Evaluation of Expandable Threaded Connections Using Finite Element Analysis

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In oil fields three long-standing issues affect virtually every well

- Conservation of hole size
- Hydraulic isolation of selected zones
- Maximization of well life

Especially in deep-drilling, in wells utilizing a liner hanger and in aging wells containing deteriorating casing

New technology-solid expandable tubulars successfully address these issues in commercial applications.

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Underlying concept of expandable tubular

- Cold-working steel tubular in downhole environment
- An expansion cone permanently mechanically deforms the pipe
- Cone deforms the steel beyond its elastic limit into plastic region, while keeping stresses below UTS
- Cone moved through tubular by hydraulic pressure and/or by a direct mechanical pull or push force
- Expansions greater than 28% based on ID have been accomplished, now pushing 35%

One unique challenge is to maintain mechanical and pressure integrity of the threaded connections between the pipes before, during and after the expansion process

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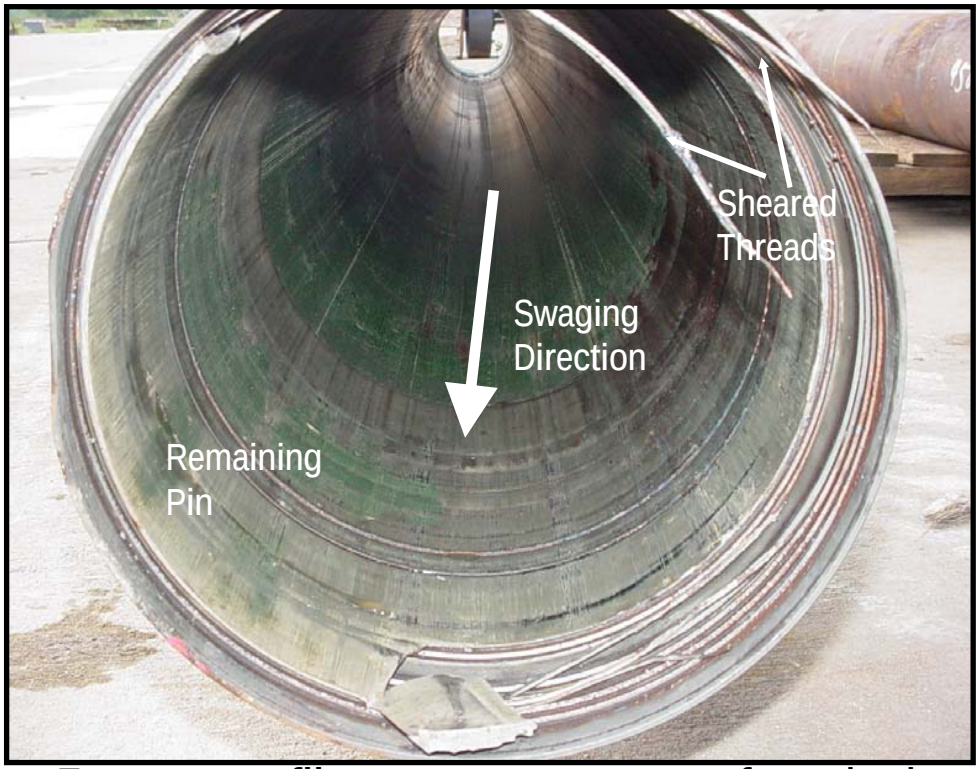
- **Failed Threaded Connection**



- Fracture profile suggests a moment force had been placed across the pin

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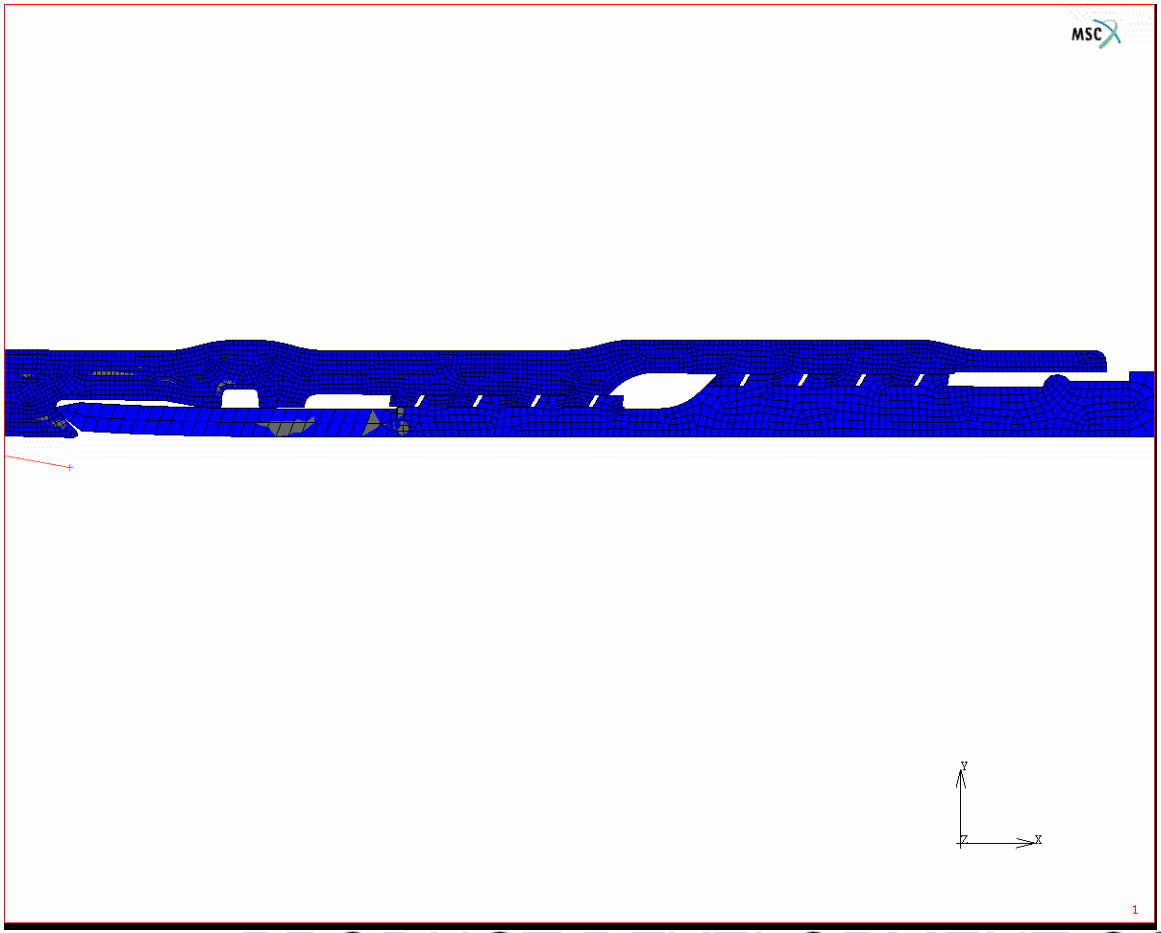
- MSC.Marc Non-Linear FEA was called on to Investigate the Causes for This Failure (click for animation)



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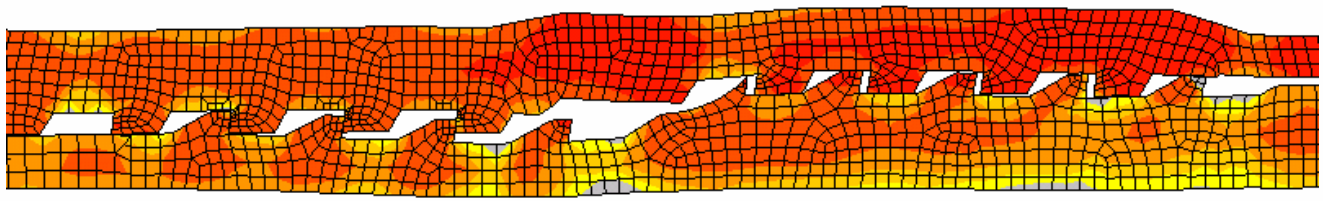
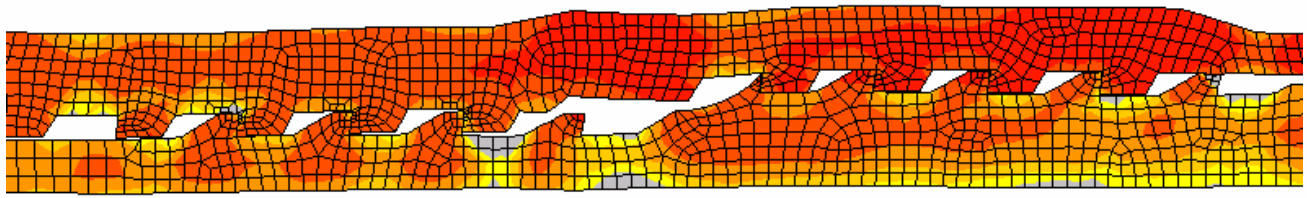
- Please Note the Gaps Between the Thread Teeth of Step 2 Thread Post Expansion



- Tension Applied, Thread Teeth About to Re-Contact



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Proposed Sequence of Events

1. Due to the gapping, only the first step thread took tension until it stretched and then the second step thread came into contact.
2. When necking happened (can be seen at the section between first and second step thread of testing piece), tensile failure started at the weakest point (void, pre-existing notch etc.)
3. This fracture progressed circumferentially around the pin until it arrested. Swaging of the pipe continued.
4. As the applied axial force increases in deviation due to non-uniform application of the tensile load through the connection (difference in engaged threads), threads below the fracture still engaged with the coupling, shear out.
5. As the fracture opens up and the angle of the applied axial tensile load increases, the crack propagates longitudinally down the length of the pin.

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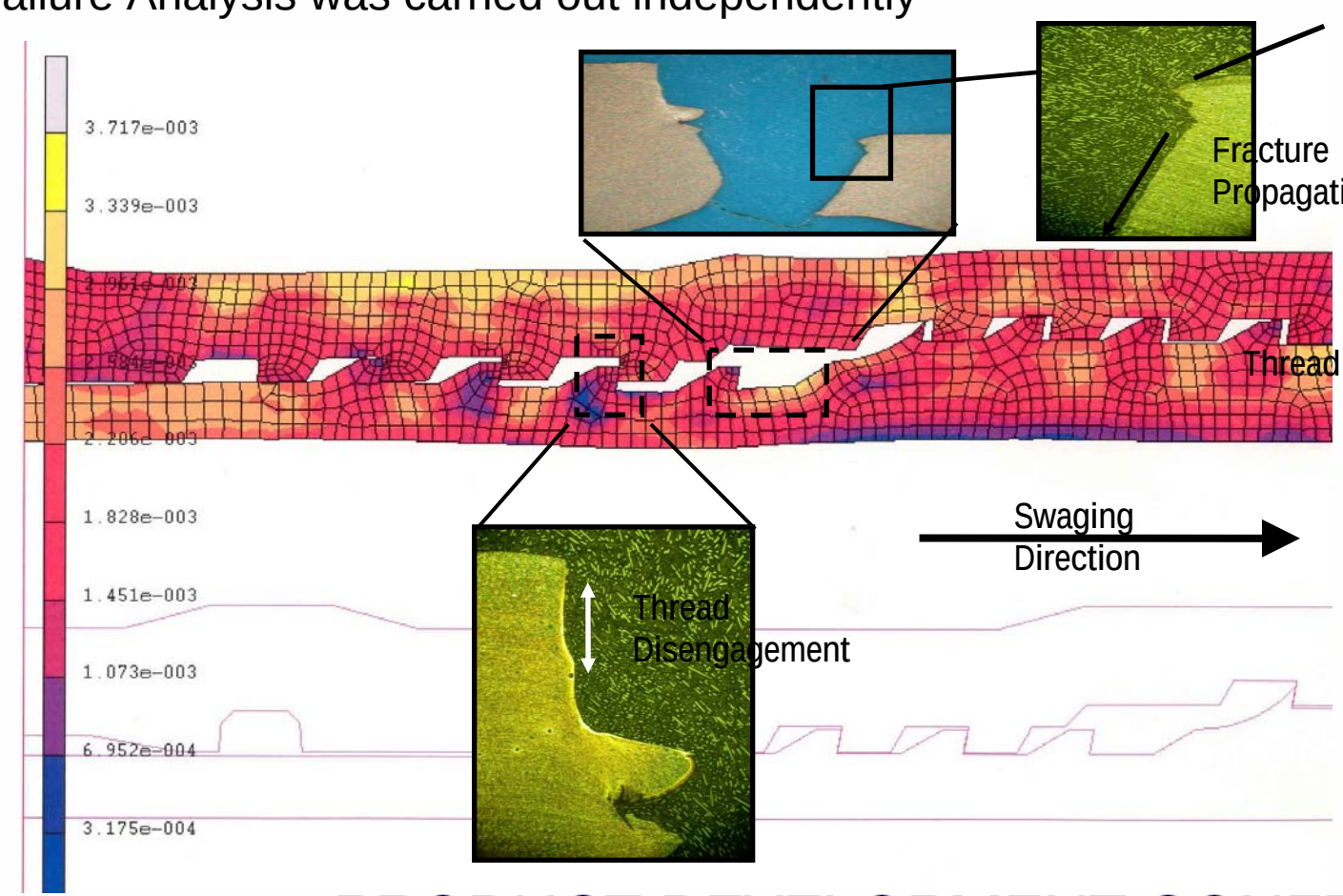
- Micro Failure Analysis was carried out independently



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- Necking showed on the testing piece and notch found from micro analysis has confirmed the proposed failure procedure
- General Microstructure shows no evidence of De-lamination; no large numbers of inclusions; no untransformed phases, or segregation (banding)
- Attack of the problem was then focused on:
  - Eliminate the gapping from expansion
  - What caused the pre-existing galling and resulting notch
  - Improve stress status in section between first and second thread steps, where necking happened

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Changing of thread connection ID/OD was tried in order to reduce post expansion gapping, since Axial shrinkage is related to radial expansion percentage

- turn off the shoulder between the first and second step thread of the Coupling
- Make the Coupling OD the same at the first and second step thread
- New cone profile for the swage tool
- Combined Coupling OD change and the new swage tool

The minimum gap changes between 0.013” and 0.0082”.

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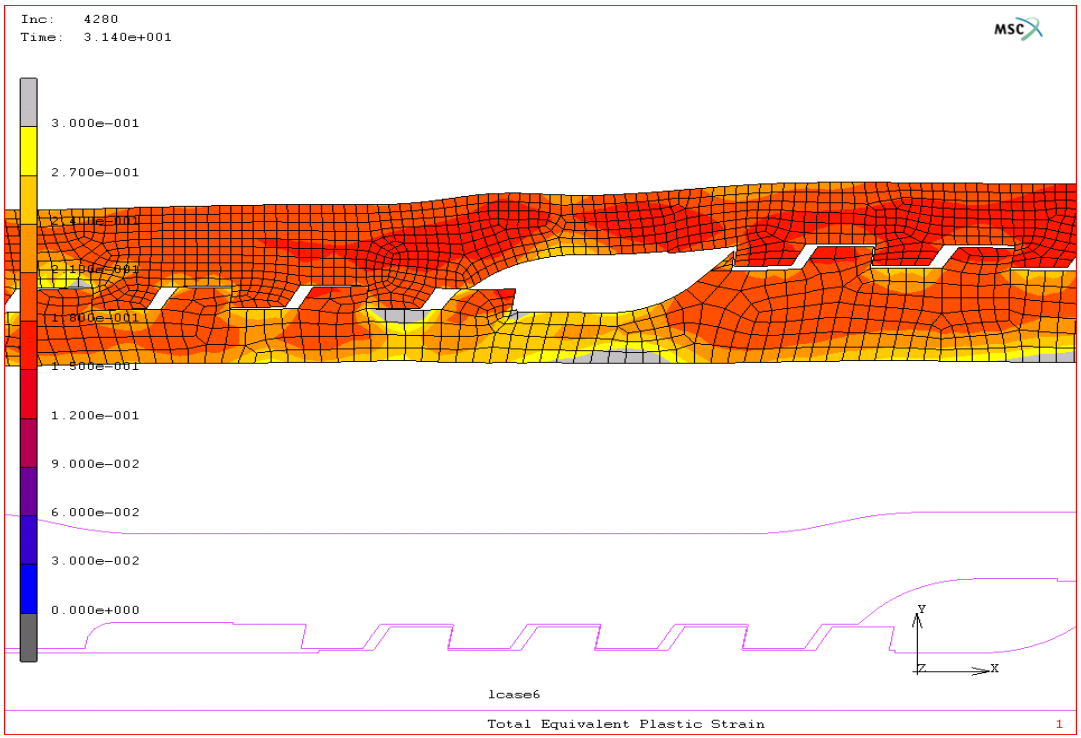
A complete last thread and thread relief, gap still there, strain level down and no problem anymore during expansion.



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Conclusions

- Probably gap can be reduced but may not be able to be eliminated
- Pre-existing notch is critical
- Keeping the plastic strain level down and eliminating notches are essential for the design to work

Questions?