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Effect of Heat Treatment and Surface Oxidation on Low-Cycle Fatigue Life of Inconel

Heat No.	Elements, Percent														
	C	Mn	Fe	S	Cu	Ni	Cr	Al	Ti	Co	Mo	Cb+Ta	P	B	Si
1	0.05	0.25	16.57	0.007	0.06	53.83	18.67	0.64	0.98	0.07	3.16	5.46	0.009	0.0027	0.30
2	0.04	0.19	18.15	0.007	0.04	53.44	18.46	0.53	0.92	0.05	2.91	4.82	0.011	0.0027	0.30
3	0.04	0.23	17.45	0.007	0.04	53.05	18.41	0.70	1.00	0.06	3.20	5.45	0.011	0.0028	0.29
4	0.03	0.29	18.12	0.007	0.06	53.36	18.40	0.50	0.94	0.07	3.15	4.85	0.013	0.0023	0.27

Table 1. As-Received Material Data for Four Inconel 718 Heats Evaluated, Spectrographic Analysis

The problem:

Low cycle fatigue data on Inconel 718 are required because fatigue is the primary mode of failure of thin-wall (0.006-0.020 inch) bellows of this alloy.

The solution:

A test program involving specimens with different heat treatment, surface condition, and chemical composition.

How it's done:

To evaluate the influence of alloy hardener (Cb + Ta) on the low-cycle fatigue properties, sheets were obtained from four heats of Inconel 718 with differing hardener (Cb + Ta) content (see Table 1). Also two thicknesses were provided in each chemical composition extreme to determine any influence of thickness on low-cycle fatigue life.

All test material was cold-reduced 15 percent from the original thickness to destroy effectively the 1900°F mill anneal. The sheets were then sheared into fatigue and tensile blanks in the longitudinal direction, and four groups of tensile and fatigue blanks from each sheet were heat treated in an argon atmosphere, each group being given one of the four heat treatments listed in Table 2. To obtain a small amount of surface oxidation, an additional four groups of tensile and fatigue blanks from each sheet were heat treated in air, using the same four heat-treat cycles. After heat treating, the tensile and fatigue blanks were machined to their final test specimen configuration.

Specimens were fatigue tested in a flexural fatigue machine with the cycles to failure being recorded as a function of the specimen deflection. Loading was completely reversed, bending with a constant frequency of 30 cpm maintained for all deflections. After the fatigue testing was completed, untested specimens in the two thicknesses were fitted with post-yield strain gages. Using special fixtures in the testing machine, the strains on the outer fibers of the fatigue specimens were recorded as a function of the cross-heat deflection. From the strain measurements, the outer fiber stresses were determined from the stress-strain curves derived from the tensile tests. The following conclusions were drawn from the test series: (1) Maximum low-cycle fatigue life was obtained with annealing temperatures in the range of 1850° to 1950°F. (2) Surface oxidation of 0.002- to 0.001-inch penetration did not have a significant effect on the low-cycle fatigue life of the test specimen. (3) Heats with high hardener content had tensile yield and ultimate

(continued overleaf)

strengths approximately 3 to 5% higher than heats with low hardener content. This increase in tensile properties did not have a significant effect on the low-cycle fatigue life.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Reference: B70-10092

Patent status:

No patent action is contemplated by NASA.

Source: Stephen D. Foster of
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Treatment Number	Solution Treatment	Aging Treatment
1	2050°F for 1/2 hour; air cool to ambient	1400°F for 10 hours; cool to 1200°F; hold for a total aging time of 20 hours; air cool to ambient
2	1950°F for 1/2 hour; air cool to ambient	1400°F for 10 hours; cool to 1200°F; hold for a total aging time of 20 hours; air cool to ambient
3	1850°F for 1/2 hour; air cool to ambient	1350°F for 10 hours; cool to 1150°F; hold for a total aging time of 20 hours; air cool to ambient
4	1750°F for 1/2 hour; air cool to ambient	1325°F for 10 hours; cool to 1150°F; hold for a total aging time of 20 hours; air cool to ambient

Table 2. Heat Treatments for Inconel 718 Fatigue Specimens