Wear Resistant Coatings for Sucker Rod Couplings

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Outline

• Motivation

• Coating Background

• Test Overview
  • Laboratory Analysis
  • Short Term Field Trials
  • Long Term Field Trials

• Summary
Motivation

Sliding, loading, and impacts between sucker rod couplings and tubing can lead to coupling wear and hole-in-tubing (HIT) failures.

Reducing wear to couplings and tubing will:

- Reduce frequency of failures
- Reduce workover costs and risks
- Reduce interrupted production
- Reduce material replacement costs

Solution

- Wear Resistant Coatings
Coating Background

Diamond-like Carbon (DLC) coatings:

• Amorphous mixture of diamond-like (sp$^3$) and graphite-like (sp$^2$) bonds
• Low friction against steel <0.15
• Low wear rates
• High hardness >1700 VHN
• Low counterface wear, “casing/tubing friendly”
• Chemically inert
• Modify properties with addition of other materials
• Deposited by vacuum chamber process: PVD, PACVD
DLC Variations

Not all DLCs are created equal

Diamond $sp^3$

Graphite $sp^2$

Hydrogen

Chemistry variation
Test Overview

**Laboratory Analysis**
- CETR Tribometer: Wear durability, Friction coefficient
- Hardness, Impact, Scanning Electron Microscopy, etc.

**Short term (3 month) field trials**
- Tested 24 unique coating variations in 3 trial phases in 1 well

**Long term durability field trials**
- Tested best 2 coatings in 8 wells

**Commercialization**
Laboratory Analysis

Block on ring tribometer configuration:
- Coefficient of friction
- Block wear
- Coating loss

DLC Coating on Coupling Ring
10kg load, lubricant with 2% sand

Uncoated
Coated
Laboratory Analysis

Block on ring tribometer configuration:

- Coefficient of friction
- Block wear
- Coating loss

![Diagram of laboratory analysis with tribometer configuration and results](image-url)
Short Term Field Trials

Objective:
- Build understanding of coating durability in field conditions
- Compare durability performance between coatings

Well Details:
- History of HIT failures
- Rod rotation
- Operated 24 hrs/day
- ~1800ft depth
- <3° dogleg severity (DLS)
Short Term Field Trials

Method:

• 24 unique coating variations on spraymetal couplings
  • 8-9 types per test phase
  • 64 couplings in well
• Install couplings without rod guides to maximize contact and wear
• Place coatings in sequential order (ABCABC…) to avoid positional bias
• Run each phase for approx. 3 months, or 4,500 miles of travel
• Assess coupling wear, rod wear, tubing wear

Results:
Short Term Field Trials

Coating Wear:

- Ranked coatings on scale of 1, 2, or 3 based on visual inspection of relative coating wear
  - 1 – near perfect
  - 3 – mostly worn
- Performance consistent with lab results

![Graphs showing wear ratings for Phase 1 and Phase 2 with coatings labeled A to M.](image-url)
Short Term Field Trials

Coating Wear vs. Uncoated Coupling Wear:

- Best coated couplings from Phase 1 and 2 show negligible wear
- Deep abrasive wear marks observed on uncoated couplings after test
- Coatings reduce wear to couplings
Short Term Field Trials

Tubing Wear:

• Data shows minimum wall thickness in each tubing joint
• Coated couplings are more tubing friendly than uncoated couplings
• Performance consistent with lab results

- 0.190" w.t.
- 0.162" w.t.
- 0.126" w.t.
Long Term Field Trials

8 wells with top 2 coatings identified from short term field trials

- ~2100ft depth (~70 couplings)
- <3° DLS

Historic average hole-in-tubing failure every 6-7 months for similar wells across field

Coated wells ran 12-18 months before HIT failure

- 50+% increase in well uptime between HIT failures
- 5 wells still ongoing

FRCs pristine after 8 months

Extensive wear and well failure at 7 months
Summary

• Sought solution for frequent HIT wear failures
• Evaluated coating friction and wear performance in laboratory tests, short term field tests, and long term field tests
• Coatings provide wear protection to couplings and to the tubing counterface
• Based on field trial results, coatings may increase the well uptime between HIT workovers by over 50%
Questions?
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