Patented Feb. 8, 1938

2,107,328

UNITED STATES PATENT OFFICE

2,107,328

TREATMENT OF STEEL

Morris G. Fowler and Lyle M. Barker, Clarkdale, Ariz., assignors, by mesne assignments, to Phelps Dodge Corporation, New York, N. Y., a corporation of New York

No Drawing. Application November 23, 1934, Serial No. 754,408

6 Claims. (Cl. 148—14)

This invention relates to the metallurgy of steel and has for an object the provision of an improved method of forming copper steel products. More particularly, the invention contemplates the provision of a process for preventing surface checking of copper steel during mechanical shaping operations such, for example, as forging, rolling and drawing operations. The invention further contemplates the production of copper steel products having improved shaping properties.

This application is a continuation in part of our application Serial Number 636,577, filed October 6, 1932.

Copper steels have long had the reputation of being "red short" and "cold short", the reason being that copper magnified the ill effects of oxygen and sulphur present in the steel. Copper steels in which the sulphur and oxygen contents have been reduced sufficiently low may be forged or rolled easily, but, after forging or rolling under usual conditions, the finished shapes have had very poor surfaces due to surface checks or cracks. Also, due to penetration of scale into these checks or cracks, the scale is very adherent, cannot be removed readily, and may be rolled into the steel.

While the scaling of steel is modified in type by the presence of copper in the steel, it should be understood that the present invention deals with the prevention of checking. The check, being a crack, usually of microscopic dimensions, merely modifies scaling by permitting scaling to start in or at the check. While one aspect of this invention involves control of scale type or scale formation in order to control or modify checking, the object in view is always the restraint of checking.

The severity of surface checking of copper steels varies with the copper content, the higher the copper content the worse the checking. A copper content of about 2% or more, in steel, will cause severe surface checking when the steel is forged or rolled under usual conditions of heating and working. A copper content of 1.5% causes only a moderate amount of surface checking, and a copper content of less than 1% causes only very slight surface checking. A copper-free steel scales easily but under comparable conditions shows little or no checking.

The surface checks on copper steels have the effect of reducing the apparent strength of the steels in that they act as "nicks" or "notches" and cause premature failure or rupture when the steel is strained beyond its elastic limit, either hot or cold. This is especially serious in steel that must be bent to shape, after being forged or rolled under usual conditions, since the checks are the beginnings of tears in the metal and result in serious weakening or complete failure at the bend.

We have demonstrated that the surface checks on copper steels are not the result of "red shortness" or "cold shortness" by grinding or machining off the surface of a forged copper steel bar, below the depth of penetration of the checks, and then testing the bar. A bar so treated will bend hot or cold as well as a bar of copper-free steel of equal hardness, thus showing that the surface checks are not the result of "red shortness" or "cold shortness".

Our researches indicate that surface checking of copper steel probably can be attributed to the existence of a film of liquid copper on the surface of the steel, resulting from selective oxidation of iron. When a copper steel is heated in the presence of a gas that will oxidize iron, the iron is selectively oxidized to iron oxide which forms scale and the copper is concentrated on the steel surface, the degree of concentration depending on the temperature and amount of scaling. The maximum concentration seems to take place at a temperature near the melting point of copper.

The following is an example of scaling tests made to determine the effect of temperature on the concentration of copper on a steel surface during scaling. Pieces of copper steel containing 2% copper were heated in an electric muffle furnace, with fairly free access of air, for times and temperatures indicated below. The pieces were cooled in air, and the scale was cracked off and analyzed for iron and copper:

Temperature	Time	Percent Fe	Percent Cu
°C.	*Hours*		
950	1	73.0	0.80
1000	1	74.4	0.51
1050	1	73.1	0.25
1086	1	74.0	0.15
1100	½	73.2	0.40
1150	½	72.2	0.25

The above figures appear to indicate that a very considerable concentration of copper on the steel surface takes place during scale formation while the steel is being heated to forging temperatures. Once the copper film is formed on the surface of the steel, further scale formation apparently takes place by transfer of iron through the cop-