REPORT

ON

RUPTURE PROPERTIES AT 1200° AND 1300°F OF A TURBINE DISC FORGING FROM A286 STEEL

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INTRODUCTION

This investigation was undertaken to determine the rupture strength at 1200° and 1300°F of A286 steel taken from a turbine disc forging.

This steel is used generally in the form of bars and forging stock for turbine rotors, shafts, buckets or blades and other uses requiring high strength up to 1300°F.

This report presents the stress-rupture properties estabished for the material taken both radially and tangentially from the forged turbine disc.

SUMMARY AND CONCLUSION

Appraisal of the data obtained on the turbine disc forging from A286 steel led to the following conclusions:

1. The 1000-hour rupture strength at 1200° and 1300°F were approximately 50,000 psi and 31,000 psi, respectively, for both radial and tangential direction.

2. The elongation to rupture in 1000 hours at 1200°F was approximately 2 to 4 percent. At 1300°F, the ductility was somewhat higher. Radial specimens near the rim exhibited the lowest elongations, about 5 percent, whereas the radial specimens from the center of the disc gave elongations as high as 10 percent.

3. The position of the specimen in the disc appeared to have very little effect on the rupture strength at 1000 hours.

4. The migration to and growth at the grain boundaries of the carbides indicate the minor structural instability at the temperatures tested.

TEST MATERIALS

A number of tensile specimens, machined to a diameter of 0.357 inches, were submitted from a turbine disc forging of A286 steel having the following chemical composition:

Heat No.	C	Mn	P	S	Si	Cr	Ni	Mo	V	Ti
02395	0.047	1.54	0.017	0.011	0.68	14.15	25.44	1.28	0.27	2.12

The forged disc was oil quenched from 1800°F and tempered for 16 hours at 1325°F to a hardness range of 248/262 Brinell.

The direction and location of the specimens within the disc and the code numbers used for identification were as follows:

Code	Direction of Test
R	Radial (near outer diameter of disc)
T	Tangential (near outer diameter of disc)
RC	Radial (from center of disc)

RESULTS AND DISCUSSION

Tests were carried out to establish the rupture characteristics at 1200° and 1300°F of both the tangential and the radial specimens from the A286 forging described above. The results of the stress-rupture tests are presented in Table I and Figure 1.

The stress - rupture time curves, Figure 1, were established initially at both temperatures for time periods out to 1000 hours from radial specimens. Check tests at both temperatures were then run on the tangential specimens taken from the outer diamter of the disc and the radial specimens taken from the center of the disc.

The rupture strengths at both temperatures for 100 and 1000 hours are shown by the following tabulation:

Specimen Direction	Temp (°F)	Rupture Strength (psi)		Elongation (%)	
		100-hour	1000-hour	100-hour	1000-hour
R	1200	60,000	50,000	3	2
T	1200	(64,000)	49,000	--	4
RC	1200	--	(47,000)	--	3
R	1300	45,000	31,000	5	5
T	1300	(48,000)	31,000	--	7
RC	1300	--	(32,000)	--	10

( ) Figures enclosed in brackets are estimated values based on extrapolations.

The rupture data indicate that there is very little variation in the 1000-hour rupture strength between specimens taken from different locations in the disc.

The two tests run at each temperature on the tangential material show a slight tendency toward higher short-time strengths and lower strengths beyond 1000 hours because of the steeper slope of the stress - rupture time curves.

There was no observable difference in microstructure between the tangential and radial specimens. The original structure of the A286 steel from this heat is shown in Plate No. 1. The 1800°F treatment of this

material resulted in ASTM grain size of 3 to 5. The structure consisted of an austenitic matrix of carbides and nitrides (or carbonitrides) distributed rather uniformly throughout the structure, both in the grains and in the grain boundaries.

The structure of the radial specimen fractured after 2156 hours at 47,000 psi and 1200°F is shown in Plate No. 2. There appeared to be lesser amounts of carbides in the grains than were observed prior to testing. However, the grain boundaries were clearly outlined by a discontinuous precipitate. These were probably formed by migration of the carbides to the grain boundary during rupture testing. Intergranular cracks are present both at the fractured surface and in the side adjacent to the fracture.

The radial specimen fractured after 738 hours under a stress of 32,500 psi at 1300°F showed the presence of larger grain boundary precipitates than were obtained for the material tested at 1200°F. Other than this, the microstructure of the specimens tested at 1200° and 1300°F were similar. There were a lesser number of intergranular cracks both at the fracture and at the surface adjacent to the fracture. There was some evidence of transgranular fracture, as may be seen in the micrograph of the fracture at 1300°F, Plate No. 3.

TABLE I

Stress-Rupture Data for a Turbine Disc Forging
from A286 Alloy (Heat 02395)

(Oil Quenched from 1800°F + 16 hours at 1325°F - 248/262 Brinell)

Code No.	Stress (psi)	Rupture Time (hours)	Elongation (% in 1 in.)	Reduction of Area (%)
		Rupture Test at 1200°F		
R	60,000	113	2.5	5.5
R	57,000	237	2.0	2.0
R	50,000	641	2.0	2.0
R	47,000	2156	(a) (b)	--
T	57,000	406	4.0 (a)	4.0
T	47,000	1437	4.0	4.5
RC	47,000	881	3.5	3.0
		Rupture Test at 1300°F		
R	55,000	11	3.0	5.0
R	45,000	101	5.5	6.5
R	36,000	470	6.0	10.5
R	32,500	738	5.0	7.5
T	45,000	208	3.0	4.0
T	32,500	745	7.0	12.0
RC	32,500	837	10.0	11.0

(a) Broke in gage mark.
(b) Broke in fillet.

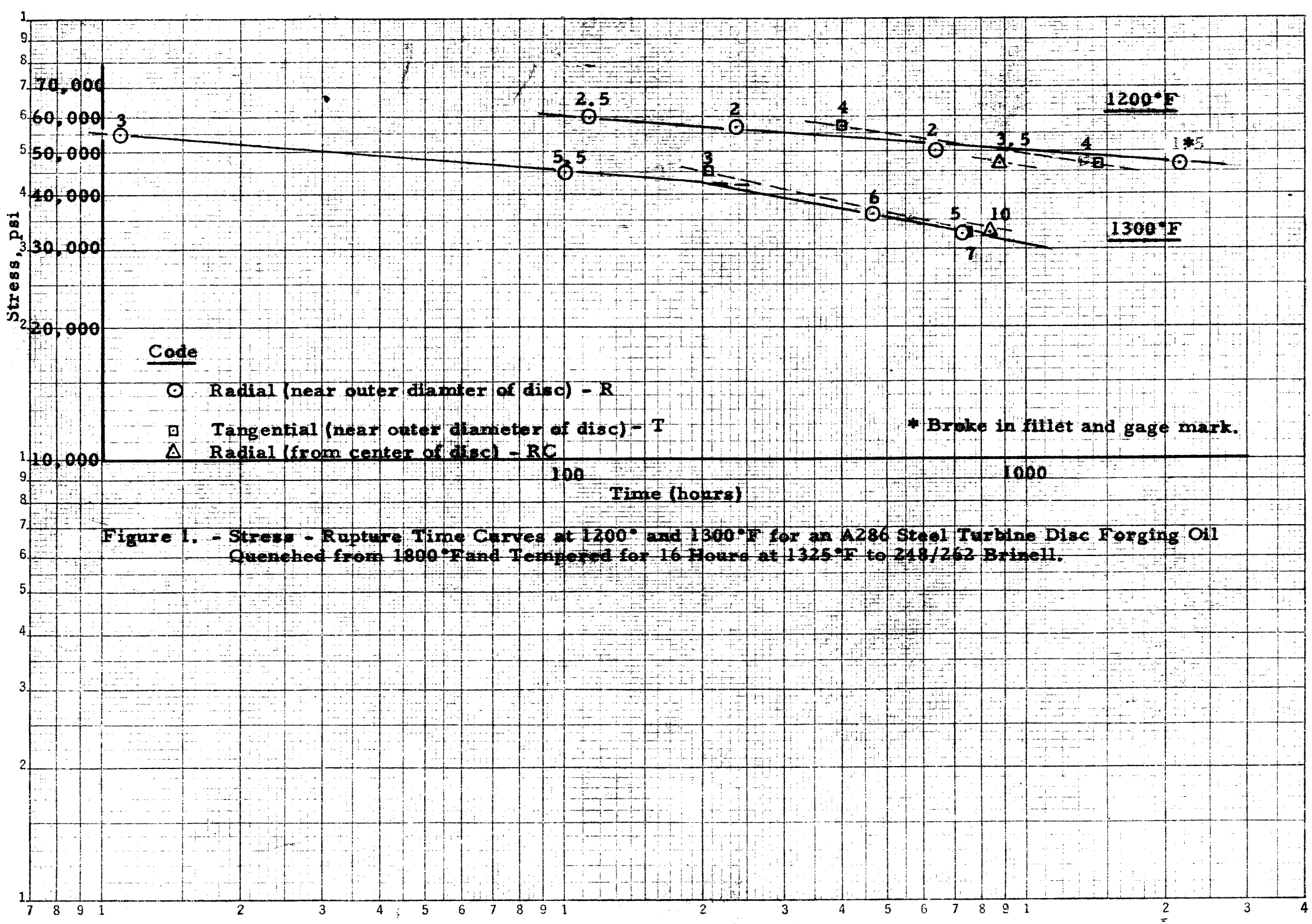

Figure 1. - Stress - Rupture Time Curves at 1200° and 1300°F for an A286 Steel Turbine Disc Forging Oil Quenched from 1800°F and Tempered for 16 Hours at 1325°F to 248/262 Brinell.

Three mounted picture pages follow here.

See E.R.I. file copy.