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(54) **COPPER-IRON ALLOY**

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(57) **ABSTRACT**

The copper-iron alloy, with micro addition of niobium and as a raw melting product, is particularly, but not exclusively, applicable in the production of electrical components and comprises, by mass: 1.5 to 2.6% of iron (Fe); 0.01 to 0.50% of niobium (Nb) and the remainder of copper (Cu) and also, optionally, alone or in combination, the elements nickel (Ni) and aluminum (Al), in a maximum total amount of 0.40% by mass of the alloy composition.

COPPER-IRON ALLOY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 USC 119 to Brazilian Patent Application No. 10 2024 003253 5 filed Feb. 20, 2024, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure refers to a copper-iron alloy containing micro addition of niobium and obtained by casting, allowing the achievement of effective advantages from a technical-metallurgical point of view and presenting differences in mechanical properties and electrical conductivity, which lead to gains in performance and durability.

BACKGROUND

[0003] The state of the art defines, as already known, different copper-iron alloys obtained from the basic components defined by copper and iron, which components define the phases and intermetallic of copper-iron, and to which different elements, such as zinc and phosphorus, can be added to adjust specific properties for the final products to be obtained by casting these metals and the alloy elements. The final products can eventually be subjected to hot working, cold rolling and heat treatment steps to relieve residual stresses, depending on the specifications and standards to be met by the products.

[0004] In final products obtained from plates and strips, for stamping electrical connectors, it is desirable that their production be carried out, by stamping processes, from a copper alloy with differentiated mechanical properties.

[0005] The well-known copper-iron alloys, designed for the manufacture of electromobility products, are formed from the addition of iron (Fe), zinc (Zn) and phosphorus (P) to copper (Cu). For copper-iron alloys, the iron (Fe), being the main alloying element, in a higher percentage by mass, is added to obtain higher hardness and its content is normally limited to 2.6%. In addition, the iron (Fe) allows a significant improvement in resistance to softening.

[0006] However, although the well-known copper-iron alloys are commonly used in the manufacture of different products for electrical conduction purposes, they still require, in many specific applications, the increase in mechanical resistance, but without a reduction in their electrical conductivity.

SUMMARY

[0007] Due to the limitations mentioned above and related to known copper-iron alloys, the present disclosure aims to provide a new copper-iron alloy presenting differences in mechanical resistance and electrical conductivity.

[0008] According to the present disclosure, the new alloy presents a composition obtained by melting metals and alloying elements and which, in addition to comprising the basic elements defined by copper and iron, also includes the micro addition of the element niobium, responsible for the difference in the mechanical resistance and electrical conductivity characteristics.

DETAILED DESCRIPTION

[0009] According to the present disclosure, the copper-iron alloy comprises, as a raw melting product and in its basic form, from 1.50 to 2.60% iron (Fe); 0.01 to 0.50% niobium (Nb); and the remainder of copper (Cu).

[0010] The iron (Fe) is used to promote greater resistance to the material, and depending on the quantity used, the iron (Fe) is added to obtain higher hardness and its content is limited to 2.6%. In addition, the iron (Fe) allows a significant improvement in the mechanical resistance. The lower and upper limits, respectively, 1.5% to 2.6% of iron, are the parameters known in the art. A lower percentage may not bring benefits to the material and, in higher percentage, it may cause defects in the material resulting from the casting.

[0011] Additionally, the new copper alloy comprises the micro addition of niobium (Nb) up to 0.50% maximum. The minimum limit of 0.01% niobium represents the smallest portion of this material that, when added, will have little or no effect on the material resulting from the casting. The maximum percentage of niobium is strategically defined so that intermetallic appear in the copper microstructure, which promote the increase in the mechanical strength of the alloy, which was evidenced by the hardness test.

[0012] When the mechanical resistance was increased by the addition of niobium, the resistance to softening was also increased. The electrical conductivity values showed a slight increase. However, considering that the increase in hardness occurred by the addition of a doping element, a material added to another pure material, it can be stated that the result, related to the electrical characteristics, was more successful than expected.

[0013] Additionally, the new copper-iron alloy may also comprise nickel (Ni) and aluminum (Al), alone or in combination, in a maximum total quantity of 0.40% by mass of the alloy composition, where nickel may be a contaminant of the copper-iron alloy and aluminum may be added, together with niobium, as an element that brings solubilization benefits to the resulting alloy.

[0014] The alloy, which is the object of the present disclosure, must be obtained by melting at a temperature sufficient to promote the fusion of all the elements of its composition, including the element niobium (Nb), which is the element, added to the alloy, with the highest melting point (2477° C.) and which participates in the composition on a micro scale. It was found that a temperature of 1,500° C. can be the one used to obtain the fusion of all the elements.

[0015] Depending on the application of the product to be obtained from the alloy of the present disclosure, the alloy may undergo subsequent cold or hot forming processes, followed by heat treatment processes.

[0016] It is recommended that the material, after the casting process, be subjected to the cold forming and heat treatment stages to obtain plates that define the raw materials used in the production of electrical connectors through the stamping process.

TABLE 1

Comparison of properties in the cast product: the new alloy, alloy of the present disclosure, between the new alloy and the UNS C19400 alloy.

Cast Product Characteristics	Alloy of the present disclosure	UNS C19400
Electrical conductivity (% IACS).	30.30	27.25
Electrical resistivity ($\Omega \cdot mm^2/m$).	0.0569	0.0633
Hardness (HB) at the point of heat extraction.	54.6	49.15
Micro hardness (HV1) at the point of heat extraction.	125.4	118.9

[0017] The values presented in table 1, comparing the alloy of the present disclosure with the UNS C19400 material, are the results of the increase in electrical conductivity, decrease in electrical resistivity, increase of hardness and micro hardness and improvement in mechanical and electrical properties.

1. A copper-iron alloy comprising as a raw fusion product: 1.5 to 2.6% of iron (Fe); 0.01 to 0.50% of niobium (Nb) and a remainder of copper (Cu).

2. The copper-iron alloy according to claim **1**, further comprising, alone or in combination, elements nickel (Ni) and aluminum (Al), as impurities, in a maximum total amount of 0.40% by mass of a composition of the alloy.

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