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From Experience

The Influence of Viscosity on Equipment and Piping Design

Ingredient and product 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 on the following page 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, 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.

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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 approximated 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 Sanitary Pump Model 018, 1.5" Port									
100°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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CONTACT US

Direct any comments or questions to:

Warren Green, P.E., Vice President

Process Engineering Manager

wgreen@hixson-inc.com

Phone: 513.241.1230

Fax: 513.241.1287

www.hixson-inc.com