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Optimum consistency for pumping pulp

Scope

This Technical Information Paper provides procedures for estimating the energy required in pipelines to overcome friction for stock transport at practical consistencies, as well as the consistency at which this energy requirement is minimum for a given tonnage of pulp. General information on friction loss in pulp flows is provided in TIP 0410-14 (1). More detailed treatments of pipeline design and consistency optimization are available in (2, 3).

Safety precaution

No safety precautions have been specified for use with this technical information paper.

Introduction

In the present treatment, the recommended consistency (%) to minimize energy costs will be shown to be approximately

$$C_d = N (T/D^2)^{0.4167} \quad (1)$$

where T is the mass flow of fibers, D is the pipe diameter, and N is a constant in Table 1. Table 1 offers two choices of units for T and D . Procedures for determining energy consumption are also given below.

Analysis

For a specified pipe diameter and fiber mass flow rate, there is an optimum consistency that minimizes pumping power. This optimum consistency is estimated here using the head-loss correlations in (1). The procedures outlined here can be applied to other correlations to estimate the optimum consistency.

The pulp velocity, (V) [m/s] flowing in a pipe of diameter D [mm] at a consistency C (%) and production rate T [oven-dry metric tons per day] is given by:

$$V = 1473 \frac{T}{CD^2} \quad (2)$$

At low consistencies, the high velocities required cause large pressure losses in the flow. High consistencies allow lower velocities, but friction increases rapidly with increasing consistency. An intermediate consistency exists where the pressure drop is a minimum (4). Multiplying the velocity by the cross-sectional area gives the volumetric flow rate, Q [m^3/s]:

$$Q = 1.157 \times 10^{-3} T/C \quad (3)$$

The power, E , required to pump a given volumetric flow rate, Q , of stock is:

$$E = \Delta P Q \quad (4)$$

or, expressing P in terms of head loss per unit length of pipe and applying specific units,

$$E = ML (\Delta H/L) Q \quad (5)$$

where L is the effective length of the piping system and M is a constant given in Table 1 for either of two sets of units. This equation employs $\Delta H/L$ as head loss per 100 meters or feet of pipe. Note: L may be longer than the actual run of pipe because additional effective lengths must be added to account for the pressure losses of valves, elbows, and other piping elements. The consistency giving the lowest pressure drop will also give the lowest power consumption. Determining this consistency requires information about the flow behavior of the pulp. Figure 1 depicts a typical head loss curve for a pulp suspension. Each of the three basic flow regimes, low velocity, intermediate, and drag reduction, requires separate consideration.

Table 1. Constants used in formulas of TIP 410-15.

$\Delta H/L$	T	E	Q	D	M	N	A	B
<u>m H₂O</u> 100 m	<u>metric tons</u> day	kW	<u>m³</u> min	mm	0.163	19.24	1.135×10^{-2}	1.049×10^4
<u>ft H₂O</u> 100 ft	<u>short tons</u> day	hp	<u>US</u> gal/min	in.	2.52×10^{-4}	1.247	4.21×10^{-3}	6.83×10^{-5}

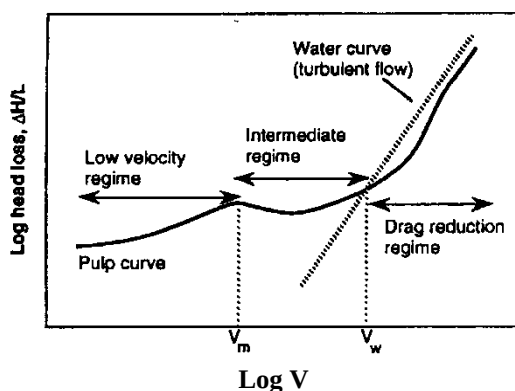


Fig. 1. Typical head loss curve for a pulp suspension.