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Development of Artificial Gold from Copper Based Alloy

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Abstract: Copper based alloys available in market are mainly classified as brass, bronze and cupronickel for various applications. These alloys are having limited ductility and corrosion resistance and these may be frequently needed cleaning for appearance. In order to improve the quality of brass and bronze for improved luster and prolonged corrosion resistance, a combination of copper based alloy classified as 'artificial gold' is proposed to be developed for few applications like reflectors, screens and ornamental items.Melting practices have been carried out several times to achieve final requirement of cast bar with shining, ductility and malleability using brass and bronze alloys. As not much required properties are sensed from these pure copper with zinc addition is tried to get final required alloy. This alloy is tested and the properties are evaluated. It is found that the new alloy has been successfully developed which has high ductility and malleability, good corrosion resistance and brightness.
Keywords: Brass, Bronze, Casting, Gold, SEM, Mechanical Properties

I. INTRODUCTION

1.1. GENERAL BACKGROUND

Brass is usually the first choice of materials for home equipment, electrical and all precision engineering industries. It is specified because of the unique combination of properties that make it essential. It can be easily cast to shape or fabricated by extrusion, rolling, drawing, hot stamping and cold forming. There are many standard compositions for brass with copper contents ranging from 58% to 95%.

Scientists have recently discovered that gold can be artificially produced by the atomic bombardment of lead, which is another basic element. However, the process is very expensive, more so than the monetary value of the resulting gold. So gold is not artificially produced on a commercial scale. Chrysopoeia, the artificial production of gold, is the symbolic goal of alchemists. Such transmutation is possible in particle accelerators or nuclear reactors. The production cost of both process were higher many times than the market price of gold. Since there is only one stable gold isotope 197Au, this isotope can produce usable gold through nuclear.[4]

1.2 OBJECTIVES AND SCOPE OF THE WORK

The project is undertaken to develop an alloy with enhanced ductility, malleability and corrosion resistant properties similar that of gold. Gold at present is having very high rate in the market and hence it is possible to develop an alloy equivalent to gold but with affordable price to have similar properties and functional abilities like brightness, reflection and corrosion resistance. As not much information is available from the literature to produce artificial gold, the present work is undertaken with the following objectives:

1. To adopt suitable melting practice to use either brass or bronze for getting refined metal product by continuous stirring at molten condition either with liquid or semi-solid state.
2. To cast the component in a graphite mold to obtain test bars.
3. To subject the test bars to identify its physical, mechanical and corrosion properties.
4. To subject the test bars for metal forming operations.
5. To subject the castings for scanning electron microscope (SEM) analysis.
6. To combine the data to analyse various qualities of artificial gold.

II. EXPERIMENTAL DETAILS

2.1. FURNACE FABRICATION

A furnace is a device used for high-temperature production. For melting copper, more than 1300^{o}c melting capacity furnace is required as copper is a highly conductive metal. As the facilities are inadequate, a crucible furnace is fabricated with facilities to keep crucible, temperature measurement and stirrer attachment.

The bricks used are fireclay bricks and is completely plastered with fireclay coating as shown in fig. (1). The top view of furnace is shown in fig. (2) The following are its specifications:

1.	Temperature withstanding capacity	1500^{o}c
2.	Height above floor level	50 cm
3.	Crucible height	30 cm

4. Blower capacity 1 HP
5. Bricks used fire bricks
6. Fuel charcoal

To prepare the furnace for melting, a deep bed of charcoal is spread at the bottom and kindled to burn until good combustion is attained .Some of the charcoal is removed to make place for a crucible .The crucible shown in fig. (3)with 5kg melting capacity is then lowered into the furnace .The charcoal is replaced and additional charcoal is put to surround the crucible on all sides. Metal is then charged in the crucible. The furnace lid is replaced to send air from the blower. When the metal melts and reaches the desired temperature .The accessories used for melting are given below.

2.2 STIRRER

A stirrer is used for stirring the molten metal as shown in fig (4). It consist of clay coated specially designed stain less steel part and an electric motor connected with it. Molten metal is stirred in crucible using this stirrer before pouring to the mould. It is a 5 speed stirrer it can vary the speed up to 300 rpm.

2.3 MOULD MATERIAL

The size of the mould diameter is 250mm. holes have been made with 13mm diameter with 10mm width to produce cast test bars as shown in fig. (5). To avoid dripping at the bottom, an additional flat plate is fixed at the bottom and the gap is filled with graphite powder. Graphite is mainly selected to use the mould for repeated use.

2.4 MELTING PRACTICE

The crucible is filled with brass alloy and bronze alloy. Trial and error methods are adopted to add brass, bronze with additives like magnesia, and melting flux.[11] Seven trials were conducted and the following combinations are found suitable for the requirement of the project work. The combination of mix is as follows:

1. Copper 100 parts
2. Zinc 25 parts
3. Magnesia 6 parts
4. Cover flux 2 parts

While reaching melting condition of copper (1100^{o}c) the above additive are added and continuously stirred with stirrer as shown in fig (4). As copper gets cooled due to high conductivity sometimes the copper alloy temperature found reaching solid-liquid temperature. Hence this method of stirring and melting is classified as Rheo-casting. After adding grain refiner and degasser for additional 20 minutes of stirring the metal is ready for pouring.

2.5 POURING MOLTEN METAL

Mould is placed over a sand bed for pouring the molten metal. Molten metal is poured into the graphite mould using pouring handle as shown in fig (6). After solidification the pieces are ejected from the mould and are subjected to various tests.

2.6 UNIVERSAL TESTING MACHINE

UTM is used to evaluate tensile strength of the specimen. The specimen is machined as per test bar as shown in fig (7) and the results are noted.

2.7 ROCKWELL HARDNESS TESTER

Rockwell hardness is used to test the hardness of the specimen. The specimen is machined as per test bar and the results are noted.

2.8 CHARPY IMPACT TEST

The impact test is conducted using charpy impact tester. The specimen is prepared as shown in fig (8) and the results are noted.

2.9 WIRE CUT EDM

Wire cut EDM is used for cutting specimen suitable for SEM analysis as shown in fig (9)

2.10 SCANNING ELECTRON MICROSCOPE (SEM)

Microstructure is analysed under scanning electron and the results are noted.

2.11 CORROSION TEST

Both chemical and electrochemical changes of the test specimen were carried out and the details are given below.

1. Atmospheric test: the test specimen is machined to powder level using lathe and is exposed to atmosphere for 2 months. The arrangement is shown in fig (10)
2. Electrochemical corrosion test: beaker with 1 litre capacity is filled with water and 50gms of common salt. The machined powder samples are kept inside the beaker for one week. The arrangement is shown in fig (11)

III. RESULTS AND DISCUSSION

Melting practice was carried out using brass, bronze and other combination for seven times and finally a bright alloy was obtained to our requirement. The composition of the alloy is given below:

Copper 75% and zinc 25%. The casting obtained from the graphite mould is subjected to test for finding mechanical properties, microstructure using SEM and corrosion properties. The details are given below.

3.1 TENSILE TEST

The results of tests using UTM is given below:

The test bar is subjected to tensile testing and is found that the ultimate tensile strength 285MPa is much less than copper base alloy which are reported in text as 338 MPa and above. The elongation is found to be 53% which shows that the alloy developed is very much suitable like gold to have good ductility and malleability. The specimens before and after testing have been given in fig (12) and fig. (13).

3.2 CHARPY IMPACT TEST

The energy absorbed by breaking the test samples using charpy impact tester is measured in joules. The energy absorbed by the specimen during impact test is found to be 230 joules. The specimens before and after testing have been given in fig (14) and fig (15)

In charpy test the specimen bend instead of breaks. This is also an evident to prove that the casting is a ductile one.

3.3 HARDNESS TEST

Rockwell hardness number for the specimen is checked with 1/16” steel ball indenter.Initial load applied to the test bar is 100kgf. The average Rockwell hardness number found in the investigation is 37.7.

3.4 MICROSTUCTURE ANALYSIS

Microstructural changes have been analysed using Scanning Electron Microscope (SEM). The microstructure of cast were observed after completion of surface preparation namely grinding, polishing and etching. The magnifications fixed for viewing SEM samples vary from X30 to X1000. For SEM tests both polished and fractured portions have been subjected and the structures are given in figures (16), (17), (8) and figures (19), (20), (21) respectively.

In fig (16), (17) and (18), it is found that the grain is fine with uniform orientation. Hence it is a very ductile one. This is also reflected in strength and fatigue tests.

The fracture test reveals that the structure is a fibrous one in all magnification and hence this also strengthens the ductile property of the test casting.

3.5 CORROSION TEST

The salt water testing otherwise known as Electrochemical reaction and oxidation testing otherwise known as chemical reaction reveal that inspite of several hours of testing no change of colour is taking place and the samples are given in figs (22) and (23). Hence it is proved that the test samples possess corrosion resistance like noble metals such as gold.

IV. FIGURES

Fig (1)newly fabricated fire brick floor furnace

Fig (2)top view of furnace

Fig (3)crucible

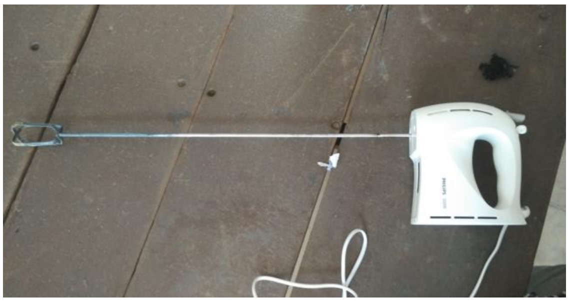


Fig (4)stirrer

Fig (5)graphite mould

Fig (6)pouring molten metal into the mould cavity

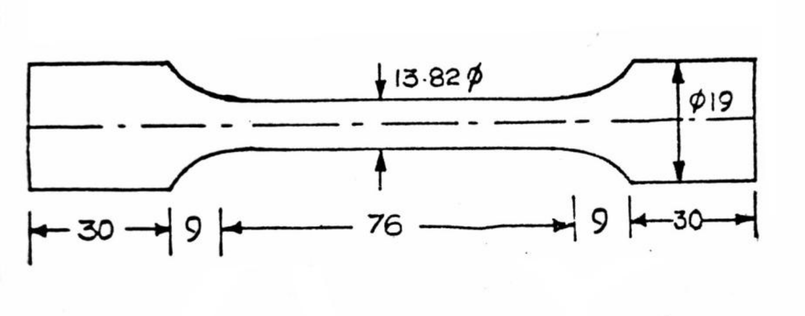


Fig (7)test bar

Fig (8)charpy impact test specimen

Fig (9)specimen for SEM analysis

Fig (10)atmospheric test

Fig (11) electrochemical corrosion test

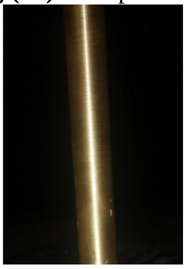


Fig (12)specimen before tensile test

Fig (13)specimen after tensile test

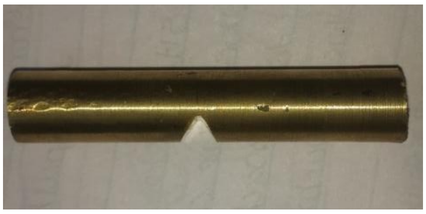
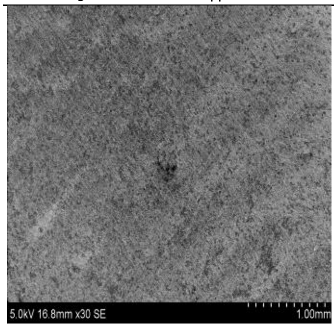


Fig (14)specimen before charpy test

Fig (15)specimen after charpy test



Fig(16) 30X magnification

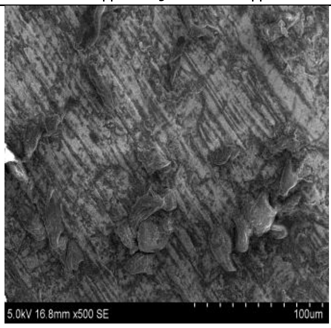


Fig (17) 500X magnification

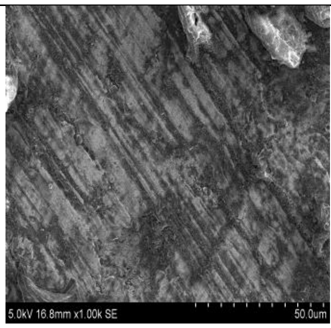


Fig (18) 1000X magnification

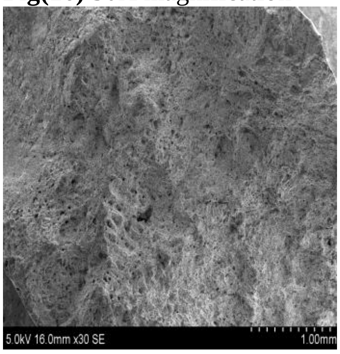


Fig (19)30X magnification

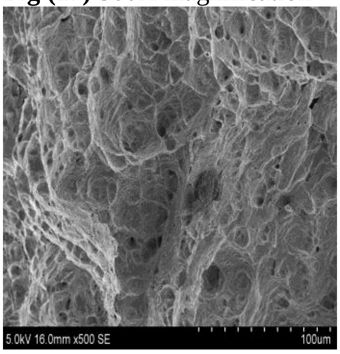


Fig (20)500X magnification

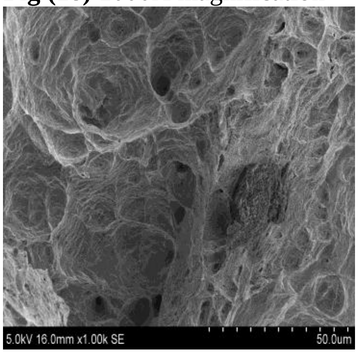


Fig (21)1000X magnification

Fig (22)electrochemical test specimen after test

Fig (23)atmospheric test specimen after test

V. CONCLUSION

The new casting produced is subjected to several tests and the following are the conclusion.

1. Tensile test reveals that the strength value is considerably lesser than copper base alloys. The elongation is also much higher and hence the copper base alloy produced in the present investigation is very much suitable like gold.
2. Hardness test also reveals that this metal is very soft.
3. From charpy test it is observed that the material is very soft, absorbing more energy without breaking unlike brass or bronze.
4. SEM analysis supports the ductile and malleable qualityofthealloyby showing fibrous and finegrainstructure.
5. Chemicalandelectrochemicaltestsindicatethatthemetalishavingverygood corrosion resistanceandcanbeusedtofabricateplates, reflective sheets, coinsandornamentalcomponents.

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