

AD 685381

D6-23717
October 1968

Methanol Cracking of Titanium 8Al-1Mo-1V

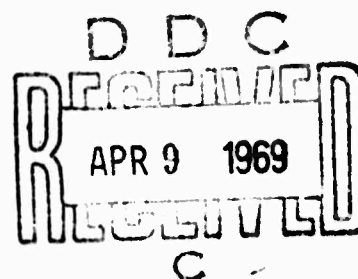
D. N. Fager

BOEING
COMMERCIAL AIRPLANE DIVISION
RENTON, WASHINGTON

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information Springfield Va. 22151

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 878

This document has been approved
for public release and sale; its
distribution is unlimited.



METHANOL CRACKING OF TITANIUM 8Al-1Mo-1V

By D. N. Fager

Stress corrosion cracking of a commercial alpha-beta alloy in methanol was compared to results obtained in 3.5% sodium chloride solution. Previous work by Meyn (1) showed that fracture in methanol occurs by cleavage similar to the cleavage in salt solutions. Beck (2) discovered another similarity to salt-solution cracking in that Ti-8Al-1Mo-1V became less susceptible in methanol as it was given higher-temperature solution treatments. The alloy became virtually immune when quenched from the beta-phase field to produce an all-martensite structure. Optical metallography was performed in the present study and, as expected, showed that the cracks tended to stop at the beta-phase particles (point A in Fig. 1). The higher resistance of the beta phase and of the martensite phase transformed from the beta is consistent with the change in susceptibility after higher temperature solution treatments in the alpha-beta phase field. This is similar to the behavior found in salt solution (2, 3).

Mill-annealed 0.5-inch Ti-8Al-1Mo-1V plate, exhibiting pronounced preferred orientation of basal planes normal to the plate surface and parallel to the rolling direction, was available from a previous study (3). Standard precracked Charpy specimens were fabricated from this material and tested in reagent-grade methanol by a procedure described in Ref. 3. No control was exercised over the water or chloride content of the methanol.

Initial tests were conducted on specimens designated transverse-longitudinal¹, in which the preferred (0001) planes were *parallel* to the main fracture path. The data are reported in Fig. 2, where the stress intensity ratio K_{Ii}/K_{Ic} as a function of time to failure is an indication of the severity of cracking² (3). These results indicate that cracking is more severe in methanol (curve A) than in sodium chloride solution (curve B). This is consistent with the data from tensile tests (0.005 min⁻¹ strain rates) performed on unnotched specimens of mill-annealed Ti-8Al-1Mo-1V in that premature failure occurred after approximately 2% plastic strain in methanol, but no effect was seen in the sodium chloride solution.

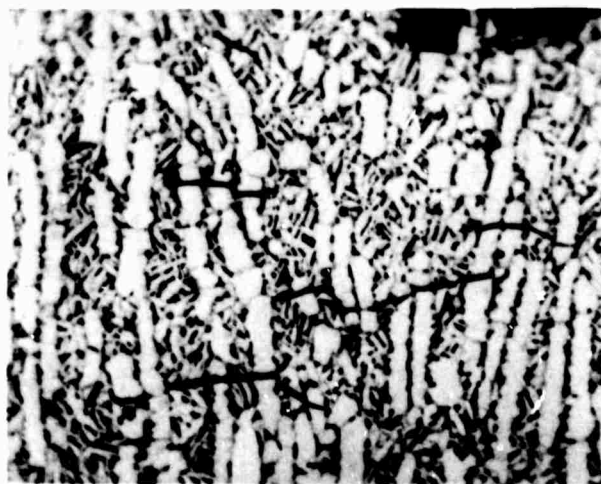


Fig. 1. Methanol cracking in Ti-8Al-1Mo-1V, longitudinal view, X 1,000 (fracture face above). Crack is arrested by beta phase at A.

¹The first direction is that of the major stress axis; the second is the direction of main crack propagation.

² K_{Ii} is the plane-strain stress intensity factor at the beginning of the test, and K_{Ic} is the plane-strain critical stress intensity factor.

The author is associated with the Commercial Airplane Division of The Boeing Company, Renton, Washington. This research was supported by the Advanced Research Projects Agency of the Department of Defense (ARPA Order 878) and was monitored by the Naval Research Laboratory under Contract N00014-66-C0365.

The cracks shown in Fig. 1 occurred approximately normal to the long dimension of the alpha grains. As determined previously by electron microscopy (3), this corresponds to the preferred orientation of the (0001) in these elongated alpha grains. It is thus reasonable to conclude that fracture in methanol occurs on or near the (0001) planes, similar to cracking in salt solution. (Blackburn (4) determined that cracking occurred on the (10 $\bar{1}$ 7) or (10 $\bar{1}$ 8) in salt solution.) This does not eliminate the possibility, however, that fracture can occur on other planes as well as those near the basal.

If fracture in methanol could occur on planes other than those near the (0001), this would explain why cracking in this environment is more severe than cracking in sodium chloride solution. Further tests were conducted on specimens designated longitudinal-transverse, i.e. the preferred (0001) planes were *normal* to the direction of the main fracture. Thus the (11 $\bar{2}$ 0) or (1 $\bar{1}$ 00) planes would be the most favorable for cracking. Data for these specimens in Fig. 2 (curve C) show that failure does not occur below

the baseline K_{Ic} . A fracture face from the specimen in this orientation is shown in Fig. 3. The crack propagated from the fatigue crack at A in a predominantly ductile manner (B) until conditions were favorable at C for cleavage near the preferred basal planes, even though these planes were unfavorably oriented to aid propagation in the main cracking direction. From the test results and the observed fracture morphology, it is apparent that ductile fracture occurs in preference to cleavage on planes not near the basal in methanol, exhibiting the same behavior as in sodium chloride solution (3).

Since the crack path characteristics in sodium chloride and methanol solutions are similar, the lower K_{Ii}/K_{Ic} levels at which failures occur in methanol (also the unnotched tensile failures, see above) demonstrate that a lower stress (or strain) is required for alpha grain cleavage in methanol. And since times to failure in salt solution and methanol are comparable at $K_{Ii}/K_{Ic} \approx 0.65$, this implies that some step in the cleavage process is slower in methanol than in sodium chloride solution.

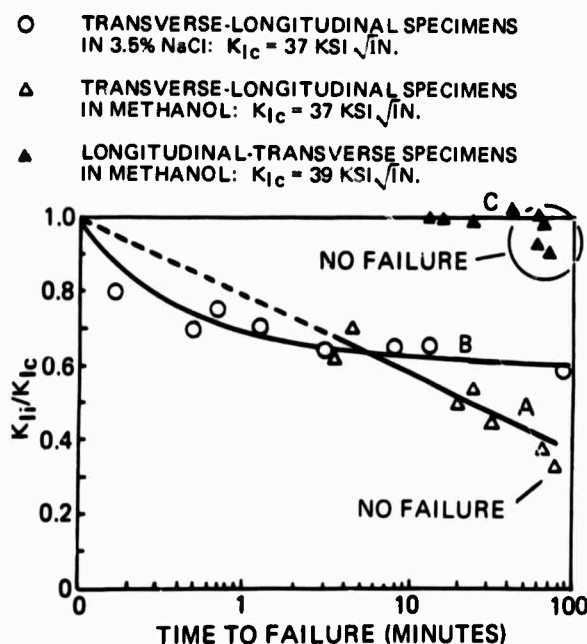


Fig. 2. Stress corrosion susceptibility of Ti-8Al-1Mo-1V in methanol and salt solution.

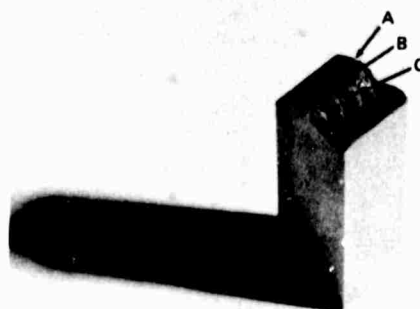


Fig. 3. Fracture face of longitudinal-transverse specimen failed in methanol. Fatigue crack at A; ductile failure at B; cleavage near preferred basal planes at C.

REFERENCES

1. D. A. Meyn, "Effect of Crack Tip Stress Intensity on the Mechanism of Stress-Corrosion Cracking of Titanium-6Al-4V in Methanol," *Corrosion Sci.* 7 (1967), p 721.
2. T. R. Beck, *Stress Corrosion Cracking of Titanium Alloys*, NAS 7-489, Progress Report No. 3, Boeing Scientific Research Laboratories (March 1967).
3. D. N. Fager and W. F. Spurr, "Some Characteristics of Aqueous Stress Corrosion in Titanium Alloys," *ASM Trans Quarterly*, 61, No. 2 (June 1968), p 283.
4. T. R. Beck and M. J. Blackburn, *Stress Corrosion Cracking of Titanium Alloys*, NAS 7-489, Progress Report No. 4, Boeing Scientific Research Laboratories (June 1967).

DOCUMENT CONTROL DATA - R & D (Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author) The Boeing Company Commercial Airplane Division Renton, Washington		2a. REPORT SECURITY CLASSIFICATION Unclassified
		2b. GROUP
3. REPORT TITLE Methanol Cracking of Titanium 8Al-1Mo-1V		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Research Report		
5. AUTHOR(S) (First name, middle initial, last name) Daniel N. Fager		
6. REPORT DATE October 1968	7a. TOTAL NO. OF PAGES 4	7b. NO. OF REFS 4
8a. CONTRACT OR GRANT NO. N00014-66-C0365	9a. ORIGINATOR'S REPORT NUMBER(S)	
b. PROJECT NO.		
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.	Boeing Document D6-23717	
10. DISTRIBUTION STATEMENT Reproduction in whole or in part is permitted by the United States Government. Distribution of this document is unlimited.		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency, Department of Defense	
13. ABSTRACT A comparison is made between methanol and salt-solution cracking of Ti-8Al-1Mo-1V. Cracking characteristics are similar in that the beta and martensite phases have higher resistance and cleavage in the alpha phase must occur near the basal plane in both environments. It is suggested that, although cracking occurs at a lower stress level in methanol, some step in the cleavage process is slower than in salt solution.		

14	KEY WORDS		LINK A		LINK B		LINK C	
ROLE			WT	ROLE	WT	ROLE	WT	
Titanium Alloy								
Stress Corrosion								
Methanol								
Preferred Grain Orientation								