Development of Naval Alloy by Casting Process

S.C. Jirapure[1], Dr. A.B. Borade[2]

[1]Research Scholar, Mechanical Engineering Department, JDIET, Yavatmal (MS), India

[2]Principal, Government Polytechnic, Vikramgad (MS), India

Abstract

This research paper focuses on the development of naval alloy by using typical casting process. Copper, nickel and chromium are the alloying elements in this new alloy. Copper is acting as a base metal whereas nickel and chromium are the main alloying elements. Chromium is used in a very small amount as it is so much costlier. All the properties of these metals are analyzed and then only they are chosen for the preparation of the alloy. After selecting the material the design and dimensions of the desired casting of the alloy are finalized and according to this design, the casting of the naval alloy is done. Typical sand casting technique is used for the preparation of the naval alloy which involves melting of the metal in the furnace and pouring the molten metal in the mould of desired shape of the casting. The specimen of the naval alloy obtained from the casting directly will not have good surface finish and so machining is done on this casted specimen to improve its surface finish. This machined specimen is the desired Naval alloy.

Keywords: Naval, alloy, chromium, casting, copper base.

1. INTRODUCTION

The Naval alloy is a best example of ternary system which contains Copper as a base metal into which Nickel and Chromium is added as a alloying element. Thus, Cu-Ni-Cr alloy is termed as a Naval alloy. Copper is non-polymorphous metal with face centered cubic lattice (FCC) as shown in fig.1.

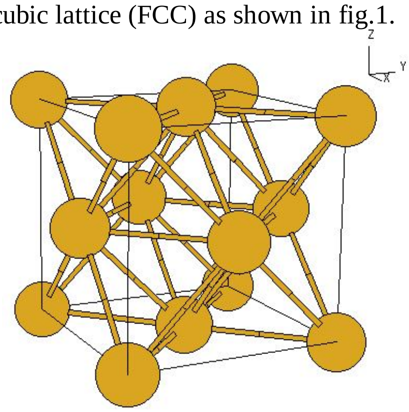

Fig.1 FCC lattice

Pure copper is in reddish colour. Melting temperature is 1083 °C and density is 8900 kg.m-3, which is three times heavier than aluminium. Silver shows better heat and electric conductivity, but it is 1.5 times larger compared to the aluminium.

Fig.2 Natural Copper

Nickel is a high-density, high-strength metal with good ductility and excellent high temperature and corrosion resistance properties. Most of the nickel used for stainless steel production. Also, it is used extensively in electroplating of various parts in variety of applications. Ni-base super alloys are a unique class of materials.

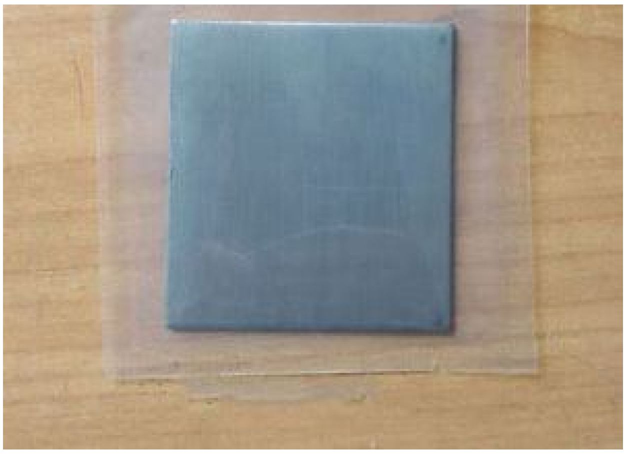

Fig.3 Nickel

Chromium is a silver-grey transition metal with a relative atomic mass 12 of 51.996, an atomic number of 24, and a melting point of 1,875°C and a density of 7.190 kg/dm3. It is in group VI of the periodic table. Chromium has a BCC crystal structure. Chromium is often used in plating and metal finishing due to its strength and its high resistance to corrosion.

Fig. 4 Chromium

The alloying elements are added to copper with the intention to improve their strength, ductility and thermal stability, without causing considerable damages in their form, electrical and thermal conductivity, and corrosion resistance.

2. PREPARATION OF THE NAVAL ALLOY

2.1 Material

All the materials used in the preparation of the alloys are of good quality. The chromium is labeled 98.99 per cent. An analysis of one sample showed 98.2 per cent chromium with the remainder consisting largely of silica, slag, etc. The nickel was labeled 99.6 per cent with a small amount of iron, and only a trace of cobalt. Two different lots of copper are used.

2.2 Dimensional specifications and design of casting of the Naval alloy

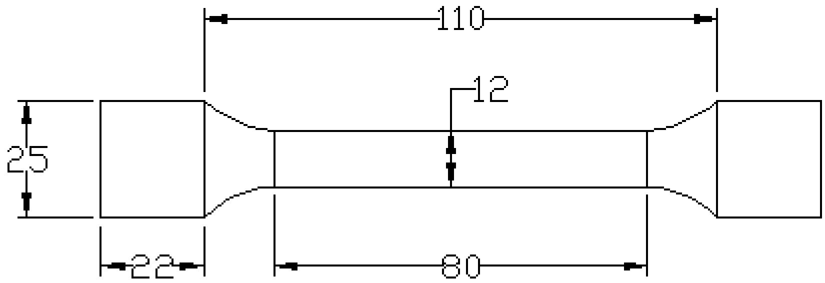

Fig.5 Design of casting of the Naval alloy

2.3 Melting of metals

Melting of Cu-based alloys are carried out in Fuel-Fired Furnaces and Electric Induction Furnaces. From Fuel-Fired Furnaces, oil- and gas-fired furnaces are the most important. However open flame furnaces are able to melt large amounts of metal quickly; there is a need for operator skill to control the melting atmosphere within the furnace at present this kind of furnaces are not often used. Also, the refractory furnace walls become impregnated with the melting metal causing a contamination problem when switching from one alloy family to another.

Here, the samples were melted in Crescent Safety crucibles in a electric furnace of the carbon plate resistor type. These crucibles are sand crucibles covered with graphite. They withstood temperatures as high as 1600 degrees C., and in only one or two cases did they seem to be softened by that heat. It was not possible to use a crucible for more than one melt because of the corrosion of the sand lining. The metals were protected by a cover of powdered cryolite which is melted easily below the melting point of copper and effectively prevents oxidation of the chromium. It was not volatilized at the temperatures used and was the most satisfactory cover, although a number of other covers and fluxes were tried. The charges of metals are of uniform size in all cases. The furnace used from 25 to 30 kw per hour and the time required for a melt varied from two to three hours.

2.4 Casting of the Naval alloy

To obtain good results from the product quality point of view, the casting processes technological specifications are the most important factor. The lowest possible pouring temperature needed to suit the size and form of the solid metal should be used to encourage as small a grain size as possible, as well as to create a minimum of turbulence of the metal during pouring to prevent the casting defects formation.

Many types of castings for Cu and its alloys casting, such as sand, shell, investment, permanent mould, chemical sand, centrifugal, and die, can be used. Of course each of them has its advantages and disadvantages. If only a few castings are made and flexibility in casting size and shape is required, the most economical casting method is sand casting. For tin, silicon, aluminum and manganese bronzes, and also yellow brasses, permanent mold casting is best suited. Definite limitation for both methods is the casting size, due to the reducing the mould life with larger castings.

Centrifugal casting process here found suitable for casting of all copper alloys. As their lead contents are low, yellow brasses, aluminum bronzes, manganese bronzes, silicon brasses and low-nickel bronzes and bronzes are best adapted to plaster mould casting. Lead should be held to a minimum for most of these alloys because lead reacts with the calcium sulfate in the plaster, resulting in discoloration of the surface of the casting and increased cleaning and machining costs.

Here, the sand mould casting technique is used for preparing the alloy of desired shape in which the molten metal was poured into various sand moulds made in the cope and drag boxes for making various samples of desired casting considering the different compositions of the alloying elements. By taking a reasonable amount of care it was possible to prevent contact of the molten alloy with the mould and to insure its easy removal from the mould when cold.

Fig.6 Molten metal pouring into the moulds

The specimen of naval alloy obtained from the casting is shown below in fig.7. Initially it is not having a good look as it had been just withdrawn from the sand mould. So, for obtaining a good aesthetic look, this specimen is machined and fig.8 shows the finished that means machined specimen of the naval alloy.

Fig.7 Casting of alloy without finishing

Fig.8 Finished casting of the desired alloy

3. CONCLUSION

The Naval alloy is developed by using a typical sand casting technique. The properties of all the alloying elements of this alloy are analysed first and then according to this alloying elements are added to the base metal. Here, Copper is considered as a base metal into which nickel and chromium are added as alloying elements to improve the properties of copper and to provide a new alloy with improved properties which is called as Naval alloy. As nickel and chromium have good corrosion resistance as compared to copper so the resulting alloy of these three metals have good corrosion resistance. Also due to the presence of copper as a base metal the strength of the resulting alloy is good. This means the Cu-Ni-Cr alloy is having good strength and good corrosion resistance. So, this alloy can be especially useful in the naval or sea environment where the ship is always susceptible to corrosion due to salty water. Due its high corrosion resistance property this alloy can be used in the ship manufacturing and hence this alloy is termed as naval alloy.

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AUTHOR

S. C. Jirapure received BE degree in Mechanical Engineering from Amravati University in 2003 and ME, in Mechanical Engineering (CAD/CAM) from SGBA University, Amravati in 2009. Currently, he is working towards Ph.D. degree in Mechanical Engineering at Sant Gadge Baba Amravati University, Amravati, from Jawaharlal Darda Institute Of Engineering & Technology, Yavatmal (MS) India. Over 13 years of teaching experience and fields of interest in Material Science & Metallurgy.

Dr. A. B. Borade has received his PhD degree in Mechanical Engineering from Amravati University in 2010. He completed his M.E in Production Technology & Management from Amravati University in 2005 and degree of Bachelor of Mechanical Engineering from Amravati University in 1996. Also he completed MBA in Marketing Management from Amravati University in 1998. He is currently working as Professor & Principal in Government Polytechnic, Vikramgadh, Palghar, MS, INDIA and Post Doctoral fellow at National Institute of Transports and Logistics, Dublin Institute of Technology, Dublin, Ireland, Southern University of Denmark, Institute of Production Engineering ,Czestochowa University of Technology, Czestochowa, Poland, working as a visiting Professor at National Scholarship Programme, Slovakia, Faculty of Material Science and Technology in Trnava , Slovak University of Technology in Bratislava. Over 20 years of Teaching, Research and Industrial experience in the field of Mechanical & Production Engineering with specialization in Supply chain management, Vendor manage inventory, Ergonomics, Production & Operation Management. Started the career as an Academician, occupied various positions such as lecturer, Assistant professor, Professor, Head of Department, Dean and Principal. He has guided 02 Ph.D., students in Mechanical & Production and guiding 07 Ph.D., in Engineering & Technology. He published many papers in various national and international journals and conferences.