TECHNICAL BULLETIN

PROGRESSING CAVITY PUMPS | LS-TB-OO3

LIFTING SOLUTIONS

BULLETIN	TOPIC	ISSUE DATE	ISSUED BY
LS-TB-003 V1	PCP FRICTION, HYDRAULIC AND TOTAL TORQUE	DECEMBER 9 2019	ENGINEERING

BACKGROUND:

It is important to understand friction, hydraulic and total torque in the context of a PCP. The friction torque component is a function of the rotor/stator fit (compression) and the coefficient of friction between the two. On a baseline pump test curve, the friction torque is equivalent to the torque at zero head/pressure. Hydraulic torque (not to be confused with surface hydraulic system pressure) is the dynamic torque required to move a specified volume of fluid against a pressure. The total torque is the combination of the two and in the case of a baseline pump test curve, this is the torque at rated head/pressure. Several important concepts clarify the factors affecting torque.

FACTORS AFFECTING FRICTION TORQUE:

- **Compression** - Higher compression increases frictional torque. Is the compression balanced or do we have an over/under compression state that contributes adversely?
- **Lubricity** - of the produced fluid. Oil vs Water vs Sand all affect the coefficient of friction between the rotor and stator.
- **Length** - The longer the pump the more contact area the more friction. This magnifies the contributions of poor compression and reduced lubricity to high torque.

FACTORS AFFECTING HYDRAULIC TORQUE:

- **Volume -** The nominal pump volume is a critical component in the calculating hydraulic torque.
- **Lift -** The lift requirement of a given pumping system is a function of the application, produced fluid and completion equipment. What is the rated lift of the pump and how much of it are we using? This is more commonly referred to as pump pressure loading or PPL.

CALCULATING TORQUE:

Based on the variables introduced in detail above, torque can be calculated using the following formula:

$$Torque\ Total = \frac{Volume * Lift}{125} * Friction\ Factor$$

*Total Torque in ft*lbs*

Volume is the nameplate volume of the pump selected in m3/day/100m

Lift is the application lift requirement, or the nameplate rated lift of the pump selected in m of head.

Friction Factor varies from 1.1x to 1.3x based on the geometry of the pump, compression set between the rotor/stator and the anticipated lubricity of the fluid being produced

SAMPLE CALCULATIONS:

For a model 30-1200 PCP with balanced compression fit the estimated torque is calculated below. The friction/total torque ratio is also calculated in this example.

$$Torque\ Total = \frac{30 * 1200}{125} * 1.2 = 346ft * lbs$$

$$\frac{Friction\ Torque}{Total\ Torque} = \frac{58ft * lbs}{346ft * lbs} = 16.7\%$$

For a model 30-1200 PCP with unbalanced compression fit the estimated torque will result in an increased friction factor which also increases the friction/total torque ratio.

$$Torque\ Total = \frac{30 * 1200}{125} * 1.5 = 432ft * lbs$$

$$\frac{Friction\ Torque}{Total\ Torque} = \frac{144ft * lbs}{432ft * lbs} = 33.3\%$$

It is important to pay attention to the friction/total torque ratio as it is the best indication of a proper fit between the rotor and stator. Lifting Solutions quantifies importance of balanced compression by evaluating the effects on friction and this ratio.

If we were to increase the size of the pump to a model 68 in the same application as above in order to bring the overall speed down, or alternatively to increase the production rate, the effects on torque can be easily calculated using the same formula and variable modifications.

$$Torque\ Total = \frac{68 * 1200}{125} * 1.15 = 751ft * lbs$$

$$\frac{Friction\ Torque}{Total\ Torque} = \frac{98ft * lbs}{751ft * lbs} = 13.0\%$$

Note that the friction factor was reduced to 1.1 as a function of the aggressiveness of the geometry and the compression requirements to seal a longer pitched pump. Now if the fit gets messed up on the larger pump the calculation changes to account for the increased friction.

$$Torque\ Total = \frac{68 * 1200}{125} * 1.4 = 914ft * lbs$$

$$\frac{Friction\ Torque}{Total\ Torque} = \frac{261ft * lbs}{914ft * lbs} = 28.6\%$$

CONCLUSION:

The above examples illustrate the importance of proper fit between the rotor and stator, especially in larger volume pumps where it is extremely critical. With the assumption of a proper balanced compression fit, the torque requirements are relatively predictable based on the PCP model, geometry and friction assumption. If you increase the nominal size of the pump, torque will increase proportionally. If the fit between the rotor and the stator is not right, torque is the best indicator.