Pump Selection

Waukesha Displacement Pumps
Summary

The selection of a displacement pump for an alcohol production (ethanol) plant will be discussed. The pump will be selected using the Waukesha manual. A procedure to solve the problem using spreadsheet will be demonstrate during the lab.

4.1 Background

In designing a liquid transport system, the need for a pump is determined on the basis of flow and pressure requirements. In selecting a pump for a given system, it is imperative that the characteristics of the system are closely defined. The pump requirements are based on the system characteristics. The following information about the system must be known:

- flow rate of liquid, the required differential pressure, the available net positive suction head, the pump capacity, pump speed, characteristics of the fluid.

4.2 Objectives

1.) To present the Waukesha manual
2.) To use the manual to select a pump for an alcohol production plant
3.) To solve the problem using spreadsheet
4.) To use the spreadsheet to change the system for apricot puree

4.4 Procedure

a.) Using the spreadsheet presented in class, modify your system to transport mayonnaise, considering the following:

- mayonnaise is a thixotropic material and can be described by:

\[
\sigma = \lambda \left[ 7 + 28.5 \eta^{0.32} \right] \\
\dot{\lambda} = (0.012 \eta^{0.13} t + 2.70)^{-1} + 0.063
\]

- the material will be transported from tank1 (processing) to the filling nozzles located a distance no less than 5 m from the pump.
- the pump will be located at 2 m from tank1 exit
Lab 2

- Calculate the viscosity at $t = 0$ for given shear rate - after being transported to the filling nozzles calculate the viscosity at the shear rate you selected to transport - the final viscosity must be large or equal 30% of initial viscosity
- Density is 1200 kg/m³
- Selected the pipe diameter, the flow rate, and system layout

b.) Determine the maximum velocity in the pipe
c.) Determine the maximum safe distance $L$ that the pump can be located
d.) Discuss the significance of fluid rheological characteristics in pump selection
Pump selections - to transport sugar cane must

From must tanks to fermentation vats

(1) GPM and viscosity

Using the VB program

Using the worksheet - INPUT

Note: do not write in the cells that are in white

Preliminary choice - based on GPM x viscosity:

\[ n = 1, \ k = 0.0015 \text{ Pa.s}; \ \text{density} = 1176 \text{ kg/m}^3; \ P_v = 7.11 \text{ psia} \]

\[
2000 \text{ L/h} = \text{_________} \text{ L/min} = \text{_________} \text{ GPM}
\]

Pipe size = 1.5 in = \text{_________} \text{ m}

Velocity of must = \( u = \frac{Q}{A} \) = \text{_________} \text{ m/s}

Determine Reynold’s number for the Newtonian Fluid

\[
N_{Re,N} = \frac{D(u)\rho}{\mu}
\]

\[
Re = \text{_________} \quad \text{Recrit = _________} \quad \text{Flow regime = _________}
\]

Determine the friction factor - \( f \) - also called fanning factor

\[
f = \text{______________}.
\]

Determine the effective viscosity

\[
\mu_e = \frac{fm}{4\pi D}
\]

\[
\mu_e = \text{_________} \text{ cPs}
\]

PReiminary PUMP choice - based on GPM x viscosity: \text{_________.}
From must tanks to fermentation vats

(2) Discharge Limitations

Waukesha pump can withstand a pressure difference of 200 psi (1370 kPa)

Using the tab - DischargePre
Using the tab - NIPR

Calculate the Pressure needed to pump the fluid to the fermentation vat

The energy balance from the pump to the fermentation tank:

\[
\frac{u_2^2 - u_1^2}{a} + \frac{P_2 - P_1}{\rho} + (z_2 - z_1)g + \sum F = -W
\]

\[
u_2 = u_1; \quad P_2 = 0; \quad W = 0; \quad (z_2 - z_1) = 0.9
\]

\[
P_1 = [(z_2 - z_1)g + \sum F] \rho
\]

\[
\sum F = \frac{2h u^2 L}{D} + \sum \frac{k u^2}{2}
\]

\[L = \text{_______ m;}
\]
\[# \text{ elbows} = \text{_______} \text{kf EL=} \text{_______}.
\]
\[\# \text{ gate valve=} \text{_______} \text{kfGV=} \text{_______}.
\]
\[\sum F = \text{_______ J/kg}
\]

\[P_1 = \text{_______ Pa} = \text{_______ psig}
\]

\[P_1 + Patm = \text{_______} + 14.69 \text{ psia} = \text{_______}.
\]

Will the pump withstand a 200 psi pressure drop? ________.

Pump speed

From manual GPR = ________.

speed = GPM/GPR = ________ rev/min
Pump selections - to transport sugar cane must

From must tanks to fermentation vats

<table>
<thead>
<tr>
<th>(3) NIPA vs NIPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIPA &gt; NIPR otherwise the pump will cavitate</td>
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</table>

Using the worksheet - NIPR
Using the worksheet - NIPA

Calculate the Pressure needed to pump the fluid to the fermentation vat

The energy balance from the must tank to the pump

\[
\frac{u_2^2 - u_1^2}{a} + \frac{P_2 - P_1}{\rho} + (z_2 - z_1)g + \sum F = -W
\]

\[
z_2 - z_1 = 1.5; \ u_1 = 0; \ P_1 = 0; \ W = 0
\]

\[
P_2 = \rho \left[ \frac{u_2^2}{a} - \sum F \right] - z_2 g
\]

From manual

______ pump; NIPR = _______psia

L = _________ m

# elbows = _______ kf EL = _______.

# gate valve = _______ kf GV = _______.

# tee = _________ kf T = _______.

\[\sum F = \text{_______ J/kg}\]

\[P_2 = \text{______ Pa = _______ psig}\]

\[P_2 + Patm = \text{______} + 14.69 \text{ psia = ________}.\]

NIPA = P2 - P_{vapor} = P2 - 7.11 = _________ psia

NIPA _____ NIPR

Power requirement

\[W = \frac{(P_1 - P_2)}{\rho} = \text{_______ J/kg}; \ HP = \text{______}; \ T = \text{HP 5250/spd = _______ ft-lb < ______ OK?}\]
CHANGE THE FLUID RHEOLOGICAL PROPERTIES

\[ n = 0.35 \]
\[ K = 8.9 \text{ Pa s}^n \]

\[ \text{Re} = \] \[ \text{Recrit} = \] \[ \text{Flow regime} = \]
\[ f = \]

Pump size =

Maximum length =

BACK TO NEWTONIAN FLUID - Change Q to 5000 L/h

\[ n = 1 \]
\[ K = 0.0015 \text{ Pa.s} \]

\[ \text{Re} = \] \[ \text{Recrit} = \] \[ \text{Flow regime} = \]
\[ f = \]

Pump size =

Maximum length =

BACK TO Q to 2000 L/h - Change the pipe diameter to 3 in

\[ n = 1 \]
\[ K = 0.0015 \text{ Pa.s} \]

\[ \text{Re} = \] \[ \text{Recrit} = \] \[ \text{Flow regime} = \]
\[ f = \]

Pump size =

Maximum length =