EFFECT OF ANNEALING AND NORMALIZING ON MECHANICAL PROPERTIES OF FORGED MEDIUM CARBON STEEL

[1]Anand Mohan Pandey, [2]R. Santosh Kumar, [3]R. Narendra Reddy, [4]CH. Jai Kishore, [5]K. Manoj Sai Kumar
[1]Assistant professor, [2,3,4,5] Student
1Department of mechanical engineering,
[1]Godavari institute of engineering and technology, Rajahmundry,533296, India

Abstract: Forging is one of the oldest known metal working processes. Forging is a manufacturing process involving the shaping of metal using localized compressive forces. Forged parts, though required in many engineering sectors, play a vital role in the automotive sector. The majority of the crucial loads bearing structural components as well as safety critical items are processed via the forging route. The mechanical properties such as ductility, toughness, strength, hardness and tensile strength can easily be modified by heat treating the medium carbon steel to suit a particular design purpose**.** The objective of this work is to establish quantitative knowledge of mechanical properties and correlate with micro structure behavior occurring during the hot working medium carbon steel at the temperature of 1150 c. the process parameters viz., percentage deformation area, heat treatment at different temperature, different cooling medium is investigated.

Key Words: -Medium carbon steel, Austenite, Martensite, Strain hardening parameter.

I. INTRODUCTION

Heat treatment operation is a means of controlled heating and cooling of materials in order to effect changes in their mechanical properties. Heat treatment is also used to increase the strength of materials by altering some certain manufacturability objectives especially after the materials might have undergo major stresses like forging and welding. It was however known that mechanical properties of steel were strongly connected to their microstructure obtained after heat treatments which are performed to achieve good hardened and tensile strength with sufficient ductility. The material modification process modifies the behavior of the steels in a beneficial manner to maximize service life i.e. stress relieving or strength properties e.g. cryogenic treatment or some other desirable properties. The Heat treatment generally is classified into (i) Thermal treatment which consists of softening process: Annealing and Normalizing, hardening process: Hardening and Tempering; (ii) Thermochemical Process which consist of Carburizing, Nitriding, Boronising; (iii) Thermomechanical Processes which consist of mechanical working operation during heat treatment cycle. Though heat treatment is not a new area, it has not been put into effective use in the fact that most of the researchers look at the process in general. It has not been localized for an improvement/modification on getting the required results from these steel materials that are abound in our daily life, especially where most of the steel products are from recycled scrap materials. Hence there is a need to carry out these tests and to be sure of the material compositions before they are put to final use.

Present work is concerned with the effect of forging and heat treatment on the mechanical properties of medium carbon steel with the objective of making sure that the steel is better suited structurally and physically for individual engaging in the design, fabrication and maintenance of steel products.

2.METHODS OF ANALYSES

To evaluate the effect of forged and heat treatment on the medium carbon steel, the investigation was carried out thus;

(i) Preparation of the specimens from 0.30% carbon steel
(ii) Forging the all specimens in two different reduction in area i.e. 50% and 60% reduction
(iii) Heat treating of forged stock (medium carbon steel)
(iv) Different types of tests (Tensile test, hardness, impact test, microstructure) of the medium carbon steel to analyze its Behavior after the forging and treatment.

2.1 Billet cutting:

The 40mm diameter billet of medium carbon steel was cut in 4 pieces for forging as per the following dimensions (1) 105mm length x 40mm dia……2 pieces (for 50% reduction) (2) 84mm length x 40mm dia…….2 pieces (for 60% reduction)

2.2 Deformation during forging:

The different sizes of stocks were heated to forging temperature at 12000C in red hot condition in the muffle furnace. The heated stock have been forged by hammer at different percentage area of reduction like 50%, 60%. The final dimension obtained after forging is as follow. (1) 50% Area of reduction Original size = 40 mm dia × 105 mm length After forging = 29 mm dia × 200 mm length (2) 60%reduction of area Original size = 40 mm dia × 84 mm length After forging = 26 mm dia × 200 mm length

2.3 Heat treatment of forged stock:

From 4 pieces forged stock, 2 pieces one from each percentage reduction has been cooled to room temperature and then stress reliving annealing at 650 0C in the furnace for soaking period of 35 min and then cooled in the furnace itself after switching off the furnace. Now remaining 2 pieces one from each percentage reduction has been normalizing at 550 0C in the furnace for soaking period of 35min and then cooled in the room temperature i.e. in the air.

2.3.1 Annealing

Is a heat treatment that alters the physical and sometimes chemical properties of a material to increase its ductility and reduce its hardness, making it more workable. It involves heating a material above its recrystallization temperature, maintaining a suitable temperature for a suitable amount of time, and then cooling. In annealing, atoms migrate in the crystal lattice and the number of dislocations decreases, leading to a change in ductility and hardness. As the material cools it recrystallizes. For many alloys, including carbon steel, the crystal grain size and phase composition, which ultimately determine the material properties, are dependent on the heating, and cooling rate. Hot working or cold working after the annealing process alter the metal structure, so further heat treatments may be used to achieve the properties required. With knowledge of the composition and phase diagram, heat treatment can be used to adjust between harder and more brittle, to softer and more ductile.

2.3.2 Normalizing

The metal is heated in a furnace for normalizing heat treatment process. The temperature of the furnace is kept 550°C and soaking period of 35 min, depending upon the carbon content in the material and then cooled to room temperature in still air. Then the physical and sometimes chemical properties of a material to increase its ductility and reduce its hardness, and to attain fine grain size than attained during annealing, less softness and ductility.

3.EXPERIMENTS

After careful preparation of the specimen samples of forged medium carbon steel, it was taken to the furnace for the heat treatment operations. To commence the operation, the furnace was initially calibrated to determine the furnace operating temperature based on the pre-set furnace temperature. To determine this, the furnace was set to an initial temperature of 200oC and the furnace was switched on. This temperature was maintained with the aid of thermostat that was used to control the furnace temperature. On attaining this temperature, a thermocouple was now introduced into the furnace chamber to measure and compare the temperature of the chamber which was adjusted until it gives same output temperatures. The various forms of the heated processes were stated below.

3.1Heat Treatment Process

3.1.1Annealing process

A full annealing was carried out on the specimen by heating the metal slowly at 650oC. It is held at this temperature for sufficient time (about 1 hour) for all the material to transform into austenite. It is then cooled slowly inside the furnace to room temperature. The grain structure has coarse pearlite with ferrite or cementite.

3.1.2 Normalizing process

Each samples of the medium carbon steel to be normalized were placed in the furnace and heated to temperature of 5500C. The samples were retained at this temperature for the period of two hours for full transformation to austenite. They were later removed from the furnace and left in air for cooling. Meanwhile another set of the sample specimens which were not heat treated were taken directly for the tensile test to serve as control samples.

3.2 MATERIAL TESTING

3.2.1 Tensile test

After the successful heat treatment operation, the various heat-treated samples were taken for the tensile test. The test was performed on Standard Universal Testing Machine. Tensile tests were conducted for all the specimens Each of the specimens was inserted one after the other into the machine jaws and having fastened the specimen properly at both ends, tensile test up to the fracture limit was carried out.

3.2.2 Impact test

The rod given the toughness value of the material which signifies the amount of energy absorbed by a material at the time of fracture under impact loading. Where a notched bar as per standards from the test material is held in a vice and a weight is allowed to using from a known height in such a way that it's the notched bar in its path and breaks it. Since the material has absorbed some amount of energy during its fracture, the swinging known part of its energy and therefore will not be able to reach the same height from above it notched the loss in height multiplied by the weight represents the weight represents the energy absorbed by the specimen during fracture which can be directly measured from the indicator on the scale. A typical izod impact test machine and a standard impact test piece.

3.2.3 Hardness test

With the help of Brinell hardness testing machine as shown in fig.11 hardness test has done of each sample. The Brinell hardness test method consists of indenting the test material with a 10mm diameter hardened steel to a load of 3000kg. For softer materials the load can be reduced to 1500kg or 100kg to avoid excessive indentation. The full load is normally applied for 10 to 15seconds in the case of iron and steel. The diameter in the indentation left in the test material was measured with a low powered microscope. The hardness value of the corresponding diameter of indentation was noted from the data table of BHN. Total 3 values of BHN have taken in 3 different locations on the sample and finally average value of all BHN values were calculated for all samples.

3.2.4 Microstructure

The micro-structure was seen by using electron optical microscope. The sample microstructures were observed with 200X magnification

IV. RESULTS

4.1 Results chart

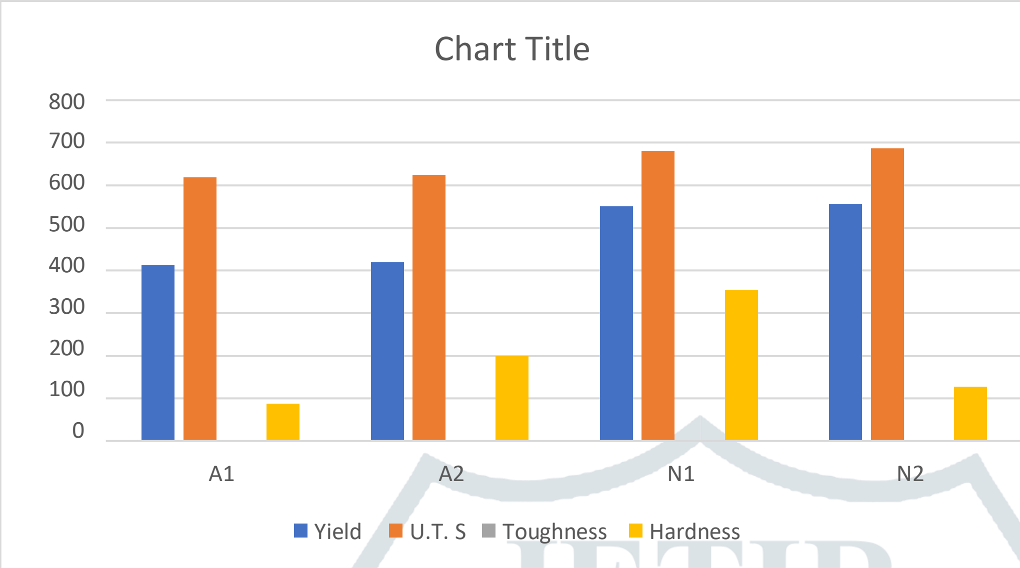

Table 4.1: Descriptive statics

specimen	% reduction	% Elongation	YIELD STRENGTH	U.T.S(MPa)	Toughness (J/mm^2)	Hardness (BHN)
A1	50%	4	413.49	619	0.43	88.4
A2	60%	5.1	418.49	625	0.39	198.9
N1	50%	2.9	550	680	0.29	353.6
N2	60%	3.7	556	686.9	0.20	127.3

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