DEVELOPMENT OF A ROD GUIDE MODEL, WHICH GENERATES A MINIMUM LEVEL OF TURBULENCE, PERFORMING CFD ANALYSIS AND HYDRODYNAMIC COMPARISONS BETWEEN DIFFERENT GUIDE DESIGNS

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TenFlow Rod Guide

Agenda

- Background
- Design and Modeling Parameters
- Considerations
- Finite Element Analysis
- Model Validation Through CFD
- Comparisons
- Conclusions
- Experience (Addendum)
Background

- High production volumes demand new design challenges
- Flow restriction due to guide geometry may cause turbulence
- Inhibitor removal (Washout)
- Erosion-corrosion condition accelerates failures on rods
Modeling Considerations

- Tubing: 2 7/8"
- Sucker rod: 7/8"
- SPM: 7
- Stroke Length: 160 in
- Average velocity: 38 in/s
- Max velocity: 58.6 in/s
- Fluid: Water 100%
- Initial Turbulence: 5%
- Flow Rate: 320 bpd
- Fluid speed: 8.6 in/s

As reference with oil API 30:
- Vf = 60 in/s, Re = 4500 - turbulent flow
- Vf = 20 in/s, Re = 1000 - laminar flow
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Modeling Features

- Shape
  - Length
  - Vanes
  - Valley

- EWV

- Fluid Dynamics
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Modeling Features

Erodible Wear Volume (EWV)
Amount of guide material outside the rod coupling OD
Modeling

Turbulence Modeling using Finite Element Analysis (FEA)

A computational fluid dynamics model (CFD) is used to predict the effects of turbulence generated by an object, as well as large and small eddies generated by the fluid alteration.
Modeling

Turbulence Kinetic Energy (TKE)

In fluid dynamics, TKE is the mean kinetic energy per unit mass associated with eddies in turbulent flow.

High turbulence creates “swirls”
Design Considerations

EWV usually affects hydrodynamics

*When designing rod guides, increasing EWV compromises hydrodynamics features.*
TenFlow Rod Guide
Design Considerations

Hydrodynamic design using CFD modeling – TENFLOW Guide
Design Considerations

- **Turbulence** remove corrosion products (corrosion-erosion) and the inhibitor, accelerating corrosion rate

- **“Dead Zones”**
  Stagnant fluid allows localized corrosion
Design Considerations

Hydrodynamic design using CFD – “Dead Zones”

Guides A, B, and C show different levels of hydrodynamic design using CFD. Guide A has a minimal fluid movement, indicated by a “Dead Zone” at the reference plane. Guides B and C show considerably reduced “Dead Zones.”
Design Considerations

Turbulence Kinetic Energy caused by Guide Geometry
Rod Guide Comparisons
For 7/8” rods and for 2-7/8” tubing
Rod Guide Comparisons

For 7/8” rods and for 2-7/8” tubing

CFD shows that TenFlow guide outperforms all samples tested causing the less turbulence kinetic energy for a guide.
Field Experience (Addendum)

- TenFlow guides were tested in a well.
- Two different guide designs were also tested.
- Test was performed for 45 days due to a well service.
- All guides were calipered.
- Results were compared.
POOH Conditions

TenFlow guide hydrodynamic design prevented the creation of washout areas that can accelerate the erosion-corrosion effect.
Caliperin Guides Procedure

- Two OD measures are made (90 degrees apart)
- Only guides at the end of the rod are measured
Caliper Results

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<tr>
<td>Average wear: <strong>1.79%</strong> AF Material</td>
<td>Average wear: <strong>3.65%</strong> AF Material</td>
<td>Average wear: <strong>64.31%</strong> Polykethone Material</td>
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Caliper Results

![Bar Chart: Average Wear on Guides (After 45 Days Running)]

- TenFlow: 1.79%
- Guide A: 3.65%
- Guide B: 64.31%
Conclusions

- Best hydrodynamic guide design using CFD validation
- Enhanced Vane Design
- Highest Erodible Wear Volume for a rod guide tested
- Swirls and “Dead Zones” conditions are minimum at the end of the guide
Questions?

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