Design of Dilute Phase Pneumatic Conveying

Product : flour

pressure drop across jet filter : 10 mbar : 0.1 psi

this value control final air velocity

particle size	mm	B.D (kg/m3)	Ut(m/s)	pipe roughness	k=mm
flour	0.02	0.6	4.64	stainless steel	0.02
sugar	0.5	0.9	4.405	carbon steel	0.05
talc	0.01				
HDPE	4	946	9.32		

mat'l of pipe : stainless steel

mass product flo : 6,000 kg/h : 13,228 lbm/h

pressure drop across blower inlet & silencer : 450 mbar : 6.6 psi

Ambient temp. : 25 ℃ : 85 °F
Ambient pressure : 1.013 bar : 14.8911 psi
particle size : 0.02 mm : 6.6E-05 ft
clean air line : 85 mm : 3.34646 inch
B.D of product : 0.6 kg/m3 : 0.03746 lbm/ft3
pipe roughness : 0.02 mm : 6.6E-05 ft
bend radius >= : 765 mm
R/D >= 6 ~ 12 : 9
mass air flow : 516 Nm3/h : 304 SCFM : 8.60 m3/min
velocity mat'l, Ut : 4.6 m/s 15.2 ft/s

conveying distance
horizontal : 15 m : 49 ft
horizontal : 15 m : 49 ft horizontal 2 has acceleration zone
vertical : 0 m : 0 ft
bend : 4 ea

Gas density at point "jet filter" from ideal gas law : 0.074 lbm/ft3 : 1.183 kg/m3
Solid mass to air mass ratio=constant : 9.8 (Generally sugar:4.9, flour:9.8)

Components sum to total Pressure drop

1. jet filter : 15.04 psi : 1.02 bar

2. Horizontal 1 : 0.7646 psi : 0.05 bar A : 0.0611 ft2 ρ_g : 0.075 lbm/ft3 : 1.195 kg/m3

Vg1 : 82.14 ft/s : 25.0 m/s

μ_g : 0.0000114 lbm/ft.s Re : 149,980

Dynamic viscosity of air (0 deg.) = 1.74 x 10^{-6} = 0.0174 cP, 1cP=6.72 x 10^{-4} lbm/(ft.s)

Dynamic viscosity of air (15 deg.) = 1.78 x 10^{-6} = 0.0178 cP

Dynamic viscosity of air (0 deg.) = 1.79 x 10^{-6} = 0.0179 cP

A : 1.48847E+21

B : 2.36333E-10

Gas friction factor from Churchill's equation, f : 0.005

$Fr_{s=constant}$: 14.4056 Fr : 752

Solids Friction Factor, λz=constant : 0.006

4. Bend : 16.98 psi : 1.15 bar Vg3 : 71.82 ft/s : 21.9 m/s

ρ_g : 0.084 lbm/ft3 : 1.349 kg/m3

5. Vertical : 16.978 psi : 1.15 bar Vg4 : 71.82 ft/s : 21.9 m/s

Vg1	82.14
Vg3	71.82
Vg4	71.82
Vg5	68.52

Fr : 574.9 ρ_g : 0.084 lbm/ft3 : 1.349 kg/m3

λz=constant : 0.008

V_p / Vg : 0.9987 V_p : 71.73 ft/s ε : −21.39 ρ^0 : −1 lbm/ft3

0   0   (ε:Void fraction of gas phase, ρ^0:Bulk density)

6. Horizontal 2 : 17.91 psi : 0.05 bar ρ_g : 0.089 lbm/ft3 : 1.432 kg/m3

ΔP_{accel} : 0.9338 psi   Vg5 : 68.52 ft/s : 20.9 m/s

ΔP_{horiz} : 0.8174 psi   Fr : 574.9

λz=constant : 0.008

Pg' : 17.80 psi

Pg : 17.91 psi

Pressure Drop Across Blower

Inlet pressure to blower P_{in} : 8.085 psi : 0.55 bar

ΔP_{blower} : 9.83 psi : 0.67 bar   668 mbar   6,817 kg/m2

This is the pressure increase required by the blower.

Electric power of blower : 13.68 kw

Check Saltation Velocity

Use the Rizk Correlation V_{gs} : 53.846 ft/s : 16.4 m/s

δ : 1.9888 χ : 2.522

From the Rizk equation, the largest saltation velocity occurs at the smallest gas density.(at the jet filter)

The smallest velocity(V_g) : 68.52 ft/s 28.61 m/s

Result

1 The conveying gas velocity is O.K

2 The blower pressure must be increased by ΔP_{blower}

Note : The conveying gas velocity(V_g) is generally equal to or above the saltation velocity(V_{gs}) of the materal being conveyed at the dilute phase conveying System.