Proper Motor Sizing
High Temperature Liquid Pumping with Hydra-Cell Pro Pumps

By: Chris Pasquali, CEO Factory Direct Pipeline Products, Inc.

This article explains how pumping high-temperature liquids affects motor sizing (horsepower requirements) for Hydra-Cell Pro pumps.

What is considered a "high temperature liquid"?
The only reference to operating temperatures in the pump datasheets and IOM manual list the maximum allowable temperature for alloy and non-alloy pump head materials with an instruction to "*Consult factory for correct component selection for temperatures from 160F (71°C) to 250°F (121°C)*".

This instruction goes beyond selection of the other pump head components for temperature compatibility as described in our article *Component Breakdown of Wanner™ Hydra-Cell® Pro Pumps, Description of components in contact with the pumped liquid*.

Applications for liquids >160°F (71°C) also effectively reduce the motor size which can be used for a given Hydra-Cell Pro pump model due to the effect such temperatures have on the pumps hydraulic system, specifically accelerated bearing wear.

Role of Oil and Hydra-Cell Pumps
This article expands upon our article *Role and importance of oil used in Wanner™ Hydra-Cell® Pro Pumps* which provides a detailed overview of the various oils that can be used and the general purpose of the oil:

1. Lubrication of sliding and rotating components
2. Dissipating heat resulting from those moving components
3. Creation of hydraulic pistons to displace the diaphragms and generate flow.

Liquid temperature and its effect on motor sizing is directly related to the oil's viscosity at elevated temperature, an aspect we did not discuss in detail in that previous article.

Hydra-Cell Pro pumps typically have a hydraulic end oil temperature of about 180°F (82°C); the design basis for optimal performance and bearing wear. Oil temperatures exceeding 180°F (82°C) result in reduced oil film for the roller bearings, contributing to accelerated bearing wear and damage to the Hydra-Cell pistons.

One might think that if the liquid is <180°F (82°C) and thus the pump head is <180°F (82°C), the pump head would act as a heat sink, helping to dissipate heat from the hydraulic end. However, the pump body has cooling fins and a certain surface area to help the oil stay in that 180°F (82°C) range, hot liquids reduce the heat sink effect of the pump body itself. This is how the 160°F (71°C) liquid temperature threshold was established; at temperatures >160°F (71°C) the resulting hydraulic end (oil) temperature is more likely to exceed 180F (82°C).

The oversized roller bearings used in Hydra-Cell Pro pumps will still provide acceptable service life for oil temperatures *slightly* exceeding 180°F (82°C) and the "acceptable service life" varies by specific applications. The purpose of this article is to explain this aspect of pump wear (a nuanced topic that is often misunderstood) to help distributors and end-users select the most appropriate pump system configuration possible.

Oil Film
Higher bearing loads require a thicker coating of oil ("oil film") to prevent metal-to-metal wear which is referred to as elastohydrodynamic lubrication (EHL). Oil viscosity at operating temperature along with bearing load dictate the thickness of oil film required.

Bearing load refers to a force measured in pounds or newtons which acts upon the bearings radially or axially. It is this pressure against the bearings which will result in metal-to-metal wear if the oil film is not thick enough to maintain proper bearing support. The purpose of the bearings is to keep the rotating parts aligned and thus to resist such forces. The bearing load is mostly related to the reciprocating nature of Hydra-Cell Pro hydraulic pistons.

Therefore, higher pump discharge pressures and pump shaft speed (RPM) increase the load on the roller bearings. This also means that higher *available* motor horsepower allows higher torque and RPM under load, which increases bearing loads.

There are two ways to maintain optimal oil film thickness:

1. Reduce the load on the roller bearings by limiting the motor's horsepower (essentially requires using a larger pump at a lower RPM). This is a design limitation, not a performance limitation.
2. Install an oil cooler to maintain the temperature of the oil at no more than 180°F

Limiting Horsepower
The following chart summarizes the maximum motor size by pump model and liquid temperature.

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Maximum Allowable Motor Horsepower		
Pump Model	Liquid <160°F (71°C) **OR** with oil cooler	Liquid >160-230°F (71-210°C) w/o cooler
M/D03	2.3	0.8
D04	5.3	1.7
D10/12	6.5	2.1
D15	20.1	6.6
H25	15.3	5.0
D35	29.8	9.8
D66	44.4	14.7
T60	64.0	32.0
T100	98.7	49.3
Q155	161.0	80.5
T200	203.0	101.5
Q330	330.0	165.0

Values represent maximum recommended applied motor horsepower, not calculated HPr.

The middle column lists the calculated horsepower required (HPr) for the highest flow rate and pressure by pump model. The right column lists the maximum HP that should be used when the pumped liquid is >160°F (71°C).

Example Application and Analysis

Model D10 pump with "X" cam for 4 GPM at 716 PSIG with an 1800 RPM motor pumping a liquid >160°F (71°C).

Using the sizing formula per the D10 datasheet (or our web-based HP calculator) calculate the hydraulic horsepower requirement (HPr):

((15*RPM)/63000) + ((GPM*PSI)/1460) = HPr

= ((15*716)/63000) + ((4*716)/1460)

= (0.042 + 1.96) = 2 HPr is required for this application

If the customer wants to incorporate a VFD then to maintain sufficient pump shaft torque this increases the motor HP size required to 5.4 HP (thus a 7.5 HP motor is required when using a VFD for this application).

When the application is for liquid temperatures >160°F (71°C) and it's a D10 pump, the maximum recommended horsepower is 2.1, so in our example a D10 pump with 7.5 HP motor and VFD is okay because the HPr for the application is 2.0 and the maximum acceptable HPr for D10 pumps for liquids >160°F (71°C) is 2.1 per the chart.

HOWEVER

Let's say that the customer eventually decides they want to use their VFD and increase their flow rate to 5 GPM. This increases the HPr for their application to 2.7. Even though their 7.5 HP motor can handle the flow/pressure and their VFD matches their 7.5 HP motor, the horsepower requirement of 2.7 *exceeds* the maximum for a D10 pump (2.1) and therefore the customer has two choices, they can add an oil cooler to their existing pump system OR increase the pump size.

If they have an existing pump system whose motor is sufficient for the desired flow rate and pressure but the HPr exceeds the values of the table for pumping high temperature liquid, the most economical solution is to incorporate an oil cooler. Air-cooled oil cooler/filters offered by Wanner Engineering cost from $5600-$7200 based upon the 2025 pricing guide.

If they did not have an existing Hydra-Cell Pro pump system, they could compare the cost and complexity using a D10 with oil cooler/filter to using the next larger size pump (H25) without an oil cooler/filter.

Let's analyze an H25 pump for this application. We'd use a 1200 RPM motor with an H25E pump and for 5 GPM @ 716 PSIG operate at 288 RPM. The HPr remains at 2.7, however the limit for an H25 per the table is 5.0 and since 5.0 > 2.7, the H25E is acceptable w/o an oil cooler for this application. **NOTE** to use a VFD with an H25 for this application requires a 15 HP motor in order to maintain sufficient shaft torque and thus would also require a 15 HP VFD (refer to our article *Calculating Horsepower Required for Wanner™ Hydra-Cell® Pro Pumps* to learn about how shaft torque is related to motor sizing).

The customer faces a decision, a D10 pump with 7.5 HP motor + 7.5 HP VFD + oil cooler OR H25 pump with 15 HP motor, 15 HP VFD w/o oil cooler? Since H25s generally cost twice as much as a D10, they are physically larger and both the VFD and motor cost for a 15 HP system is greater than the 7.5 HP option, therefore adding an oil cooler to the D10 system is the "economical" approach.

And this is still the case w/o a VFD. Let's say you used a belt-drive or gearbox to deliver the exact RPM required per the formula; using the model D10 the 2.7 HPr is more than the charts 2.1 limitation, thus you would need an oil cooler or go with an H25 where the HPr is still 2.7 but its limitation is 5 HP. When not using a VFD the added expense is only the larger pump size and maybe its baseplate. For VFD driven systems when you increase the pump size the motor HP and VFD size will increase also even though the HPr hasn't changed.

Oversizing the pump can be a cost-effective alternative and it's valid because larger pumps have larger bearings (handle higher loads) and a larger oil reservoir providing better heat dissipation.

Therefore, incorporating an oil cooler/filter into your Hydra-Cell Pro pump system may be a cost savings alternative compared to using a larger pump. Either way, it is important to consider the horsepower required for pumping liquids that exceed 160°F (71°C) to maximize longevity of the hydraulic end components.