AD-A064 804 DREXEL UNIV PHILADELPHIA PA DEPT OF MATERIALS ENGINEERING F/G 11/4
EFFECT OF OXIDATION ON THE TOUGHNESS AND STRENGTH OF THE CO, CR--ETC(U)
JAN 79 M H LATIF, A LAWLEY N00014-76-C-0205

UNCLASSIFIED NL

1 OF 1
AD A064804

END
DATE FILMED
4-79
DDC

(12)

LEVEL II

EFFECT OF OXIDATION ON THE TOUGHNESS AND STRENGTH OF THE Co,Cr-$(Cr,Co)_7C_3$ IN-SITU COMPOSITE

M. H. Abdel Latif and A. Lawley

January 1979

Technical Report

Office of Naval Research
Arlington, Virginia 22217

Contract #N00014-76-C-0205

Drexel University
Department of Materials Engineering
Philadelphia, Pa. 19104

unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

(9)

4. TITLE (and Subtitle)

(6) Effect of Oxidation on the Toughness and Strength of the Co,Cr-$(Cr,Co)_7C_3$ In-Situ Composite

5. TYPE OF REPORT & PERIOD COVERED

Technical Report

January 1979

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

(10) M. H. Abdel Latif and A. Lawley

8. CONTRACT OR GRANT NUMBER(s)

(15) N00014-76-C-0205

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Drexel University
Department of Materials Engineering
Philadelphia, Pa. 19104

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

Office of Naval Research
Arlington, Virginia 22217

(11)

12. REPORT DATE

January 1979

13. NUMBER OF PAGES

8

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

(12) 8 p.

15. SECURITY CLASS. (of this report)

unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

In-situ composite, cobalt-rich matrix, carbide reinforcement, isothermal exposure, oxidation, toughness, strength.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Some preliminary observations on the oxidation response of Co,Cr-$(Cr,Co)_7C_3$ in air at 1121°C are presented. These include weight gain and subsequent room temperature strength, hardness and toughness. The composite shows superior oxidation resistance to several other in-situ composites by virtue of its high chromium content. Oxidation enhances toughness but leads to a decrease in hardness and strength. The toughness increase is associated with fiber coarsening.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

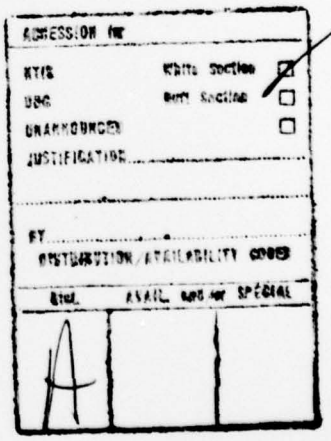
unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

409 593

SUMMARY

Some preliminary observations on the oxidation response of Co,Cr-$(Cr,Co)_7C_3$ in air at 1121°C are presented. These include weight gain and subsequent room temperature strength, hardness and toughness. The composite shows superior oxidation resistance to several other in-situ composites by virtue of its high chromium content. Oxidation enhances toughness but leads to a decrease in hardness and strength. The toughness increase is associated with fiber coarsening.



The development of advanced gas turbines has resulted in the need for alloys possessing superior high temperature stability and mechanical properties to the conventional superalloys. This need has stimulated interest in and development of in-situ metal-matrix composites. While the importance of oxidation resistance is realized, relatively few investigators have studied the high temperature oxidation of this class of materials (1-8).

The only information on the Co,Cr-$(Cr,Co)_7C_3$ composite is that of Staub and Erdös (9) who suggest a preferential attack of the Cr_7C_3 carbide. El-Dahsham et al.(10) conducted a detailed study of the oxidation of conventionally cast Co-Cr-C alloys in which the principal carbide was $M_{23}C_6$. It was found that overall oxidation rate was similar to that of binary Co-Cr alloys of the same chromium content. In the present study some initial observations are reported for the oxidation response of Co,Cr-$(Cr,Co)_7C_3$ in air, both in the as-grown condition and following post-solidification isothermal heat-treatments. Particular attention was directed to possible effects of oxidation on toughness.

Composites were directionally solidified at 7×10^{-6}m/s and 47.6×10^{-6}m/s to give an aligned rod-like reinforcement of Co,Cr-$(Cr,Co)_7C_3$ in a cobalt-rich matrix at $V_f = 0.3$. Sections of the ingot were then exposed at 1121°C in air and oxygen for times up to 26×10^5s. Toughness was evaluated by the work of fracture test. Details of the growth and toughness testing procedures are given elsewhere (11).

It was found that spalling began after $\sim 43.2 \times 10^4$s and that this compensated approximately for the weight gain caused by oxidation. Thus, specimens were exposed in a ceramic container and the weight change determined for the specimen and the container as one unit.

Weight gain is plotted as a function of exposure time at 1121°C in Figure 1. Data for other in-situ composites and two superalloys are included for

comparison; these are taken from reference (8) and refer to tests in air at 1100°C. With the exception of Ni-Ni_3Al-Ni_3Ta+6%Cr, the oxidation resistance of Co,Cr-$(Cr,Co)_7C_3$ is superior to that of the lamellar in-situ composites and Mar-M-509. This is attributed to the relatively high chromium content of the composite, namely 41% by weight.

Work of fracture G_f and peak load P_ℓ measured in the toughness test are plotted as a function of thermal exposure in Figure 2. Data refer to composites grown at 7 x 10^{-6}m/s. While the G_f values were comparable for air and argon exposure, the P_ℓ values were significantly inferior as a result of exposure at 1121°C in air. Peak load (P_ℓ) is a measure of the strength of the composite and the decrease is consistent with the observed changes in hardness and compressive strength. Figures 3 and 4 show that both hardness and compressive strength decrease as a result of isothermal exposure in air at 1121°C. The increase in the room temperature work of fracture (compared to the as-grown condition) has been shown (11) to be the result of fiber coarsening with an attendant increase in interfiber spacing and fiber diameter. The extent of fiber coarsening should be similar in air and argon. Hence, the similarity in the curves for G_f after exposure in argon or air mean that any microstructural changes occurring during oxidation are not detrimental to toughness. More work is needed to understand the difference in the response of strength and toughness to oxidation.

References

1. J. Stringer, AGARD Conference Proceedings No. 156, p. 131-140 (Harford House, London, 1974).
2. J. G. Smeggil and M. D. McConnell, Oxid. Metals, 8, 309-311 (1974).
3. J. G. Smeggil,,Oxid. Metals, 9, 31-44 (1975).
4. J. C. Hubert, F. R. Mollard and B. Lux, Proceedings of the 1972 Conference on In Situ Composites, Publication NMAB 308, volume II, p. 323-331 (Washington, 1973).
5. F. R. Mollard, B. Lux and J. C. Hubert, Z. Metallkunde, 65, 461-468 (1964).
6. J. C. Hubert, W. Kurz and B. Lux, J. Crystal Growth, 18, 241-249 (1973).

7. J. G. Smeggil, Conference on In-Situ Composites - II, Editors: M. R. Jackson, J. L. Walter, F. D. Lemkey and R. W. Hertzberg, Xerox Individualized Publishing, Lexington, Mass., 1976, p. 397.

8. F. R. Mollard and B. Lux, ibid., p. 385.

9. F. Staub and E. Erdös, private communication.

10. M. E. El-Dahsham, J. Stringer and D. P. Whittle; work reported in reference #1 as unpublished.

11. M. H. AbdelLatif and A. Lawley, "Effect of Heat Treatment on the Structure and Toughness of Co,Cr-$(Cr,Co)_7C_3$"; submitted to Met. Trans., 1979.

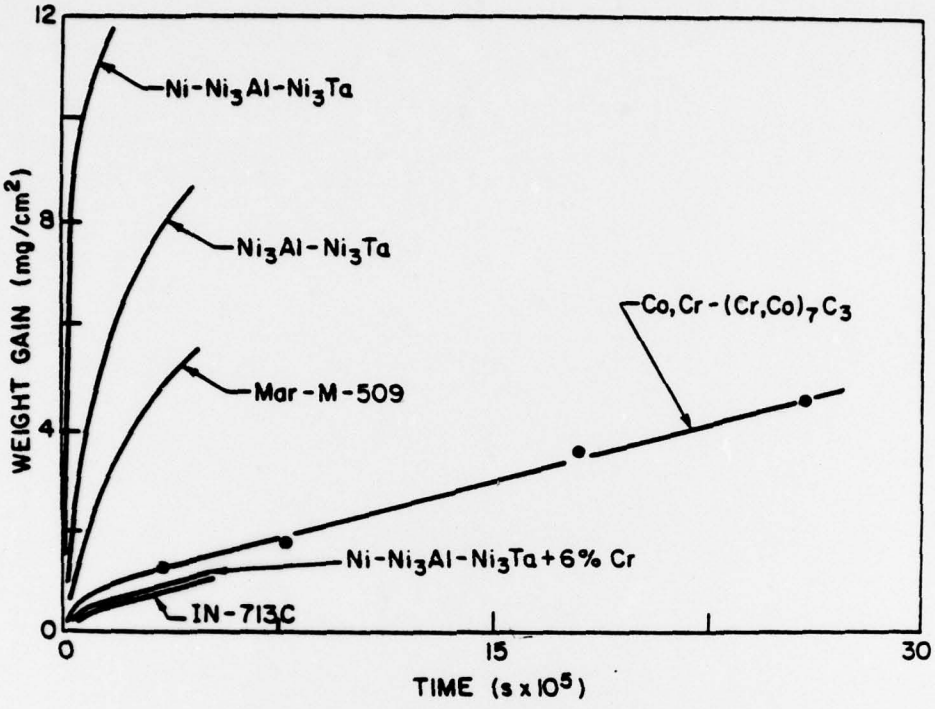


Figure 1. Comparison of the oxidation behavior of $Co,Cr-(Cr,Co)_7C_3$ in air at 1121°C with that of other in-situ composites and two superalloys at 1100°C.

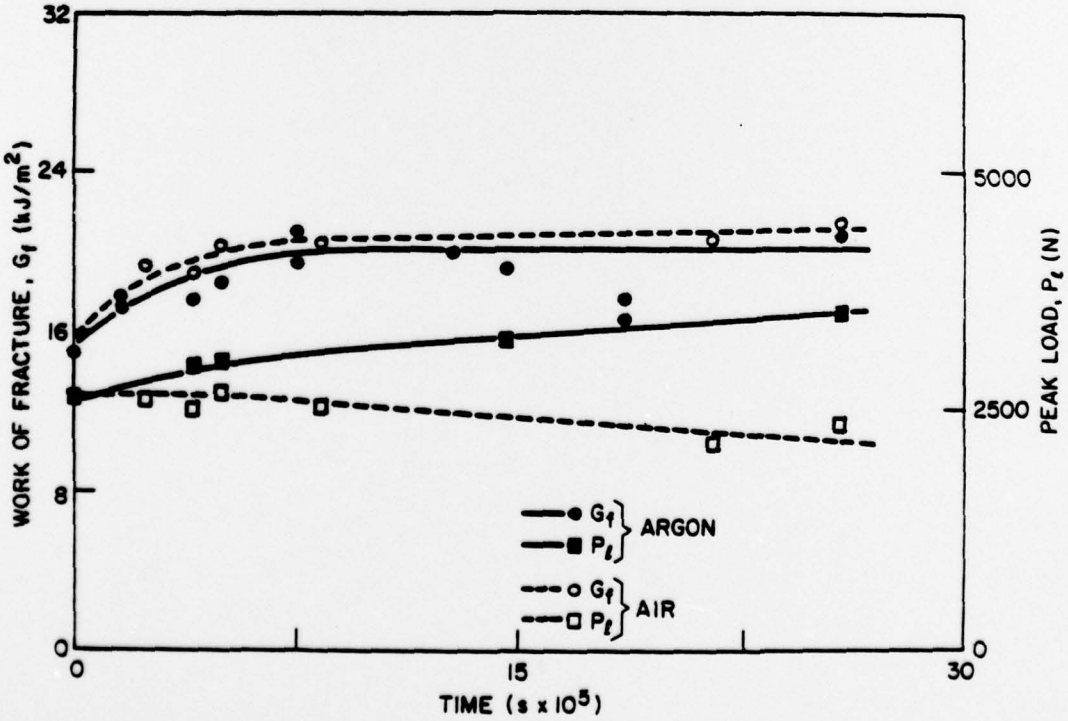


Figure 2. Comparison of the work of fracture (G_f) and peak load (P_ℓ) as a function of exposure time at 1121°C in air and argon.

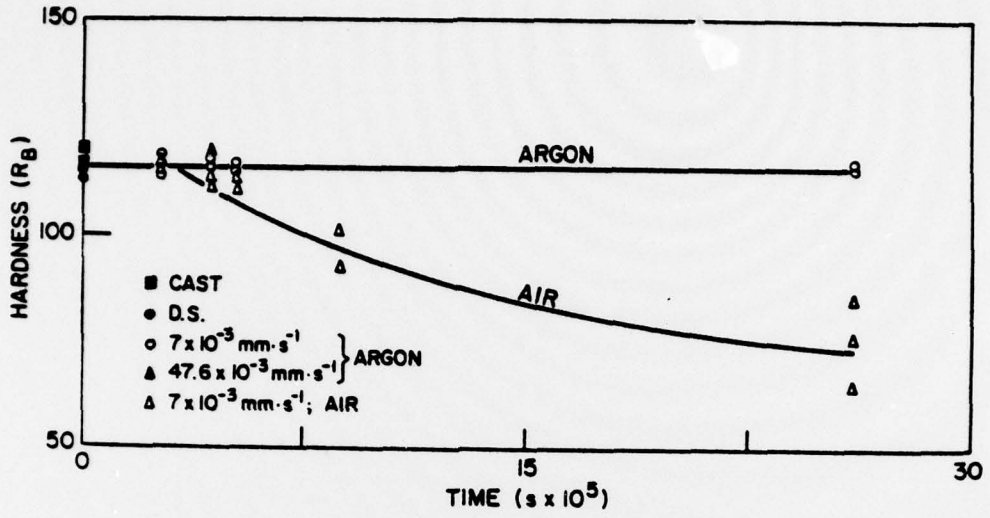


Figure 3. Hardness as a function of isothermal exposure at 1121°C in air and argon.

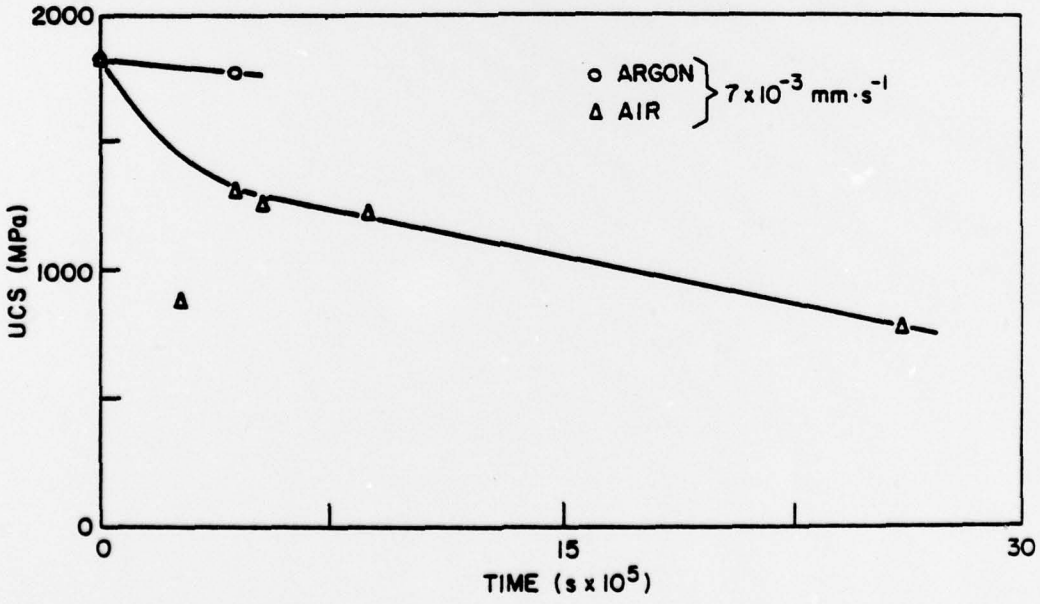


Figure 4. Ultimate compressive strength as a function of isothermal exposure at 1121°C in air and argon.