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Hot Tensile Test- A Literature Review

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Abstract: Hot Tensile Test (HTT) is the method of testing the material properties at high temperature. High-temperature properties of materials are a vital concern in many applications such as power generation plant, aerospace, and automotives. Based on applications, many components like turbine blades, piston, valves, cylinder head, etc are subjected to high temperature; this high temperature will induced thermal stress which causes failure of components. So it is important to study the effect of high temperature on strength of material. This paper will focused on effect of high temperature & strain rate on tensile strength, microstructure of aluminium alloy by using hot tensile test. Also high temperature microstructural analysis by SEM.

Keywords- Hot Tensile Test, High Temperature, Strain Rate, Tensile Strength, SEM, etc.

I. INTRODUCTION

Among commercial aluminium casting alloys, aluminium silicon alloy are the most important ones. Mainly due to their excellent combination of properties such as good castability, good surface finish, light weight, fewer tendencies to oxidation, lending to modification, low coefficient of thermal expansion, high strength-to-weight ratio and good corrosion resistance. These properties led to their excessive use in many automobile and engineering sectors where wear, tear and seizure are the major problems in addition to the weight saving. Some of these components are cylinder heads, pistons, connecting rods and drive shafts for automobile industries and impellers, agitators, turbine blade, valves, pump inlet, in many marine and mining sectors. [5]

II. 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 shows the standard 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 cross-sectional area Ao of the test piece, is plotted. The engineering strain E, defined as the change in length dL divided by the initial gauge length La is plotted on the x-axis. The % elongation is obtained by multiplying the engineering strain by 100.

A. Types of Tensile Testing:

i) Room Temperature Tensile Testing:

This type of tensile test use UTM at room temperature. The component is fixed in jaw of UTM & loaded by weight at room temperature. The component elongates at room temperature & shows the tensile strength, elongation, yield strength, micro structure after fracture on SEM. 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 parameter. 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. [1]

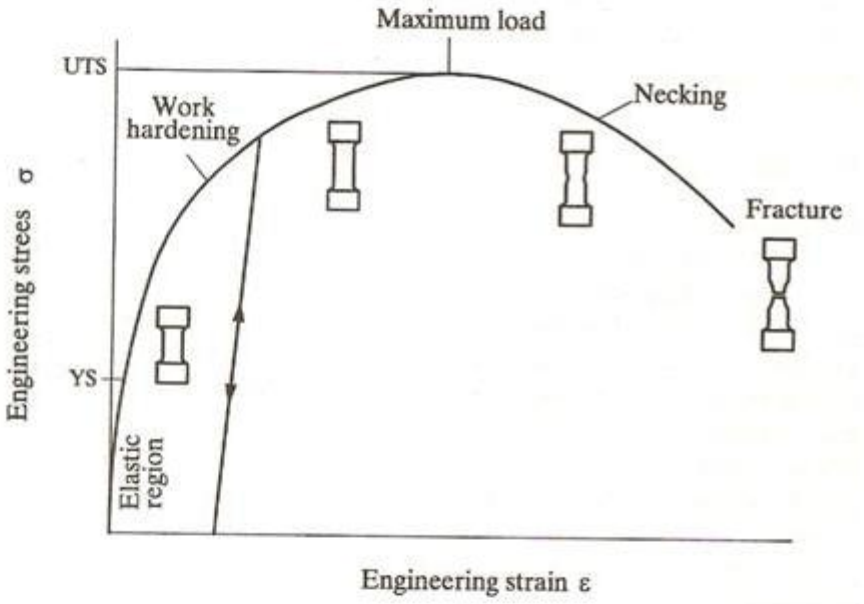

Fig 1: Standard Cylindrical Test Specimen with Stress-Strain Curve [1]

ii) High temperature Tensile Test [HOT TENSILE TEST]

Fig 2: Hot Tensile Testing Set-Up-INSTRON static [7]

Hot tensile test is the method in which we use tensile testing machine with furnace & extensometer where the specimen is hold. By using this method we can find out the tensile strength, elongation, yield strength properties of different materials and its alloy, at high temperature. Also we can study the micro structural changes at high temperature by examine the fractured components under SEM, TEM. [7]

B. Objective of Hot Tensile Test:

As many components from IC engine like cylinder heads, pistons, connecting rods and drive shafts for automobile industries and impellers, agitators, turbine blade, valves, pump inlet, in many marine and mining sectors operated at high temperature.

1. To investigate the behavior of material at high temperature.
2. To study the mechanical, thermal properties of material at elevated temperature.
3. To determine elastic limit, elongation, modulus of elasticity, proportional limit, reduction in area, tensile strength, yield point, yield strength at high temperature.
4. To study changes of micro structure at elevated temperature.

III. LITERATURE REVIEW

Table 1: Summary of Researchers Works on Hot Tensile Test:

Investigator	**Name of material**	**Temperature range(°C)**	**Effect/ result**
Amro M et al [2007]	Al6061 Reinforced with Submicron Alumina Composite	23,150,200, 250, 300°C. crosshead speed of 3 mm/min	1. The composite was able to retain over 35% of room temperature strength when tested at 300°C. Strain to fracture increases with temperature up to 250 °C. 2. The maximum strength of 341 MPa at room temperature reduces to 124 MPa at 300 °C.
Jennarong tungtro et al. [2009]	Boron Alloy Steel	900 -1200 °C	1. The tensile strength at 1200°C is 60 MPa less than the tensile strength at 900°C. As the temperature increase, tensile strength decrease.
L.J. Huang, [2008]	Ti 6.5Al–3.5Mo–1.5Zr–0.3Si alloy	900–980 °C	1. The elongation of all the specimens exceeds 200% in the temperature range of 920–980°C. 2. Increasing temperature leads to higher elongation and the highest elongation (400%) is observed at 960 °C (The volume fraction of b-phase is about 50%). Then the elongation begins to decrease at 980°C when the volume fraction of b-phase is above 50%.
Y.C. Lin et.al, [2013]	Ni-based superalloy	920–1040 °C	1. The flow curves show two different characteristics under the studied deformation conditions. Under relatively low deformation temperatures (920, 950 and 980 °C), the flow curves are composed of three distinct stages, i.e., work hardening stage, steady stress stage and flow softening stage.
Yuan-Chun Huang et al. [2013]	42CrMo steel	850–1100 (850,950,1050 ,1100 °C)	1. With the increase of deformation temperatures (950 and 1050°C), the true stress–true strain curves start to show the dynamic recrystallization behavior with a relatively prolonged dynamic softening stage after

			the peak strain. 2. As the deformation temperature is further increased to 1100°C, grain rapidly grows up during the hot deformation process, which weakens the plastic deformation capability of the material.
Deepak Sharma [2011]	Aluminium	37,90,130,170 ,210,250,290, 325ºC	1. It is seen that as the temperature increases the ultimate tensile strength decreases but the ductility increases by graph & polynomial equations.
Mi Zhou, et al. [2014]	Al–Zn–Mg–Cu alloy	340,380,420 ,460 ºC strain rate of 0.01–0.001S^{-1}	1. The tensile true stress–true strain curves of the studied Al– Zn–Mg–Cu alloy under all the deformation conditions can be divided into four distinct stages, i.e. elastic stage, uniform deformation stage, diffusion necking stage and localized necking stage. The flow stress decreases with the increase of deformation temperature or the decrease of strain rate. Microvoids coalescence is the main fracture mechanism under relatively low deformation temperatures. With the increase of deformation temperature, the intergranular fracture occurs.
Guohua Zhanga, et al. [2012]	Al–Si piston alloy	37,200,350ºC	1. At elevated temperatures (200 ºC and350 ºC), the cyclic deformation behavior of the alloy mainly presented cyclic softening effect except the in initial hardening behavior (about10cycles) at200 ºC. The dislocation motion was thermally activated to bypass or shear the precipitates, leading to the cyclic softening effect
Jiao Deng, et al, [2013]	AZ31 Mangnesium alloy	250-450 ºC	1. The flow curve shows considerable strain hardening & no diffuse necking stage at temperature 250-450 ºC 2. 2. Rapid drop of elongation to fracture at 450 ºC due to abnormal grain course, inter granular fracture
M. Morakabati et al, [2010]	NiTi and NiTiCu alloys	750-1000 ºC	1. The highest hot ductility for the NiTi is obtained at temperature range of 750–1000 _C, while this occurs at temperature range of 800–1000 _C for the NiTiCu alloy. 2. 2. The lower hot ductility of NiTiCu alloy in comparison with the NiTi alloy is due to the formation of cavities and cracks with higher volume fraction and larger sizes than those of the NiTi alloy.

CONCLUSION

1] The literature survey shows that there was very less work reported on high temperature behaviour of material i.e. on hot tensile test (HTT), analysis of micro structure of material at high temperature.

2] Hot tensile test is very important to study the thermal stress generated in components which are subjected to high temperature to avoid failure of components.

3] Most of the work done on steel material. So there will be scope to apply this test for low weight material for application in automobiles, aerospace components.

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