United States Patent [19]

Shapiro et al.

[11] **3,882,712**

[45] **May 13, 1975**

[54] **PROCESSING COPPER BASE ALLOYS**

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[22] Filed: **Oct. 1, 1973**

[21] Appl. No.: **402,479**

[52] **U.S. Cl.** ..... **72/364;** 148/11.5 R

[51] **Int. Cl.** **B21b 3/00**

[58] **Field of Search** ..... 148/11.5 R; 72/364

[56] **References Cited**

UNITED STATES PATENTS

2,676,123	4/1954	Gregory	148/11.5
3,046,166	7/1962	Hartmann	148/11.5
3,287,180	11/1966	Eichelman et al.	148/11.5

OTHER PUBLICATIONS

Metals Handbook, American Society for Metals, 8th Ed., Vol. 2, page 285.

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[57] **ABSTRACT**

Processing copper alloys to obtain an improved combination of yield strength and elongation and the restoration of high yield properties in formed parts. The process is characterized by cold rolling, followed by heat treating, forming and finally heat treating to restore desired properties.

10 Claims, No Drawings

PROCESSING COPPER BASE ALLOYS

BACKGROUND OF THE INVENTION

The process of the present invention is concerned with treating copper base alloys in order to obtain an improved combination of yield strength characteristics and elongation and the restoration of high yield properties in formed parts.

Since most engineering components, springs in particular, must operate in the elastic regime, information regarding the onset of plastic flow in metal systems has long been one of the most important engineering design criteria. The mechanical property of great interest in this region is the elastic limit. However, there are practical difficulties in determining the elastic limit with information from the engineering tensile test. Since the elastic limit can be as much as 10–15 ksi greater than the proportional limit, which is the stress at which the stress-strain curve becomes nonlinear in the elastic regime, determination of the elastic limit would require that each tensile specimen be alternatively loaded and unloaded to increasingly higher loads until that load is reached which produces a permanent set in the specimen.

However, the 0.01 percent offset yield strength approximates and is frequently used in place of the elastic limit in spring design. Thus, for engineering applications in which little or no plastic flow can be tolerated an enhanced 0.01 percent offset yield strength would lead to improved materials utilization and performance. Formed parts, however, will lose a portiion of the yield properties and it is naturally desirable to be able to restore high yield properties.

Accordingly, it is a principal object of the present invention to provide a process for obtaining improved yield strength characteristics in copper base alloys, particularly high 0.01 percent offset yield strength and restore high yield properties in formed parts.

A further object of the present invention is to provide a process as aforesaid which is suitable for manufacturing parts while allowing retention of the desired high yield strength properties.

A further object of the present invention is to provide a process as aforesaid which is simple, inexpensive, easily practiced commercially and versatile.

Further objects and advantages of the present invention will appear hereinbelow.

SUMMARY OF THE INVENTION

In accordance with the process of the present invention it has been found that the foregoing objects and advantages may be readily obtained. The process of the present invention comprises:

A. providing a copper or copper base alloy material in plate form having a thickness of from 0.300 to 1.800 inches;

B. cold rolling said material to a total reduction of at least 65 percent and preferably more than 85 percent, said cold rolling may be accomplished directly or by cycles of cold rolling with an intermediate heat treatment between each cold rolling cycle of from 100° to 350°C for from 1 to 4 hours, provided that the rolling reduction in each cold rolling cycle is at least 25 percent;

C. subjecting said material to a final heat treatment after cold rolling, said final heat treatment being at a temperature of from 100° to 350°C for from 30 minutes to 8 hours;

D. forming said material into a desired shape; and

E. heat treating said material at 100° to 350°C for from 30 minutes to 8 hours to restore high yield properties.

The material produced in accordance with the process of the present invention may be readily utilized to manufacture parts having high yield properties. We have found that when the part is manufactured, the yield strength properties fall off due to the cold work which is given to the part as a result of the forming operation. Therefore, in accordance with the process of the present invention a further thermal treatment is performed on the formed part of a temperature of from 100° to 350°C for from 30 minutes to 8 hours in order to restore the desirable high 0.01 percent offset yield strength properties. Furthermore, it can be seen that the process is simple and easy to perform and inexpensive in a commercial operation.

Further advantages of the instant process will appear hereinbelow.

DETAILED DESCRIPTION

The process of the present invention, as indicated hereinabove, may be readily utilized with any copper or copper base alloy material. Thus, commercial purity or pure copper may be readily employed. A particularly suitable series of copper alloys for use in the process of the present invention are the phosphor bronzes, which are copper base alloys containing from 1 to 10 percent tin, such as CDA copper alloy No. 505, 510, 521 and 524. In addition, the iron containing copper alloys containing from 1 to 5 percent iron may be readily utilized, such as CDA copper alloy 194 and 195. In addition, the nickel-silvers are desirably suitable for use in the process of the present invention. These alloys are copper base alloys containing from about 10 to 20 percent nickel and from about 5 to 40 percent zinc, such as CDA copper alloy No. 762, 752 and 745. A further series of copper alloys which may be desirably utilized include the aluminum-bronzes and brasses containing from 2 to 13 percent aluminum, such as CDA copper alloy 638 and 688. Naturally, many other copper alloys may be desirably utilized in the process of the present invention. Generally, any copper base alloy may be conveniently utilized, such as: the CDA 2XX series, brasses containing from about 5 to 40 percent zinc; copper alloys containing beryllium; the CDA 4XX series, tinbrasses containing tin and zinc; silicon bronzes; manganese-zinc containing copper alloys as CDA alloys 669 and 672; and cupronickels containing from about 5 to 35 percent nickel as CDA alloys 706 and 715.

The starting material should be a copper or copper base alloy material in plate form having a thickness of from 0.300 to 1.800 inches. The plate material may be obtained by any desired method. For example, one may start from a copper base alloy ingot which is hot or cold rolled to plate thickness. The cold rolled plate may then be annealed to the fully recrystallized condition. Alternatively, one may provide a continuously cast copper base alloy plate as starting material.

The process of the present invention cold rolls the plate to a total reduction of at least 65 percent or alternatively cold rolls the plate material in at least two cold rolling cycles to a total reduction of at least 70 percent,

with an intermediate heat treatment of from 100° to 350°C for from 1 to 4 hours between each cold rolling cycle. The rolling reduction in each cold rolling cycle should be at least 25 percent and the total reduction in all cold rolling cycles is preferably greater than 85 percent. Thus, one may cold roll directly to final gage. Alternatively, one may desirably utilize two, three or four cold rolling cycles with one, two or three intermediate heat treatment steps.

Following the final cold reduction step, the material is subjected to a low temperature heat treatment at final gage. This heat treatment step should be for from 30 minutes to 8 hours at a temperature of from 100° to 350°C.

In accordance with the present invention the material may be readily formed into a desired shape from the thermally treated strip. Conventional forming operations may be employed, such as stamping, drawings, stretching or bending. We have found that formed parts lose a portion of the desirably high yield properties due to the cold work which they have been subjected to. In order to restore the high yield properties, the formed parts are given a further low thermal temperature treatment of from 30 minutes to 8 hours at temperatures between 800°C and 350°C.

In the heat treatment steps generally longer times are used with lower temperatures.

In addition to imparting improved 0.01 percent offset yield strength, the process of the present invention also obtains numerous advantages. The material of the present invention retains the finely structured cold worked matrix. In addition, the process of the present invention maintains and strengthens the deformation texture, resulting in improved texture strengthening of the sheet and formed part. Still further, the process of the present invention allows sufficient recovery of ductility at a marginal strength loss in order to enhance cold rollability for the additional cold rolling steps and for subsequent forming of the final material.

The process of the present invention and advantages obtained thereby may be readily understood from a consideration of the following illustrative examples.

EXAMPLE I

A copper base alloy ingot was provided having the following composition: tin, 4.4 percent; phosphorus, 0.07 percent; balance essentially copper. The ingot was initially hot rolled and milled to 0.600 inch gage and was cold rolled from the hot rolled plate 96.7 percent to a final thickness of 0.020 inch. The material was then heat treated at a temperature of 250°C for 2 hours, followed by a cold reduction of 2.4 percent, 4.4 percent or 6.8 percent to simulate a forming operation. The materials were given an additional heat treatment after each cold reduction of 250°C for 2 hours to recover the properties lost by the forming operation. The tensile properties were determined after each processing step in both the longitudinal (rolling) and transverse directions as indicated in Table I below.

TABLE I

Material	Strengths in ksi 0.01% Yield Strength	0.1% Yield Strength	0.2% Yield Strength	Ultimate Tensile Strength	Percent Elongation
Transverse					
CR 96.7%	89	117	128	148	2.8
250°C-2 Hours	97	118	124	131	5.0
CR 2.4%	86	112	122	137	4.4
250°C-2 Hours	102	122	128	133	6.2
CR 4.4%	86	114	124	140	4.6
250°C-2 Hours	97	118	124	130	6.7
CR 6.8%	90	116	125	139	4.7
250°C-2 Hours	96	118	124	129	4.8
Longitudinal					
CR 96.7%	82	113	123	129	1.5
250°C-2 Hours	83	101	107	112	5.0
CR 2.4%	70	95	105	114	5.0
250°C-2 Hours	87	101	105	109	7.4
CR 4.4%	73	98	107	116	4.8
250°C-2 Hours	84	101	105	110	4.9
CR 6.8%	62	99	108	118	4.0
250°C-2 Hours	82	99	105	110	4.9

EXAMPLE II

In accordance with this example the hot rolled phosphor bronze alloy obtained in Example I at a gage of 0.600 inch was cold rolled 98 percent directly to 0.012 inch gage. The material was then heat treated for 2 hours at 250°C followed by reductions of 2.3 percent, 8.4 percent or 13.7 percent to simulate a forming operation. The material thus produced in each cold reduction was given a second 2 hour anneal at 250°C and the tensile properties for each processing step are shown in Table II.

TABLE II

Material	Strengths in ksi 0.01% Yield Strength	0.1% Yield Strength	0.2% Yield Strength	Ultimate Tensile Strength	Percent Elongation
Transverse					
CR 98%	96	126	140	153	less than 0.5%
250°C-2 Hours	106	128	134	138	4.7
CR 2.3%	97	120	128	140	5.0
250°C-2 Hours	105	124	129	133	4.4
CR 8.4%	100	123	132	145	2.5

TABLE II – Continued

Material	Strengths in ksi 0.01% Yield Strength	0.1% Yield Strength	0.2% Yield Strength	Ultimate Tensile Strength	Percent Elongation
250°C-2 Hours	107	124	129	133	4.4
CR 13.7%	103	124	132	145	2.8
250°C-2 Hours	108	126	131	136	4.0
Longitudinal					
CR 98%	89	118	127	133	less than 0.5%
250°C-2 Hours	94	109	113	115	5.0
CR 2.3%	85	105	110	115	4.8
250°C-2 Hours	92	108	113	115	4.1
CR 8.4%	87	108	115	123	3.1
250°C-2 Hours	95	108	112	114	4.8
CR 13.7%	88	113	121	127	less than 1%
250°C-2 Hours	95	110	113	116	4.1

Therefore it can be seen from the foregoing examples that the desirable high 0.01 percent offset yield strength is lost as a result of forming operations. In accordance with the present invention even after small deformations resulting from these operations, the high 0.01 percent yield strength can be restored.

This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency are intended to be embraced therein.

What is claimed is:

1. A method for obtaining improved 0.01 percent offset yield strength characteristics in copper or copper base alloy formed parts which comprises:

A. providing a copper base alloy material in plate form having a thickness of from 0.300 to 1.800 inches;

B. cold rolling said material to a total reduction of at least 65 percent;

C. heat treating said material at 100° to 350°C for from 30 minutes to 8 hours to decrease the tensile strength and increase the 0.01 percent offset yield strength while retaining the cold worked matrix;

D. forming said material after said heat treatment step into a formed part; and

E. heat treating the formed part at 100° to 350°C for from 30 minutes to 8 hours to decrease the tensile strength and increase the 0.01 percent offset yield strength while retaining the cold worked matrix, thereby providing a formed part having high yield strength characteristics.

2. A method according to claim 1 wherein step (B) includes cold rolling said material in at least two cold rolling cycles to a total reduction of at least 70 percent with an intermediate heat treatment of from 100° to 350°C for from 1 to 4 hours between each cold rolling cycle provided that the rolling reduction in each cold rolling cycle is at least 25 percent.

3. A method according to claim 1 wherein the total reduction in step (B) is at least 85 percent.

4. A method according to claim 2 wherein the total reduction in step (B) is at least 85 percent.

5. A method according to claim 4 wherein step (B) includes three cold rolling cycles with two intermediate heat treatment cycles.

6. A method according to claim 4 wherein step (B) includes two cold rolling cycles with one intermediate heat treatment cycle.

7. A method according to claim 1 wherein the starting material in step (A) is provided by hot rolling an ingot to plate form having a thickness of from 0.300 to 1.800 inches.

8. A method according to claim 1 wherein said copper alloy is a phosphor bronze.

9. A method according to claim 1 wherein the copper alloy is a nickel-silver.

10. A method according to claim 1 wherein said copper alloy contains iron in an amount of from 1 to 5 percent.

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