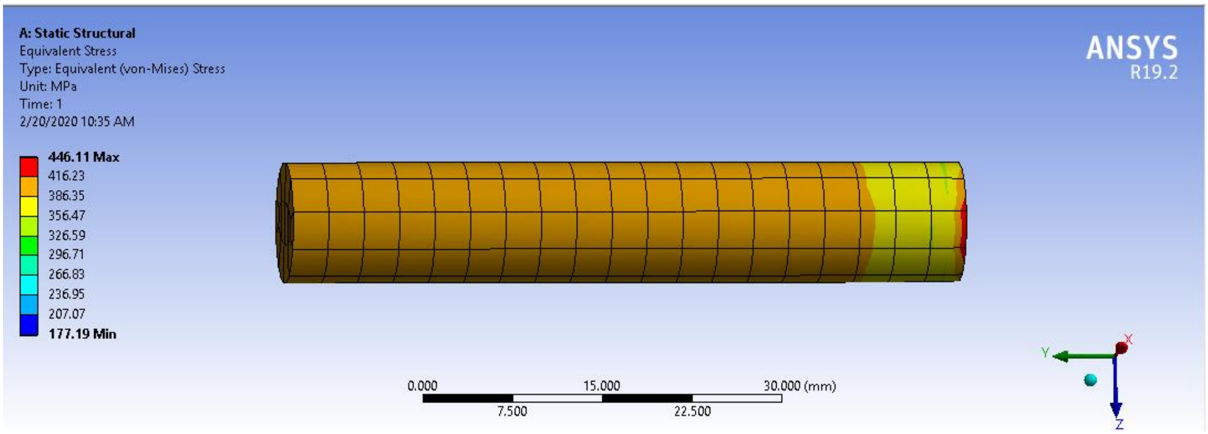

Fig 4.11Compression test analysis for 710^{0}c

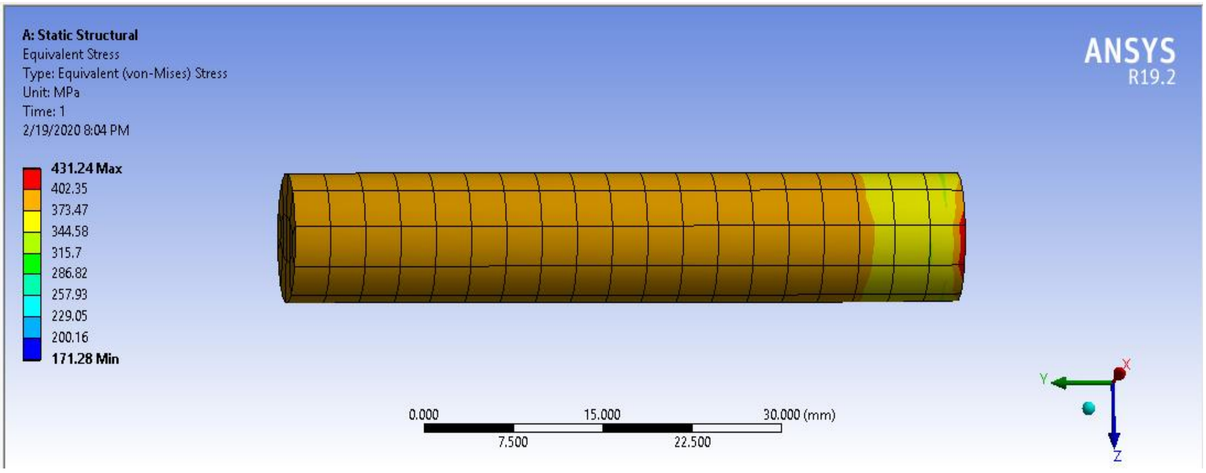

Fig 4.12Compression test analysis for 740^{0}c

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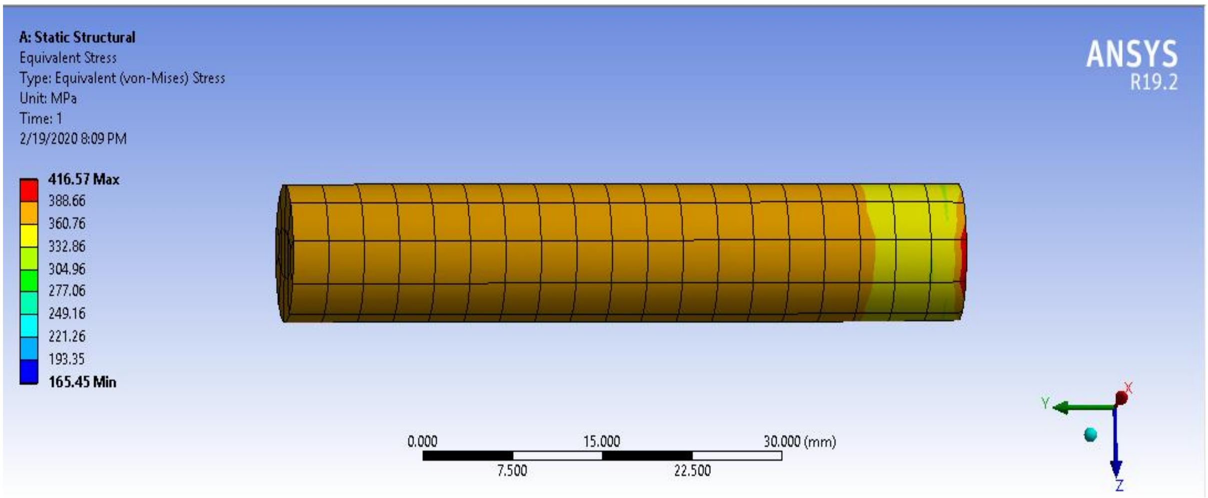

Fig 4.13Compression test analysis for 770^{0}c

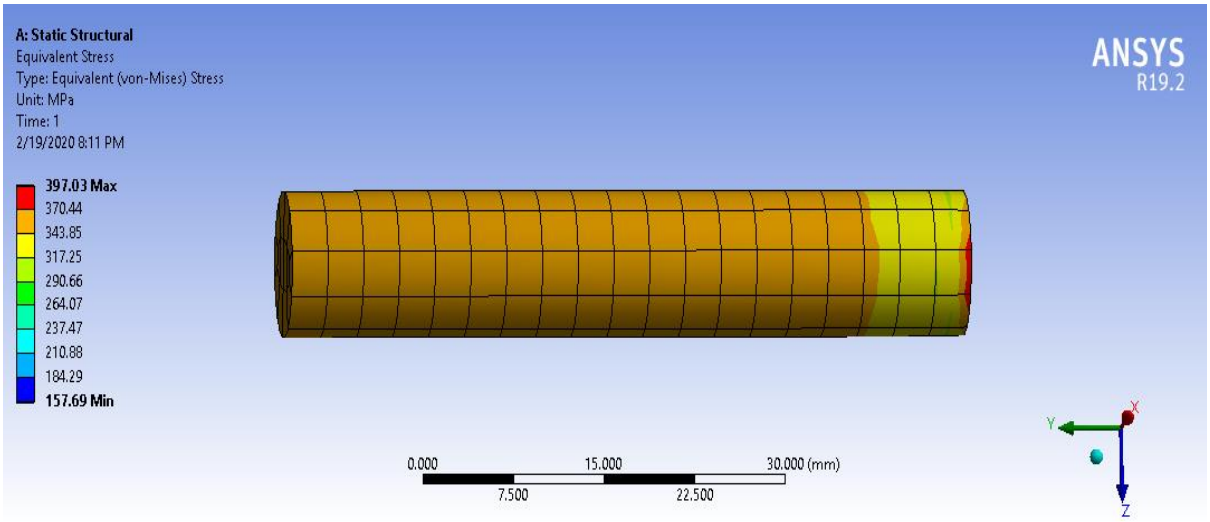

Fig 4.14Compression test analysis for 800^{0}c

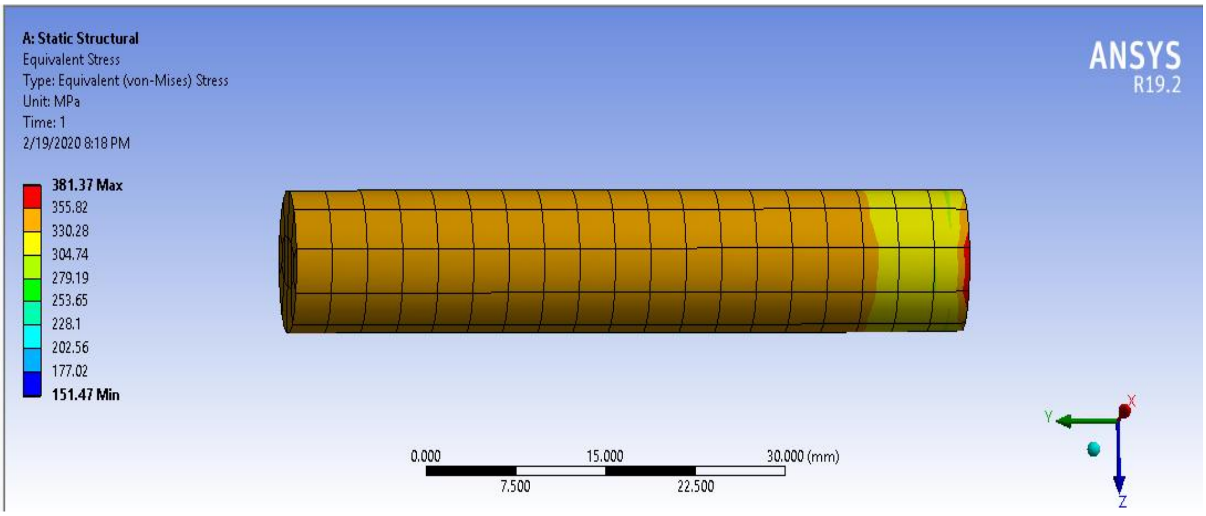

Fig 4.15Compression test analysis for 830^{0}c

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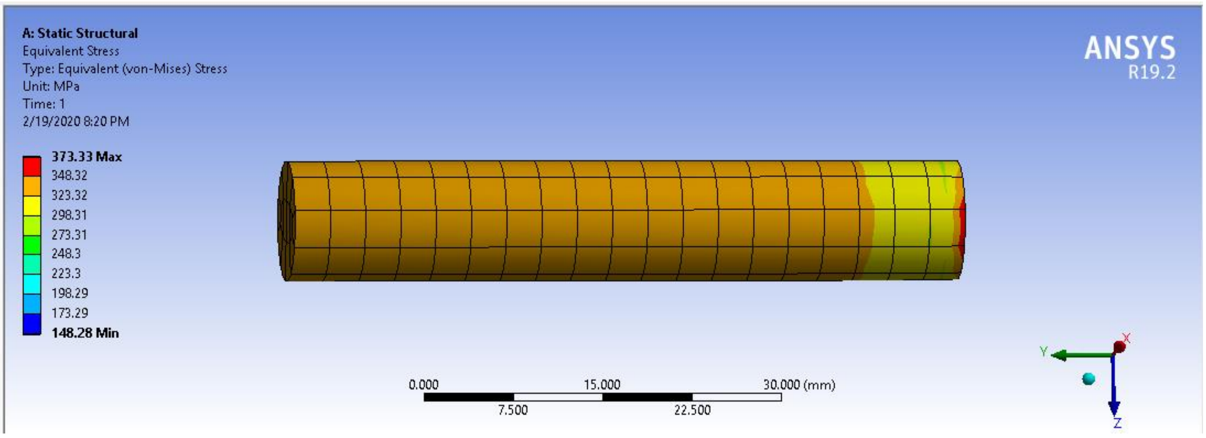

Fig 4.16Compression test analysis for 860^{0}c

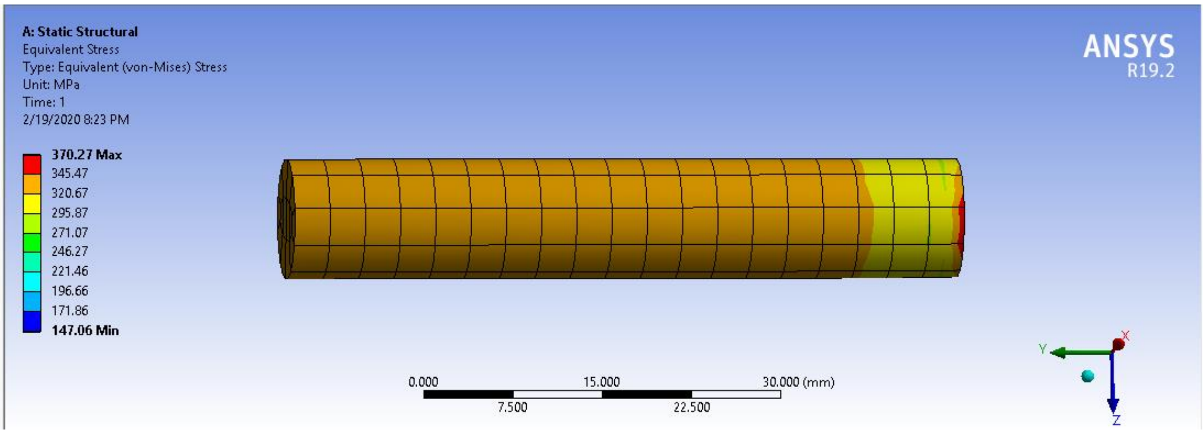

Fig 4.17Compression test analysis for 890^{0}c

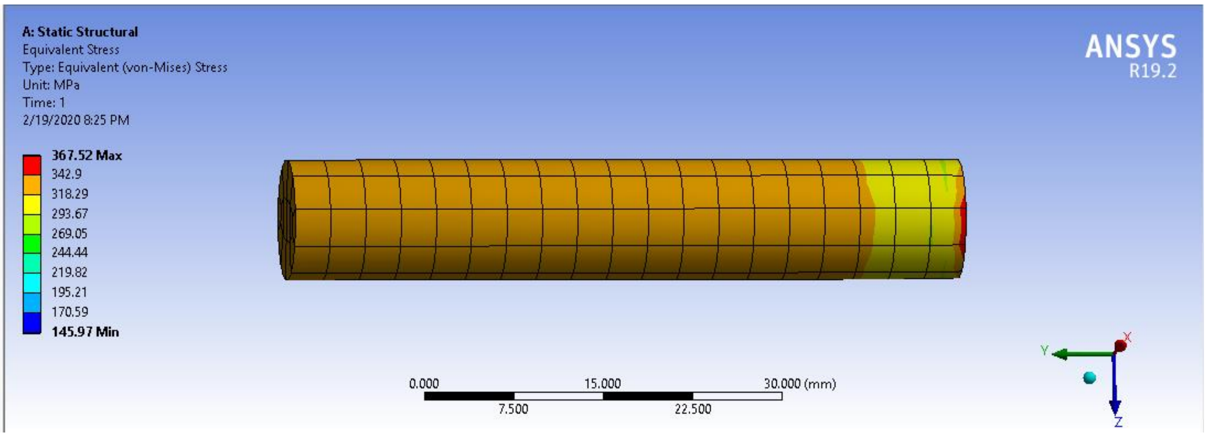

Fig 4.18Compression test analysis for 920^{0}c

Table 1.2Compression Strength Readings through ANSYS

S.No	Temperature (ºC)	Without stirring (Compression Strength) MPa	With stirring(Compression Strength)MPa
1	680	259.09	452.21
2	710	253.75	446.17
3	740	228.81	431.24

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4	770	217.03	416.53
5	800	187.38	393.03
6	830	183.34	381.33
7	860	179.18	373.33
8	890	172.39	376.23
9	920	169.39	362.82

We observe that different tests are conducted for different specimen at various temperature. Tests like hardness, tensile, compression tests are conducted for these samples. We notify that as the temperature increases the hardness, tensile, compression test values are decreasing. This decrease in these values is due to the amount ash formed during casting increases with rise in temperature and this effects the hardness, tensile strength. The maximum values are found at low temperature. The below table shows the compression strength at different temperatures.

CONCLUSIONS

Al 7075 reinforced with graphene was successfully produced with stir casting and without stirring process. On the basis of laboratory trials, the following conclusions were drawn:

a) Different samples are produced with varying temperatures both with stirring and without stirring process.
b) The casting of these samples is done and specimens are prepared according to ASTM standards.
c) Different tests like hardness, tensile and compression test are carried out, it was found that these values are decreasing with increasing temperature.
d) The maximum tensile strength was found at low temperature, hardness number and compression strength was increased by reinforcing with graphene.

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