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REPORT

ON

THE RUPTURE PROPERTIES OF OIL QUENCHED "17-22-A"S AT 1000°F

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The purpose of this investigation was to determine how oil quenching and tempering of "17-22-A"S barstock, instead of normalizing and tempering, influences the rupture properties. A stress-rupture time curve was to be established for the oil quenched material at 1000°F and compared with results previously obtained for normalized material as presented in Timken Report No. 198.

In addition to rupture testing, metallographic examinations were made of the original and of the rupture tested material.

Summary and Conclusions

Examination of the data obtained and comparison with data previously reported led to the following conclusions:

(1) The rupture strength at 1000°F of the "17-22-A"S material oil quenched from 1725°F and tempered is considerably lower than that normalized from 1725°F and tempered. The comparative strengths were as follows:

Heat No.	Treatment	Rupture Strength (psi) 100-hr	1000-hr	10,000-hr
10420	O. Q. 1725°F + Tempered 1200°F	62,000	43,500	(21,000)
16030	N. 1725°F + Tempered 1200°F	75,000	60,000	(30,000)

( ) Extrapolated value

(2) The elongation at rupture was slightly higher for the oil quenched material for comparable rupture time periods.

(3) The structure of the oil quenched material was tempered martensite as compared to tempered bainite and ferrite for the normalized material. In the past, it has generally been found that a bainitic structure usually resulted in

in higher rupture strengths than those obtained for martensitic structures.

Test Material

Tensile specimens (.505 inches in diameter) were supplied from "17-22-A"S Heat 10420. The material had been oil quenched from 1725°F and tempered at 1200°F to a Brinell hardness of 285/302. The analysis of the heat was as follows:

C	Mn	P	S	Si	Cr	Ni	Mo	V
.29	.61	.016	.016	.67	1.30	.18	.47	.26

Where the stress in the rupture test was above 40,000 psi, the diameter of the specimen was remachined to 0.400 inches to bring the load requirements within the capacity of the stress-rupture units.

Results and Discussion

Stress-rupture tests were run on the oil-quenched and tempered "17-22-A"S material at 1000°F. The rupture test data obtained are presented in Table I and the log stress-log rupture time curve (Figure 1) obtained from this data is compared with a curve for "17-22-A"S barstock from Heat 16030 normalized from 1725°F and tempered for 6 hours at 1200°F to a Brinell hardness of 311/331 (Timken Report No. 198).

The 100-hour, the 1000-hour, the extrapolated 10,000 hour rupture strengths and the estimated elongations at fracture are compared in the following tabulation:

Heat No.	Heat Treatment (All Tempered at 1200°F)	BHN	Rupture Strength (psi) 100-hr	1000-hr	10,000-hr	Rupture Elongation(%) 100-hr	1000-hr
10420	Oil Quenched 1725°F	285/302	62,000	43,500	(21,000)	18	5.5
16030	Normalized 1725°F	311/331	75,000	60,000	(30,000)	11	2

The data and the tabulation show that oil quenching the material lowered the rupture strengths considerably. The stress-rupture time curve in Figure 1 is not well established because only one test point was available past the break in the curve. The curve was drawn parallel to the curve for the normalized condition. The ductility at fracture was slightly higher. It, however, continued to decrease with time beyond 1000 hours. The hardness of the oil quenched material was somewhat lower and thus may have to some extent contributed to the lower rupture strength and higher ductility.

The data also indicate that a break in the stress-rupture time curve occurred at about 1000 hours for both heat treatments.

The time elongation curve for the single creep rupture test run at 35,000 psi and 1000°F is presented in Figure 2. The minimum creep rate obtained for this test was approximately 0.56 percent/1000 hours. Data for the normalized material were unavailable for comparison.

The microstructure of the material after oil quenching from 1725°F and tempering at 1200°F is shown in Plate 1. The structure was largely tempered martensite. The structure at the fracture and at the surface adjacent to the fracture from the specimen that ruptured after 2060 hours at 35,000 psi and 1000°F are shown in Plate 2. Very little change in structure other than possible some additional tempering of the transformed products is evident. In rupture testing, cracks formed at and adjacent to the fracture in the usual manner though somewhat more pronounced than those obtained for the normalized material from Heat 16030 and tested under approximately the same condition. (Report 198).

Previous work on "17-22-A"S steel indicated that normalizing from 1725°F and tempering resulted in a structure of ferrite and tempered carbides presumably tempered bainite.

Vickers diamond pyramid impressions under a 10 Kg load were made on both metallographic specimens from the oil-quenched material and the resulting hardness values indicated that a considerable amount of tempering occurred during the rupture test. The measurements converted to Brinell hardness values were as follows:

Original material	-	305 Brinell
After Rupture Testing		255 Brinell

TABLE I

Rupture Data for "17-22-A"S Steel at 1000°F

(Heat 10420 Oil Quenched from 1725°F and Tempered at 1200°F to a

Brinell Hardness of 285/302)

Stress (psi)	Rupture Time (hours)	Elongation (% in 2 in.)	Reduction of Area (%)
60,000	117	18.5	46.0
55,000	210	16.0	39.5
43,000	1063	5.5	7.5
35,000	2060	3.5	4.5

FOR PLATES 1 and 2 and Fig. 1 and 2,
see File Copy