Drill Pipe Fatigue Tracking System Validation

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Cerberus for Drilling - Designed and built as a joint project between CTES and Fearnley Procter Group
What is CfD?

- Fearnley Procter and NOV CTES decided to develop drill string design software based on the NS-14 design manual.
- CTES (with the help of Prof Steve Tipton, U of Tulsa) is the industry leader with the Cerberus CT and slickline (SL) fatigue software.
- Once CfD T&D was developed, Tipton provided the calculations necessary for DP fatigue.
NS-14 was created as a drill string design manual to provide engineers with a set of simple tables to use when designing drill strings.

Included in the manual are the calculations upon which all the tables are based. These calculations are all based on API RP7G formulae or common Industry formulae in use by operators at the time NS-14 was compiled.
Cerberus for Drilling

- Drill string design and limits (NS-14)
- Dynamic Finite Element Torque and Drag
- Drill pipe fatigue
- Stall torque simulation
- Slip stick simulation
- Casing wear
- Jarring analysis
Drill String Design and Analysis

- Input your well, drill string and fluid.
- Analyse torque and drag.
- Analyse drill string design.
  - Stiffness ratio
  - Bending strength ratios
  - Von misses analysis
  - Buckling calculations
- Perform a detailed review of connection stresses, including seal area stress to prevent galling in drill string components.
- Take into account bending and pressures in your string tension calculations.
- Perform previously complicated and time consuming drill string design reviews in seconds.
- Menu-based software hierarchy.
- Graphical well data created automatically

Layered software, front layer for quick data entry. Back layers for advanced users.
Drill String Design Utility

- Analyse connection stresses usually ignored.
- DP data sheets created automatically.
- Tri axial drill string design every time.

Individual graphs change depending on dogleg severity and differential pressure.

CFD features - ‘Quick look’ design reviews in the drill string editor.

Combined loading of drill string components (graph to left)

Combined Loading of Tool Joint and Tube, taking into account dogleg severity and internal/external pressures (graph above)

This makes CFD a very convenient package to use for quick look string design projects.
Drill String Editor

Quickly choose a string of DP via 3 drop boxes –

OR

Enter advanced drill string and connection information to define your own specialist drill string component.

*Drill String Editor was designed to easily accommodate simple or complex equipment selection*
Basic analysis for simple quick look drag charts.

Advanced operations mode for detailed analysis of one drill string.

Capability to quickly compare two drill string options in same well – for optimisation
FEA T&D Model Calculates Force, Torque & Moment
Unique: Stall TorQ

Stall TorQ is a unique method for preventing drill string twist-offs when performing rotational drilling or milling operations.
Unique: Slip Stick

Slip Stick is a unique method for preventing drill string twist-offs when performing rotational drilling or milling operations.
Casing Wear

Casing Wear Calculation

Properties for Event 1

- Operation: Drilling
- Date: 1/28/2010
- Top: 3000 ft
- Bottom: 5200 ft
- Description: Well Example 1: Hole Section 2) Casing to 5200 (Bit 10.750): MyTestDrillString: 10 PPG WBM
- Speed: 2 ft/hr
- Rotational: 250 rpm
- Weight on Bit: 2000 lbf
- Wear Coefficient: 3.47

Update

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Casing Wear
Dynamic Jarring Simulation

jarring.wmv
Drill String Fatigue

• Intended to answer the questions:
  – When should the drill string be inspected?
  – How should stands be moved to minimize fatigue?
  – How will one DS compare to another DS?

• Benefits:
  – Maximize the life of a drill string
  – Reduce the number of inspections required
  – Reduce the number of drill string failures
What is Drill String Fatigue?

- **True Fatigue** – *currently ignored by drilling industry*
  - New DP has no fatigue damage
  - Rotating DP in a curved section causes fatigue damage
  - Fatigue damage accumulates until a crack is formed
  - This type of fatigue is analogous to CT and SL “fatigue”

- **Fracture Mechanics** – *called “fatigue” by drilling industry*
  - Start with a small crack
  - Rotating DP in a curved section causes the crack to propagate
  - Calculate the crack propagation through the wall thickness
Current Drill String Fatigue Tracking Process

• Assume a crack exists just slightly smaller than the inspection equipment can find
• Use fracture mechanics to calculate the crack propagation
• When crack reaches a certain depth, inspect the DP again
• If no cracks are found, reset the calculation to a small crack and restart process
• Currently CfD uses this historical process
DP Sections for Fatigue Tracking in CfD

- Drill Pipe (DP) fatigue is tracked for “sections” of DP
- All the joints in a section are assumed to be the same
- A section can be used in multiple drill strings, allowing it to be run with various BHAs, etc.
- Joints or stands within a section can be moved and/or replaced
Fatigue Section “Locked”
Example L Shaped Well
Input Parameters to Calculate Fatigue
Fatigue Calculation Process

- An initial crack depth (0.04” in this example) is assumed in each joint.
- The FEA is run in regular increments (200 ft in this case).
- The forces, torques and moments from the FEA are used to calculate the crack growth for each revolution using fracture mechanics equations from Prof. Steve Tipton, University of Tulsa.
- The accumulated crack growth is stored for the section.
- Multiple wells, or portions of wells, can be calculated at one time.
- Additional tripping, reaming, drilling operations can be added to the fatigue database.
Fatigue Profile from Drilling Example Well

Cerberus for Drilling - L Well Fatigue

Parameters
- Design Factors
- Drilling Operations
- Drilling
- Reaming
- Tripping
- Tubular Expansion
- Units

Scenario Analysis
- Graphs
- Special Calculations
- Casing Wear
- Fatigue Analysis

Graphs
- Fatigue Crack Depth (in)
- Drill String Length (ft)

Fatigue Analysis
- Section Name: 5 inch straight_5.5_1
- Crack Depth: 0.050 in
- String Position: 6,445 ft
- Total Rotations: 800,000
- Wall Thickness

Analysis completed for drill string: 5 inch straight
Processing Event 1 Drilling From 6000 to 10000 Speed 0.5 rpm 100 Max Fatigue 0.081

Warning: All fatigue calculations are still under evaluation at this time.
Re-drilling Last 3,000 ft of the Same Example
Joint Editor Used to Move High Fatigue Stands to Top
Database of Fatigue Event History - pulled in for next well
Next Well – Same Example
Next Well with no Joints Moved
DEA Project - Objectives

• Acquire data for actual drill strings
  – DS info, EDR data for each operation, history of changes to DS sections
  – Participants would identify DS for tracking and obtain required data

• NOV CTES (with Tipton) will develop true fatigue calculation

• Use data acquired to validate model

• Full report to participants
DEA Project - Proposal

• Validation process to be performed on 10 drill strings over 18 months

• Five participants sought who would pay $25K each to participate and would agree to provide the required data for 2 drill strings

• Each participant will receive a copy of CfD for the duration of the project
Questions?