A Comparative Study of Tensile Properties of Two Different Grades of Stainless Steel at Different Temperatures

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Abstract

Two grades of stainless steel: 316 and 201 were annealed at constant temperature for suitable duration of time. The annealed specimens were first tested at 300K, up to fracture. Afterwards, the test temperature was increased to 500K, with an interval of 50K.The stress-strain curves were obtained with the help of software operated Universal Testing Machine (UTM).The study was carried out to draw a comparison between the tensile parameters like Yield stress, Tensile stress and Ultimate tensile stress of the chosen grades of stainless steel at various temperatures.

Introduction

Stainless steel is a solitary versatile material. Stainless steel is used by people in food, medical instruments, transportation, restaurants, kitchens, toasters, vacuum cleaners, new vehicles and continues to influence their lives every day. Stainless steel is itself fully recyclable according to our requirements. Stainless steel being familiar metal of 21st century .Introductory and invention credentials of Stainless steel goes to Harry Braerley, son of steel melter.In 1908, proper working on stainless steel was started in Brown Firth Laboratories, Sheffield, England [1].

Stainless steels are defined as iron based alloys containing at least 10.5% chromium and a maximum of 1.2% carbon[2].Stainless steel have drawn wide attention as versatile material for multiple applications due to their excellent “Corrosion Resistance”. Corrosion resistance is not an intrinsic property of a material, but the behavior of that material that stems from the interaction with the surrounding medium and the material’s surface. The corrosion resistance in stainless steel is provided by a passive surface film which acts as a barrier between the alloy and surrounding medium [3].Chromium plays an essential role in the formation and the stabilization of the passive material.

A minimum of 10.5% chromium is required for the formation of a protective layer of chromium oxide on the sheet surface. The stability of the passive films depends upon the chromium content, by increasing the chromium content from 10.5% to 18% provides more stability of passive films.

Every Metal has its disadvantages and stainless steel is no exception. Some of the primary disadvantages include: its fabrication without using the proper techniques, the difficulty in welding due to its fast dissipation of heat which can also produce ruined pieces.

Stainless steels are generally classified according to their microstructure as

a) Ferritic
b) Austenitic
c) Duplex
d) Martensitic

The relationship between composition, structure and properties of different grades of stainless steels is summarized in Fig.1.

Fig.1 Composition, Structure and Property Relationship of Stainless Steels [4]

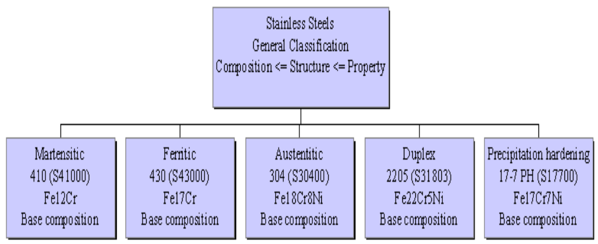
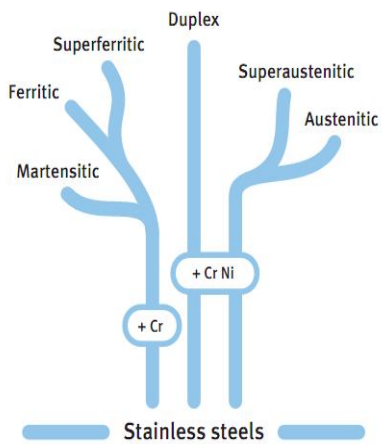


Fig.2 Stainless Steels classification [5]

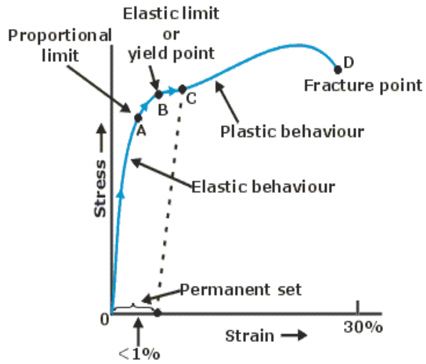


In our current research, we study the mechanical properties of Stainless Steel; tensile strength, yield strength, elongation and hardening. The tensile properties were studied with the help of Japanese Universal testing machine. The tensile properties of a stainless steel are generally determined from tension tests on small specimens in accordance with standard procedures. The behavior is closely related to the behavior of structural-steel members under static loads. Because, for structural stainless steels, the yield points and moduli of elasticity determined in tension and compression are nearly the same, compression tests are seldom necessary.

In studying the tensile properties, Hooke's law determined the limit of proportionality. Almost every material obeys Hooke's Law, which states that if a load is applied to a material, it will deform in a proportional manner to the amount of applied load.

The modulus of elasticity is simply the ratio of stress to corresponding strain below the proportional limit of the specimen. It is also referred to as Young's modulus; it has units of psi or N/m^2.Yield point is that point where a tensile test piece begins to extend permanently. If the load is reduced to zero, the test piece will not return to its original length. The yield point marks the end of elastic behavior and the beginning of plastic behavior.

Fig 3: Stress Strain Graph[6]



For many materials that do not have a well-defined yield point, a quantity called yield strength is substituted. Yield Strength is the stress at which a material has undergone some arbitrary chosen amount of permanent deformation, often 0.2 percent. The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing. This is the point at which the maximum stress the specimen and material is capable of withstanding is reached.This is the point at which the sample finally breaks. It should be noted that the Breaking point and the Ultimate point are, more often than not, two separate, distinct points on the stress / strain curve.

Experimental Work:

Step(a) Selection of materials and setting its dimensions:

The material involved in our current study is Stainless Steel Grades 316 and 201.The grade 201 and 316 stainless steel specimen cut into the desired length.

Step(b) Grinding and Polishing of Specimens:

In our research study, Grinding and polishing of specimens is very important for removing the dirt layers on the surface of specimen and regain its original shine. The specimens were polished with silicon carbide paper .Silicon carbide no.120 and 320 were used for polishing the specimen. The grinding and polishing were carried on both sides of specimens.

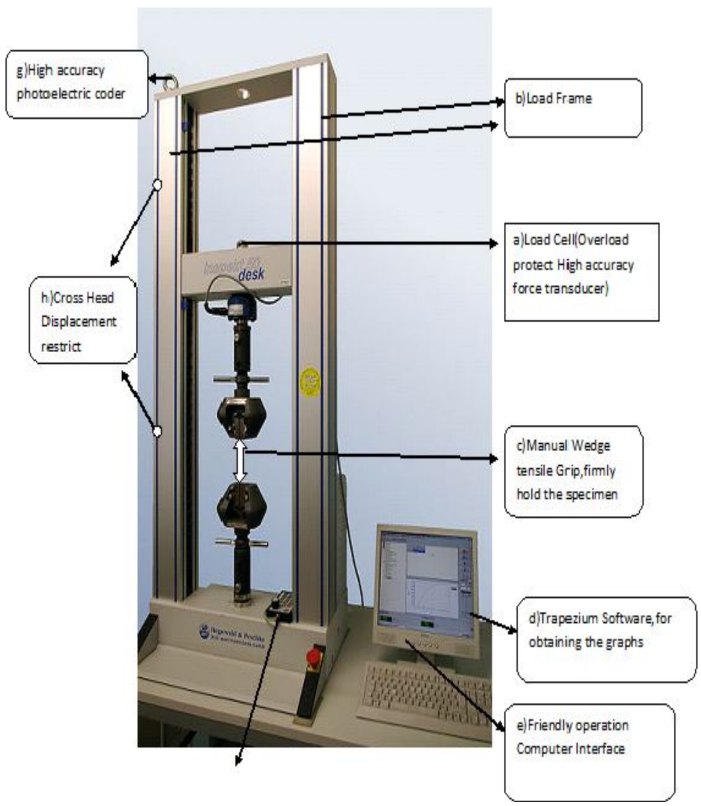
Step (c) Setting the specimen in Universal Testing Machine:

For our research purpose i.e Tensile tests, were carried out using the Trapezium software operated machine called Universal Testing Machine. A UTM has ability and efficiency to perform standard tensile and compression tests on specimens, components, and structures.

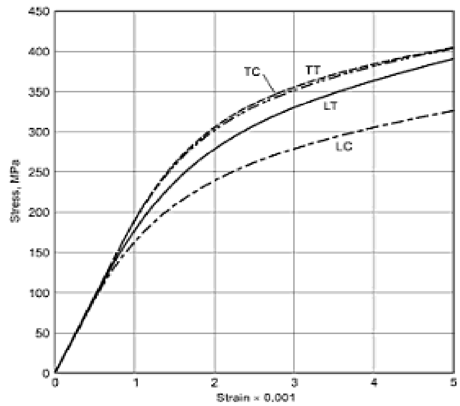
The main components of Universal testing machine used to carry out experimental results are;

a)Load cell (Overload protect High accuracy force transducer).
b) Manual wedge tensile grip (tensile Grip, firmly holds the specimen).
c) Cross head displacement restricts.
d)Software operated (Trapezium).

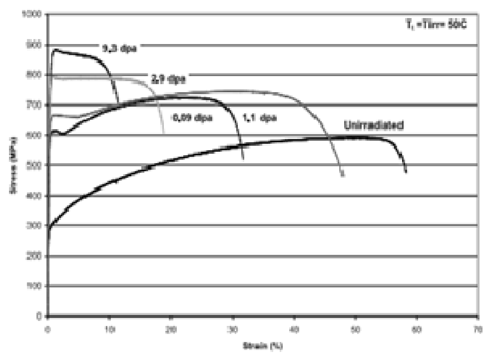
The specimens were mounted in the cross heads of machine, cross heads firmly hold the specimen in the jaws. After mounting the specimen the tension was subjected, the cross heads moved with a speed of 1mm per second. The tensile force was recorded as a function of the increase in gauge length, as shown in the graph (a) .The specimens were first tested at room temperature. The temperature was then increased with an interval of 50K and finally the specimens were tested at 500K.



Graphs
a)Stress Strain graph(Grade 201)



b)Stress Strain Graph(Grade316)



Results:

Specimen	Gauge length	Diameter	Cross head speed
Grade 316	5.6cm	0.56cm	1mm/min
Grade 316	5.6cm	0.56cm	1mm/min
Grade 201	3cm	0.39cm	1mm/min
Grade 201	3cm	0.39cm	1mm/min

Specimen	Tempt	Tensile Strength	Proof Stress	%age elongation
Grade 316	At room temperature	495 MPa	185MPa	20%
Grade 316	500K	510 MPa	201MPa	26%
Grade 201	At room Temperature	1800 MPa	1490MPa	33%
Grade 201	500K	1880MPa	1570MPa	39%

The above table displays the results of Stainless Steel grades: 316 and 201 at room temperature and 500K.The percentage elongation was measured to be 20% at room temperature and 26% at 500K in case of Grade 316.While the elongation was found out to be equal to 33% and 39% at room temperature and 500K respectively. This was the observation made in case of Grade 201.The effect of increasing test temperature on the tensile properties shows the increase in uniform elongation while the yield stress increases as the test temperature is raised.The response of mechanical properties shows that the ductility of specimen increases as the yield stress increases. The rise of temperature results increase in yield stress, tensile stress and ultimate tensile strength of the specimens. This happens as plastic deformation, registers an increase with the rise of deformation temperature.

Conclusion

The research work has been taken up to study the effects of different temperatures on the Stainless Steel Grades:316 and 201. Tensile properties of the specimens were determined from the autographic records by using the Universal Testing Machine of 50 KN in temperature ranging up to 500K. From the different graphs maximum stress and strain points were observed and the %age elongation was measured through these curves. The percentage elongation increases with the increase of test temperature increase of test temperatur

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