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Tensile Test of Aluminium at High Temperature

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ABSTRACT
The necking of specimen is specifically related to the decrease in cross section when specimen is subjected to tensile strength greater than ultimate tensile strength (UTS). The strain distribution no longer hold uniform along the gauge length. As the tensile load is applied, due to which length of specimen increases but there is decrease in cross section.

The present work laid stress on determining the tensile properties from stress strain curve by tensile testing of aluminium (specimen) at different range of high temperature The tensile testing is carried out on INSTRON static series 600 KN. The specimens were tested at different range of high temperature (Room Temperature -325 degree Celsius). True Stress and strain is calculated using the engineering equation. Using the values of true stress and true strain the true stress strain curve was plotted. The polynomial equation is obtained from each specimen curve. The graph is plotted between temperature and ultimate tensile strength (UTS) which indicates that the ultimate tensile strength decreases with the increase in temperature[1].

I. LITERATURE REVIEW

From the literature review , the work on "High temperature tensile behaviour of a Cu–1.5 wt.% Ti alloy" By **S.** Nagarjunaand M. Srinivas was done at Defence Metallurgical Research Laboratory at Defence Research and Development Org. The high temperature tensile Properties of a Cu–1.5 wt.% Ti alloy[2]\ have been investigated in the temperature range of 100–550 °C.Substantial increase in yield and tensile strengths of solution treated alloy is observed with increasing temperature, with a peak at 450 °C and decrease in strength beyond this temperature.Cu–Ti alloys have been developed with the aim of substituting them for the toxic and expensive Cu–Be alloys.It reports the results obtained on high temperature tensile properties of a Cu–1.5 wt. % Ti alloy in solution treated (ST) and peak aged (PA) conditions.

In the paper "Tensile properties of Ti_3SiC_2 in the 25–1300°C temperature range"By M. Radovic M. W. BarsoumT. El-RaghyJ. Seidensticker and S. Wiederhorn.The ternary carbide Ti_3SiC_2 exhibits a unique combination of properties that have been studied.It report on the functional dependence of the tensile response of finegrained (3–5 μm) Ti_3SiC_2 samples on strain rates in the 25–1300°C temperature range. High temperature mechanical properties; Stress–strain relationship measurements; Plastic; Creep; It reported on the properties of fine- and coarsegrained, predominately single-phase Ti_3SiC_2 samples in compression and flexure. In both cases, a brittle-to-plastic transition occurs at ≈1200°C, at which point large plastic deformation levels (strains >20%) are obtained prior to failure[3].

In paper High-temperature mechanical properties of aluminium alloys reinforced with boron carbide particles J. O˜noroa,∗, M.D. Salvadorb, L.E.G. Cambroneroc.The tensile properties and fracture analysis of these materials were investigated at room temperature and at high temperature to determine their ultimate strength and strain to failure. The fracture surface was analysed by scanning electron microscopy.

However, very little work is devoted to tensile testing of aluminium at high temperature. The present work focuses on determining the tensile properties of aluminium when subjected to necking at high temperature[4].

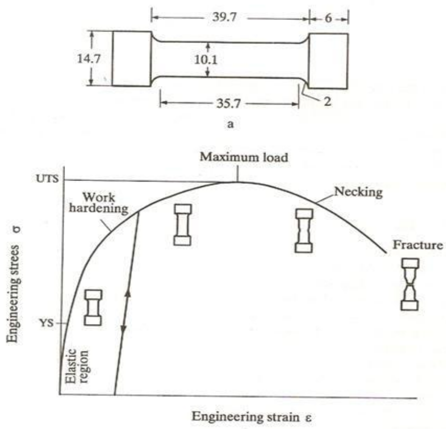
II. INTRODUCTION

The tensile properties of Al, Cu, stainless steel and its alloy examined in the high temperature the need for materials with useful strength above 1600k has stimulates the interest in refractory alloys .Cast aluminium alloys have found wide application to manufacture lighted-weight components of complex shape in automotive and aerospace industries. To improve the strength and ductility of cast aluminium alloys,

it is necessary to study their fracture properties by conducting a series of tests.
The tensile properties of Al are strength ductility creep. The temperature range of 37°C to 350°C That temperature is maintain inside furnace .Tensile testing of aluminium with high temperature in INSTRON static series. The aluminium is tested with different temperature range we have taken the range. 37°C (room temp.), 90,130,170,210,250,290,325°C

THE TENSILE TEST

The engineering stress-strain curve Specimens used in a tensile test are prepared according to standard specifications. The test pieces can be cylindrical or flat. Figure S.la shows the standard dimension of a typical cylindrical specimen. It is gripped at the two ends and pulled apart in a machine by the application of a load. The stress-strain curve obtained from the tensile test of a typical ductile metal is shown in Fig. On the y-axis, the engineering stress, defined as the load P divided by the original crosssectional area Ao of the test piece, is plotted. The engineering strain E, defined as the change in length 1L divided by the initial gauge length La is plotted on the x-axis. The % elongation is obtained by multiplying the engineering strain by 100. The stress-strain curve starts with elastic deformation. The stress is proportional to strain in this region, as given by Hooke's law. At the end of the elastic region, plastic deformation starts. The engineering stress corresponding to this transition is known as the yield strength (YS), an important design[5]



The tensile test: (a) a standard cylindrical test specimen (dimensions in mm), and (b) the engineering stress-strain curve.

plastic deformation starts[6]. The engineering stress corresponding to this transition is known as the yield strength (YS), an important design parameter. Many metals exhibit a continuous transition from the elastic region to the plastic region. In such cases, the precise determination of the yield strength is difficult. A parameter called proof strength (or offset yield strength!

that corresponds to a specified permanent set is used. After loading up to the proof stress level and unloading, the specimen shows a permanent elongation of 0.1 or 0.2%[8].

The stress-strain curve has a positive slope in the plastic region, indicating that the stress required to cause further deformation increases with increasing strain, a phenomenon known as work hardening or strain hardening. If the load is removed when the specimen is in the plastic region, it retraces a straight line path parallel to the initial line and reaches zero stress at a finite value of permanent elongation, see Above fig. Thus, the elastic part of the deformation is recovered. On reloading, plastic deformation starts only on reaching the stress level prior to unloading.

The engineering stress reaches a maximum and then decreases. The maximum value is known as the ultimate tensile strength (UTS) or simply the tensile strength Up to the UTS, the strain is uniformly distributed along the gauge length .Beyond UTS, somewhere near the middle of the specimen, a localized cease in cross section known as necking develops. Once the neck forms, further deformation is concentrated in the neck. The strain is no longer uniform along the gauge length. The cross-sectional area of the neck continuously decreases, as the % elongation increases. Voids nucleate in the necked region at the interface of hard secondphase particles in the material. These voids grow and coalesce, as the strain increases. The true cross-section bearing the becomes very small, as compared to the apparent

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cross-section, due to the growth of these internal voids. At this stage, the specimen may fractural shows that ductility measured in terms of the true strain at fracture ec below for definition of true strain) decreases with increasing concentration[9].

PROPERTIES

Aluminium has a flexible durable. Lightweight malleablemetalby means of appearance range from silvery to dull grey, dependingon the surface roughness. Al is nonmagnetic and non sparking. It may too unsolvable in alcohol, though it may be soluble in the water forms. The yield strengthof pure Al is 6to12MPa, while aluminium alloyshas yield strengths from 201 MPa to 600 MPa. Aluminium has about one third the densityand stiffnessof the steel. It is ductile, and simply machined,cast,drawnand extruded.

Corrosionresistance may be brilliant due to a slim surface layer of aluminium oxidewhen the metal is uncovered to air, effectively prevent additionaloxidation. The strongest Al alloys are not as much of corrosion resistant due to galvanicreaction with alloyed copper.It corrosion resistance has also frequently greatly reduced when many aqueous salts are in attendance however, mainly in the presence of unlike metals[10].

Aluminium atom is arranged in a face centrecubic(fcc) structure. Al is stacking fault energyof approximately 200 mJ/m².

Aluminium is one of the small number of metals that keep full silvery reflectance in thinly powdered form making it significant constituent of silver paints. Aluminium is a superior thermaland electrical conductor, by weight improved than copper. Aluminium is able of being a superconductor, among a superconducting critical temperature of 1.2 kelvin.

STRENGTH WEIGHT RATIO

Aluminiumhas density approximately one third that of steel and is utilize benefit in application where high strength and low weight are required. That is include vehicle where low mass consequences in greater load capability and reduced fuel utilization.

CORROSION RESISTANCE OF AL

When the surface of aluminiummetal has uncovered in to air. The protective oxide coating form almost instantaneously. This oxide film has corrosion resistant Aluminium is good corrosion resistance.

ELECTRICAL AND THERMAL CONDUCTIVITY OF AL

Aluminiumis an brilliant conductor of both heat and electricity. The huge benefit of Al is that by weight, the conductivity of Al is twice that of copper. That means the Al is at present the most normally used material in large power transmission lines[11].

LIGHT AND HEAT REFLECTIVITY OF AL

Aluminiumis high quality reflector of both able to be seen light and heat creation it perfect material for light fittings. thermal liberate blanket and architectural insulation.

TOXICITY OF ALUMINIUM

Aluminiumis not only nontoxic but also does not discharge any spoil products with which it is in get in touch with. This makes Alappropriate for used in covering for responsive products such as food .where Al foil is used.

RECYCLABILITY OF AL

The recyclability of has unparalleled. When recycled there no degradation in properties when recycled Al can compared to virgin aluminium. Furthermore recycling of Al only require approximately 5 percent of the input energy necessary to create virgin Al metal.

ALUMINIUM PRODUCTION

Aluminium is extracted the principal ore, bauxite. Significant bauxite deposits have found in Australia. the Caribbean. China and South America. Open cut techniques has normally used to mine the bauxite.

SMELTING OF ALUMINIUM

The removal of aluminiumfrom alumina has achieve using an electrolytic method. A cell or vessel has used that consists of a carbon lined steel shell. That shell forms a cathode. A consumable carbon anode has suspended in liquid cryolite held inside the pot at 950°C. Alumina is dissolve in the cryolite by transitory low voltages at high amperages through pot. That consequences in pure Al being deposit at the cathode.

ENVIRONMENTAL CONSIDERATIONS

The aluminiumindustry has very conscious of the environmental impact of it is activities. The mining and smelting of Al benefit the removal of red sludge can have a main environmental impact

PROPERTIES OF AL

Aluminium is unique and unbeatable combination of properties this making it's into the versatile. High usable and attractive construction material.

WEIGHT

Al is the light material compare to other material like steel density is 2.700 kg/m3 **Strength**
Aluminium has strong with the tensile strength 70 to 700 MPa depend on the alloy and manufacture processing[12].

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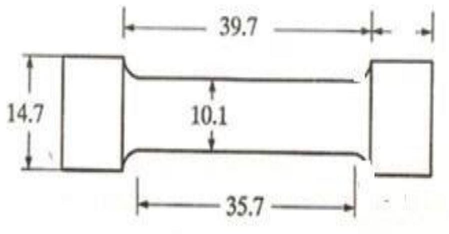
Atomic number-13
Atomic mass - 26.98154 g.mol $^{-1}$
Electronegativity according to pauling– 1.5
Density - 2.7 g.cm $^{-3}$ at 20 °C
Melting point - 660.4 °C
Boiling point - 2467 °C
Vanderwall radius - 0.143 nm

CHEMICAL PROPERTIES:-
Ionic radius - 0.05 nm
Isotopes - 3
Artificial isotopes – 16
Electronics shells -1s2 2s2 2p6 3s2 3p1
Energy of first ionization - 577.4 kJ.mol $^{-1}$
Energy of second ionization- 1816.1 kJ.mol $^{-1}$
Energy of third ionization- 2744.1kJ.mol $^{-1}$
Standard potential - 1.67 V
Discovered by - Hans Christian Oersted in 1825

EXPERIMENTAL PROCEDURE

Before performing the test. Specimen of standard size and shape must be produced from the material to be tested for the result to be comparable. It is strongly advised to manufacture .the specimen size and shape according to standard. We are using the round test bar .Round test bar are used for sheet/plate with thickness. We are show the standard size specimen



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In this specimen size and shape are standard .standard are thread radius gauge length of reduction section and diameter and we have used specimen is not that size it is different nomenclature . first one when we are preparing the specimen we have taken the aluminium rod 1000mm long and diameter is 12mm.then we have cut that rod in 100mm ten part. Each part having the same length 100mm .now we are making the thread in specimen both side 15 mm length by using the thread making die (screw thread).

THREAD DIE- Die is cuts the thread on performing rod. Which has been produced the male thread. the die is shown are top left an older split die with top adjusting a cylindrical blank. Which has usually slight less than. That is required diameter has machined with the tapper at thread end .thus taper allow the die to ease onto the blank before it is cut the sufficient threads to pull itself along[13].

Thread making die

MAKING A SREW THREAD- the thread are three type parallel thread for piping(pf) a tapper thread for piping (pt) and unified thread (unf) . two type term are used for thread . first one is the male thread as the making outer thread and second one is the inner thread . we have making the inner thread .

Lathe machine

Because the 70mm middle part making the 6mm diameter for standard size and shape

Turning introduction; turning is one of the main types of machining where material is removed using cutting tool .it's allow rotating parts to be produced using a single edge cutting tool. After completing the turning the finishing of the specimen by using the sand paper .after doing that work we have make a standard size specimen that specimen having the 100mm long and 12mm diameter .both side 15mm having the thread and middle part having the diameter is 6 mm .that is our specimen standard size and shape .

To receive exact result when performing a tensile test. First one we need a perfect prepared tensile specimen this specimen has to meet the standard as well as the mechanical requirement .if the specimen has a bad quality the result of ours test are wrong and not reliable [14].

Tensile specimens those do not have a perfect edge flank never will give you the high elongation the material is able to do. often youloose 1/8….1/3 of the possible elongation .

METALLOGRAPHIC SPECIMEN PREPARATION BASICS

Metallographic has the study of materials basic and fundamental .Analys of the materials micro structure aid in determine if the material has processes. therefore the critical step for determine the product reliability and for determine why that material material failed. The fundamental and basic steps for exact metallographic specimen preparing include documentation section and cutting mounting, planar grinding, rough polishing, final polishing, etching, microscopic analysis, and hardness testing.

Documentation - Metallographic analysis has the valuable tool. properly documenting the initial specimen condition the proceeding micro structural analysis, metallography provides the powerful quality control an invaluable investigative tool.

Sectioning and Cutting - most metallographic samples need to sectioned to the area of interest and for easier handling. Depending upon the material the sectioning operation may be obtained by abrasive cutting Proper sectioning is required to minimize damage, which may alter the microstructure and produce false metallographic characterization. Proper cutting requires the correct selection of abrasive type, bonding, and size and proper cutting speed, load and coolant[15].

Mounting - The mounting operation accomplished three important functions first its protect the specimen edge and maintain the integrity to the materials surface features second has the fills voids in porous materials and third one is the improves

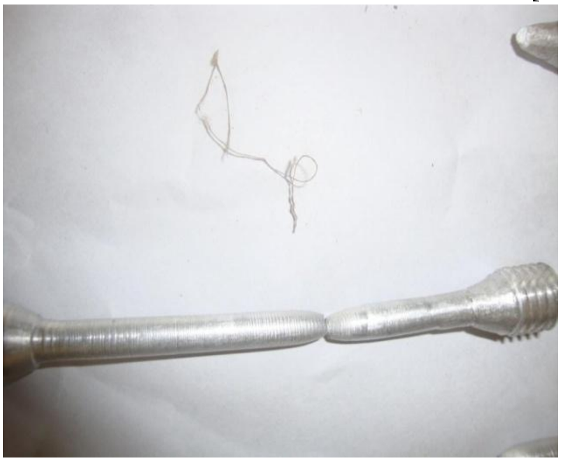
After making the thread we have doing the turning in the middle 70mm part ofspecimen .it's mean 700mm length where we are doing the turning in lathe machine handling of irregular shaped samples especially for automated specimen preparation[16].

Planar Grinding - ofcourse grinding has required to planarize a specimen and reduce the damage created by sectioning. The planar grinding step has accomplished by decreasing the abrasive particle size and shape to obtain the surface finishes that is ready to polishing. Care must be taken to avoid being too abrasive in that step and actually creating greater specimen damage than produced during cutting The machine parameters which effect the preparation of metallographic specimens, include grinding/polishing pressure, relative velocity distribution, and the direction of grinding/polishing[17].

Rough Polishing - the rough polishing step has been use to remove the damage produced during cutting and planar grinding. Exact rough polishing shall be maintain specimen flat. By eliminating the previous damage and maintaining the micro structural integrity of the specimen

Final Polishing – the final polishing has be remove only surface damage. It shall not be used to remove any damage remaining from cutting and planar grinding[20]. If the damage has not complete. The rough polishing should be repeated . **Reference (** Metallographic Specimen Preparation BasicsByDonald C. Zippering, Ph.D.Pace Technologies)

Thus finally we have prepare the specimen of aluminiummaterial[18]



Aluminium specimen

III. EXPERIMENT& RESULT:-

After carrying out the experiment on each aluminium specimen subjected to necking at different range of high temperature. We determined the stress from load that is applied gradually to specimen and strain is determined from change in length of specimen during necking. With the help of stress and strain values obtained in former, we plot the stress versus strain. The tabulation for each specimen and their respective stress strain plots are given below[19]:

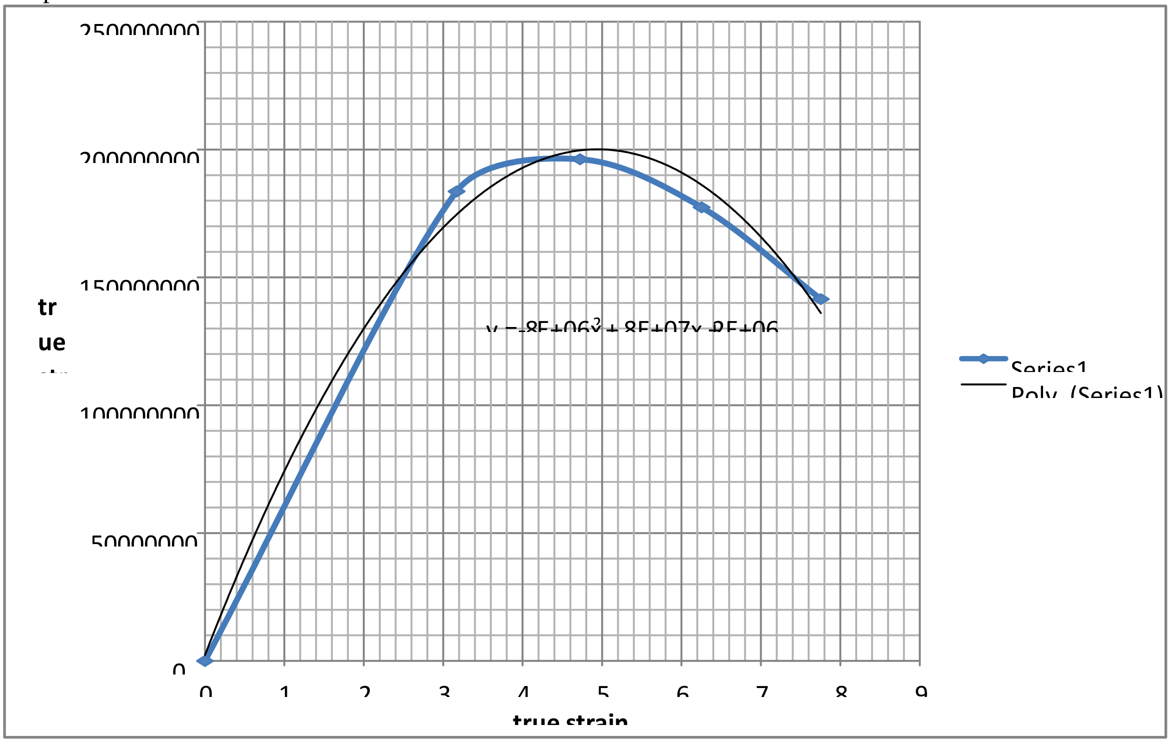
SPECIMEN FIRST TABULATION:TEMPERATURE (37 DEGREE CELSIUS)

Extension	load N	load KN	Initial length	True strain %	True stress
0.003	1.23	0.001	61.993	0	0
0.998	5545.03	5.545	62.988	3.169	1.84E+08
1.999	5832.119	5.832119	63.989	4.722806	1.96E+08

3.001	5191.903	5.191903	64.991	6.254332	1.77E+08
4.003999	4078.458	4.078458	65.994	7.755293	1.42E+08

Extension	load N	load KN	Initial length	True strain %	True stress
0	0	0	61.99	0	0

Graph between the true strain and stress true strain is the X direction . and the true stress is the Y direction



IV. CONCLUSION:

1. The characteristic commercially available aluminium at different high temperature is tested to determine its suitability to be used at elevated temperature.
2. It is seen that as the temperature increases the ultimate tensile strength decreases but the ductility increases.

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