Theta Enterprises, Inc.
NEWSLETTER

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Using RODSTAR to design Rod Pumping Systems for "Worst Case Scenario"

When designing a new rod pumping system, it is wise to design it to handle the worse loading conditions for the well. To most people this means designing the system for a full pump with the fluid level at the pump intake. The reason for this is because when the fluid level is at the pump, this creates the maximum pressure difference across the pump plunger which results in the highest fluid load on the plunger. Using a full pump maximizes the work done by the pump.

Most people think that when you design a system for full pump with fluid level at the pump, the system will be able to handle any other fluid level or pump condition without being overloaded. **This is true is most cases** but not in all cases. Which brings up the question: "How do I design my rod pumping system for the worst case to avoid overloading the pumping unit, the rods and the motor?"

To answer this question we need to discuss what factors contribute to the loading and power requirements of the rod pumping system.

Dynamometer Card Area

The area of the surface dynamometer card represents the work done by the system for one cycle. This area along with the pumping speed of the system allows us to calculate the power required at the polished rod which in turn is used to calculate the minimum required motor size. This means that the more area the surface dynamometer card has and the faster the unit is running, the bigger the motor we need. Also, the area of the dynamometer card affects the gearbox loading. The closer the dynamometer card gets to the permissible diagram, the closer we get to overloading the gearbox. Therefore, when the area of the dynamometer card increases, this does not only affect the motor size we need, but also the gearbox and rod loading. The reason the rod loading is affected is because the load range is the biggest factor in the rod loading fatigue calculations.

Factors Affecting the Area of the Surface Dynamometer Card

The main factors that contribute to the shape and area of the surface dynamometer card are:

- Fluid load (which depends on the fluid level and plunger size.
- Pump and surface stroke length.
- Pumping speed.
- Pumping unit type and prime mover type.

Fluid load also affects rod stretch which in turn affects stroke length. The complex nature of the relationships between these variables is why we need to use sophisticated wave equation simulators such as RODSTAR to model what happens in rod pumping systems. However, it does help to be aware of the relationships between these variable to understand why **in some cases, a certain fluid level over the pump can result in higher gearbox loading than when the fluid level is at the pump.**

This rarely if ever happens with steel rod strings. However, it can occur if you use fiberglass & steel rod strings that have overtravel (stroke at the pump is longer than the stroke at the surface). The explanation for this is as follows: For a fixed SPM, the area of the dynamometer card is a function of both stroke length and plunger load (fluid load). When the fluid level over the pump rises, this reduces the fluid load. This in turn reduces the stretch on the rods and the pump stroke increases. If the pump stroke increase is larger than the fluid load reduction, the overtravel increases (stroke at the pump gets longer). This means the system is doing more work than before and the area of the surface dynamometer card increases. However, Since the surface stroke is fixed, the dynamometer card area can only increase if the dynamometer gets fatter in the vertical direction only. This brings the dynamometer card closer to the permissible load diagram which increases the gearbox loading.

To illustrate this phenomenon, I ran an 8000 foot deep case with fiberglass and steel rods and varied the fluid level from 8000 to 2000 feet from surface to see what happens to the loads on the system. Figure 1 shows the surface and downhole dynamometer cards with a fluid level of 7000 feet from surface. The gearbox loading for this condition was 68%. Figure 2 shows the surface and dowhole dynamometer cards when the fluid level is 3000 feet from surface. The gearbox loading for this condition was 125%. Notice that the reason the surface dynamometer card has a much larger area as compared to figure 1 is because of pump plunger overtravel. This more than makes up for the smaller fluid load on the plunger.

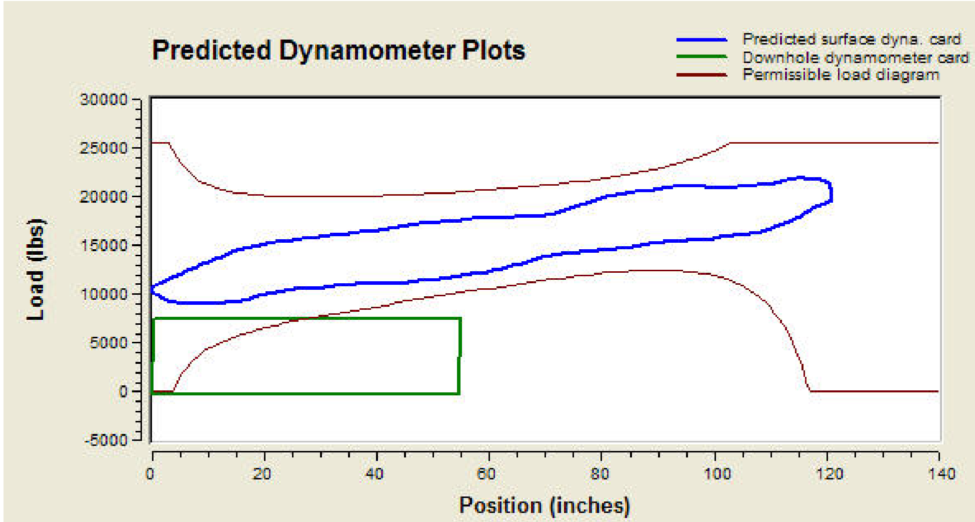

Figure 1. Example Dyno Plots for Fluid level of 7000 feet from Surface

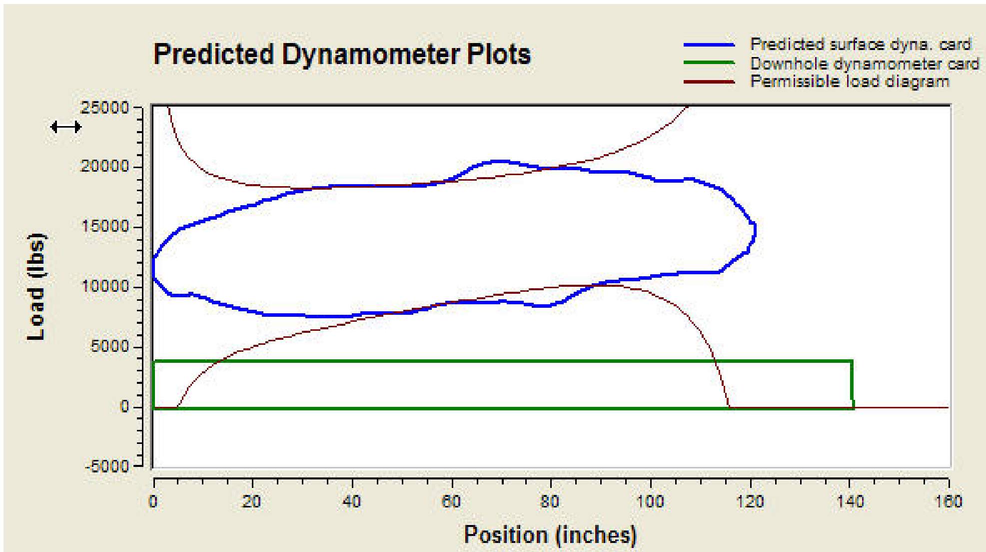

Figure 2. Example Dyno Plots for Fluid level of 3000 feet from Surface

The maximum rod loading was higher when the fluid level was 7000 from surface (93% vs. 87%) but the required motor size was significantly different for the two fluid levels. For the 7000 ft fluid level run, the required motor size was 30 hp. For the 3000 ft fluid level run, the required motor size was 50 hp. This means that if you work on this type of well and the fluid level rises above the pump, when you put the well back on production, the gearbox and the motor will be overloaded until the fluid level goes back to 7000 feet from surface and the system reaches a stabilized condition.

In the above comparisons, it was assumed that the unit would be perfectly balanced for each of these conditions (ran RODSTAR with unknown Max. CB Moment). However, if this was a real well that we designed to normally operate with a fluid level of 7000 ft from surface and the unit was balanced for this condition, if the fluid level is 3000 ft from surface after the well is worked on, then when you restart the unit, the gearbox loading will be 160% and the required motor size will be 60 hp. This indicates that sever overloading can occur when you least expect it (when the fluid level is much higher than what most people think is worse case condition.)

Full Pump versus Fluid Pound

Another common belief is that new rod pumping systems must be designed for a full pump. Of course this is true in most cases since a full pump requires more work and is the pump condition that must be used to correctly size the motor you need. However, a full pump may not give you worse case loading or the correct number of sinker bars needed.

For example, I ran a RODSTAR design for an 8000 ft deep system. Using the traditional approach, I selected a full pump condition and fluid level at the pump. Then, I compared my results with a second run for the same system but with a fluid pound condition with a 50% pump fillage.

The results were interesting. The rod and gearbox loadings were higher with the full pump condition. The structural loading was slightly higher with fluid pound (97% vs. 96% for full pump) but not enough to worry about. When I designed the case with a full pump, I used a 76 rod string with 300 feet of 1 ½ inch sinker bars on the bottom to keep the ¾ inch rods in tension (with buoyancy effects not included). Then, I fixed the rod string design after running RODSTAR by selecting “Manual rod string entry” from the Rod string entry option list. This brings in the rod string that RODSTAR designed and enters it as if it was entered manually. Then, I ran the case with fluid pound with 50% fillage. Even though most loads were worse for the full pump condition, the ¾ inch rods were now in compression. To avoid compression I had to add another 50 feet of sinker bars for a total of 350 feet of 1 ½ inch sinker bars. Then, I reran this case with a full pump using the longer sinker bar section.

I hope that the above examples help you improve your designs with

RODSTAR and help avoid unnecessary failures by designing your rod pumping systems for worse case conditions that take in consideration other transient or steady state conditions your systems may experience such as fluid pound or a high fluid level over the pump.

If you found this article useful and have more questions about it please email me your questions and I will be happy to further clarify some of these concepts for you. Also, I would appreciate any suggestions for items of interest to discuss in this newsletter in the future.

Upcoming Rod Pumping Optimization Schools for first half of 2004:

Bakersfield, CA: August 23-27
Midland, TX: March 15-19
Maracaibo, Venezuela: April 12-16
Midland, TX: September 13-17
Midland, TX: November 17-19
Calgary, AB: May 3-7
Calgary, AB: September 27-Oct. 1
Houston, TX: December 6-10

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