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OTTAWA October 20th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1724.

The Isothermal Annealing of an A/P Shot Cap Steel.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Request and Object of Investigation:

On August 15th, 1944, Mr. J. G. Smith, Metallurgist, St. Catharines Steel Products, St. Catharines, Ontario, submitted a sample of A/P Shot Cap steel for determination of the parts of the S-curve of interest to one planning an isothermal annealing treatment.

Chemical Analysis:

		Per Cent
Carbon	-	0.76
Manganese	-	0.27
Silicon	-	0.27
Chromium	-	2.06
Nickel	-	Nil.
Molybdenum	-	0.25

Critical Point Determination:

The critical points were determined with an electronic dilatometer capable of recording both temperature and change in length. At a heating rate of 15 Fahrenheit degrees per minute the critical range was from 1350° F. to 1445° F.

Isothermal Treatments:

Specimens ($\frac{1}{2}$" x $\frac{1}{2}$" x 0.050") were cut from the steel supplied, and austenitized at 1525° F. for one hour in an atmosphere of purified nitrogen. Under these conditions, only a slight surface decarburization took place. The specimens were then transferred to a skimmed lead bath covered with charcoal and allowed to transform for various lengths of time before being quenched into water. The lead bath was maintained within 5 Fahrenheit degrees of the following temperature levels: 1305, 1275, 1225, 1175, 1125, and 1075.

After quenching, the specimens were polished on one edge for hardness tests and microscopic examination. In this way the beginning and ending lines of the S-curve were located. The hardness was measured on a Vickers testing machine using a 10-kilogram load. Grain size was determined from a tempered martensite sample, using Vilella's etch.

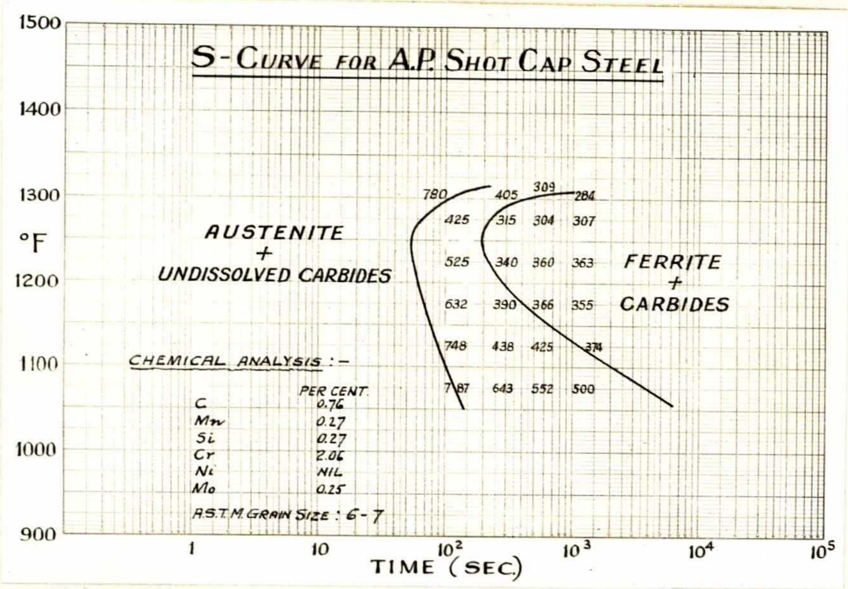
The results obtained are summarized in Figure 1.

(Continued on next page)

(Isothermal Treatments, cont'd) -

Figure 1.

Temp.



Time.

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Discussion and Conclusion:

The S-curve developed shows that it is possible to isothermally transform this shot-cap steel in a reasonably short time at 1200° to 1300° F. However, considerations of machinability would make it necessary to transform the steel in a temperature range of from 1275° to 1300° F., at which temperatures a hardness of 300 Vickers or under can be obtained. Although transformation at 1300° F. produces best conditions for machinability in this particular steel, it should be noted that transformation times increase greatly at slightly higher temperatures. Even a slight lowering of the curve, such as might be produced by variations in composition, grain size, degree of carbide solution, might increase tremendously the necessary time of transformation at 1300° F. If the steel is not completely transformed, small quantities

(Discussion and Conclusion, cont'd) -

of the martensite will be formed on subsequent air-cooling and will give great trouble in machining. This could result from insufficient time being allowed at the chosen transformation temperature. In view of the danger that transformation may not be complete under certain conditions when transformation at 1300° F. is attempted, it is felt that the safer procedure of isothermally transforming at 1275° is desirable. At this temperature a hardness of about 300 Vickers (30 Rockwell 'C') can be obtained after a half-hour period. If a lower hardness than this is definitely required, it can be obtained by careful transformation at 1300° F., which would result in a product of about 280 Vickers hardness.

The austenitizing conditions were such that some spheroidization took place, resulting in a mixture of spheroidized and lamellar products. This can be seen in the microphotograph, Figure 2.

Figure 2.

X1000, nital etch.

SHOWING PARTIAL SPHEROIDIZED AND LAMELLAR STRUCTURE DEVELOPED AFTER 30 MINUTES AT 1305° F.

If for purposes of subsequent machining it is desirable to develop an entirely spheroidized structure the steel should be austenitized at lower temperatures. A temperature

(Discussion and Conclusion, cont'd) -

of about 1425 to 1450° F. for this steel should be favourable for development of a completely spheroidized product.

The influence of the number and size of the undissolved carbides is important. Their presence reduces the effective carbon content of the austenite as regards hardenability and they further decrease the hardenability by their nucleating effect on the precipitation. They also lower the hardness of the transformation product at a given temperature level because they increase the carbide spacing. The state of the carbides therefore greatly affects the position of the S-curve. It is known that the carbides are relatively more effective in accelerating the transformation at higher temperatures.

It has already been mentioned that grain size and composition also play an important part in the rates of transformation and the heat treater should take all these factors into account in austenitizing and subsequently transforming.

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The sample of steel submitted, after austenitizing under conditions which may be considered quite similar to commercial conditions, behaved in the manner summarized in the S-curve of Figure 1.

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RLC:AD:GHB.