

Failure Analysis of Turbine Engine Compressor Front Hub/Disk

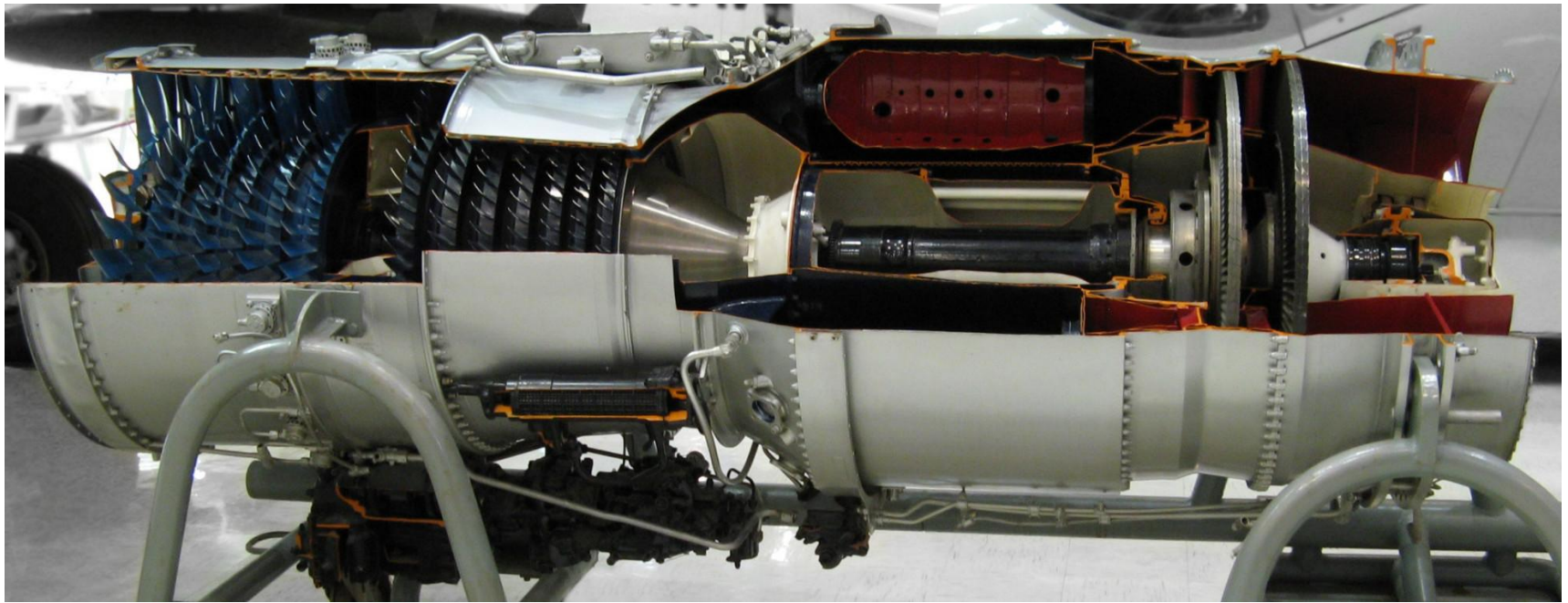
**Luis R. Carney, P.E.
Materials Engineer
Jacksonville, Fl.**

AEROMET CONFERENCE

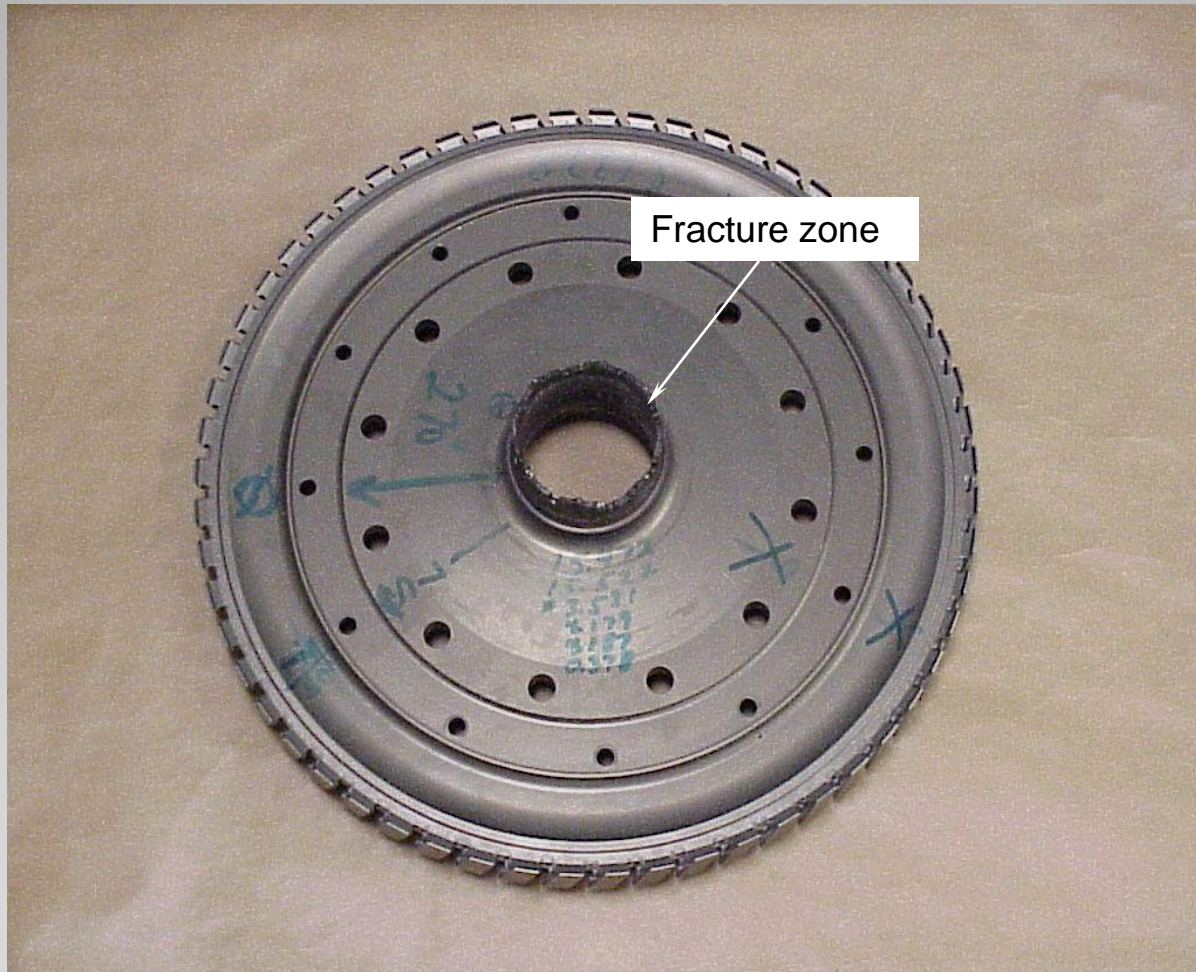
Background

- Engine being test run after overhaul
- Time Since Overhaul: 0 hours
- Time on Hub: Apx 1,893 hours.
- Test run revealed high breather pressure & oil out of bleed valves
- Disassembly revealed fractured N2 hub

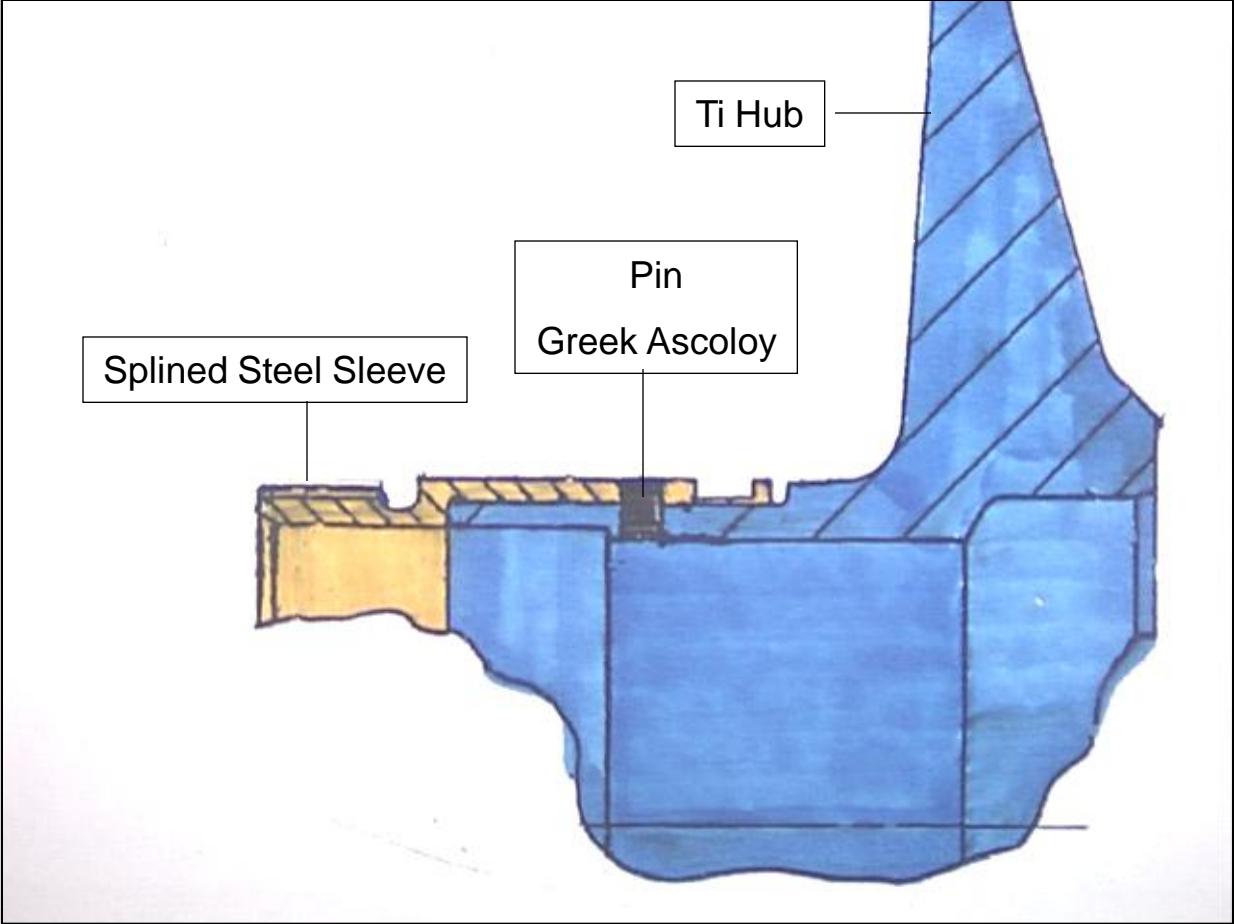
Engine Cross section



N2 Front Hub/Disk as received



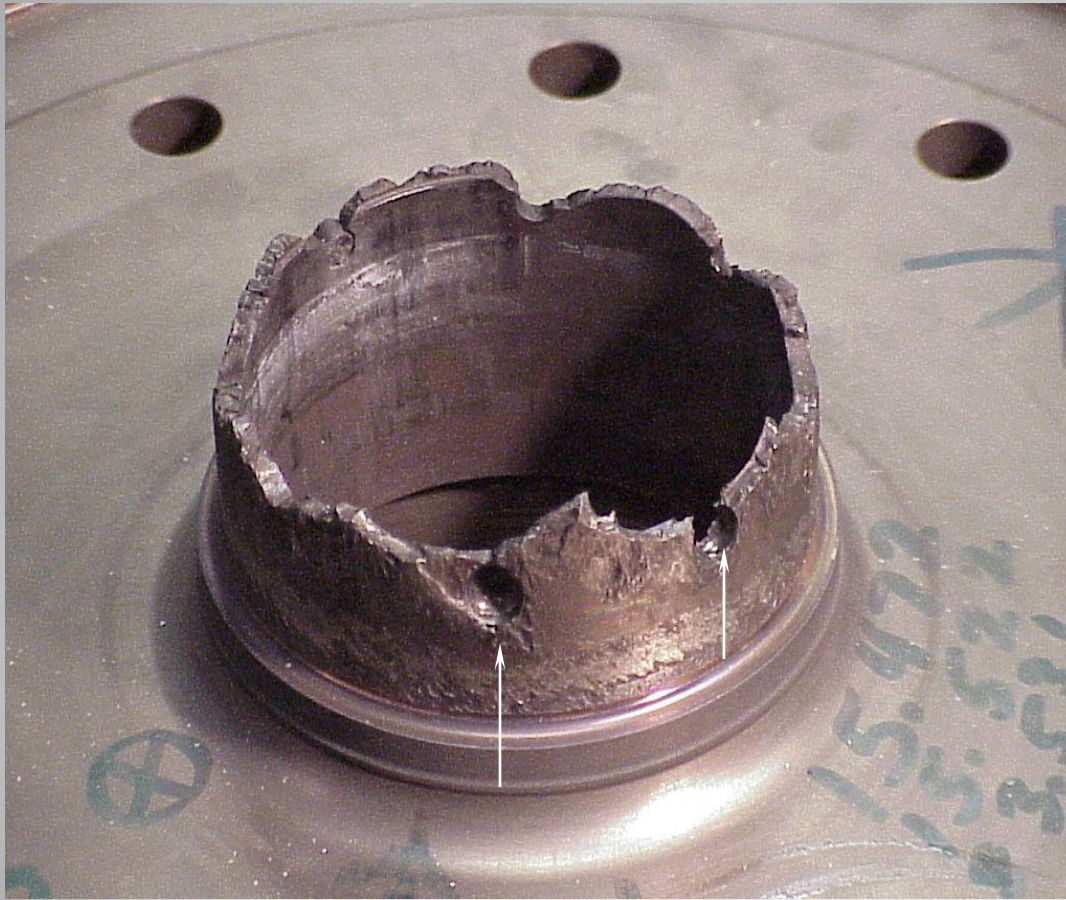
Drawing of Ti Hub to Steel Sleeve modification



Visual Observations

- Hub repair instituted in 1968 to resolve premature wear problem.
- All N2 Hubs modified this way.
- Sleeve pressed in and secured with 8 pins.
- Fracture plane was along pinned Hub plane.

Visual Observations



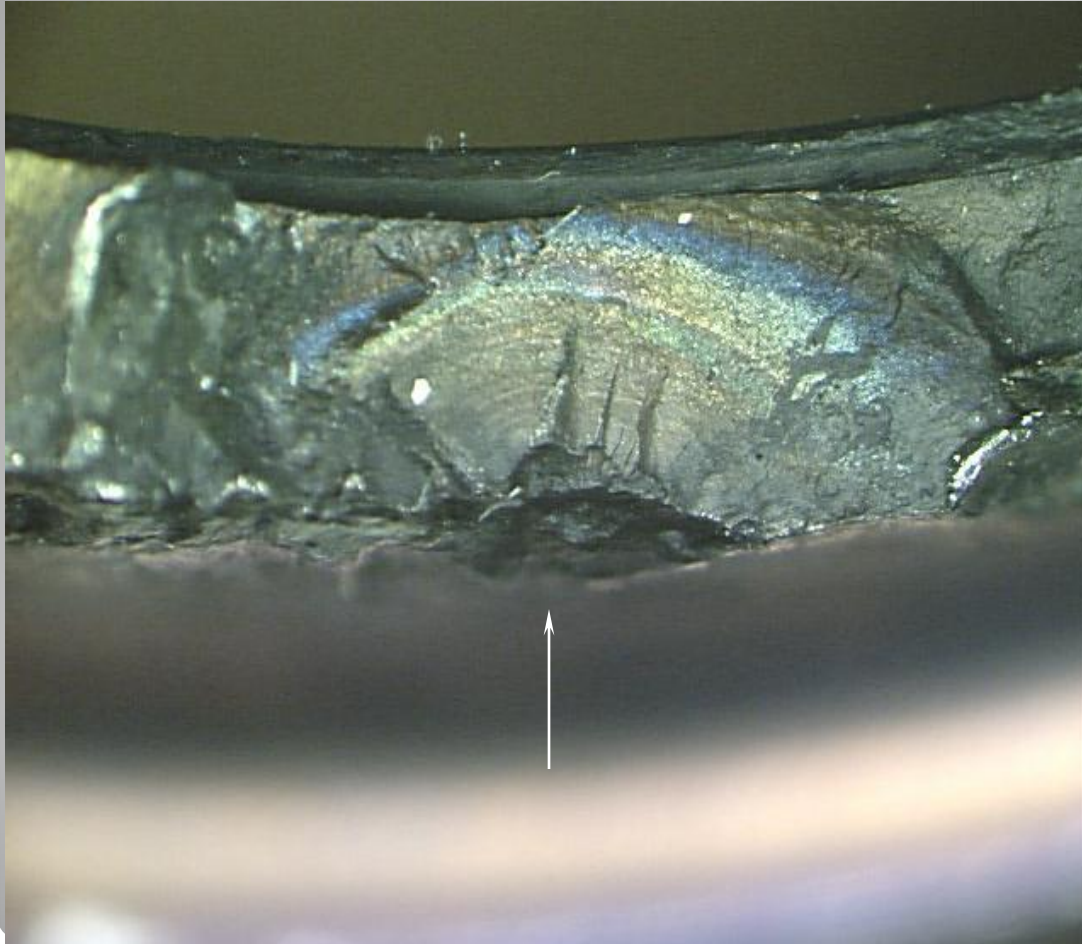
- Hub OD severely galled.
- Pin bores elongated and deformed.
- 3 of 8 pins severely deformed.
- 5 pins remained in their bores.

Visual Observations



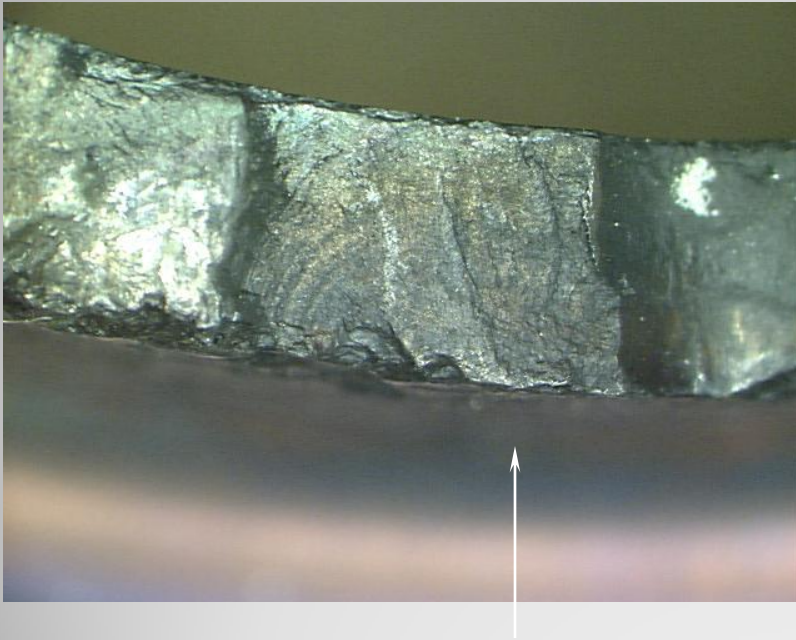
- Five of the pins had been fractured through the interface between sleeve ID and Hub OD

Visual Observations

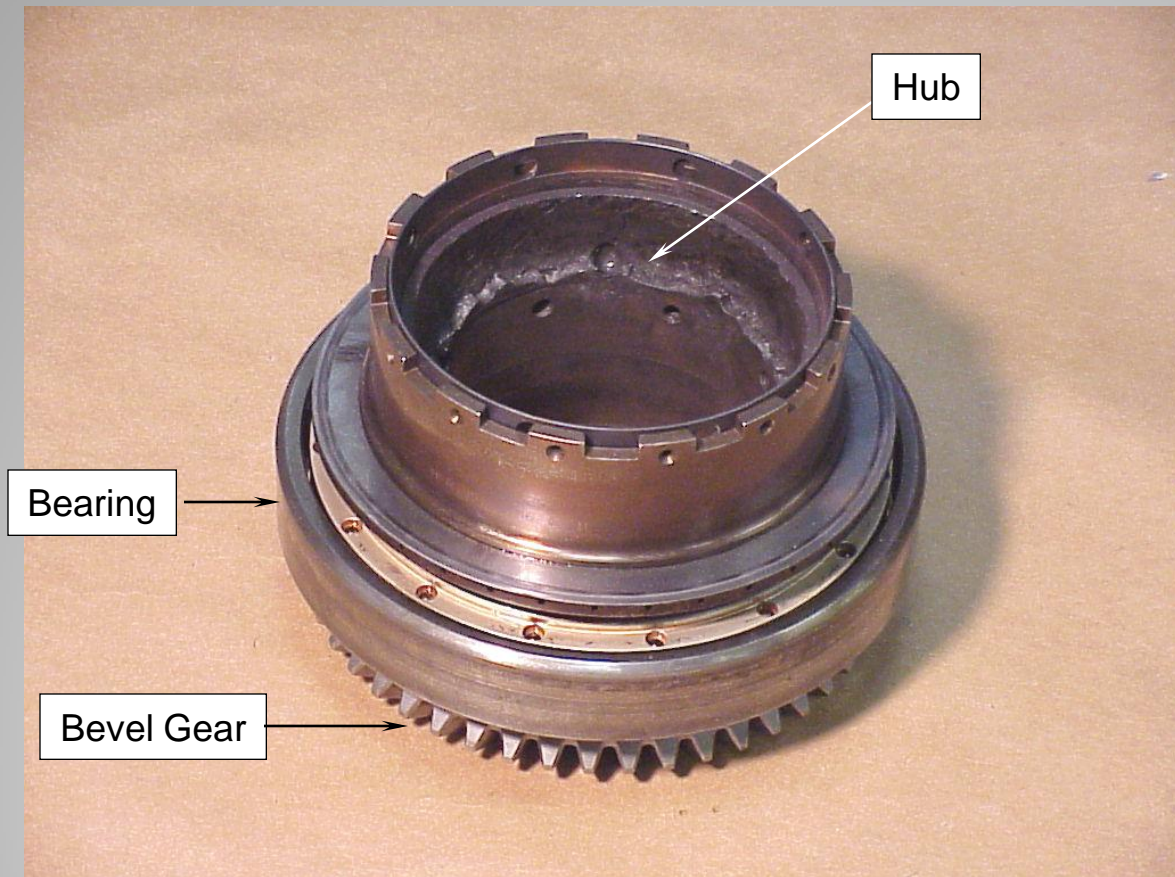


- One of many thumbnail shaped cracks that formed part of the larger fracture surface.
- Origin at a severe galling pit.
- Cracks progressed from OD to ID.

Visual Observations



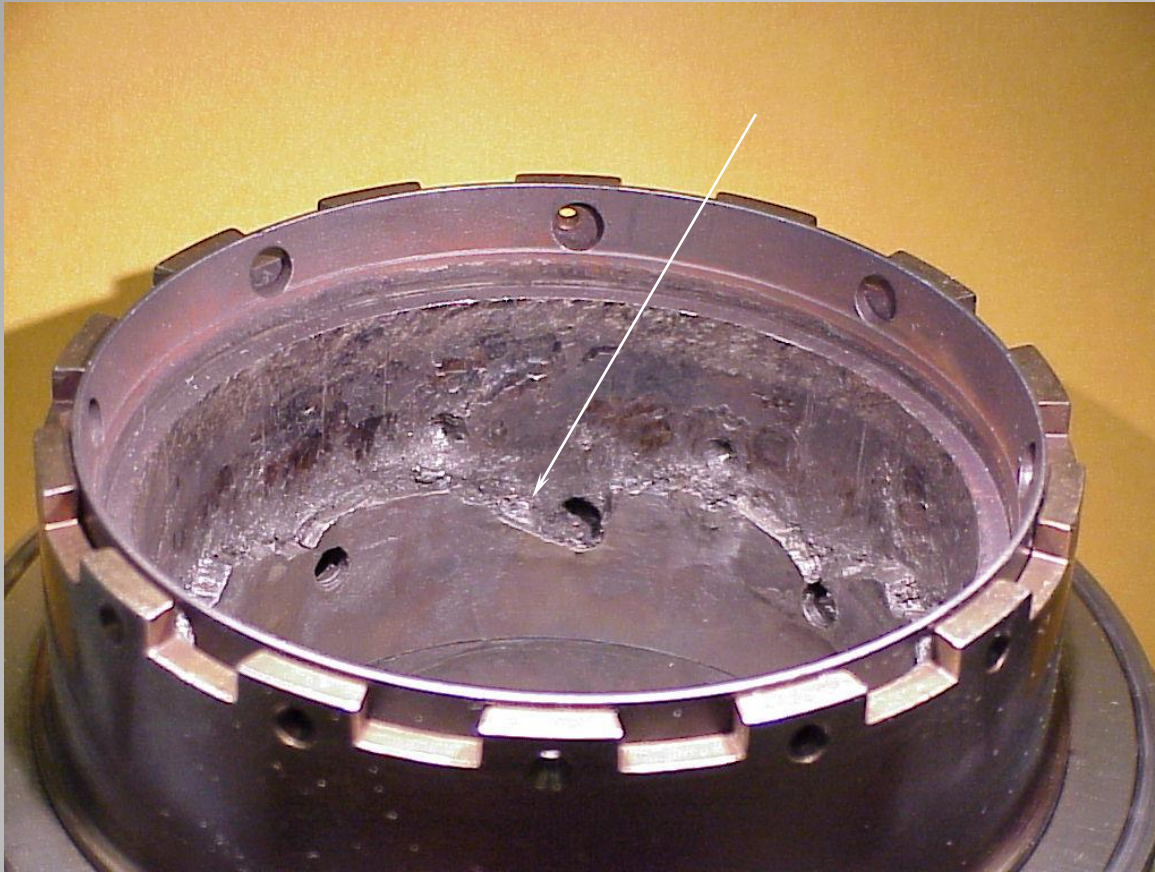
- Another hub crack. Note that origin (Arrow) is at Hub OD not pin bore.
- Bores containing fractured pins were in "good" condition



N2 front bearing assembly
Part of the N2 hub and steel splined end are still inside the assembly.

Visual Observations

Visual Observations



- Fractured Hub (arrow) inside steel sleeve.
- Sleeve is still captured inside its mating splines and bearing assembly.
- No circumferential scoring noted.

Visual Observations



- Three of the group of five pins in relatively good condition.

Visual Observations

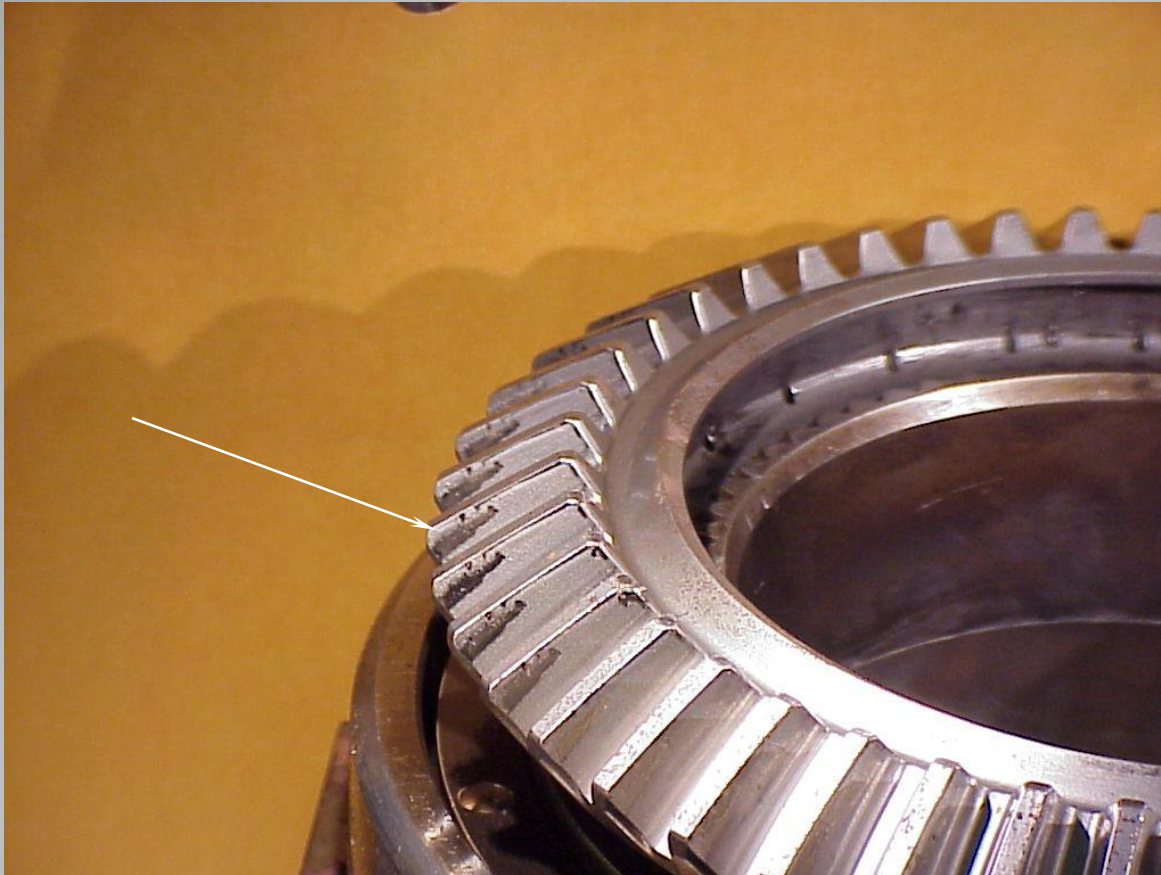


- Three of the five pins were severely deformed.

Chemistry and Heat treatment

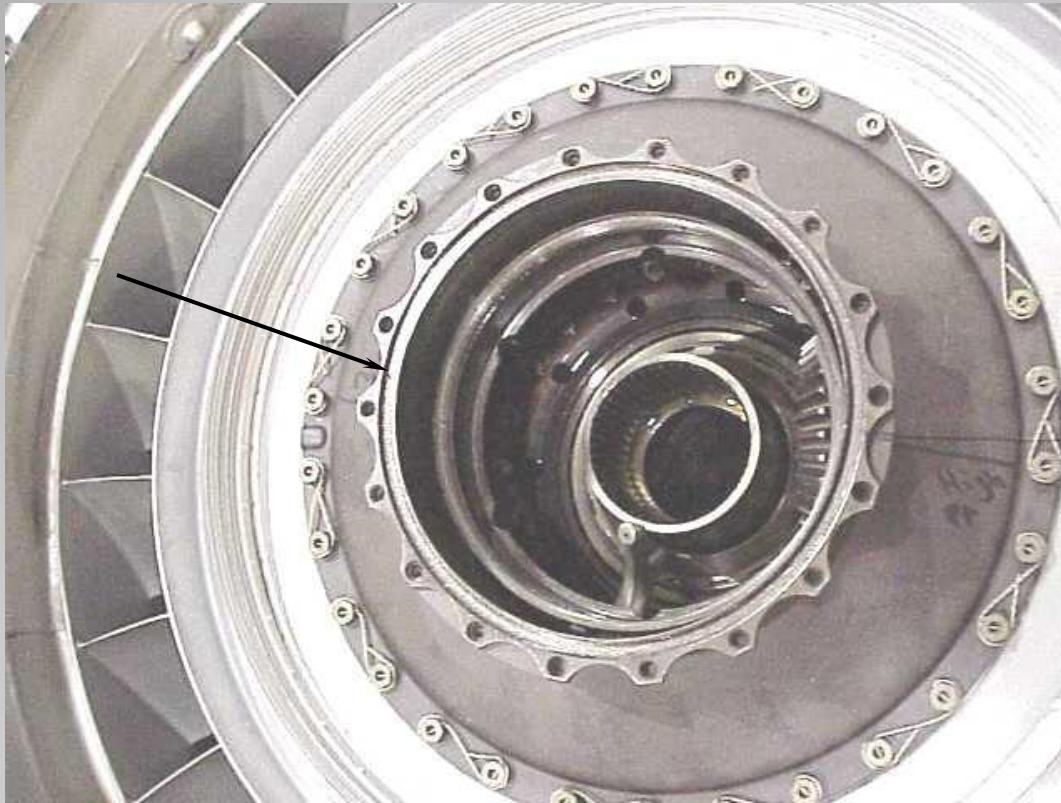
- Hub found to meet specified compositional and heat treatment requirements.
- The five relatively intact pins met the required compositional and heat treatment requirements.
- The three mushroomed pins were consistent with the required composition, however, precise analysis would have not have produced meaningful results.

Visual Observations



- Gearbox drive bevel gear.
- This unit is connected to and operates at the front of the N2 Hub.
- Teeth never operated in proper contact. Note abnormal wear pattern.

Visual observations



- Observations led to the notion bending stresses had been introduced into the front hub.
- Bearing housing examined.
- Housing found warped.

Visual Observations



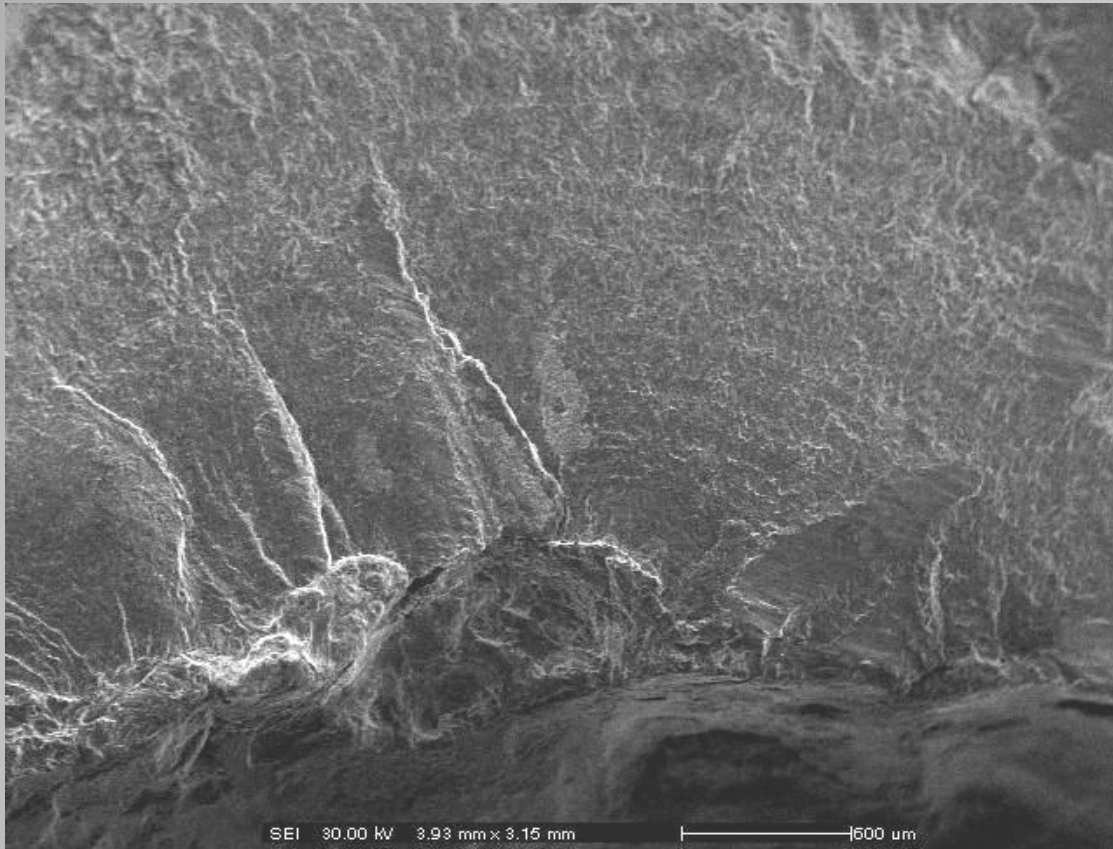
- Bearing housing found warped.
- Reason for warpage unknown.
- Component may have been struck or dropped during engine assembly.

Visual Observations



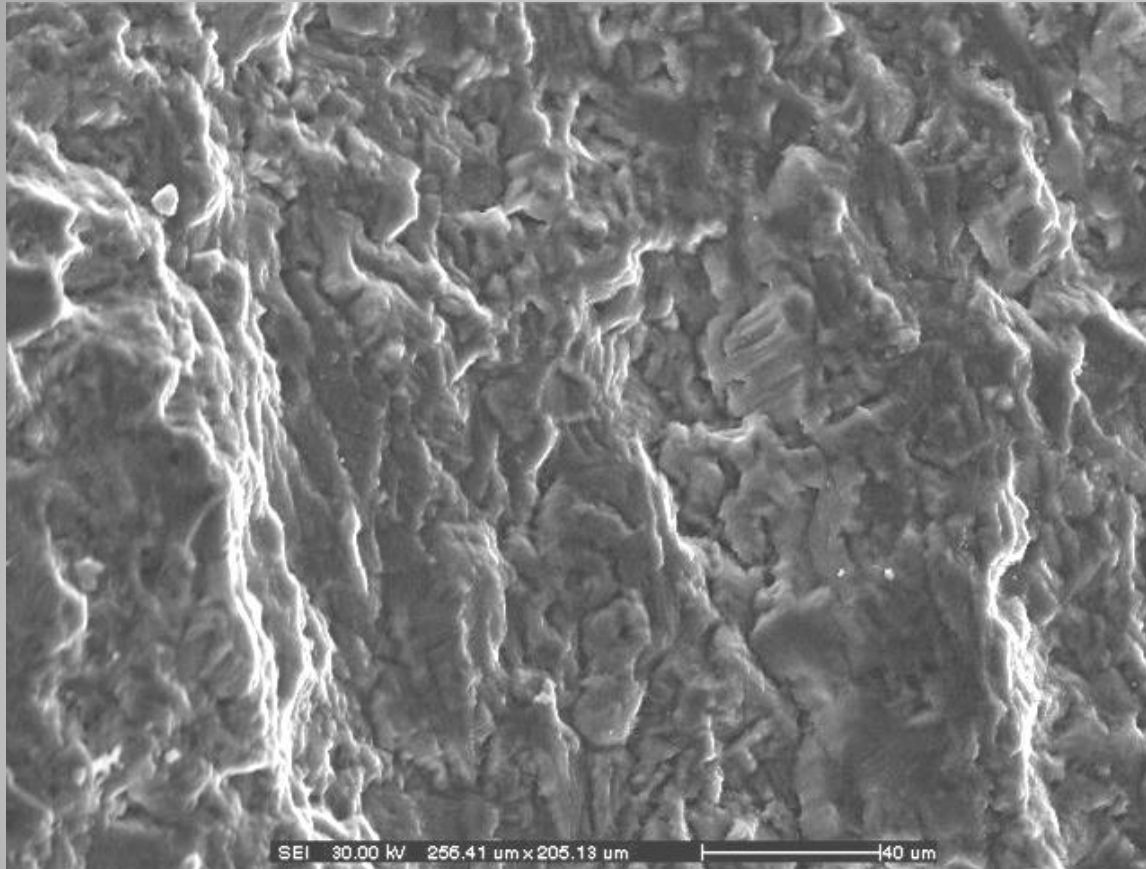
- Warped section of the bearing housing
- Warped housing induced abnormal bending stresses into hub.

Electron Microscopy



- SEM view of a typical hub crack.
- Bands typical of fatigue.
- Damage at origin caused by galling.

Electron Microscopy



- SEM view of hub fracture surface.
- Features typical of fatigue in Ti alloys.
- Striations notoriously difficult to see.

Conclusions

- Hub fractured due to fatigue initiated by galling.
- No material chemistry or heat treatment problems encountered.
- Pins appeared to have been machined and fit properly (5 of 8).
- Pins fractured by overload and/or fatigue resulting from abnormal bending moment.
- Mushroomed pins probably last three to fail. Deformed by overload.
- Galling attributed to severe bending moment introduced into the hub end.
- BENDING MOMENT TRACED TO WARPED BEARING HOUSING.
- Origins of bearing housing damage probably due to assembly, handling or transportation.

Comments

- This was a case of assembly problems leading to a failure.
- The real problem was away from actual failed part (housing warped).
- The failed hub merely reacted to flawed assembly not an inherent component problem.
- Determined to be an isolated event.