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MDPI

Methodological Routes for Failure Analysis in Continuous Rods for Artificial Lift Systems: A Data-Driven and Damage Characteristic Approach

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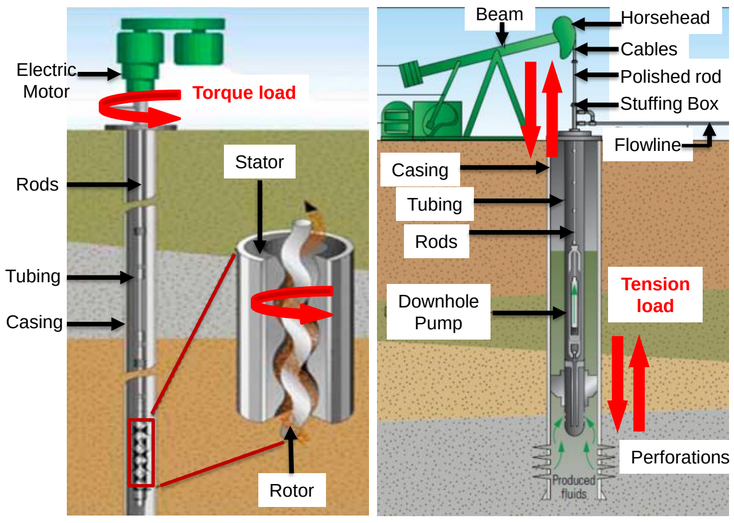
INTRODUCTION & AIM

Oil Production – Upstream section

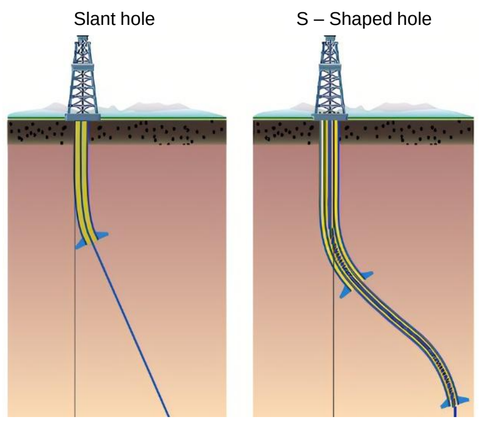
Progressive Cavity Pump System (PCP) | **Reciprocating Pump System (RRP)**

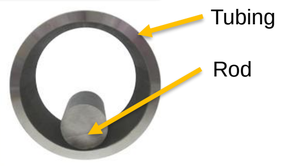


Different types of Artificial Lift Systems (ALS) (pumps) to extract oil

Reciprocating Pump System (RRP) and Progressive Cavity Pump System (PCP) use Rod String to transmit movement from surface to the pump

Well Construction

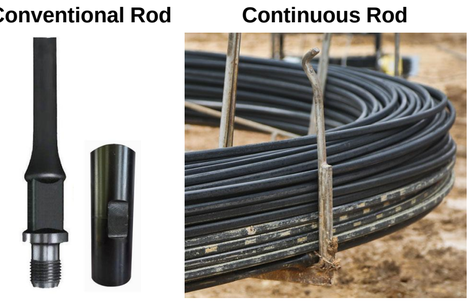


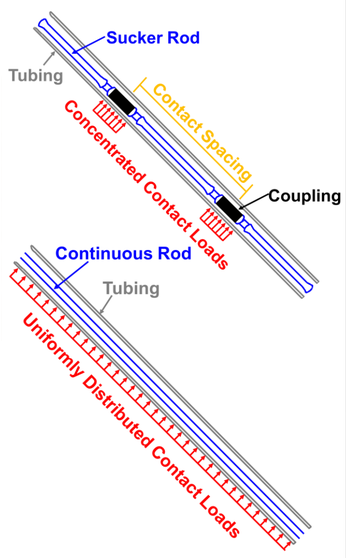


Tubing and rod follow the well trajectory

- Flexion loads
- Contact loads which let wear by friction
- Buckling
- ALS service consists of cycles (fatigue loads)

Conventional Rod | **Continuous Rod**



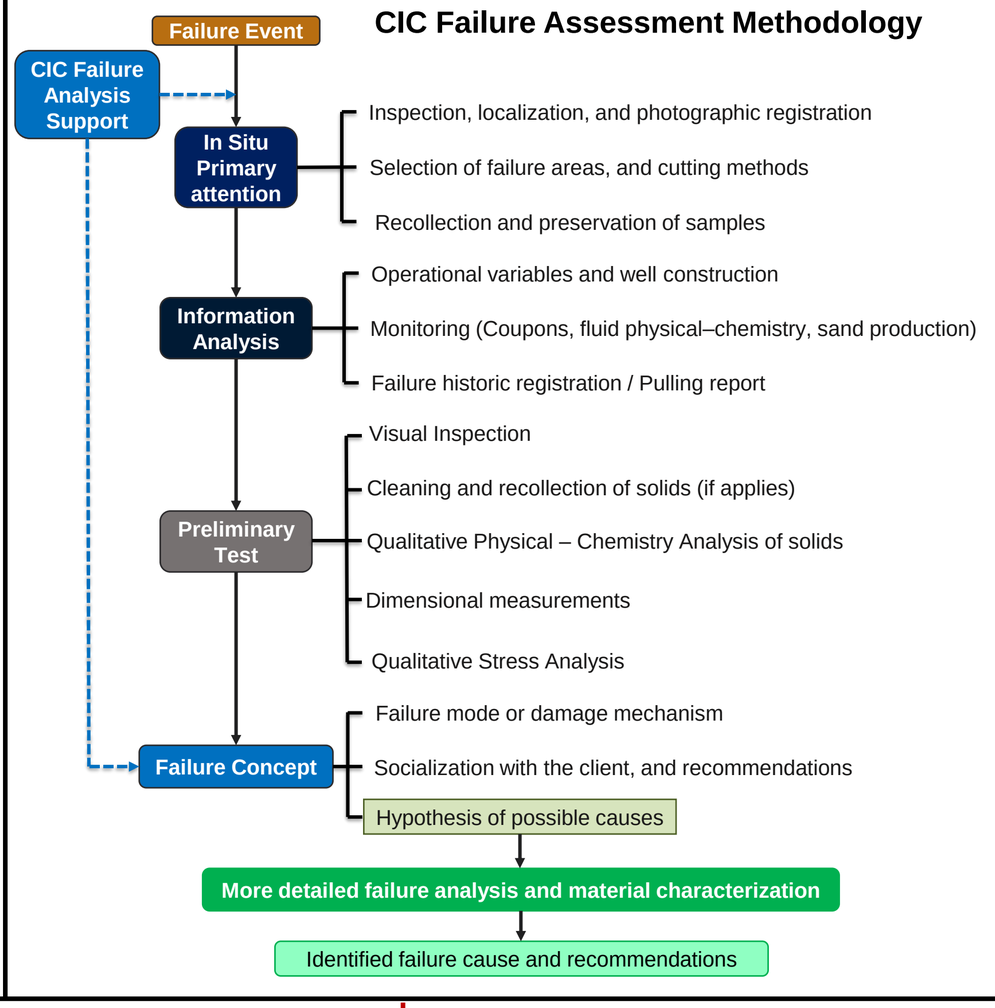


Continuous rod is a relative new technology with no API standard

Need to understand and identify the main failure causes, in order to propose alternatives to avoid those failure mechanisms

METHOD

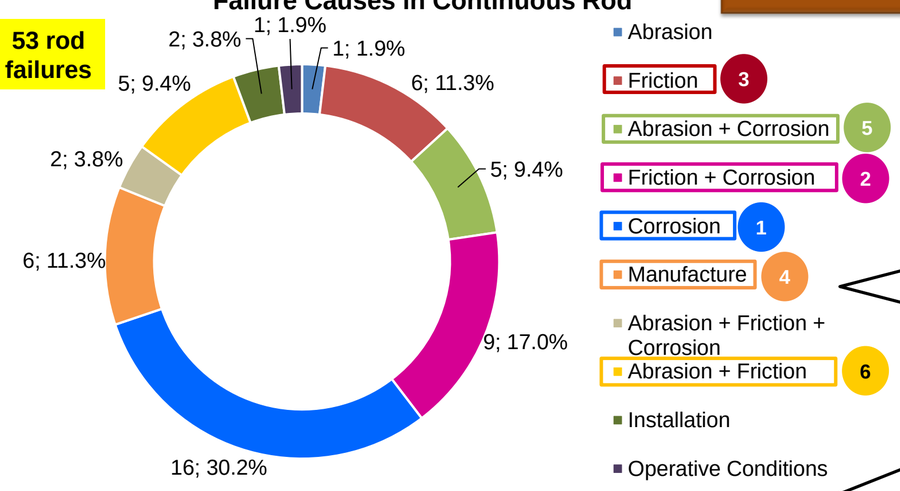
CIC Failure Assessment Methodology



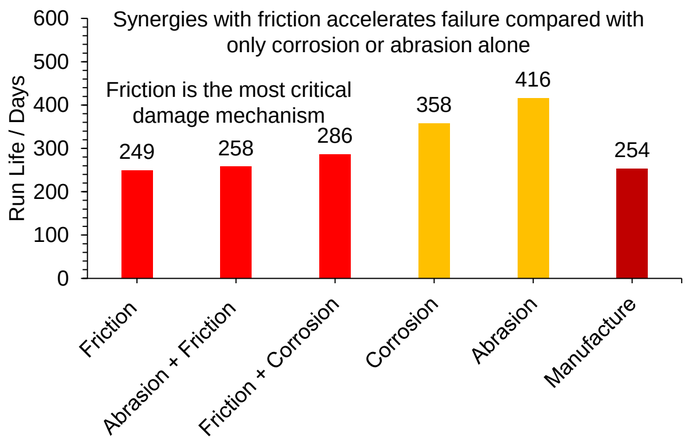
RESULTS & DISCUSSION

53 rod failures

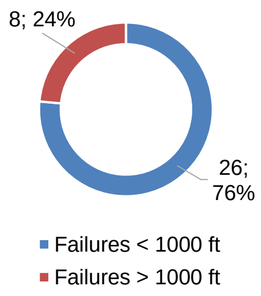
Failure Causes in Continuous Rod



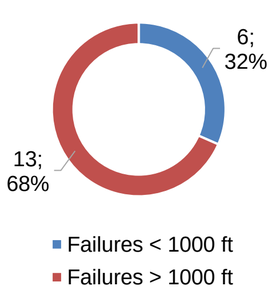
Average Run Life of failure causes



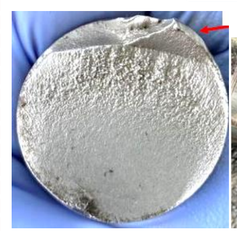
Distribution of failure depths at RRP

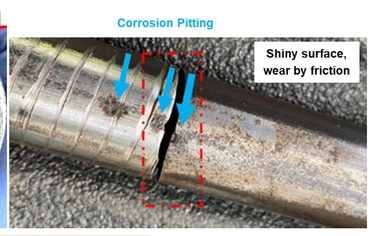


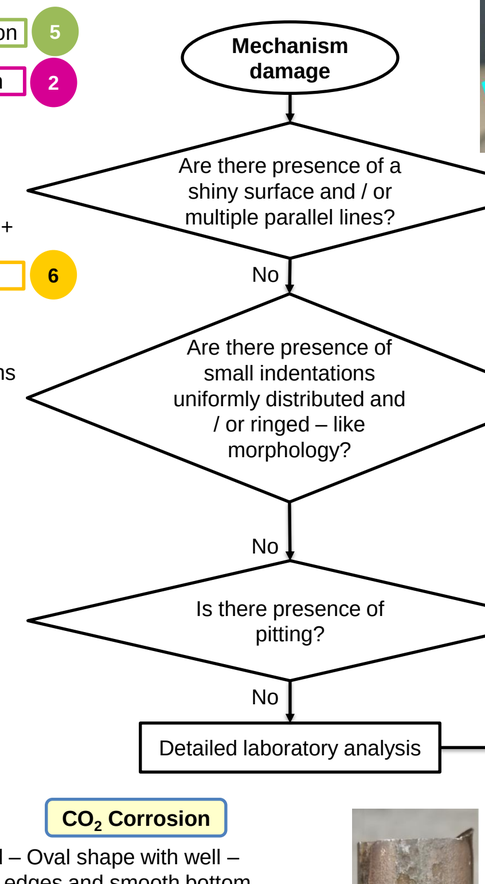
Distribution of failure depths at PCP



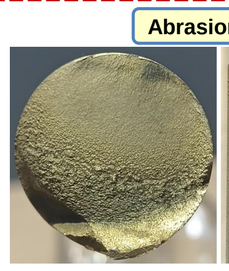
Friction



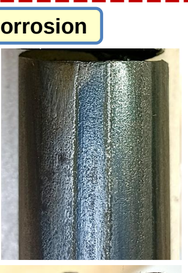




Abrasion

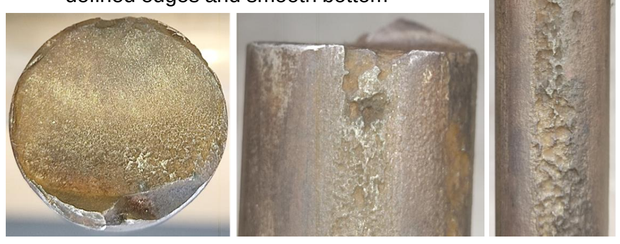


Abrasion + Corrosion



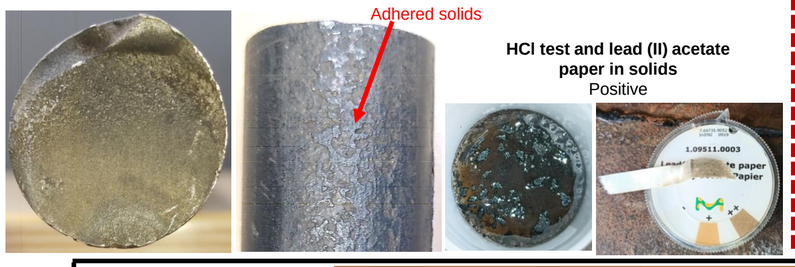
CO_2 Corrosion

Round – Oval shape with well – defined edges and smooth bottom



MIC Corrosion

Irregular shape with not - defined edges and stratified bottom. Confirmed with qualitative sulfide test of adhered corrosion products



Coating Options proved in Oil and Gas Industry elements

Plating and Electroplating

- Electroless Nickel
- Hard Chromium plating

Good option for corrosion protection if well construction and sand production are not critical

Big disadvantage of galvanic corrosion when the coating is removed

Hot Dip Coating

- Hot Dip Galvanizing (Zn, Al, Al–Si, Zn–Al, Zn–Fe)

The best option for corrosion protection if Dogleg and sand production are not critical

If there are big removed portions of the coating, the galvanic protection will decrease its effectivity

Epoxy – Based Paintings

- Fusion – Bonded Epoxy

Good option for corrosion and better resistance to friction and abrasion than Hot Dip Coatings

More versatile for high dogleg and sand production

If coating is removed there is no galvanic effect

Polymer Based Coating

- High Density Polyethylene
- Polyketone

Good option for corrosion and better resistance to friction and abrasion than Hot Dip Coatings

More versatile for high dogleg and sand production

If coating is removed there is no galvanic effect

Ceramic Coating

- Boronizing

Option that could be the next generation of coatings

Superior corrosion and wear resistance than the other coatings herein described

Need of industrial development to make it cheaper and generate joining processes

CONCLUSION

Friction generates a shiny surface or multiple parallel lines in axial or circumferential direction. Corrosion generates continuous bands or localized pitting, and abrasion is seen as small indentations uniformly distributed / or ringed – like morphology. These damage mechanisms are enough to initiate fatigue failures

For both ALS friction, corrosion and abrasion are the main failure causes and the best option to mitigate this damage mechanisms is the use of industrial coatings.

Epoxy – Based paintings and polymer – based coatings are the most balanced options nowadays to mitigate friction, abrasion and corrosion. Ceramic – based coatings could be the next generation but need more investigation and technological development to be feasible in costs.

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