Dynamic Relative Rod Stretch

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Quick Overview

• What is “Dynamic Relative Rod Stretch”? 
  – Sucker rods stretch and contract due to load & velocity changes
  – Think: A bouncing slinky

• Key points:
  – What is the relative elongation?
  – What is the “zero” position?

• If the rods get “too short” they may be in compression
Rod Loading – Rod Stretch

• How long is the rod string?

• When the rods are hanging in the well, they are as long as we say they are
  – Approximately [25ft] x [# of rods]

• But the top half of a given rod is “longer” than the bottom half…
  – Because the top half holds the weight of the bottom half
Gravity Affects Rod Length

- Gravity does not change, so we tend to ignore it
  - Relatively speaking, hanging rods are the frame of reference
  - We don’t calculate based on absolute lengths (impossible to measure)

These rods are slightly longer than these rods which is mostly irrelevant…
How can we just ignore gravity like this?

Simple Answer: Pump Spacing
- Plunger is set relative to the barrel
- Slowly lower the rods till they tap – no dynamic stretch
- We no longer care about the exact “total” length
- Everything becomes relative to some static configuration

When spacing the pump, the rods are already stretched under their own weight
- So if the rods are already stretched (some more than others) what does it take to put a rod into compression?
- The plunger is spaced relative to the bottom of stroke
A bit about the wave equation

• Pump card loads move up & down due to calculation method, rod buoyancy effects, etc.

• Pump cards can also move left & right
  – Gibbs, 1963
  – See page 43 of Gibbs’ book

• So why are all pump cards aligned at zero?
  – We would “rather” see relative stroke length
  – We lose a valuable piece of information – Relative Position
A bit more on the wave equation

• “Position is almost more important than load”
  – Depending on the method of calculation, downhole load is calculated from position
    ◦ Positions are relative to a static position
  – Errors in position translate into errors in load
    ◦ Errors compound/magnify down the rodstring

• What does it take to compress or “buckle” a section of sucker rods?
  – Commonly thought of in terms of forces
  – What about expressing it in terms of length?

These are all relative positions
What is a Dyno Card?

- Load vs. Position
- Implicit time component
- Surface vs. Pump?
  - Time sync’d points
  - Mouseover highlight

Large horizontal spacing between points
Moving Fast

Close horizontal spacing between points
Moving Slow
Dynamic Rod Elongation

- Allow wave equation to place the card left/right
  - Don’t align pump with surface card
- Plot difference in position over time
- Dynamic rod elongation is relative to the static hanging rod length

Surface – Pump = Relative Stretch
Dynamic Rod Elongation

- Gravity lengthens rods
  - This is considered the “normal static” rod length
- Rod length changes with dynamic motion

Static Elongation due to gravity

Rod Compression

Un-stretched Rod (No Gravity/Weight)

Neutral Rod Length “un-stretched”

Static Rod Length (Due to Gravity)

Dynamic forces can elongate rods

Dynamic forces can shorten rods
Visualizing Potentially Compressive Data

• Dyno cards present a lot of data
  – Three dimensions – load, position, and time

• Add some more dimensions
  – Use line/dot colorization
    ◦ Indicate other dimensions
    ◦ Velocity, acceleration, compression…

• Plunger Velocity
  – How close the dots are spaced
  – Close spacing = low velocity
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• Dynamic Stretch
  – Less useful over the full length of the rodstring
  – Compression occurs locally
    ◦ Better to look at individual rods/sections
Dynamic Stretch Correlation (1)

Colors indicate stretch scale

This dip is due to load

Dynamic Stretch = \( \text{Position}_{\text{Sfc}} - \text{Position}_{\text{Pump}} \)

This dip is due to position only (or relative stretch)
Dynamic Stretch Correlation (2)

Colors indicate stretch scale

This dip is due to load

Dynamic Stretch = Position_{Sfc} – Position_{Pump}

This dip is due to position only (or relative stretch)
• This well is “lightly” tapping...
  – But we don’t see that in the dynamic stretch graph?
    ° Because we are looking at the whole rod string
Localized View

- Individual 25’ rod ~2500ft depth
  - Don’t see anything interesting…
  - Zero does not indicate compression…
  
At least not yet…

What does this zero line mean?
Localized View

- Individual rod ~5000ft depth
  - Deeper, but still nothing...
Localized View

- Individual rod ~7500ft depth
  - Not yet...
Localized View

• Keep an eye on this region
  – Dynamic stretch is changing rapidly as we go deeper in the well
  – In the same timeframe as the tap

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Rod #380
~9,500ft
(~1,500’ over pump)
Localized View

- Hey, what just happened?
  - This rod is getting shorter
  - In the same time-span as the tag

Rod #415
~10,375ft
(~625’ above pump)

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Localized View

- Hey, what just happened?
  - This rod just got significantly shorter
  - In the same time-span as the tag

Rod #430
~10,750ft
(~250’ above pump)
Localized View

- Short duration (tap happens fast)
  - Hard to determine true magnitude, but something is obviously happening
  - Appears to affect bottom ~25-30 rods

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Next Steps

• Determine the relative un-stretched rod lengths
  – Better approximate & identify “compression”

• Incorporate wellbore geometry & friction
  – See HWDDDA project

What is the un-stretched length?

Unstretched rod length relative to statically stretched rods
Conclusions

• Dynamic relative stretch can indicate potential issues
  – Provides a more concise view than load indicators alone

• Color-coding dyno graphs can further identify issues

• How does this affect the industry or your bottom-line?
  – Better understanding of rod dynamics
  – Identify when & why it would be wise to slow down
  – Conditions change – pumped off states generally have greater change in dynamic relative stretch
Where can I try this for myself?

- **http://pump-card.com**
  - Still under development – Not fully functional
  - Contact me with questions or comments

- You can upload DYN files and configure the rodstring details to calculate the pump card

- Pre-loaded demo data:
  - [http://pump-card.com/pumpedoff](http://pump-card.com/pumpedoff)
  - [http://pump-card.com/full](http://pump-card.com/full)
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