Experimental Analysis of the Mechanical Properties of Aluminum-Based Alloy Metal

A thesis report submitted to the department of mechanical engineering for the partial fulfillment of the degree of Bachelor of Science in Mechanical Engineering

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APPROVAL

This is to certify that the project on " EXPERIMENTAL ANALYSIS OF MECHANICAL PROPERTIES OF ALUMINIUM, MAGNESIUM, ZINC AND LEAD ALLOY By (MD. Tipu Sultan ID No: BME 1602009131, MD. Selim Reza ID No: BME 1602009190, Tarun Chandra Kirtunia ID No: BME 1602009215, Kamrul Islam ID No: BME 1602009218) has been carried out under our supervision. The project has been carried out in partial fulfillment of the requirements of the degree of Bachelor of Science (B.Sc.) in Mechanical Engineering of years of 2020 and has been approved as to its style and contents.

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DECLERATION

We, hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of Md. Mahedy Hasan, Lecturer, Department of Mechanical Engineering, Sonargaon University (SU). We also declare that no part of this project and thesis has been or is being submitted elsewhere for the award of any degree.

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ABSTRACT

An Aluminum based alloy was manufactured and tested in this thesis using Pb (Lead), Mg (Magnesium), Zn (Zinc), along with Al (Aluminum) as the base alloy is three different compositions. For each of the compositions different tests were carried out individually ie. Tensile test, impact test and hardness test. From these experiments the alloy with most hardness and strength was found for specimen 03, where have maximum strength 64622.57 KN/m^2, Maximum hardness 67.75 HRN, Maximum impact force $117.6\ lbf$ was measured which was better than the base alloys. From the experimental studies, the optimum volume fraction of alloy reinforcement in this alloy on the basis of mechanical properties and testing analysis is also determined. The hardness test is a mechanical test for material properties which are used in engineering .design, analysis of structures, and materials development. The principal purpose of the hardness test is to determine the suitability of a material for a given application, or the particular treatment to which the material has been subjected. The ease with which the Hardness test can be made has made it the most common method of inspection for metals and alloys. A method for determining behavior of material subjected to shock loading in bending, tension, or torsion. The quantity usually measured is the energy absorbed in breaking the specimen in a single blow, as in the Tension Impact Test. Impact tests also are performed by subjecting specimens to multiple blows of increasing intensity. Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area.

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Chapter 1
General

1.1 Introduction

An alloy is a combination of a metal with at least one other metal or nonmetal. The combination must be part of a solid solution, a compound, or a mixture with another metal or nonmetal in order for it to be considered an alloy. The most common way to combine metals into an alloy is by melting them, mixing them together, and then allowing them to solidify and cool back to room temperature [1].

Although Aluminum alone isn't the strongest metal, it is used in combination with other metals to create conductive, heat and tarnish resistant alloys. Aluminum is used in many essential mechanical components including car engines, airplane body panels, and boat hulls

Introduction for 70 years, aluminum alloys have been the materials of choice for both military and commercial aircraft structures. The ingot metallurgy (IM) alloys of the 2000 (Al, Mg, Pb, Zn) and 7000 (Al, Mg, Pb, Zn) series used thus far show several disadvantages caused by the production process. Such problems are primarily coarse intermetallic constituent phases, coarse grains, and macro segregation, resulting in low fracture toughness [2].

Recent advances in aluminum alloy and temper development are maintaining aluminum alloys as the materials of choice for future commercial aircraft structures to meet cost and weight savings objectives. Aluminum producers have increased research activity in the area of advanced aluminum alloys to provide improved performance characteristics. During the past decade increased efforts have been made to improve the structural efficiency and properties of aerospace materials through the development of lighter weight, stiffer and stronger materials via rapid solidification processing (RSP) [3].

Rapid solidification processing improves the mechanical properties of many alloys in terms of increased tensile strength, ductility and fatigue and crack propagation resistance [5].

Such improvements are mainly associated with large solid solubility extensions of alloying elements, reduced macro segregation, refinement of the alloy grain size and changes in the second phase particle size, shape and distribution due to high cooling rates. There are a number of well-established techniques that may be readily utilized for rapid solidification. Alloys produced by atomization, one of the rapid solidification techniques, followed by powder metallurgy (PM) consolidation overcome the formation of coarse grains, coarse constituents, and macro segregation because of the high cooling rates [6].

Metal alloys are used because they typically have enhanced mechanical or chemical properties. Alloying elements can be added to a metal to increase a number of properties including hardness, strength, corrosion resistance, machinability and much more.

1.2 Objective:

The objectives of this thesis are

i) To study about different types of alloy.
ii) To composition of alloy using Al, Mg, Pb, Zn.
iii) To investigate different mechanical properties of this alloy.

Chapter 02

Literature Review:

2.1 Alloy:

An alloy is a combination of metals or a combination of one or more metals with non-metallic elements. For example, combining the metallic elements gold and copper produces red gold, gold and silver becomes white gold, and silver combined with copper produces sterling silver.

7000 series commercial Aluminum alloys offer some of the highest strength aluminum alloy material on the market. Our range of 7000 series aluminum is alloyed with zinc and can be precipitation hardened to provide the highest strength of all commercially available aluminum's. Used extensively in industries such as aerospace, our range is selected to meet the most stringent customer demands. Our material is fully traceable with all of our products carrying a unique barcode [8].

7000 series commercial aluminum alloys utilize zinc as the major alloying element and when combined with a smaller amount of magnesium, the result is a heat-treatable alloy which offers very high strength. 7075 for example, is one of the highest strength commercial aluminum alloys available and is used widely in applications such as high stressed parts and air frames. The corrosion resistance of the alloy is reduced due to the inclusion of zinc and magnesium, so copper is often introduced into the alloy to improve corrosion resistance. Applications for this range include critical parts used in the aerospace sector, automotive and sports equipment [11].

2.2 Types of alloy:

There are different types of alloy based on their base metal. Some of these are described below: Aluminum alloys, Nickel alloys, Stainless Steel Products, Gold alloys, Magnesium alloy and Copper alloys.

2.2.1 Aluminum Alloys:

Aluminum is not a very strong metal, but its conductive qualities make it useful for a variety of applications. For this reason, manufacturers mix aluminum with other metals to strengthen it, forming several different aluminum alloys. Alloy using aluminum include alnico, which contains nickel, iron and cobalt; magnesium, which contains magnesium and duralumin, also known as duralumin and duralumin, which contains copper and, in some instances, magnesium and manganese. While manufacturers use alnico in the production of magnets, they use magnesium primarily in instruments. Duralumin is often a component in car and aircraft engines. [14]

2.2.2 Copper Alloys:

The element copper is prone to oxidation, which makes it surface turn a dull, pale-greenish color. To prevent oxidation, and to increase its strength, manufacturers fuse copper with several different elements. One of the most common copper alloys is brass, which contains approximately 20 percent zinc. Manufactures often use the alloy for decorative items such as jewelry, as well as for nuts and bolts. Another common copper alloy is bronze, which contains about 10 percent tin. Nowadays, people commonly use bronze for making coins, statues and, as with copper, decorative items [14].

2.2.3 Stainless Steel alloy:

All steel alloys are actually made from iron and carbon. The carbon prevents the iron from oxidizing. Chromium and Nickel are added as well to produce stainless steel. There are four classes of alloy steel: structural steels, magnetic alloys, tool and die steels, and heat-resisting stainless steels. Consumers are very familiar with the last type since refrigerators, sinks, forks, knives, and my other products are made from stainless steel [14].

2.2.4 Gold Alloys:

As a soft metal, pure gold is easy to work. For this reason, jewelry makers often mix it with other elements to increase its strength. The most common gold alloys include yellow gold, which contains copper, silver and in some instances cobalt -- and white gold, which contains copper, zinc, nickel and, in some instances, palladium. All types of jewelry, such as rings, bracelets, necklaces and earrings consist of both these alloys.

2.3 Alloy makeup procedure:

When considering working and manufacturing with metals, particularly with aluminum, the first thoughts are centered on the heating process with hot furnaces where the metal is heated to extremely high temperatures and then wrought or cast into form. However, there is another type of process to strengthen the metal that involves adding other alloys to pure aluminum and then working the metal without using heat. This method is called cold working. Cold working is done to create vacancies and dislocations in the structure of the aluminum and alloying element. These deformations cause permanent defects in the crystalline makeup of the material by inhibiting movement made by the atoms. Once the atoms cannot move, the alloy actually increases in strength because it is resistant to further deformation. While the aluminum increases in strength and hardness, it does lose some ductility. Cold forming is performed through several different forging and rolling methods. The methods can involve squeezing, bending, shearing and drawing the aluminum alloy. One of the most common ways to harden aluminum is through cold rolling as the metal is reduced in thickness by being passed through rollers while being compressed. A second method is called drawing. Drawing is where the aluminum alloy is pulled through a small die until its diameter is reduced. A third method involves bending as the aluminum's geometry is changed by deforming the alloy over a work axis. So the aluminum alloy becomes strengthened without changing the volume of the metal as instead the shape of the aluminum is changed.7000 series refer to the aluminum material used in certain Apple Watch models including 1st generation, Series 1 and Series 2 models.

2.4 Applications of different alloys in modern technologies:

Apple Watch (1st generation) models have a single core processor. Newer models - in the Series 1 and Series 2 ranges - have a faster, dual-core processor. Series 2 models also have: A higher level of water resistance. The watch can be worn, for example, when shallow water swimming and is also more resistant to water than other models during general daily use. A brighter display (twice as bright as 1st generation and Series 1 models). Built-in GPS. This can be used to track workout route maps for certain outdoor workouts when the paired iPhone is not also taken along and can also be used to help locate a lost watch. Aluminum models have Ion-X glass (these watches are lighter in weight than stainless steel models of the same case size). Stainless steel watches have a sapphire crystal, which is more scratch resistant than Ion-X glass. All Apple Watch models are able to run the latest software (watch OS) version. You may find the following resources helpful when choosing an Apple Watch:

2.5 Experimental Method:

The alloys, namely SS70, N707 and 7075, investigated in the present study were produced by Alcan Osprey Ltd. at Bunbury, UK using the spray deposition process. SS70 was spray cast as a cylindrical preform with a diameter of 240 mm and height of 1100 mm and extruded down to a 25 mm diameter rod. The N707 was also spray cast as a preform, which was 235 mm in diameter and 790 mm in height, extruded down to a 63 x 25 mm rectangular section. The 7075 alloy was similarly processed; i.e. spray cast to a ∼240 mm diameter cylindrical preform and extruded to a 65 x 30 mm rectangular section [5].

Chapter 03

Methodology

3.1 Manufacturing Process:

First, the bauxite ore is mechanically crushed. Then, the crushed ore is mixed with caustic soda and processed in a grinding mill to produce a slurry (a watery suspension) containing very fine particles of ore. The slurry is pumped into a digester, a tank that functions like a pressure cooker. The slurry is heated to 230-520°F (110-270°C) under a pressure of 50 lb/in ^{2} (340 kPa). These conditions are maintained for a time ranging from half an hour to several hours. Additional caustic soda may be added to ensure that all aluminum-containing compounds are dissolved.

Fig 3.1.1: Crucible Furnace

The hot slurry, which is now a sodium aluminate solution, passes through a series of flash tanks that reduce the pressure and recover heat that can be reused in the refining process.

The slurry is pumped into a settling tank. As the slurry rests in this tank, impurities that will not dissolve in the caustic soda settle to the bottom of the vessel. One manufacturer compares this process to fine sand settling to the bottom of a glass of sugar water; the sugar does not settle out because it is dissolved in the water, just as the aluminum in the settling tank remains dissolved in the caustic soda. The residue (called "red mud") that accumulates in the bottom of the tank consists of fine sand, iron oxide, and oxides of trace elements like titanium.

After the impurities have settled out, the remaining liquid, which looks somewhat like coffee, is pumped through a series of cloth filters. Any fine particles of impurities that remain in the solution are trapped by the filters. This material is washed to recover alumina and caustic soda that can be reused.

The filtered liquid is pumped through a series of six-story-tall precipitation tanks. Seed crystals of alumina hydrate (alumina bonded to water molecules) are added through the top of each tank. The seed crystals grow as they settle through the liquid and dissolved alumina attaches to them.

Fig 3.1.2: Casting Mold

The crystals precipitate (settle to the bottom of the tank) and are removed. After washing, they are transferred to a kiln for clenching (heating to release the water molecules that are chemically bonded to the alumina molecules). A screw conveyor moves a continuous stream of crystals into a rotating, cylindrical kiln that is tilted to allow gravity to move the material through it. A temperature of 2,000° F (1,100° C) drives off the water molecules, leaving anhydrous (waterless) alumina crystals. After leaving the kiln, the crystals pass through a cooler.

3.2 Description of lathe operation Before Testing Metal:

3.2.1 Turning:

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix tool path by moving more or less linearly while the work piece rotates. Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces (holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of processes known as lathing. The cutting of faces on the work piece, whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset.

Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is computer numerical control, better known as CNC.

The general process of turning involves rotating a part while a single-point cutting tool is moved parallel to the axis of rotation.[1] Turning can be done on the external surface of the part as well as the internal surface (the process known as boring). The starting material is generally a work piece generated by other processes such as casting, forging, extrusion, or drawing.

3.2.2 Tapered turning:

Tapered turning produces a cylindrical shape that gradually decreases in diameter from one end to the other. This can be achieved a) from the compound slide b) from taper turning attachment c) using a hydraulic copy attachment d) using a C.N.C. lathe e) using a form tool f) by the offsetting of the tailstock - this method more suited for shallow tapers.

3.2.3 Spherical generation:

Spherical generation produces a spherical finished surface by turning a form around a fixed axis of revolution. Methods include a) using hydraulic copy attachment b) C.N.C. (computerized numerically controlled) lathe c) using a form tool (a rough and ready method) d) using bed jig (need drawing to explain).

3.2.4 Facing:

Facing on the lathe uses a facing tool to cut a flat surface perpendicular to the work piece's rotational axis. A facing tool is mounted into a tool holder that rests on the carriage of the lathe. The tool will then feed perpendicularly across the part's rotational axis as it spins in the jaws of the chuck. A user will have the option to hand feed the machine while facing, or use the power feed option. For a smoother surface, using the power feed option is optimal due to a constant feed rate. Facing will take the work piece down to its finished length very accurately. Depending on how much material needs to be taken off, a machinist can choose to take roughing or finishing cuts. [1] Factors that affect the quality and effectiveness of facing operations on the lathe are speeds and feeds, material hardness, cutter size, and how the part is being clamped down.

3.2.5 Thread cutting:

Thread cutting, as compared to thread forming and rolling, is used when full thread depth is required, when the quantity is small, when the blank is not very accurate, when threading up to a shoulder is required, when threading a tapered thread, or when the material is brittle.

3.2.6 Taps and dies:

A common method of threading is cutting with taps and dies. Unlike drill bits, hand taps do not automatically remove the chips they create. A hand tap cannot cut its threads in a single rotation because it creates long chips which quickly jam the tap (an effect known as "crowding" possibly breaking it. Therefore, in manual thread cutting, normal wrench usage is to cut the threads 1/2 to 2/3 of a turn (180 to 240 degree rotation), then reverse the tap for about 1/6 of a turn (60 degrees) until the chips are broken by the back edges of the cutters. It may be necessary to periodically remove the tap from the hole to clear the chips, especially when a blind hole is threaded.

For continuous tapping operations (i.e., power tapping) specialized spiral point or "gun" taps are used to eject the chips and prevent crowding.

Single-point threading

Single-point threading, also colloquially called single-pointing (or just thread cutting when the context is implicit), is an operation that uses a single-point tool to produce a thread form on a cylinder or cone. The tool moves linearly while the precise rotation of the work piece determines the lead of the thread. The process can be done to create external or internal threads (male or female). In external thread cutting, the piece can either be held in a chuck or mounted between two centers. With internal thread cutting, the piece is held in a chuck. The tool moves across the piece linearly, taking chips off the work piece with each pass. Usually 5 to 7 light cuts create the correct depth of the thread.

The coordination of various machine elements including leadscrew, slide rest, and change gears was the technological advance that allowed the invention of the screw-cutting lathe, which was the origin of single-point threading as we know it today.

Today engine lathes and CNC lathes are the commonly used machines for single-point threading. On CNC machines, the process is quick and easy (relative to manual control) due to the machine's ability to constantly track the relationship of the tool position and spindle position (called "spindle synchronization"). CNC software includes "canned cycles", that is, preprogrammed subroutines that obviate the manual programming of a single-point threading cycle. Parameters are entered (e.g., thread size, tool offset, length of thread), and the machine does the rest. All threading could feasibly be done using a single-point tool, but because of the high speed and thus low unit cost of other methods (e.g., tapping, die threading, and thread rolling and forming), single-point threading is usually only used when other factors of the manufacturing process happen to favor it (e.g., if only a few threads need to be made, if an unusual or unique thread is required, or if there is a need for very high concentricity with other part features machined during the same setup.

3.3 Materials:

The materials used for making the alloy are: Aluminum (Al) Magnesium (Mg), Lead (Pb), Zinc (Zn). Their properties are given below.

3.3.1 Materials and their properties:

Properties of Aluminum (Al): are given below.

Table 01: Properties of Aluminum

Property	Value
Melting Point	660ºC
Density	2.70 g/cm³
Thermal Expansion	$23.5\times 10^{-6}/K$
Thermal Conductivity	201 W/mK
Electrical Resistivity	0.033×10^{-6} Ohom.m
Modulus of Elasticity	69.5 GPa

Fig 3.3.1.1: Aluminum (Al)

Properties of Magnesium (Mg) are given below

Table 02: Properties of Magnesium

Property	Value
Melting Point	650ºc
Density	1.738 G/Cm³
Thermal Conductivity	160 W/mK
Electrical Resistivity	43.9 nΩ·m
Modulus Of Elasticity	37 Gpa
Bending Stress	160-240 MPa
Density	1.738 g/cm^3

Fig 3.3.1.2: Magnesium (Mg)

Properties of Lead (Pb) are given below

Table 03: Properties of Lead (Pb)

Property	Value
Melting Point	327.5ºC
Density	11.34 g/cm³
Thermal Conductivity	34.7 W/mK
Electrical Resistivity	22 Ohom.m
Modulus of Elasticity	14 GPa

Fig 3.3.1.3: Lead (Pb)

Properties of Zinc (Zn) are given below

Table 04: Properties of Zinc (Zn)

Property	Value
Melting Point	419.5ºC
Density	7.14 g/cm³
Thermal Conductivity	61 W/mK
Electrical Resistivity	5.5×10^{-8} Ohom.m
Modulus of Elasticity	14 GPa

Fig 3.3.1.4: Zinc (Zn)

3.4 Alloy Casting Procedure:

In sand casting, re-usable, permanent patterns are used to make the sand molds. The preparation and the bonding of this sand mold are the critical step and very often are the rate-controlling step of this process. Two main routes are used for bonding the sand molds:

The "green sand" consists of mixtures of sand, clay and moisture.

The "dry sand" consists of sand and synthetic binders cured thermally or chemically.

The sand cores used for forming the inside shape of hollow parts of the casting are made using dry sand components.

This versatile technique is generally used for high-volume production. An example of half sand mold is given in Figure 1.

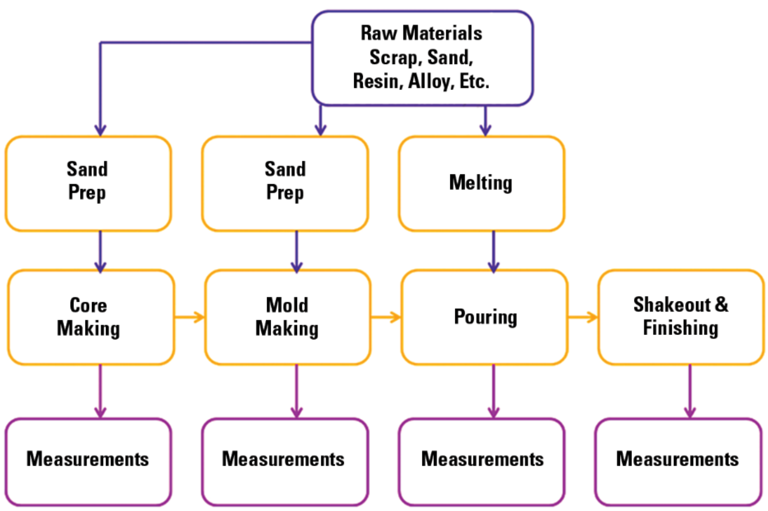

Fig 3.4.1: Casting flowchart

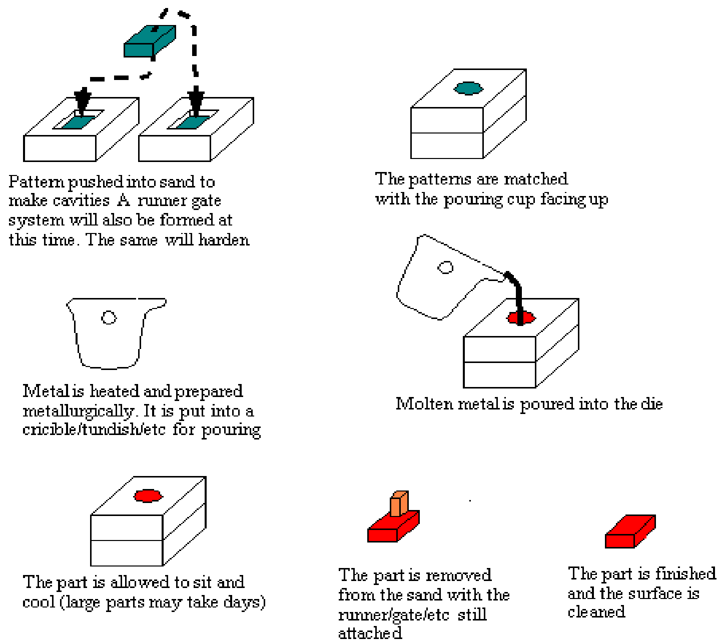

Fig 3.4.2: Sand Casting mold

3.5 Compositions used:

Three different compositions were used to make three alloys. Their composition are as follows,

a. Specimen 01:

Table No 05: Percentage of 1st composition

METALS	Weight Percent
Al	65%
Mg	10%
Pb	10%
Zn	15%

b. Specimen 02:

Table No 06: Percentage of 2nd composition

METALS	Weight Percent
Al	45%
Mg	20%
Pb	15%
Zn	20%

c. Specimen 03:

Table No 07: Percentage of 3rd composition

METALS	Weight Percent
Al	50%
Mg	15%
Pb	15%
Zn	20%

3.6 Alloy testing:

Metal testing is a process or procedure used to check composition of an unknown metallic substance. There are destructive processes and nondestructive processes. Metal testing can also include, determining the properties of newly forged metal alloys. With many chemical-property databases readily available, identification of unmarked pure, common metals can be a quick and easy process. Leaving the original sample in complete, re-usable condition. This type of testing is nondestructive. When working with alloys (forged mixtures) of metals however, to determine the exact composition, could result in the original sample being separated into its starting materials, then measured and calculated. After the components are known they can be looked up and matched to known alloys. The original sample would be destroyed in the process [8].

3.7 Tensile Test:

The ultimate tensile stress is the maximum stress that a specimen is exposed to during testing. This may differ from the specimen's Properties. Strength when breaking depending on if it is brittle, ductile or has properties of both. These material properties can change depending on environment, for example in extreme hot or cold conditions.

1. Modulus of Elasticity
2. Yield Strength
3. Offset Method
4. Alternate Moduli

3.7.1 Tensile Specimen Preparation:

Tensile test specimens are prepared in a variety of ways depending on the test specifications. The most commonly used specifications are BS EN ISO 6892-1 and ASTM E8M. Most specimens use either a round or square standard cross section with two shoulders or a reduced section gauge length in between. The shoulders allow the specimen to be gripped while the gauge length shows the deformation and failure in the elastic region as it is stretched under load. The reduced cross section gauge length of specific dimensions assists with accurate calculation of engineering stress via load over area calculation [10].

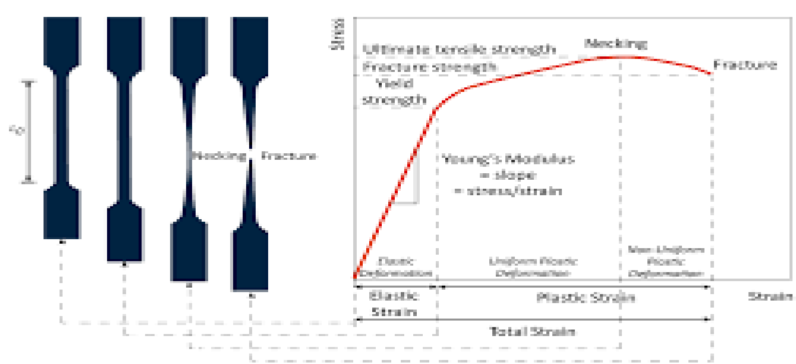

Fig 3.7.1.1: Stress & strain curve

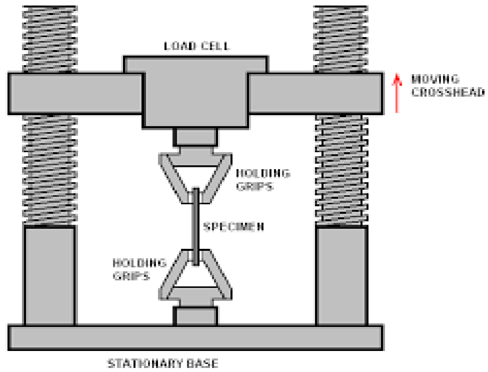

Fig 3.7.1.2: Tensile testing procedure

3.8 Hardness Test:

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material.

3.8.1 Rockwell Hardness Testing:

The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. First, a preliminary test force (commonly referred to as preload or minor load) is applied to a sample using a diamond or ball indenter. This preload breaks through the surface to reduce the effects of surface finish. After holding the preliminary test force for a specified dwell time, the baseline depth of indentation is measured.

After the preload, an additional load, call the major load, is added to reach the total required test load. This force is held for a predetermined amount of time (dwell time) to allow for elastic recovery. This major load is then released, returning to the preliminary load. After holding the preliminary test force for a specified dwell time, the final depth of indentation is measured. The Rockwell hardness value is derived from the difference in the baseline and final depth measurements. This distance is converted to a hardness number. The preliminary test force is removed and the indenter is removed from the test specimen.

Test Method Illustration

A = Depth reached by indenter after application of preload (minor load)

B = Position of indenter during Total load, Minor plus Major loads

C = Final position reached by indenter after elastic recovery of sample material

D = Distance measurement taken representing difference between preload and major load position. This distance is used to calculate the Rockwell Hardness Number.

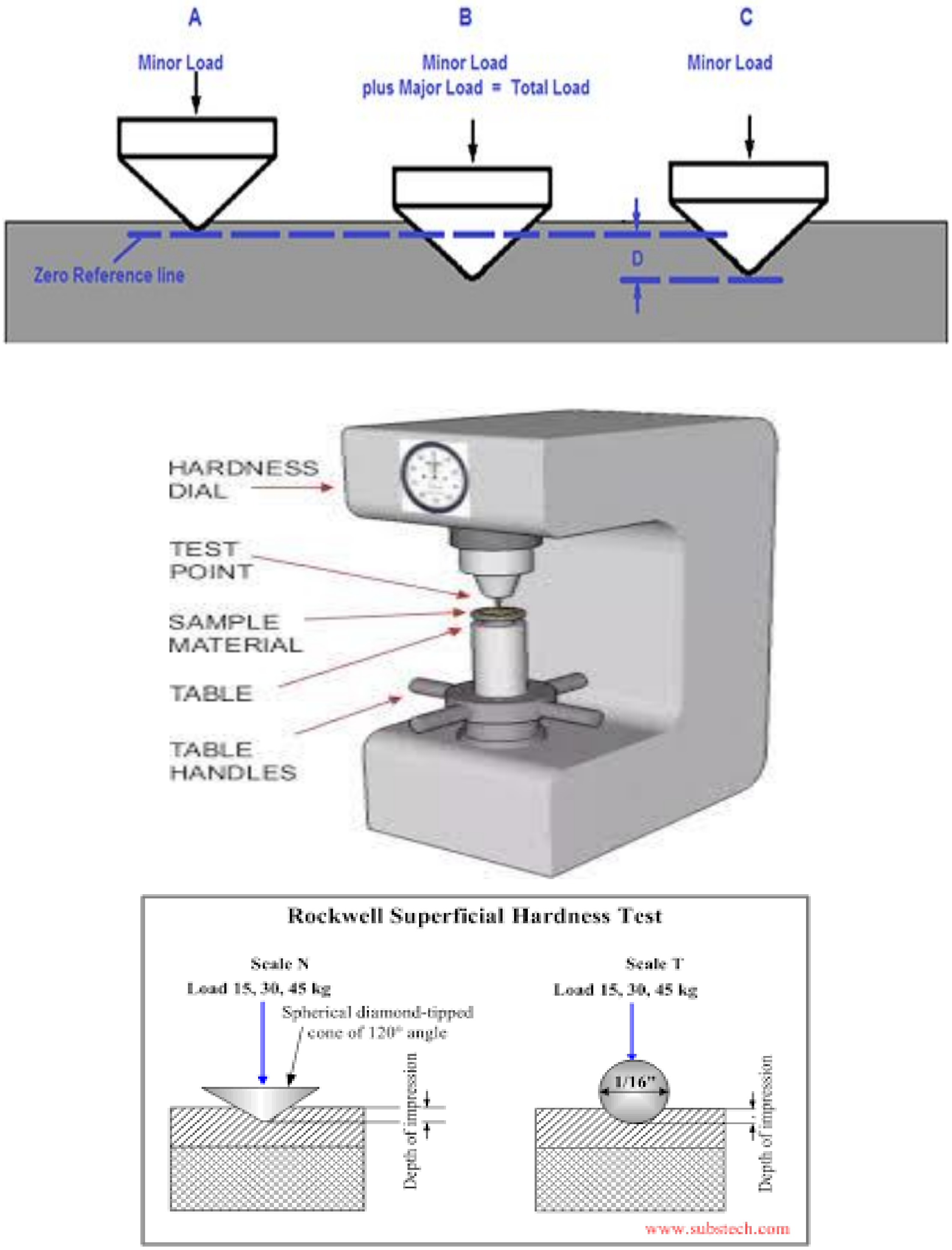

Fig 3.8.1.1: Hardness Test

3.9 Impact Test:

An impact test is used to observe the mechanics that a material will exhibit when it experiences a shock loading that causes the specimen to immediately deform, fracture or rupture completely. To perform this test, the sample is placed into a holding fixture with the geometry and orientation determined by the type of test that is used and then a known weight generally but not always in the shape of a pendulum is released from a known height so that it collides with the specimen with a sudden force. This collision between the weight and specimen generally results in the destruction of the specimen but the transfer of energy between the two is used to determine the fracture mechanics of the material.

a. Purpose of impact testing:

The purpose of an impact test is to determine the ability of the material to absorb energy during a collision. This energy may be used to determine the toughness, impact strength, fracture resistance, impact resistance or fracture resistance of the material depending on the test that was performed and the characteristic that is to be determined. These values are important for the selection of materials that will be used in applications that require the material to undergo very rapid loading processes such as in vehicular collisions.

b. Types of impact tests:

For a single impact test the three most popular types of test are the Charpy V-notch test, the Izod test and the Tensile Impact test. These three tests all essentially determine the same characteristics of the material but differ in the orientation of the test sample which causes the sample to be stressed in different directions and involve a known weight released from a known height colliding with the specimen in its test fixture. All of these tests are useful in determining the impact mechanics of the test specimen.

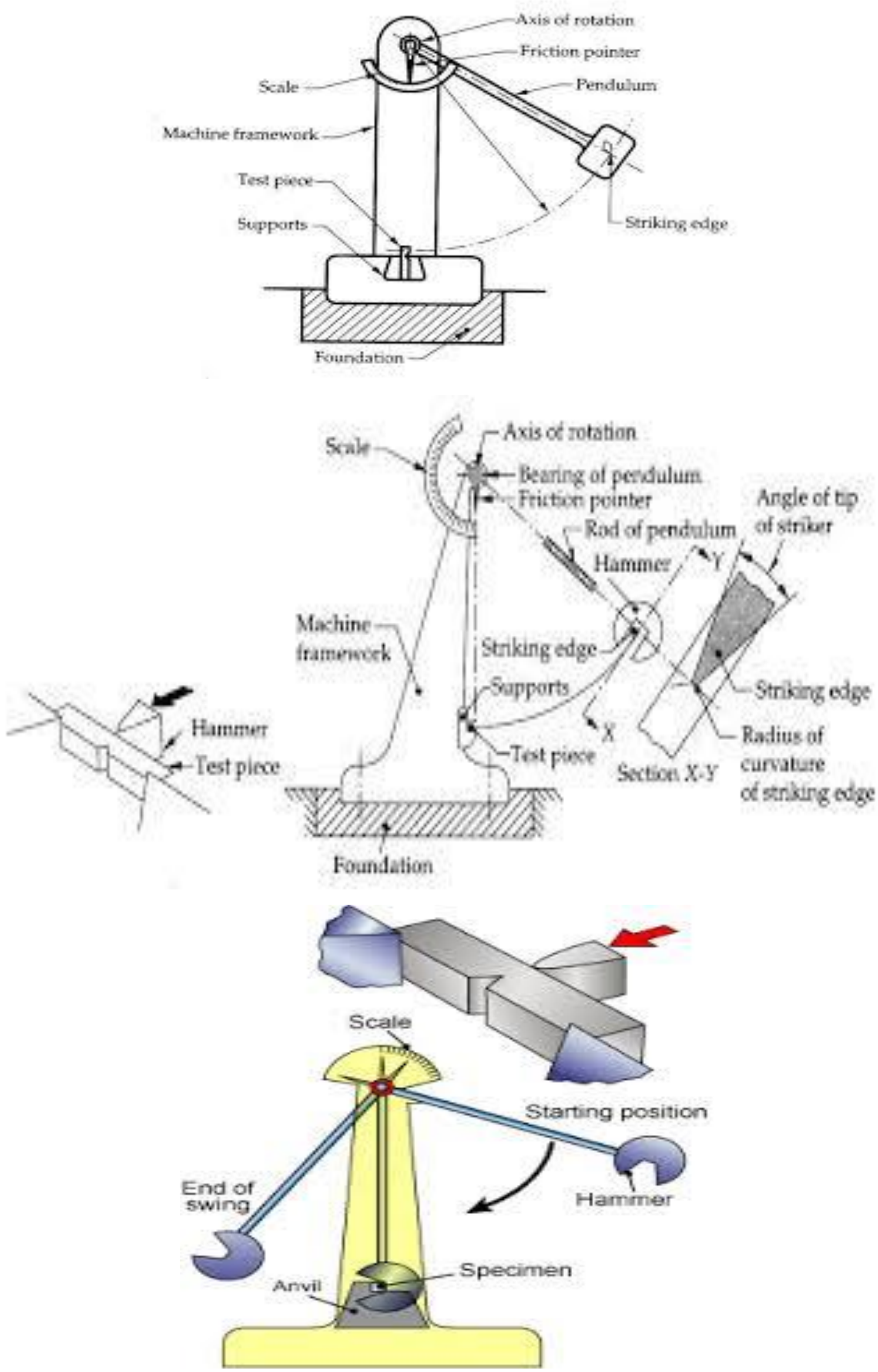

Fig 3.9.1: Impact Test

Chapter 4

Result and discussion

4.1 Result:

4.1.1 Specimen type: 01

Three tests were performed on specimen test 01. The details of the test are given below:

a) Impact Test:

The impact test was performed on impact testing machine.

For simple beam,

30 lbf,

32 lbf,

So, the average impact force is = $\frac{30+32}{2} = 31\ lbf$ or, 42 Nm

For cantilever beam

20 lbf,

23 lbf,

So, the average impact force is = $\frac{20+23}{2} = 21.5\ lbf$ or, 29.15 Nm

b) Tensile Test:

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 2kN and the material failed at 5kN. So, from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times 10^{-4}$

$= \frac{5\times10^3}{1.43\times10^{-4}}$

So, Stress,σ = 34931.126 KN/m²

Again,

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 2.5kN and the material failed at 6kN. So from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times\ 10^{-4}\ m^2$

$\sigma = \frac{6\times10^3}{1.43\times\ 10^{-4}}$

So, Stress, σ = 41917.35127 KN/m²

So, the average Stress, $\sigma = \frac{34931.126\ +41917.35127}{2} = 38424.23864\ KN/\text{m}^2$

c) Hardness Test:

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 01 was carried out twice and the results obtained were 60 HRN, 63 HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 01 = $\frac{60+63}{2}$ = 61.5 HRN

Again,

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 01 was carried out twice and the results obtained were 65 HRN, 68 HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 01 = $\frac{65+68}{2}$ = 66.5 HRN

So, the average HRN for specimen 01 = $\frac{61.5 + 66.5}{2}$ = 64 HRN

4.1.2 Specimen type: 02

a) Impact test (Impact Testing Machine):

The impact test was performed on impact testing machine. For surface tension rod the impact force at which the specimen fails are found at:

For simple beam,

34 lbf,

36 lbf,

So the average impact force is = $\frac{34+36}{2} = 35\ lbf$ or, 47.45 Nm

For cantilever beam,

24 lbf,

26 lbf,

So, the average impact force is = $\frac{24+26}{2}$ =25 lbf or, 33.89 Nm

b) Tensile Test (UTM):

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 3KN and the material failed at 8KN. So from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times 10^{-4}\ m^2$

$= \frac{8\times10^3}{1.43\times 10^{-4}}$

So, Stress, σ = 55889.8 KN/m²

Again,

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 3.5KN and the material failed at 9 kN. So, from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times 10^{-4}\ m^2$

$= \frac{9\times10^3}{1.43\times 10^{-4}}$

So, Stress,σ = 62876 KN/m²

So, the average Stress, $\delta = \frac{55889.8 + 62876}{2} = 59382.9\ KN/\text{m}^2$

c) Hardness Test (Rockwell Hardness Testing Machine):

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 02 was carried out twice and the results obtained were 62 HRN, 64 HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 02 = $\frac{62+64}{2}$ = 63 HRN

Again,

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 02 was carried out twice and the results obtained were 67 HRN, 70 HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 02 = $\frac{67+70}{2}$ = 68.5 HRN

So, the average HRN for specimen 01 = $\frac{63 + 68.5}{2}$ = 65.75 HRN

4.1.3 Specimen type: 03

a) Impact test (Impact Testing Machine):

The impact test was performed on impact testing machine. For surface tension rod the impact force at which the specimen fails are found at:

For simple beam,

36 lbf,

38 lbf,

So, the average impact force is = $\frac{36+38}{2} = 37\ lbf$ or, 50.17 Nm

For cantilever beam,

26 lbf,

28 lbf,

So, the average impact force is = $\frac{26+28}{2}$ =27 lbf or, 36.6 Nm

b) Tensile Test (UTM):

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 4KN and the material failed at 9KN. So from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times\ 10^{-4}\ \ m^2$

$= \frac{9 \times 10^3}{1.43 \times\ 10^{-4}}$

So, Stress, σ = 62876 KN/m²

Again,

The tensile test was performed on Universal Testing Machine (UTM). For this test the diameter of the material was 13.5 mm. Necking of the material started at about 4.5KN and the material failed at 9.5 KN. So, from the formula of stress we know that,

Stress, $\sigma = \frac{\text{Load}}{\text{Area}}$

Now, Area = $\frac{\pi}{4} \times d^2$

$= \frac{\pi}{4} \times (0.0135)^2$

$= 1.43 \times 10^{-4}\ m^2$

$= \frac{9.5 \times 10^3}{1.43 \times 10^{-4}}$

So, Stress, σ = 66369.14 KN/m²

So, the average Stress, $\sigma = \frac{62876+66369.14}{2} = 64622.57\ KN/\text{m}^2$

c) Hardness Test (Rockwell Hardness Testing Machine):

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 03 was carried out twice and the results obtained were 64HRN, 66 HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 03 = $\frac{64+66}{2}$ = 65 HRN

Again,

Rockwell hardness test of the specimen was performed on Rockwell Hardness Testing Machine. For this machine the diameter of the steel ball was 0.0625 inch and load applied on the specimen was 100 kg for 3 minutes. The test on the specimen 03 was carried out twice and the results obtained were 69 HRN, 72HRN. So, the average Rockwell hardness number (HRN) for specimen was

HRN for specimen 03 = $\frac{69+72}{2}$ = 70.5 HRN

So, the average HRN for specimen 03 = $\frac{65+70.5}{2}$ = 67.75 HRN

So, the total results of the tests in a nutshell

Table No 08: Summary of test results

Specimen Type	**Hardness test**	**Impact test**		**Tension test**
		Simple beam	Cantilever beam	
01	64 HRN	42 Nm	29.15 Nm	$38424.23864\ KN/\mathrm{m}^2$
02	65.75 HRN	47.45 Nm	33.89 Nm	$59382.9\ KN/\mathrm{m}^2$
03	67.75 HRN	50.17 Nm	36.6 Nm	$64622.57\ KN/\mathrm{m}^2$

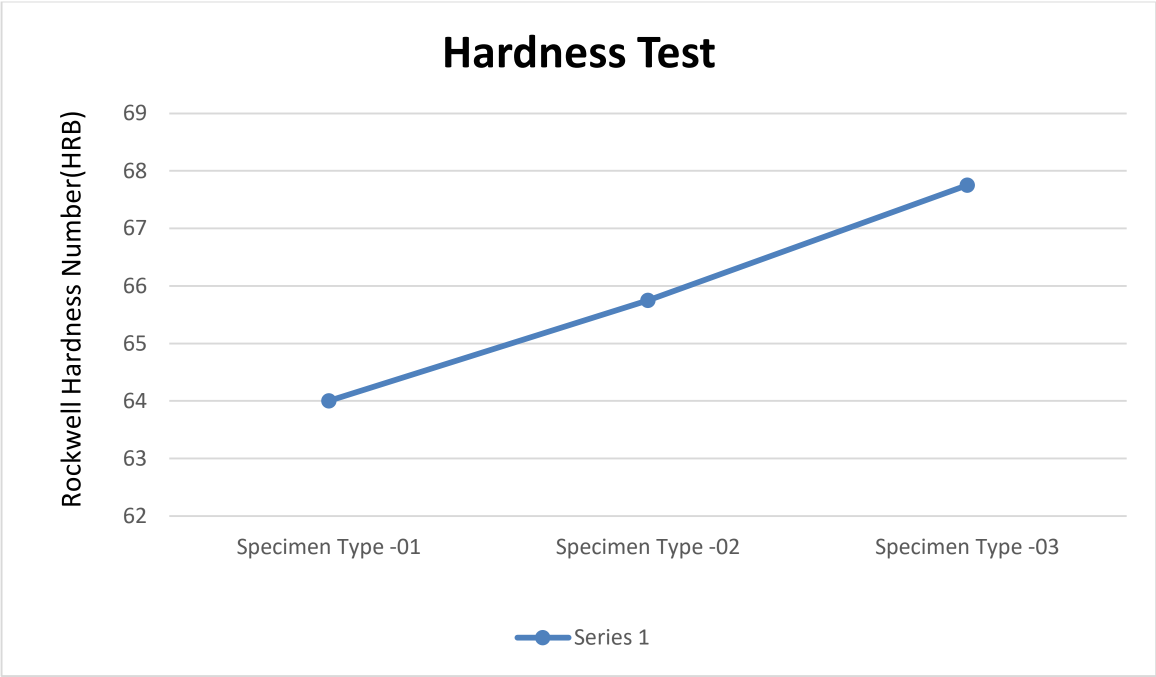

Fig- G.1: Variation of Rockwell Hardness number for different specimen

Description of Hardness Test Graph:

The chart value shown that the Specimen type-03 metal is more hard to others specimen. So we can prefer specimen type-3 metal for more load used.

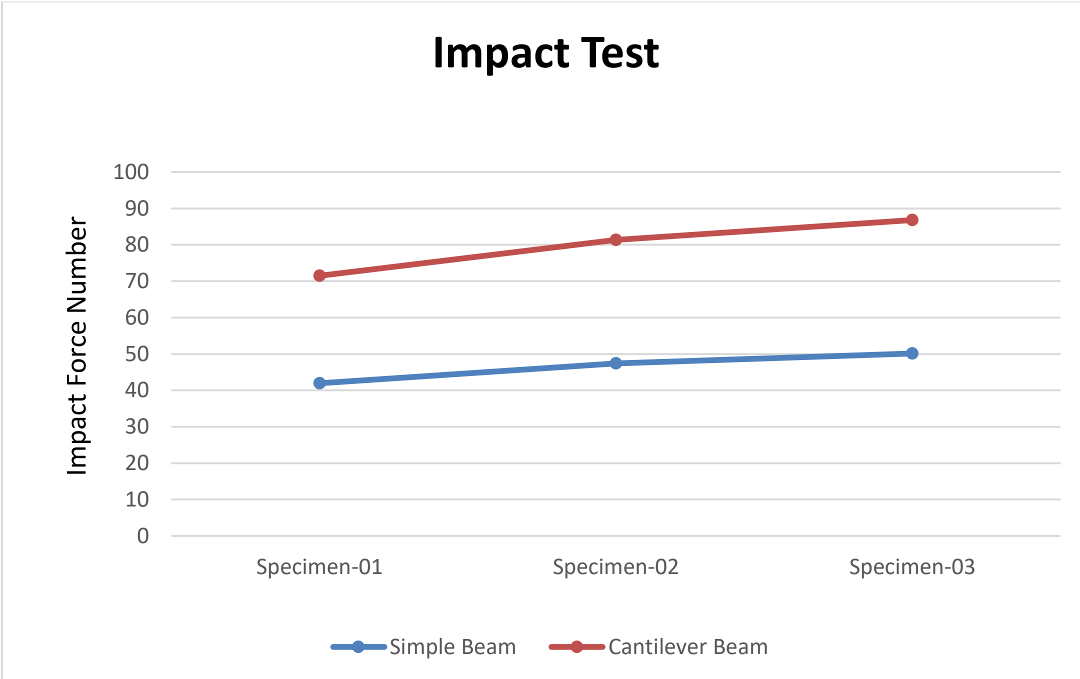

Fig-G.2: Variation of Impact force for different specimen

Description of Impact Test Graph:

Specimen type-03 metal is absorb more impact force to others specimen. So we can prefer specimen type-3 metal used for more impact force where need it.

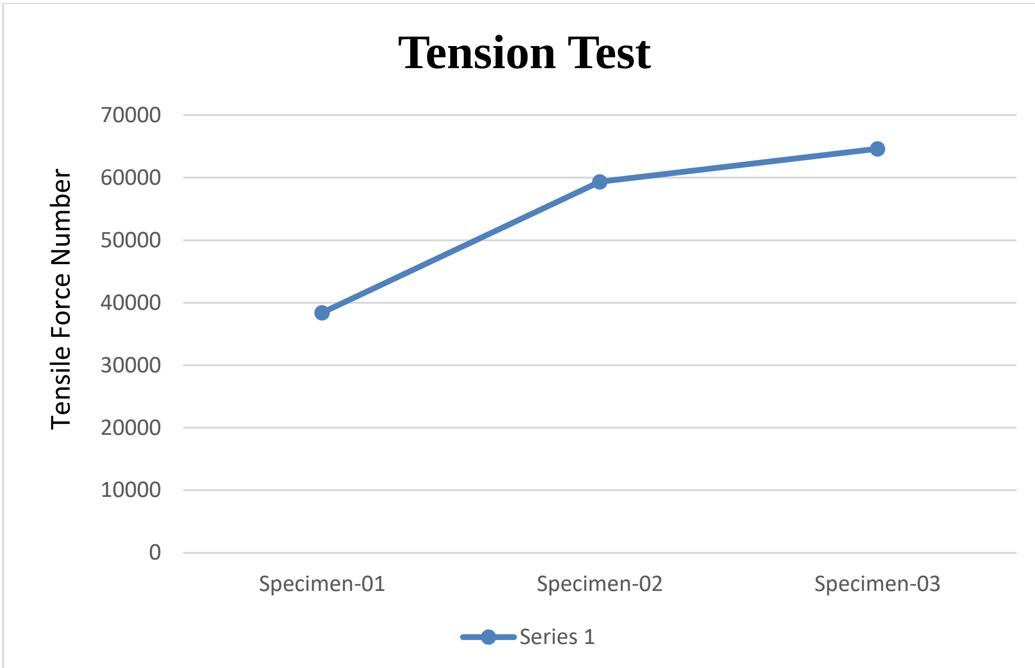

Fig –G.3: Variation of tensile force for different specimen

Description of Tensile Test Graph: Specimen type-03 metal is absorb more tensile force to others specimen. So we can prefer specimen type-3 metal used for more tensile force where need it.

Rockwell hardness number & Brinell hardness number Conversion: We are found the direct conversion chart [20] of Rockwell hardness number to brinell hardness number. That's the conversion chart are,

Table No 09: Conversion between Rockwell & Brinell hardness number

Specimen number	Rockwell hardness number	Brinell hardness number
1	64 HRN	722
2	65.75 HRN	749
3	67.75 HRN	797

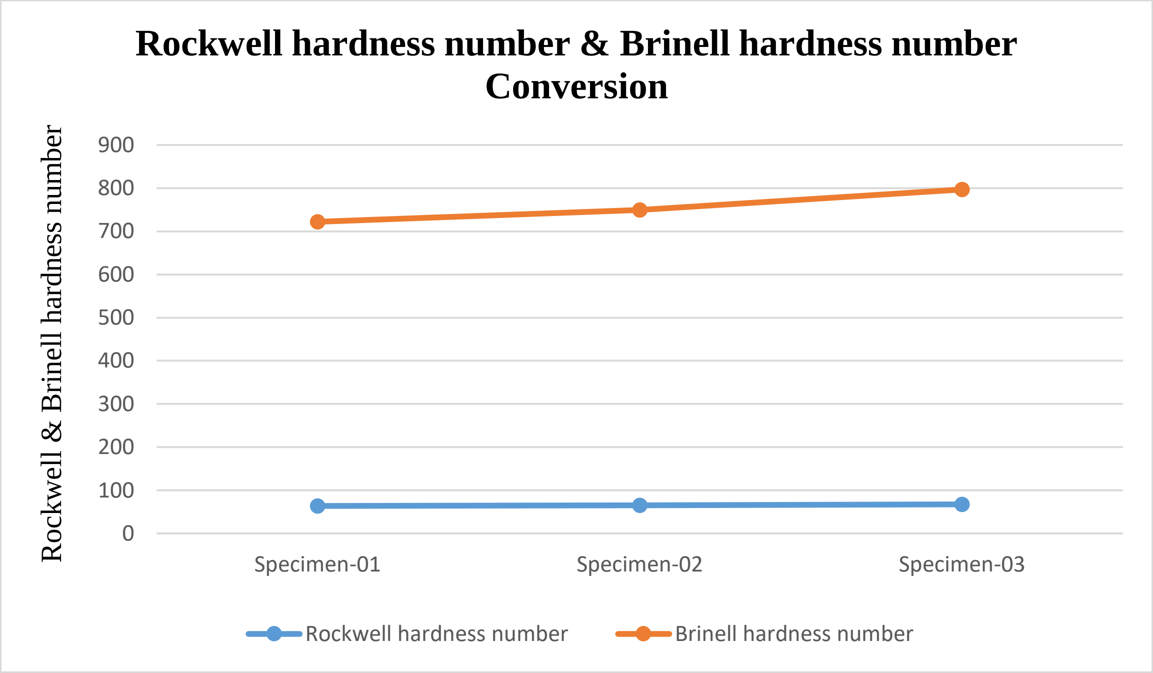

Fig -G.4: Rockwell & Brinell hardness number Conversion graph

4.2 Strain value:

We could not determine strain value for our experiment. Main reason behind this is the type of base metal we used i.e. Aluminum, Zinc, Lead, Magnesium. These metals ruptured at around 5 kN, hence we could not manage to determine strain value at required force

4.3 Discussion:

Hardness, impact and tensile test was performed on Al based alloy on three different compositions. For the different tests different results were obtained. From the results we can see that specimen type 01 for average hardness test 64 HRN, Maximum impact 96.26 Nm, average Tensile strength $38424.23864\ KN/\mathrm{m}$. Then specimen type 02 for average hardness test 65.75 HRN, Maximum impact 116.6 Nm, average Tensile strength $9382.9\ KN/\mathrm{m}^2$. Then specimen type 03 for average hardness test 67.75 HRN, Maximum impact 117.96 Nm, average Tensile strength $64622.57\ KN/\mathrm{m}^2$.The aim of this thesis was to make an alloy with most hardness that can withstand a great amount of load. So, the specimen type 03 meets the demand.

Chapter 5

Conclusion

Alloys were manufactured using different compositions using Aluminum (Al), Magnesium (Mg), Lead (Pb) and Zinc (Zn). These alloys were subjected to three different tests ie. Tensile test, impact test and harness test and from this test we obtained their mechanical properties. Also, we found that the specimen type (3) to be the best of all of our specimens.

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