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PROCESS FOR INCREASING THE MECHANICAL STRENGTH PROPERTIES OF STEEL

Filed June 30, 1931

Influence of annealing on the strenth qualities of cold shaped steel

Fig. 1.

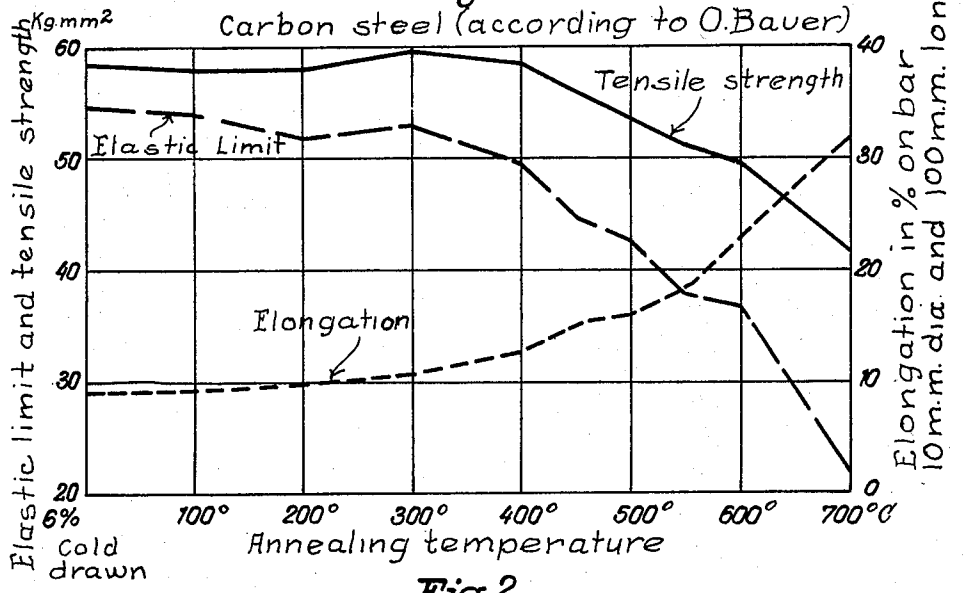
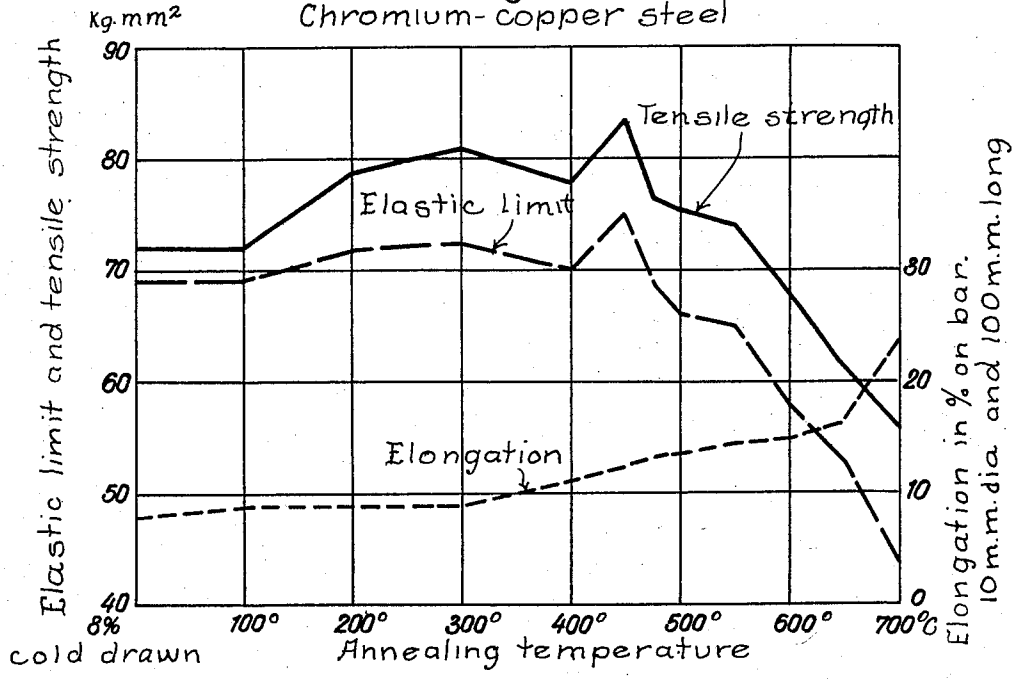


Fig. 2



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PROCESS FOR INCREASING THE MECHANICAL STRENGTH PROPERTIES OF STEEL

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7 Claims. (Cl. 148—12)

This invention relates to a process for increasing the mechanical strength properties of steel.

It is known that in general, the tensile strength and elastic limit of cold worked steel continually decrease when annealing at temperatures above about 350° C. in proportion as the temperature and the period of annealing increase, whilst the deformation value increases at the same time.

In contradistinction to the foregoing, it has been found that the mechanical strength properties of a steel which has been worked below its A_1-point and preferably below 550° C., and which contains copper preferably to the extent of 0.4 to 3% with a maximum of 5% thereof, can be increased to an effective degree by annealing at temperatures between about 350° and 600° C.

The progress of the tensile strength, elastic limit and the elongation, with increasing annealing temperatures may be perceived for a carbon steel from the attached Fig. 1 and for a chromium copper steel from Fig. 2.

In the steel investigated in Fig. 1, it is a question of a steel of circular cross-section cold-drawn to the extent of about 6% and containing 0.29% of carbon. The curves allow the progress of the tensile strength properties and the elongation to be perceived on annealing for two hours. Dependent on the chemical composition and upon the extent of the cold working, there is observed up to an annealing temperature of about 300° inter alia a certain small increase in tensile strength and elastic limit in excess of the initial values. These phenomena come under the province of "ageing".

Fig. 2 relates to seamless tubing consisting of chromium copper steel containing 0.2% carbon, 0.3% silicon, 0.8% manganese, 0.4% chromium and 0.8% copper. The tubes are cold drawn by about 8% and are annealed for one hour at increasing temperatures and are tested at room temperature. The curves allow the progress of the elastic limit or the 0.2 limit, the tensile strength and the elongation to be followed in relation to the annealing temperatures. As is known, the elastic limit and tensile strength of cold drawn carbon steels are increased by an annealing treatment above 300° to 350° which has been carried out for a duration of more than half an hour. This is also to be seen from the curve of Fig. 1. In contradistinction to this normal behavior such steels which contain more than 0.4% copper and up to about 0.4% carbon do not surrender a continuous decrease of their tensile strength if they are annealed in accordance with the present invention but they show in the range between 400 and 550° C. in accordance with the annealing duration a distinct increase of their strength qualities as compared with the original state. Thus the normal decrease in the tensile strength is superimposed between 400 and 550° C. by a new phenomenon which results from the precipitation of a dissolved copper excess. Simultaneously the elongation and toughness are greatly increased. If the annealing temperature and the period of annealing are suitably adjusted, after annealing for six hours, for example, at 450° C., the values of 75 kilograms per sq. mm. for the elongation limit, 84 kilograms per sq. mm. for the tensile strength and the elongation of 12% are obtained. At the same time the resistance to oscillatory or vibratory stresses is considerably increased by the annealing treatment.

As the experiments of the applicant have shown, the increase in the tensile strength properties of this cold worked copper alloy steel is to be attributed to the separation hardening caused by an excess of copper in solution, which is superimposed over the normal decrease in the tensile strength and the elastic limit. The maximum annealing temperature and the maximum annealing period are determined by the amount of excess dissolved copper and by the extent of the cold working, these two factors work in the same sense. The higher the excess is of dissolved copper and the greater the extent of the cold working, then the maximum tensile strength properties will be reached at a lower temperature given a suitable period of working. The lower limit to this temperature may be considered to be 350° C. and the upper limit 600° C. In general, temperatures lying below 500° C. and annealing periods which for technical reasons, amount to from 1 to 6 hours, are preferable. By combining different annealing temperatures and different periods of annealing, it is possible to get very different grades of tensile strength properties. The particular characteristics of the properties attained in this way are a high proportion of the elastic limit and relatively high deformation values.

The shaping and annealing may advantageously be effected in the same working, which entails advantages from economical standpoint. Working the steel and effecting deposition hardening at the same time thus leads to a very considerable increase in the elongation limit and tensile strength. Thus by stretching a copper alloyed steel to the extent of 10% at 450° C., said steel having in the rolled state an elastic limit of 38 kilograms per sq. mm. and tensile strength of 55

kilograms per sq. mm., the elastic limit will increase to 60 kilograms per sq. mm. and the tensile strength to 67 kilograms per sq. mm. with excellent values for the elongation and toughness.

The carbon content of the copper alloyed steels should preferably not exceed 0.4% since the ferrite is the carrier of the hardness on annealing. This implies that the ferrite content of the copper alloyed steels treated according to the invention should preferably be kept high for obtaining the desired tempering hardness. The steels must therefore contain as little iron-combined carbon as possible; for this reason, it is recommended to use carbon contents below 0.4%. With increasing carbon content, the percentage of ferrite is lowered, as is known.

Since the ferrite is regarded as the carrier of the tempering hardness, this reduces the possibility of improving the strength qualities by tempering or annealing even in the case of a sufficient amount of copper capable of precipitation or separation. The limit of 0.4% must therefore be maintained as the upper limit. The spirit of the invention is not altered by adding certain amounts of other austenite formers (below 2%) individually or in combination to the copper alloyed steel, this being desirable in view of producing a high toughness, such austenite formers are, as is known by anyone skilled in the art, chromium, manganese and silicon which are mentioned in the above given example and furthermore nickel, vanadium, molybdenum, tungsten and cobalt.

The cold shaping may be carried out in the usual way and within the usual limits, for example, by drawing, rolling, upsetting or pressing.

I claim:—

1. A process for increasing the mechanical strength properties of steel, which comprises cold shaping a steel containing carbon only in low amounts lying not substantially above 0.4% and about 0.4 to 5% of copper annealing it at temperatures lying between about 350° and 600° C. during a considerable duration of time in which the state of equilibrium in respect to the general strength qualities is practically reached.

2. A process for increasing the mechanical strength properties of steel, which comprises cold shaping a steel containing carbon only in low amounts lying not substantially above 0.4% and 0.4 to 3% of copper and annealing it at temperatures lying between about 350 and 600° C. during a considerable duration of time in which the state of equilibrium in respect to the general strength qualities is practically reached.

3. A process for increasing the mechanical strength properties of steel, which comprises cold shaping in a single working operation a steel containing carbon only in low amounts lying not substantially above 0.4% and about 0.4% to 5% copper and annealing it at temperatures lying between about 350 and 600° C. during a considerable duration of time in which the state of equilibrium in respect to the general strength qualities is practically reached.

4. A process for increasing the mechanical strength properties of steel, which comprises cold shaping a steel containing about 0.4% to 5% copper and 0.4% carbon, and annealing it at temperatures lying between about 350 and 600° C. during a considerable duration of time in which the state of equilibrium in respect to the general strength qualities is practically reached.

5. A process for increasing the mechanical strength properties of steel, which comprises cold shaping a steel containing carbon only in low amounts lying not substantially above 0.4% and about 0.4% to 5% copper at the maximum and 2% at the maximum of austenite formers the balance consisting substantially of iron with the usual accompanying elements, and annealing it at temperatures lying between about 350 and 600° C. during a considerable duration of time in which the state of equilibrium in respect to the general strength qualities is practically reached.

6. A process for increasing the mechanical strength properties of steel, which comprises cold shaping a steel containing carbon only in low amounts lying not substantially above 0.4% and 0.4% to 3% of copper and annealing it for a considerable duration of about 1 to 6 hours at a temperature lying between about 350 and 600° C.

7. A steel with increased mechanical strength containing carbon in amounts not exceeding about 0.4% and copper in an amount between 0.4% and 5% and possessing such improved strength qualities as are caused by an annealing treatment of considerable duration at temperatures between about 350 and 600° C. carried out after a cold shaping operation below the temperature of re-crystallization.

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