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EXPERIMENTAL ANALYSIS OF MECHANICAL PROPERTIES OF DIFFERENT TYPES BRASS ALLOY

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Abstract*-An Experimental study was conducted to evaluate the enhancement of mechanical properties of different type of brass using various types of specimen (rectangular cube, cylindrical shape). In this experiment, there are 3 types of brass used with corresponding composition of Al brass (cu72%, zn22% ,Al2%), Red brass (cu85%, zn5%, sn5%, pb5%) and Lead Brass (cu60%, zn38%, pb2%). The experimental specimen are fabricated by using different chemical components of alloy brass and then the mechanical properties includes tensile strength, impact strength and hardness number (Brinell hardness) of brass alloy are to be measured. The results show that the mechanical and other relevant properties of brass depends on the composition and their solidification processes (melting, hot rolling, annealing & cold rolling, finish rolling). Properties of new brass alloy is different from original brass with different physical colour. Hardness number and energy absorption capacity is higher in aluminium brass. Stress-strain relationship is also developed here (For brittle material). This experimental investigation will definitely provide much helpful information while contributing to the knowledge about the mechanical properties of different type's brass in practical field or the field of manufacturing.*

Keywords: *Brass alloy; Brinell hardness number; Impact Strength; Stress-strain Diagram.*

1.INTRODUCTION

Modern world concentrates on the alloy material in which properties of alloy material can be tailored according to appointed requirements. Recently, there has been a remarkable growth in interest in alloy materials because for limited sources of material and using them for large number of population. Consequently, huge number of researchers are giving time into converting trite alloy materials to make them more user-friendly and into designing new alloy materials by mixing new element in them. Mixture of copper and zinc gives brass alloy. It is one kind of substitutional alloy. Adding new element to brass alloy changes its physical and chemical properties. Different procedure are performed for determining mechanical properties of brass alloy. Helps to select a better material for usual or industry purpose. By keeping fixed copper and zinc with other materials different types of brass alloy are produced. Metal displacement process i.e. microstructure is also changed with adding new material in brass alloy.

This investigation are performed for check manually the potentiality of metal when combining with others. We can easily calculated every mechanical value for that alloy. First, we have to select our goal properly then match it with newly formed alloy. Melting and solidification should be done very carefully so that exact amount are added and no foreign metal can mixed with it. This is the most effective process for evaluating alloy material properties. Nowadays it is one of the most important topics to minimizing the material cost.

Although forms of brass have been in use since prehistory[1], its true nature as a copper-zinc alloy was not understood until the post medieval period because the zinc vapor which reacted with copper to make brass was not recognized as a metal[2]. The king james bible makes many references to brass [3]. The Shakespearean English form of the word bra ss can mean any bronze alloy, or copper, rather than the strict modern definition of brass. The earliest brasses may have been natural alloys made by smelting zinc-rich copper ores[4].By the Roman period brass was being deliberately produced from metallic copper and zinc minerals using the cementation process, and variations on this method continued until the mid-19th century[5].It was eventually replaced by speltering, the direct alloying of copper and zinc metal which was introduced to Europe in the 16th century.

By the 15th century there is evidence for the renewed use of lidded cementation crucibles at Zwickau in Germany. These large crucibles were capable of producing c.20 kg of brass. There are traces of slag and pieces of metal on the interior. Their irregular composition suggests that this was a lower temperature, not entirely liquid, process. The crucible lids had small holes which were blocked with clay plugs near the end of the process presumably to maximize zinc absorption in the final stages. Triangular crucibles were then used to melt the brass for casting[6].

16th-century technical writers whom are very special, such as as Biringuccio, Ercker and Agricola described a variety of cementation brass making techniques and came closer to understanding the true nature of the process noting that copper became heavier as it changed to brass and that it became more golden as additional calamine was added. Zinc metal was also becoming more commonplace. By 1513 metallic zinc ingots from India and China were arriving in London and pellets of zinc condensed in furnace flues at the Rammelsberg in Germany were exploited for cementation brass making from around 1550.

Eventually it was discovered that metallic zinc could be alloyed with copper to make brass, a process known as speltering[7] and by 1657 the German chemist Glauber had recognised that calamine was "nothing else but unmeltable zinc" and that zinc was a "half ripe metal." However some earlier high zinc, low iron brasses such as the 1530 Wightman brass memorial plaque from England may have been made by alloying copper with *zinc* and include traces of cadmium similar to those found in some zinc ingots from China.

However, the cementation process was not abandoned, and as late as the early 19th century there are descriptions of solid-state cementation in a domed furnace at around 900–950 °C and lasting up to 10 hours. The European brass industry continued to flourish into the post medieval period buoyed by innovations such as the 16th century introduction of water powered hammers for the production of battery wares and it's necessary part. By 1559 the Germany city of Aachen alone was capable of producing 300,000 cwt of brass per year. After several false starts during the 16th and 17^{th} centuries the brass industry was also established in England taking advantage of abundant new coal fired reverberat furnace in which cheap copper is smelted. In 1723 Bristol brass maker champion patented the use of granulated copper, produced by pouring molten metal into cold water. This increased the surface area of the copper helping it react and zinc contents of up to 33% wt were reported using this new technique.

In 1738 Nehemiahs son William Champion patented a technique for the first industrial scale distillation of metallic zinc known as distillation per descencum or "the English process." This local zinc was used in speltering and allowed greater control over the zinc content of brass and the production of high-zinc copper alloys which would have been difficult or impossible to produce using cementation, for use in expensive objects such as scientific instruments, clocks, brass buttons and costume jewellery. However Champion continued to use the cheaper calamine cementation method to produce lower-zinc brass and the archaeological remains of bee-hive shaped cementation furnaces have been identified at his works at Warmley [8]. By the mid-to-late 18th century developments in cheaper zinc distillation such as John-Jaques Donys horizontal furnaces in Belgium and the reduction of tariffs on zinc as well as demand for corrosion-resistant high zinc alloys increased the popularity of speltering and as a result cementation was largely abandoned by the mid-19th century.

The main objectives of present work are given below:

1. To find the Brinell hardness number (BHN) of alloy brass.
2. To find the impact strength (Absorb energy) of alloy brass.
3. To find the Stress-Strain relation of alloy brass.

2. METHODOLOGY

The manufacturing process used to create brass involves adding the appropriate raw materials into a molten metal, then it is allowed to solidify. The shape and characteristics of the solidified metal are then altered through controlled process to get desired specimen for doing the required task.

Melting-

The necessary amount of different type of brass alloy scrap is weighed and transferred into a furnace for melting all the components where it is melted at about 1050^{0}C. A small amount of additional zinc may be added to compensate for any zinc that vaporizes during the melting operation. If any other materials are required for the particular brass formation, they are also added. The molten metal is poured into the molds about 20 cm × 20 cm × 25 cm and allowed to solidify into slabs. When the slabs are cool enough to be moved, they are taken out from molds and moved to the rolling area.

Hot rolling-

Slabs are reheated until they reach the desired temperature .This reheated slabs are fed through a series of opposing steel rollers which reduce the thickness. Then it passes through a milling machine called scalper. This machine cuts a thin layer for removing oxides formed at their surfaces. This layer is formed because of hot metal's exposure to the air.

Annealing and cold rolling-

For hot rolling, it loses it's ductility. Now, it is heated again to relieve some of it's hardness and to make it ductile. This process is called annealing. It is further rolled to reduce thickness. This process is called cold rolling. It increases its hardness and strength. It is given an acid bath and rinse to clean it.

Finish rolling-

It is given a final cold rolling to produce a very smooth surface finish. --

By this standard process, small bar of brass can be produced. Then, it cuts into desired length. For making this experiment, make the small bar of cylindrical shape and rectangular cube.

Two types of rectangular cube shape had made. For hardness test it is of 40mm x 40mm x 15mm and for impact test it is of 90mm x 10mm x 10mm. For determining stress-strain relationship it is of Cylindrical shape have 90mm length and gauge length of 6.5 mm diameter.

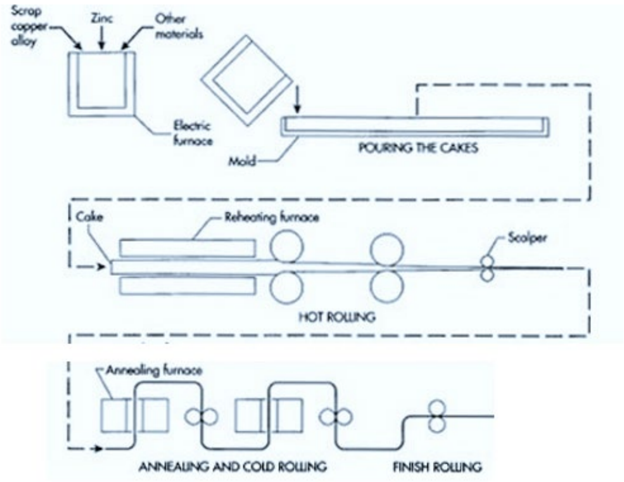

Fig. 1: Schematic diagram [9]

This is standardize process of making brass. But for small amount we can make it very easily using small crucible. Then turn the block into our desired shape.

After melting process, two types of specimen have been made. One is rectangular cube and another one is cylindrical shape.


Fig. 2: Melting of components of brass

Rectangular cube shape

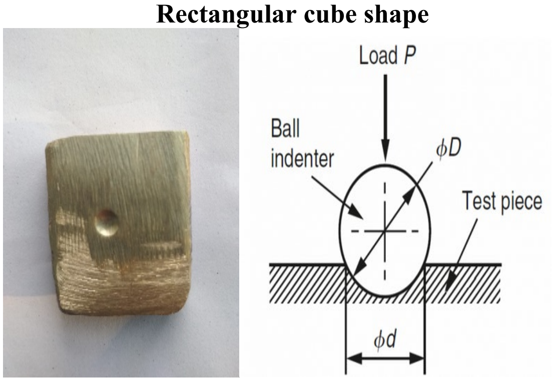

Fig. 3: Hardness test specimen

Rectangular cube shape

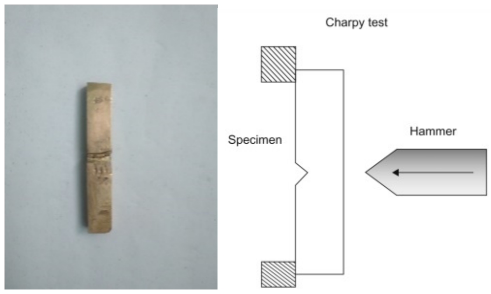

Fig. 4: Impact test specimen

Cylindrical shape

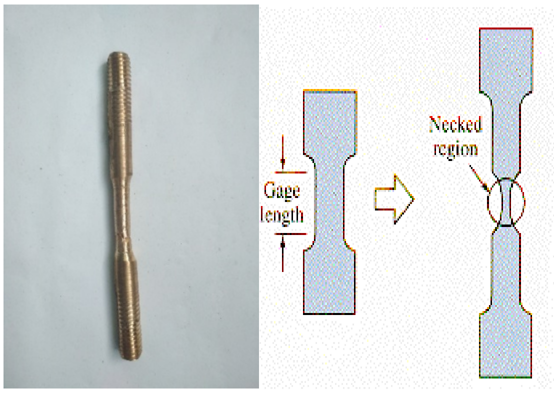

Fig. 5: Specimen for Stress-strain relationship

3. MATHEMATICAL FORMULATIONS

Mechanical properties of brass alloy was calculated by using the following equations.

Hardness number calculation

$$BHN = \frac{P}{\pi D(D-\sqrt{D^2-d^2})} \qquad (1)$$

Here,

BHN= Brinell hardness number
D= Diameter of the indenter (mm)
d= Diameter at the rim of impression (mm)
P= Force applied (kg)

Impact strength calculation

Absorb energy= $(MgH - Mgh)\,J$ (2)

Here, $H = (R - Rcos\alpha)\ m$
$h = (R - Rcos\beta)\ m$
R= Radius of hammer (m)
M= Mass of hammer (kg)
α= Hammer angle before fracture (degree)
β= Hammer angle after fracture (degree)

Percentage of elongation

$$\text{Percentage}=\frac{(Q-p)}{p}\times 100\%$$

Here,

P= Initial gauge length (mm)

Q= Final gauge length (mm)

4. EXPERIMENTAL RESULTS

Alloy brass	Hardness number	Absorb energy(J)	Amount of elongation (%)
Al brass	141	11.01	16.4
Pb brass	78	7.61	11.6
Red brass	49	6.14	19.6

5. DISCUSSION

Through the study, it can be said that the percentage amount of adding element to brass alloy changes hardness number, impact strength and stress-strain behaviour and it also called with a newly formed alloy. This three measurements gives a good indication for selecting alloy brass. From the study, it was found that hardness number and impact strength absorption quality is high in Al-brass. Increasing Al in brass rather than adding Sn and Pb is very easy to get better properties. But increasing more amount of AL have a bad impact. Because, it increases brittleness. For high impact strength absorbing, Al brass alloy is better from any other alloy. Excess amount of Pb is also harmful for human health. From the graphical representation, it is easily said that all three brass alloy are brittle material. Brass having a small percentage of aluminium gives a bright golden color in physical looks & lead gives good machinable properties. Also, Tin helps in corrosion resistance and lessen the effect of dezincification.

Aluminium brass

Relationship between the stress and strain that a particular material shows is said as that particular materials stress–strain diagram. The above graph shows the relation curve between stress and strain. At the initial stage, for small interval of strain value the value of stress is much high, this is the Elastic range. But after a certain limit, the value of stress shows a similarities between them i.e. the values are near to one another. This region is called plastic range. After this, fracture occurs and this is maximum stress point. Here, maximum stress is 117.5Mpa. Diameter of the specimen is 6.5mm.

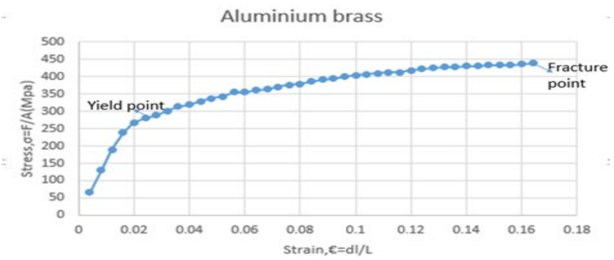

Fig. 6: Stress-strain diagram (Al brass)

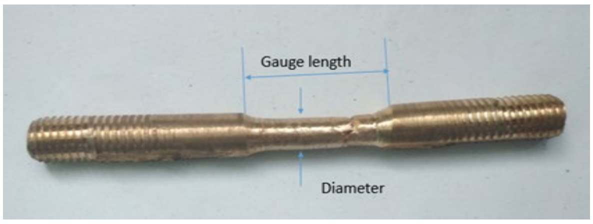

Fig. 7: Specimen (Cylindrical shape)

Pb brass

In the same way as Al brass, after a certain limit, the value of stress shows a similarities between them i.e. the values are near to one another. This region is called plastic range. After this, fracture occurs and this is maximum stress point. Here, maximum stress is 117.5Mpa. Diameter of the specimen is 6.5mm.

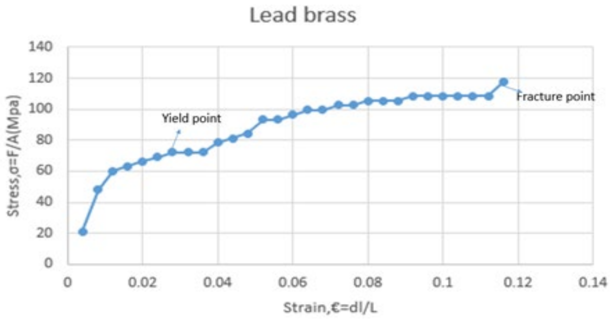

Fig. 8: Stress-Strain diagram (Pb brass)

Red brass

At the initial stage, for small interval of strain value the value of stress is much high, this is the Elastic range. Then, ductility occurs. But after a certain limit, the value of stress shows a similarities between them i.e. they are near to one another. This region is called plastic range. After this, fracture occurs. Here, maximum stress is 247.5Mpa. Diameter is 6.5mm.

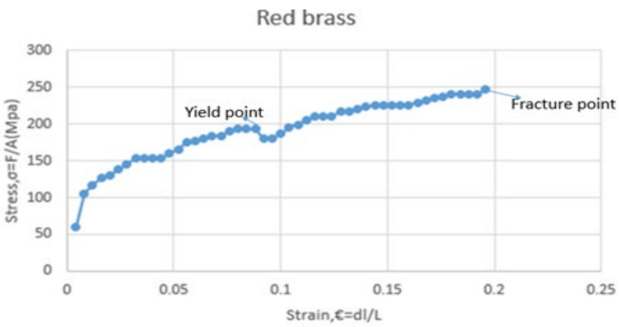

Fig. 9: Stress-strain diagram (Red brass)

6. CONCLUSION

Determination of mechanical properties value of alloy brass is an important part in the field of manufacturing. Some of the new alloy brass created is very helpful for us to meet our required criteria. For getting more information have to check adding different amount of percentage amount of different element. Different material have different special properties. Different new approach should be adopted to get better result. Melting and solidifying process should be occurred in proper way. Hence, better result can be expected.

7. ACKOWLEDGEMENT

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9. NOMENCLATURE

Symbol	Meaning	Unit
P	Force	(Kg)
D	Indenter diameter	(mm)
d	Impression diameter	(mm)
R	Radius of hammer	(m)
M	Mass of hammer	(kg)
α	Hammer angle before fracture	(Deg.)
β	Hammer angle after fracture	(Deg.)
P	Initial gauge length	(mm)
Q	Final gauge length	(kg/s)
σ	Stress	(Mpa)
ϵ	Strain	Dimensionless