Hopper Discharge Devices

with traction

1. Belt feeder
   1.1 Belt conveyor
   1.2 Apron belt conveyor
   1.3 Belt balance for dosing

2. Chain conveyor as feeder:
   2.1 Skeleton flight conveyor
   2.2 Chain feeder

3. Vibratory feeder:
   3.1 Pushed chute
   3.2 Discharge chute
   3.3 Dosing chute, pipe
   3.4 Vibratory bin
   3.5 Dosing screen, beams, perforated bottom
   3.6 Pendular bottom (walking floor)

4. Rotary feeder:
   4.1 Screw feeder
   4.2 Rotary feeder, star feeder
   4.3 Rotary scraper
   4.4 Table, Disk, Roller feeder
   4.5 Agitator, Stirrer
   4.6 Rotary plough, arms, beams

5. Other devices:
   5.1 Hopper outlet valves, gates

without traction

3. Vibratory
   3.1 Pushed chute

4. Rotary
   4.2 Rotary feeder, star feeder

5. Other
   5.1 Hopper outlet valves, gates
Arrangement of Bin-Feeder Interface for Mass Flow

1. Flange arrangement of bin-feeder transition
   a) wrong  b) right

2. Double plates
   a) wrong   b) right

3. a) gate with horizontal obstacle
      b) partially opened plate within the outlet area

4. Discharge of easy flowing powder
   a) plough
   b) outer wall step
   c) under scratching

5. Arrangement of rotary plough feeder
   a) plough
   b) outer wall step
   c) under scratching
6. Draw-off behaviour of belt conveyor

a) in front at smooth belt and large vertical gate opening, back at rough belt and small vertical gate opening

b) uniform at sloping striker plate (increasing draw-off height)

c) uniform at widen chute opening

d) uniform at increasing weir level (sloping cross-sectional area of outlet) (sloping draw-off height)

7. Boundary (interface, shear zone) of horizontally drawn-off powder layer

b) uniform powder draw-off

a) draw-off from back

c) only in front draw-off

gate or weir level and bulk height on belt $h_b$

8. Skeleton flight conveyor with sloping plates within chute interface

Feeders for Powder Discharge of Mass Flow Bunker

1. Belt and skeleton flight (Redler) conveyor for mass flow

a) wrong

b) right

chute interface with guide skirt

2. Vibratory chute for mass flow

a) wrong

b) right

\[ \frac{\Delta V_d}{\Delta \alpha} = \frac{0.02 - 0.05}{1^\circ} \]

\[ \theta_2 = \theta_1 - (5 - 8^\circ) \]

3. Rotary feeder for mass flow

a) wrong

b) right

\[ h_s = (1 - 1.5)b \]

double rotor
4. Screw feeder for mass flow at wedge-shaped hopper

I) wrong

- constant pitch
- dead zone

II) right

- uniform draw by variable pitch

a) progressive pitch $s_s$

b) progressive screw diameter $d_s$

c) degressive core diameter $d_k$ ($\alpha = 5^\circ$)

d) degressive screw wall thickness $b_s$

e) progressive paddle pitch $\alpha$

f) right- and left-hand screw with centric or periphere discharge
5. Vibratory bin for mass flow ("Bin Activator")
Vibratory Bin

Module size (bin outlet diameter) $D$ in mm

- Installed power consumption $P$ in kW
- Specific power consumption $P/m$ in W/kg
- Mass $m$ in kg
- Specific price $K/m$ in DM/kg
- Recommended price $K$ in TDM

Graph showing the relationship between module size and various parameters.
1. Vertical stress $\sigma_v$ and tangential (horizontal) draw-off force $F_h$ on
a) Rubber belt conveyor without guide skirt      b) Apron belt conveyor with guide skirt
\[ F_h = \sigma_{v,0} \cdot b \cdot \tan(\phi_e) \]
\[ F_h \approx \sigma_{v,0} \cdot \frac{1}{2} b \left[ \tan(\phi_e) + 2 \tan(\phi_w) \cdot \frac{\lambda_E \cdot h}{b} \right] \]

c) Skeleton flight conveyor (Redler)
\[ F_h \approx \sigma_{v,0} \cdot \frac{1}{2} b \left[ \tan(\phi_e) + \tan(\phi_w) \cdot \left(1 + 2 \frac{\lambda_E \cdot h}{b}\right) \right] \]

2. Time dependent filling height $H_{\text{Fill}}$, vertical stress $\sigma_v$ and horizontal force $F_h$

3. Vertical stress $\sigma_{v,G}$ as function of displacement of discharge device $\Delta z$ at filling
Active and Passive Rankine's Stress State Limits

given: \( p_v = \sigma_1 = \rho_y g y \)
\( \tau_c, \varphi_i \)

<table>
<thead>
<tr>
<th></th>
<th>active</th>
<th>passive</th>
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<tbody>
<tr>
<td>principal stresses</td>
<td>( \sigma_{2,a} = \frac{1 - \sin \varphi_i}{1 + \sin \varphi_i} \cdot \sigma_1 + \frac{2 \cdot \cos \varphi_i}{1 + \sin \varphi_i} \cdot \tau_c )</td>
<td>( \sigma_{1,p} = \frac{1 + \sin \varphi_i}{1 - \sin \varphi_i} \cdot \sigma_{2,p} + \frac{2 \cdot \cos \varphi_i}{1 - \sin \varphi_i} \cdot \tau_c )</td>
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<td>lateral or horizontal stress ratio</td>
<td>lower limit for ( \tau_c = 0 )</td>
<td>upper limit for ( \tau_c = 0 )</td>
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<td>( \frac{p_{h,a}}{p_v} = \lambda_{a} = \frac{1 - \sin \varphi_i}{1 + \sin \varphi_i} = \tan^2 \left( \frac{\pi}{4} + \frac{\varphi_i}{2} \right) )</td>
<td>( \frac{p_{h,p}}{p_v} = \lambda_{p} = \frac{1 + \sin \varphi_i}{1 - \sin \varphi_i} = \tan^2 \left( \frac{\pi}{4} + \frac{\varphi_i}{2} \right) )</td>
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Vertical Pressure upon a Discharge Device

Filling
active - plastic stress state

Discharge
passive - plastic stress state

vertical load $F_v = \int p\,dA$

Filling
$p_v = f(\text{filling height } H(t))$

Discharge
$p_v \neq f(H) \quad p_v = f(b)$

unload peak at bridging

steady-state flow
Force Balance at Hopper Outlet with “Walking Floor” as Discharge Device for Post-Consumer Waste

funnel flow zone
passive stress field
Kernflußzone
passives Spannungsfeld
Entleerungsdrücke

stagnant zone
active stress field
stehendes Gut
aktives Spannungsfeld
Fülldrücke

\[ F_h = \int \mu \cdot p_{\text{Boden}} \, dA \]
\[ F_h = F_{h,E} + F_{h,F} \]
\[ F_h = 0.8 \cdot \tan \varphi_c \cdot b \cdot l_E \cdot \sigma_{l,E} + \tan \varphi_{w,pb} \cdot b \cdot l_F \cdot p_{v,F} \]
\[ F_h \approx 0.8 \cdot \tan \varphi_c \cdot b^2 \cdot \sigma_{l,E} + \tan \varphi_{w,pb} \cdot b \cdot (1 - b) \cdot p_{v,F} \]