

UNITED STATES PATENT OFFICE

FRANZ NEHL, OF MUHLHEIM-BUHR, GERMANY, ASSIGNOR TO THE FIRM VEREINIGTE STAHLWERKE AKTIENGESellschaft, OF DUSSELDORF, GERMANY

PROCESS OF HARDENING COPPER CONTAINING STEELS FOR STRUCTURAL AND SIMILAR PURPOSES

No Drawing. Application filed April 5, 1929, Serial No. 352,918, and in Germany April 5, 1928.

In order to obtain in the ordinary steels for structural and similar purposes a ratio between the elastic limit and the tensile strength of more than 70%, such steels had up to now to be subjected to a heat treatment. For the purpose of carrying out such a heat treatment it was necessary to raise the temperature of the steel to above the upper change-point (A_{c_3} point), whereupon the steel was allowed to cool from a temperature above the said point and tempered to a temperature below the A_{c_1} change-point.

In carrying out such heat treatment, it has been proposed to treat an alloy steel containing approximately .05% up to 5% of copper by subjecting the steel after it has been cast into ingots or worked into finished parts to normalizing treatment by heating it to a relatively high temperature, for example, 845° C. for a time sufficient to ensure the entire mass reaching the said temperature and by maintaining the said temperature for a relatively short period and then allowing the steel to cool slowly, preferably in air, such treatment being followed by a reheating treatment to a temperature of between 510 and 550° C. at which temperature the steel is maintained for a relatively short time before being again cooled. The result of this two-stage heat treatment is a change in the physical properties of the steel which shows increases in the yield point, ultimate strength, elongation, reduction of area and the Brinell hardness.

The object of the present invention is to provide a process according to which a hardening of a copper-containing steel may be obtained by only tempering the steel, thus doing away with any additional heating. It will be understood that such a process offers considerable economical advantages in the production of structural and other elements of construction by casting, rolling or forging.

The process is based upon the discovery that in steels having a copper content of more than 0.6% but not more than about 10% and a carbon content of up to 0.5%, a hardening effect may be produced by tempering at a temperature below the A_{c_1} point until the

elastic limit as well as the tensile strength is increased, whereas the elongation, contraction and notch-bar toughness is decreased, the increase in the elastic limit being greater than that in tensile strength so that the ratio elastic limit to tensile strength will thus be raised to about 70 to 80%.

According to the present invention the said steel is subjected to a single heat treatment by maintaining it for at least an hour at a temperature below the A_{c_1} point, until an increase in the elastic limit and the tensile strength is secured, accompanied by a decrease in the elongation, contraction and notch-bar toughness.

According to the invention, moreover, in circumstances where the decrease in notch-bar toughness is undesired, this may be avoided by subjecting the steel to the final shaping operations at a temperature range of 900 to 800° C. before it is subjected to the single heat treatment hereinbefore referred to.

The tempering temperature which is best suited for the purpose of the invention depends upon the chemical composition, yet will always lie below the A_{c_1} change point (the lower limit being about 400° C.). It may be necessary to determine the most suitable temperature for any particular steel by experiment. In order to obtain the maximum increase in tensile strength a tempering period of at least sixty minutes duration is required. If desired, the steel may be air cooled.

The new process makes it possible to increase the elastic limit of the copper steel by more than 50% and the tensile strength by more than 20%. The marked decrease in notch-bar toughness, which in some cases would prevent the commercial application of the process, may as hereinbefore stated, be successfully avoided by effecting the final shaping operation whether effected by rolling or forging at a temperature range of 900 to 800° C., whereupon the workpiece, after having been air-cooled, will be tempered in the described way.

The following example is given for the purpose of making the advantages of the

process better understood. The material employed was of the following composition:

	Per cent
C-----	0.08
P-----	0.017
Si-----	0.05
Mn-----	0.41
S-----	0.014
Cu-----	1.01

The cast ingot was rolled down into a bar of 118 x 8 inch. The following physical properties were obtained:

	Rolled under normal conditions, air cooled	Rolled under normal conditions, air cooled, tempered at 600° C.	Finishing rolling temp. 820° C., air-cooled, tempered at 600° C.
Elastic limit-----	37036	65274	65558 lbs./sq. in.
Tensile strength-----	62017	81734	84004
Elongation-----	22.6%	15.6%	17.5%
Contraction-----	60%	57%	60.05%
Notch-bar toughness-----	326	57	318 lbs./sq. in.

The steel was maintained at the temperature of 600° C. for a period exceeding one hour. It may be mentioned that by quenching, according to known processes, in water at 930° C. an elastic limit of only 53212 lbs./sq. in. and a tensile strength of 65274 lbs./sq. in. had been obtained.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent is:

1. Process for improving the physical properties of copper containing steels for structural or similar purposes, which consists in subjecting a steel having a copper content of more than 0.6% but no more than about 10% and a carbon content of up to 0.5% to a single heat treatment by maintaining it for at least an hour at a temperature below the A_{c1} point until a substantially maximum increase in the elastic limit and in the tensile strength is obtained while at the same time a decrease in the elongation, contraction and notch-bar toughness is secured.
2. A steel having a copper content of more than 0.6% but less than 10% and a carbon content of up to 0.5%, which has been subjected to a single heat treatment by being tempered for at least an hour at a temperature below the A_{c1} point until it acquires a substantially maximum increase in its elastic limit and its tensile strength and at the same time a decrease in its elongation, its contraction and its notch-bar toughness.

FRANZ NEHL.