

UNITED STATES PATENT OFFICE

2,237,774

TREATING SILICON COPPER-BASE ALLOYS

Maurice L. Wood, Waterbury, Conn., assignor to
Chase Brass & Copper Co., Incorporated,
Waterbury, Conn., a corporation

No Drawing. Application July 23, 1940,
Serial No. 347,002

8 Claims. (Cl. 148—21.2)

This invention relates to improvements in the heat treatment of silicon copper-base alloys, that is, copper-base alloys containing silicon, with the silicon in amount from about 1.5% to about 3.5%.

It is an object of this invention to provide an improved heat treatment for silicon copper-base alloys, and to produce improved articles of manufacture made of such alloys.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features of the said disclosure which are novel over the prior art.

Where silicon copper-base alloys, or copper-base alloys containing silicon, are referred to in this application, it is intended to include such alloys as may consist substantially entirely of copper and silicon in an amount from about 1.5% to about 3.5%, and also copper-base alloys containing the before stated amount of silicon plus one or more additional elements such as zinc, manganese, iron, aluminum, tin, lead, tellurium, etc. While one such silicon copper-base alloy which contains about 1% of zinc is particularly useful, the present invention contemplates the treatment of silicon copper-base alloys in which the zinc may be as high as about 5% or more. Where only one of the elements manganese, iron, aluminum, tin, lead or tellurium is used in an alloy, they may be present respectively up to about 3%, 2%, 8%, 2%, 1% and $\frac{1}{2}\%$. Of course, where more than one of these additional elements are present in the silicon copper-base alloy, the useful upper limit of such additional elements will be lower than those herein given for the individual use of one of the elements only. Where an alloy consists mostly of silicon and copper, with or without a minor percentage of one or more of the added elements referred to, it is frequently referred to commercially as silicon bronze.

Heretofore it has been usual to submit silicon copper-base alloys to annealing temperatures of from about 1000° F. to about 1300° F. for a period up to one hour, in order to soften them sufficiently to permit of further cold work.

Over a period of years in large scale production of silicon copper-base alloys, repeated difficulties have been encountered, the causes of which were quite obscure. The troubles resulted from a tendency toward brittleness and lack of ductility, sometimes evident after the initial hot-working operation and sometimes only after several cold-workings and annealings and fabrication into bolts or other structures. This lack of

ductility has been variable both with respect to time and with respect to position within the rod, bar or other form being made. Thus, in extruded rod considerable difficulty has been encountered just after extrusion, as a result of what is called "extrusion pipe" which is very commonly present in extruded copper-base alloys. This extrusion pipe is confined to the rear end of the rod which is the last part to come from the extrusion die. In general it is very pronounced right at the back end and becomes progressively less obvious toward the front. Usually it is entirely eliminated by cutting off the rear 20% of the extruded article. In the silicon copper-base alloys this extrusion pipe is usually located either at the surface or immediately below the surface and usually on a cylindrical or partially cylindrical plane or surface more or less concentric with the outer surface of the rod itself. It is fibrous and is usually due to entrainment of oxides or other foreign matter originally present in the surface of the cast billet.

I have found that considerable of the brittleness or lack of ductility above referred to is due to causes quite distinct from extrusion pipe, and a close study of its outward manifestations shows a distinct difference from the manifestations of extrusion pipe. For instance, the defect which is the cause of brittleness or lack of ductility with which my invention is concerned, is never oxidized, but the fracture is always clean and bright. The texture of the fracture is granular rather than fibrous. Further, the fractures tend to be on flat planes parallel to the axis of the rod but at random orientation in azimuth. Further, such fractures are apt to be found on a certain plane at one point in the rod, and on a plane at a considerable angle to the first in a portion but slightly separated longitudinally from the first. Also, the occurrence of this defect is discontinuous lengthwise of the rod and is of as common occurrence near the front end as near the back end. In short, it appears that there is no connection whatever between this defect and the common extrusion pipe.

Careful studies of large numbers of such defective sections failed to reveal any appreciable segregation or inhomogeneity when subjected to the ordinarily used etching agents and microscopic examination of various sections at various magnifications. And even when these studies were supplemented by chemical analysis of carefully taken small samples in the vicinity of and at various distances from the defect no significant variations were found.

Fractures of such material exhibited a peculiar, clean, granular structure very evident when examined at low magnification, and even visible to the naked eye. The brittleness causing this abnormal structure was obviously due to some intergranular condition which had not been detected.

After trial of a large number of solutions as etching reagents, a solution consisting of concentrated ferric chloride and concentrated hydrochloric acid in acetone was found to show the presence of intergranular films of a second phase in the normally single phase alloy. Very careful preparation and examination at high magnification were necessary. Such films apparently were dissolved or masked by the usual etching reagents and therefore were not seen. Analyses were of no value because of the crudeness of any sampling method in comparison with the thickness of the films. Examination of many samples established the fact that the films were present in the original castings and persisted through the preheating, extrusion and subsequent cold working and annealing operations.

Prior to making my invention, I tried various annealing treatments and various sequences of working and annealing treatments all within the usual temperature range, but none of these were effective in overcoming the difficulty. Finally, however, I found that a prolonged soaking at a very high temperature was fully effective in overcoming the difficulty on sections which were known to be quite brittle before such treatment. The exact time and temperature of heat treatment to overcome the effect is not too critical, there being a range of about 200° F. over which it can be suitably performed. I have found, for instance, that a heat treatment at as low a temperature as about 1500° F. is fairly effective if the alloy is held at that temperature for at least about two hours after being heated to about 1500° F., but better and more certain results can be accomplished by holding it at that temperature for about three to four hours. If a temperature of about 1600° F. is utilized, fairly satisfactory results are obtained in as little as about one and one-half hours and more certain results are obtained with a two and one-half hour or more exposure. If a temperature of about 1700° F. is utilized, fairly satisfactory results are obtained in as little as about one hour and more certain results are obtained with a two-hour or more exposure.

My improved treatment is equally effective when applied to the alloys in all the ordinary forms of material whether they be in the cast condition or in the wrought condition, and whether in the form of rods, tubes, sheets or other forms, and whether they have been wrought by extrusion, hot or cold rolling or otherwise. But it is particularly effective when applied to extruded or rolled sections or forms.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. The process of improving the properties of a copper-base alloy containing from about 1.5% to about 3.5% silicon, which consists in heat treating the alloy within a temperature range of from about 1500° F. to about 1700° F. for a period of time corresponding to, at least about two hours at a temperature of about 1500° F. or at least about one and one-half hours at a temperature of about 1600° F. or at least about one hour at a temperature of about 1700° F.

2. The process of improving the properties of a copper-base alloy containing from about 1.5% to about 3.5% silicon, which consists in heat treating the alloy at a temperature of about 1500° F. for at least about two hours.

3. The process of improving the properties of a copper-base alloy containing from about 1.5% to about 3.5% silicon, which consists in heat treating the alloy at a temperature of about 1600° F. for at least about one and one-half hours.

4. The process of improving the properties of a copper-base alloy containing from about 1.5% to about 3.5% silicon, which consists in heat treating the alloy at a temperature of about 1700° F. for at least about one hour.

5. An improved article of manufacture which has been wrought from a copper-base alloy containing from about 1.5% to about 3.5% silicon, and which has been heat treated within a temperature range of from about 1500° F. to about 1700° F. for a period of time corresponding to, at least about two hours at a temperature of about 1500° F. or at least about one and one-half hours at a temperature of about 1600° F. or at least about one hour at a temperature of about 1700° F.

6. An improved article of manufacture which has been wrought from a copper-base alloy containing from about 1.5% to about 3.5% silicon, and which has been heat treated at a temperature of about 1500° F. for at least about two hours.

7. An improved article of manufacture which has been wrought from a copper-base alloy containing from about 1.5% to about 3.5% silicon, and which has been heat treated at a temperature of about 1600° F. for at least about one and one-half hours.

8. An improved article of manufacture which has been wrought from a copper-base alloy containing from about 1.5% to about 3.5% silicon, and which has been heat treated at a temperature of about 1700° F. for at least about one hour.

MAURICE L. WOOD.