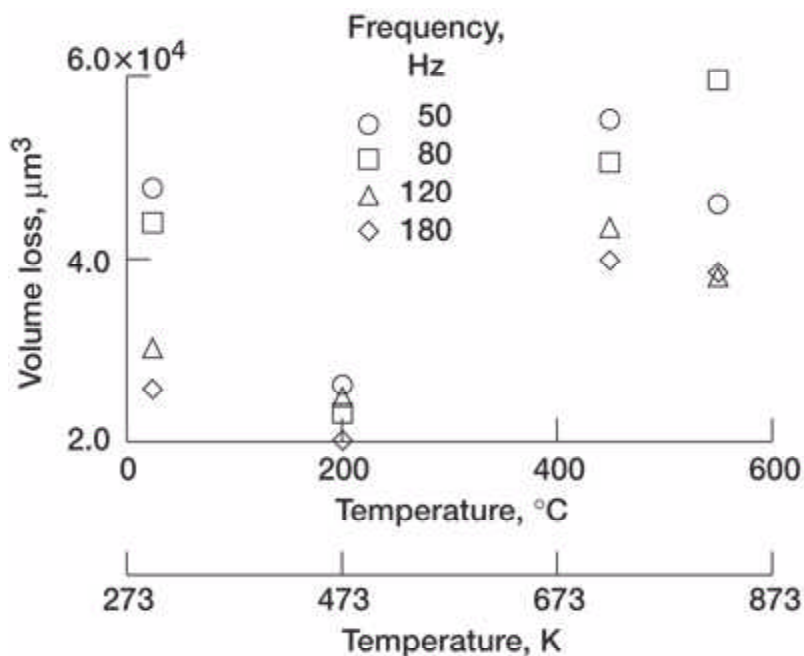


Ti-48Al-2Cr-2Nb Evaluated Under Fretting Conditions

Material parameters govern many of the design decisions in any engineering task. When two materials are in contact and microscopically small, relative motions (either vibratory or creeping) occur, and fretting fatigue can result. Fretting fatigue is a material response influenced by the materials in contact as well as by such variables as loading and vibratory conditions. Fretting produces fresh, clean interacting surfaces and induces adhesion, galling, and wear in the contact zone. Time, money, and materials are unnecessarily wasted when galling and wear result in excessive fretting fatigue that leads to poorly performing, unreliable mechanical systems.

Fretting fatigue is a complex problem of significant interest to aircraft engine manufacturers. It can occur in a variety of engine components. Numerous approaches, depending on the component and the operating conditions, have been taken to address the fretting problems. The components of interest in this investigation were the low-pressure turbine blades and disks. The blades in this case were titanium aluminide, Ti-48Al-2Cr-2Nb, and the disk was a nickel-base superalloy, Inconel 718 (IN 718). A concern for these airfoils is the fretting in fitted interfaces at the dovetail where the blade and disk are connected. Careful design can reduce fretting in most cases, but not completely eliminate it, because the airfoils frequently have a skewed (angled) blade-disk dovetail attachment, which leads to a complex stress state. Furthermore, the local stress state becomes more complex when the influence of the metal-metal contact and the edge of contact are considered.



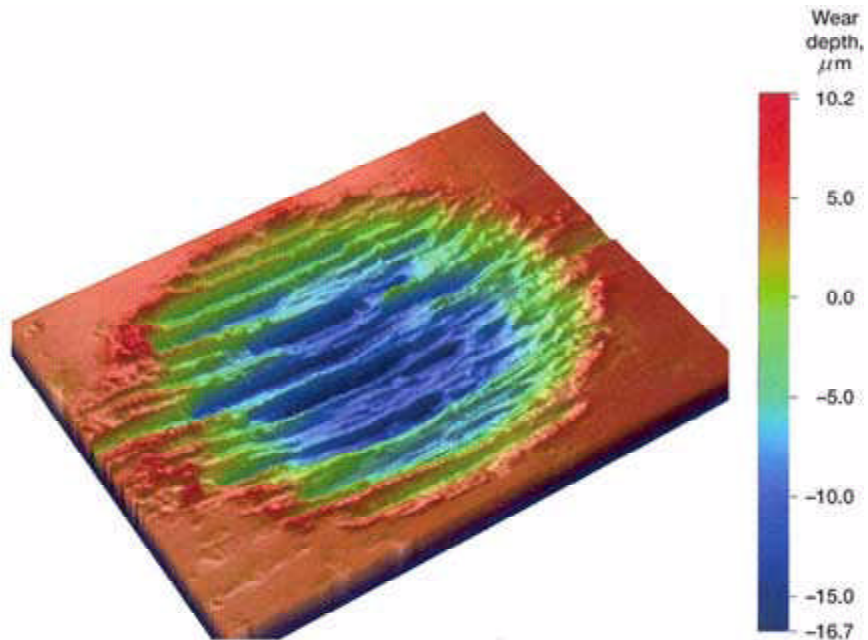
Wear volume loss of Ti-48Al-2Cr-2Nb flat in contact with an IN 718 pin in air as function of fretting temperature. Fretting conditions: load, 30 N; slip amplitude, 50 mm;

total number of cycles, 1 million; environment, air.

Long description

At the NASA Glenn Research Center, the fretting behavior of Ti-48Al-2Cr-2Nb (γ -TiAl) in contact with nickel-base IN 718 was examined in air at temperatures from 296 to 823 K (23 to 550°C). All fretting wear experiments were conducted at loads from 1 to 40 N, frequencies of 50, 80, 120, and 160 Hz, and slip amplitudes between 50 and 200 μm for 1 million to 20 million cycles. The interfacial adhesive bonds between Ti-48Al-2Cr-2Nb and IN 718 were generally stronger than the cohesive bonds within Ti-48Al-2Cr-2Nb.

The failed Ti-48Al-2Cr-2Nb was transferred to the IN 718 at all fretting conditions, such that from 10 to 50 percent of the IN 718 contacting surface area became coated with Ti-48Al-2Cr-2Nb. The maximum thickness of the transferred Ti-48Al-2Cr-2Nb was approximately 20 μm . In reference experiments, Ti-6Al-4V transferred to IN 718 under identical fretting conditions. Compared with Ti-48Al-2Cr-2Nb transfer, the degree of Ti-6Al-4V transfer was greater, such that from 30 to 100 percent of the IN 718 contacting surface area became coated with Ti-6Al-4V. The thickness of the transferred Ti-6Al-4V ranged up to 50 μm . The wear scars produced on Ti-48Al-2Cr-2Nb contained metallic and oxide wear debris, scratches, plastically deformed asperities, cracks, and fracture pits. Although oxide layers readily formed on the Ti-48Al-2Cr-2Nb surface at 823 K, cracking readily occurred in the oxide layers both within and around the contact areas. The wear volume loss of Ti-48Al-2Cr-2Nb generally decreased with increasing fretting frequency. The increasing rate of oxidation at elevated temperatures led to a drop in wear at 473 K (see the graph). Mild oxidative wear and low wear volume were observed at 473 K. However, fretting wear increased as the temperature was increased from 473 to 823 K. At 723 and 823 K, oxide film disruption generated cracks, loose wear debris, and pits on the Ti-48Al-2Cr-2Nb wear surface. Both increasing slip amplitude and increasing load tended to produce more metallic wear debris, causing severe abrasive wear (e.g., see the photomicrograph) in the contacting metals.



Wear scar on Ti-48Al-2Cr-2Nb flat in contact with an IN 718 pin, showing scratches. Fretting conditions: load, 30 N; fretting frequency, 50 Hz; slip amplitude, 200 μm; total number of cycles, 1 million; environment, air; and temperature, 823 K.

Long description

Τηρεε-διμενσιοναλ, οπτιχαλ ιντερφερομετρψ μαγε οφ τηε Τι-48Αλ-2Χρ-2Νβ ωεαρ σχαρ. Ιν τηε ωεαρ σχαρ αρε λαργε, δεεπ γροοωεσ ωηερε τηε ωεαρ δεβρισ παρτιχλεσ ηαωε σχρατχηεδ τηε Τι-48Αλ-2Χρ-2Νβ συρφαχε ιν τηε σλιπ διρεχτιον. Τηε φρεττινγ εξπεριμεντσ ωερε χονδυχτεδ ατ α λοαδ οφ 30 N, α φρεθυενχψ οφ 50 Ηζ, ανδ α σλιπ αμπλιτυδε οφ 200 μm for 1 million cycles in air at a temperature of 296 K.

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