HIXSON
ARCHITECTURE ENGINEERING INTERIORS

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From Experience

The Influence of Viscosity on Equipment & Piping Design

Ingredient viscosity is a property that greatly influences equipment design and piping layouts. During the design process, it is important to understand the extent of viscosity changes with temperature, and the impact of the corresponding pressure drop on pipe design and the selection of the process pump. In Hixson's experience, product reformulations and plant layout changes that commonly occur after the initial installation and operation are commissioned can result in reduced production rates, product quality issues, and occasionally pump failures.

Using corn syrups as a specific example of a product reformulation, the viscosity of 63/43 DE and 43/43 DE corn syrups are significantly higher than 42 DE high-fructose corn syrup (HFCS). With such increased viscosity, it is likely that larger line sizes and/or more pump horse power will be required. The table below outlines the differences in pressure drop and brake horse power that result from viscosity changes, increased line sizes, and increased pipe length. All data was calculated at 100°F.

As indicated by the chart on the next page, the chosen pump would be satisfactory for 42 HFCS in any of the four conditions. If the product formulation changes, however, it is not appropriate to assume that the same pump, gear reducer or motor will function as intended. In fact it may even fail to operate at all. Other considerations when formulating design solutions include product integrity loss when pumping at higher pressures, drops in temperature over longer piping runs (resulting in higher viscosities) and low CIP cleaning velocity if a line size is increased.

Continued on next page. >

EXPERIENCE IN BRIEF

The change in the developed head (ΔP) for laminar, viscous flow due to changes in viscosity, pipe length, flow rate, or pipe diameter can be calculated using the following formulas:

$$\Delta P \propto \Delta \text{viscosity}$$
$$\Delta P \propto \Delta \text{pipe length}$$
$$\Delta P \propto \Delta \text{gpm}$$
$$\Delta P \propto \left(\frac{\text{current pipe diameter}}{\text{new pipe diameter}}\right)^4$$

For example, doubling a fluid viscosity doubles pressure drop.

Waukesha Cherry-Burrell Sanitary Pump Model 018, 1.5” Port									
100^{0}F		2” Sch 10, 10 GPM				3” Sch 10, 10 GPM			
		50 ft of pipe		150 ft of pipe		50 ft of pipe		150 ft of pipe	
Corn Syrup	Viscosity (cP)	ΔP (psi)	BHP	ΔP (psi)	BHP	ΔP (psi)	BHP	ΔP (psi)	BHP
43/43 DE	20,613	130	3.10	390	*	25	2.5	75	2.8
63/43 DE	9,374	59	2.15	177	2.85	11	1.83	33	1.95
42 HFCS	120	0.76	0.25	2.27	0.27	0.15	0.25	0.44	0.25

*In this case the pressure drop is too large for the chosen pump

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