1. Screening

Contents

1. Introduction
2. Passage probabilities
3. Kinetics
4. Parameters
5. Decks
6. Efficiency
7. Capacity
8. Equipment
9. Sieve analysis

Objectives

- Splitting in several size classes, each intended for a process optimised for that particular size class

- Classifying into sizes as required by the market (examples: heating coal, gravel, sands)

- Undersize removal before crushing

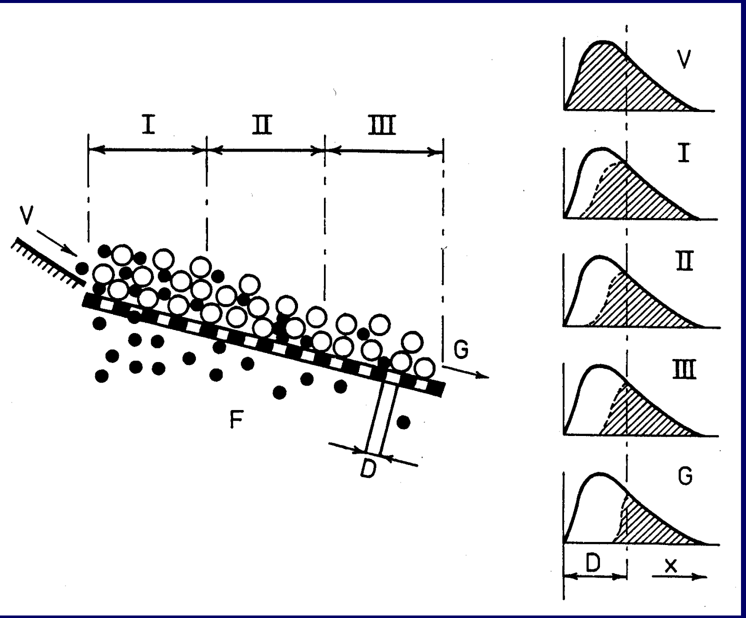
- Recovery of HMS medium solids (drain and rinse screening)

- Desliming (generally below 0.5 mm)

- Dewatering

Effect of **material properties**:

- particle shape
- bulk density
- moisture content
- electrostatic charge
- percentage of problematic size fraction (0.7<x<1.5) with x = mesh size.



Effect of the **screening method**:

- amplitude of vibration
- frequency of vibration
- screen angle with the horizontal
- screen length and width
- direction of vibration
- feeding method
- capacity.

Effect of the **screen deck**:

- mesh size
- mesh shape
- uniformity of the deck
- free screen surface
- construction material (steel, rubber or plastics).

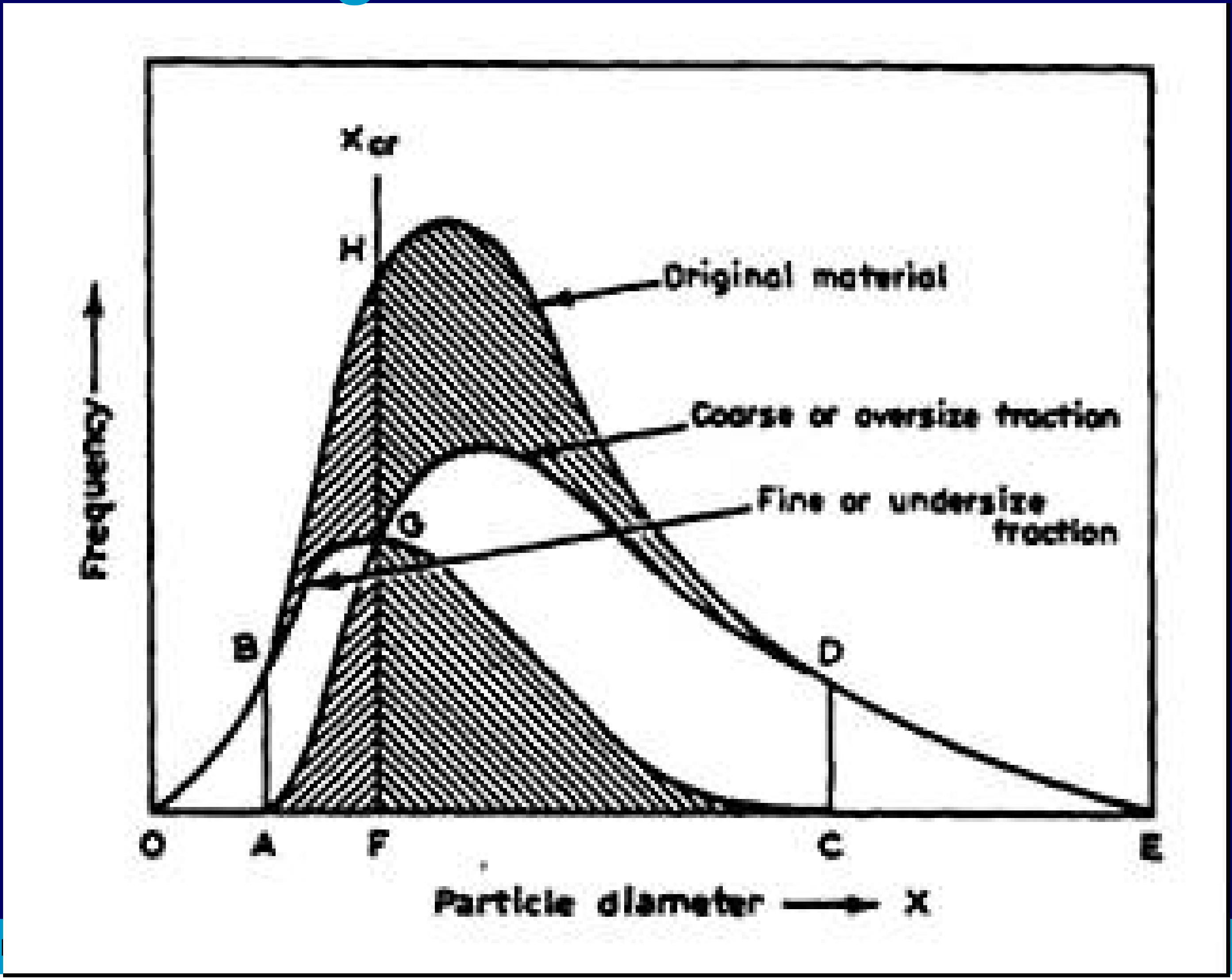
TU Delft

Mesh versus µm

Tyler mesh size is the number of openings per (linear) inch of mesh.
To calculate the size of the openings in a mesh the thickness of the wires making up the mesh material must be taken into account.

Sieve size (mm)	Tyler (approx)
4.75	4
2.00	9
1.00	16
0.422	35
0.251	60
0.152	100
0.125	115
0.104	150
0.066	250
0.044	325

Screening result



X_{cr} = critical particle size

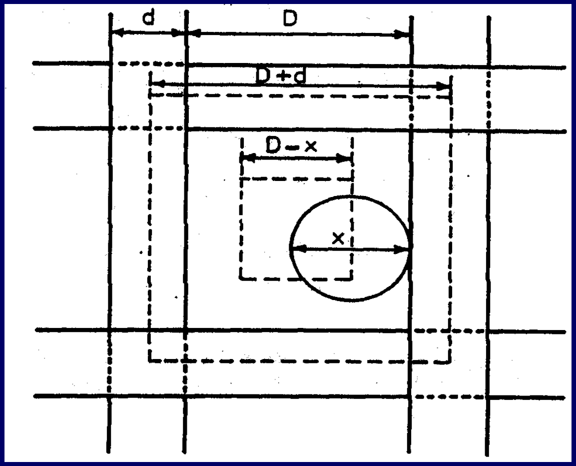
Passage probability

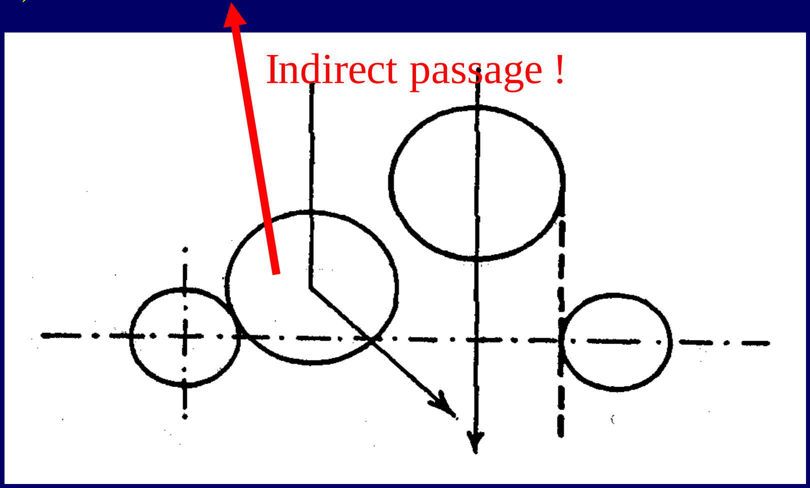
Passage probability:

Part. Size / Mesh width — Open / Total surface

$$P = \frac{(D-x)^2}{(D+d)^2} \rightarrow P = \frac{(D-x)^2}{D^2} \cdot \frac{D^2}{(D+d)^2}$$

$$P \geq \frac{(D-x)^2}{D^2}$$ when d<<D





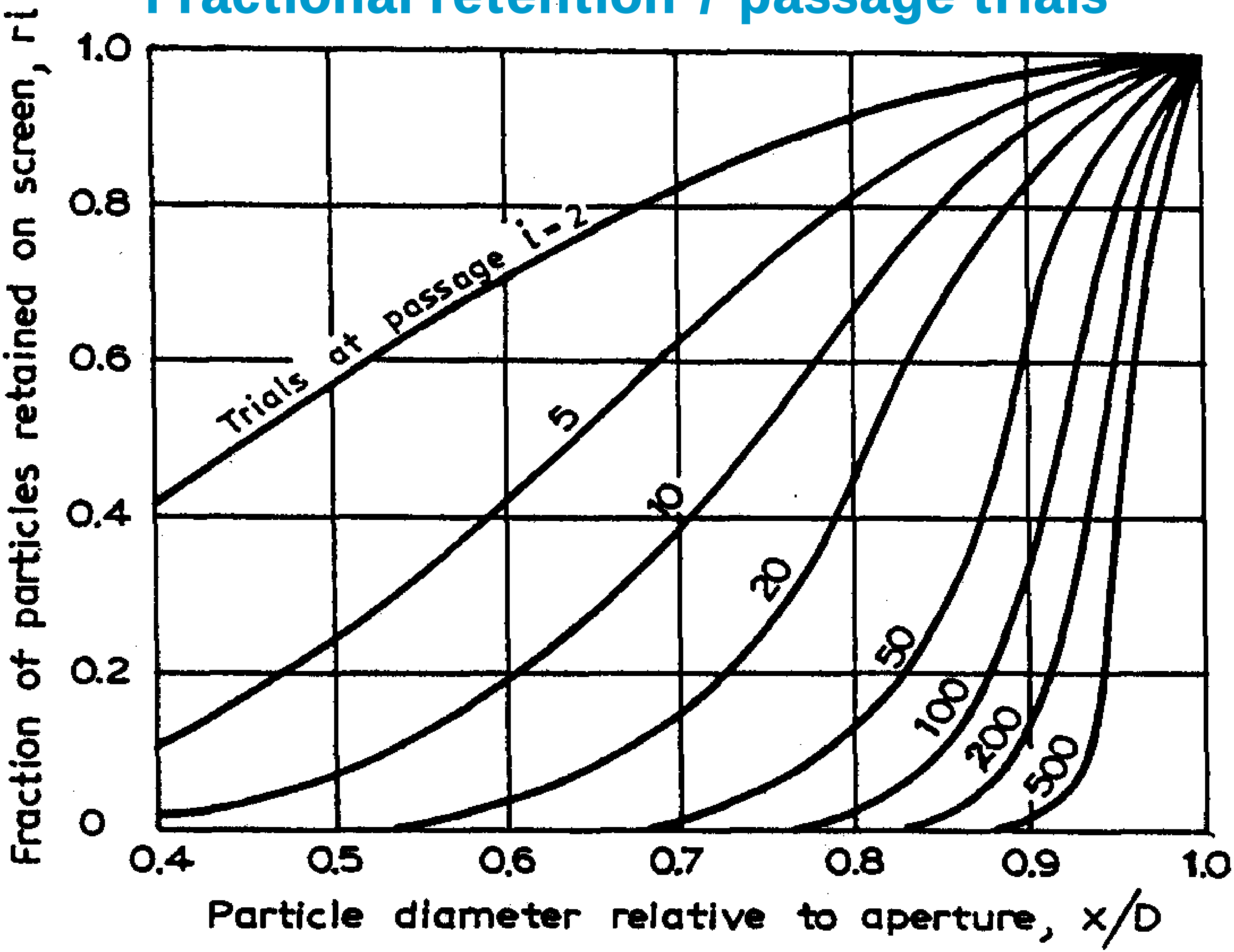
Probability that particle is still on the screen:

after 1 attempt $1 - P = \left[1-\left(\frac{D-x}{D}\right)^2\right]$

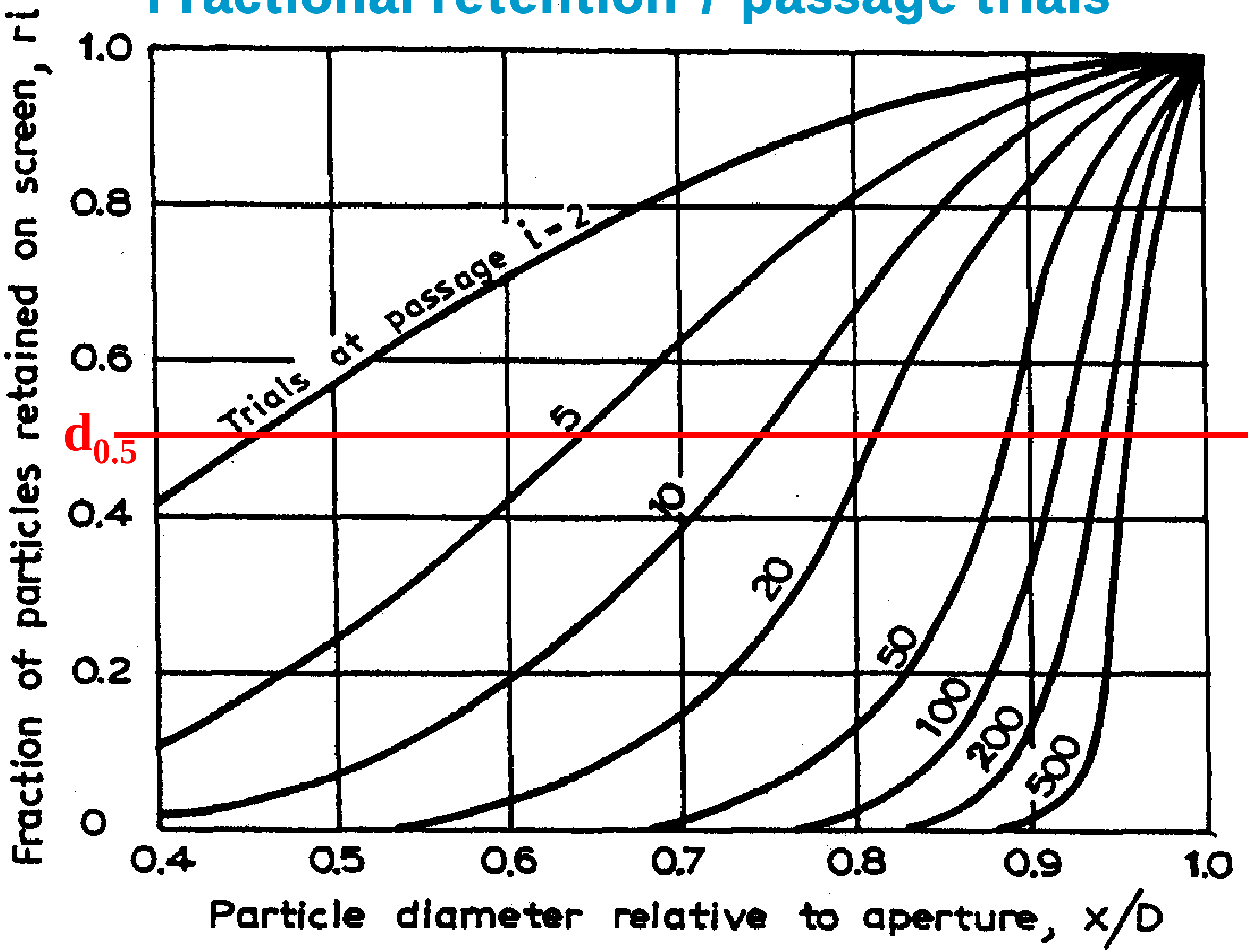
after i attempts $r_i = \left[1-\left(\frac{D-x}{D}\right)^2\right]^i$

TU Delft

Fractional retention / passage trials



Fractional retention / passage trials



Screen index / effective opening

$$r_i = \left[1 - \left(\frac{D-x}{D}\right)^2\right]^i \quad \rightarrow \text{Simplify} \rightarrow \quad \ln(r_i) = i \cdot \ln\left[1 - \left(\frac{D-x}{D}\right)^2\right]$$

TUDelft

Screen index / effective opening

$$r_i = \left[1 - \left(\frac{D-x}{D}\right)^2\right]^i$$ → Simplify → $$\ln(r_i) = i \cdot \ln\left[1 - \left(\frac{D\text{-}x}{D}\right)^2\right]$$

→ Taylor series → $$\ln(r_i) \approx i\left(\frac{D-x}{D}\right)^2$$

TU Delft

Screen index / effective opening

$$r_i = \left[1 - \left(\frac{D-x}{D}\right)^2\right]^i$$ → Simplify → $$\ln(r_i) = i \cdot \ln\left[1 - \left(\frac{D\text{-}x}{D}\right)^2\right]$$

→ Taylor series → $$\ln(r_i) \approx i\left(\frac{D-x}{D}\right)^2$$

→ Take $x=d_{0.5}$ and $r_i=0.5$ → $$\ln(0.5) = -i \cdot \left(1 - \frac{d_{0.5}}{D}\right)^2$$ → $$d_{0.5} = D - \left(\frac{0.832 \cdot D}{\sqrt{i}}\right)$$

Screen index / effective opening

$$r_i = \left[1-\left(\frac{D-x}{D}\right)^2\right]^i$$ → Simplify → $$\ln(r_i) = i \cdot \ln\left[1 - \left(\frac{D\text{-}x}{D}\right)^2\right]$$

→ Taylor series → $$\ln(r_i) \approx i\left(\frac{D-x}{D}\right)^2$$

→ Take x=$d_{0.5}$ and r_i=0.5 → $$\ln(0.5) = -i \cdot \left(1-\frac{d_{0.5}}{D}\right)^2$$ → $$d_{0.5} = D - \left(\frac{0.832 \cdot D}{\sqrt{i}}\right)$$

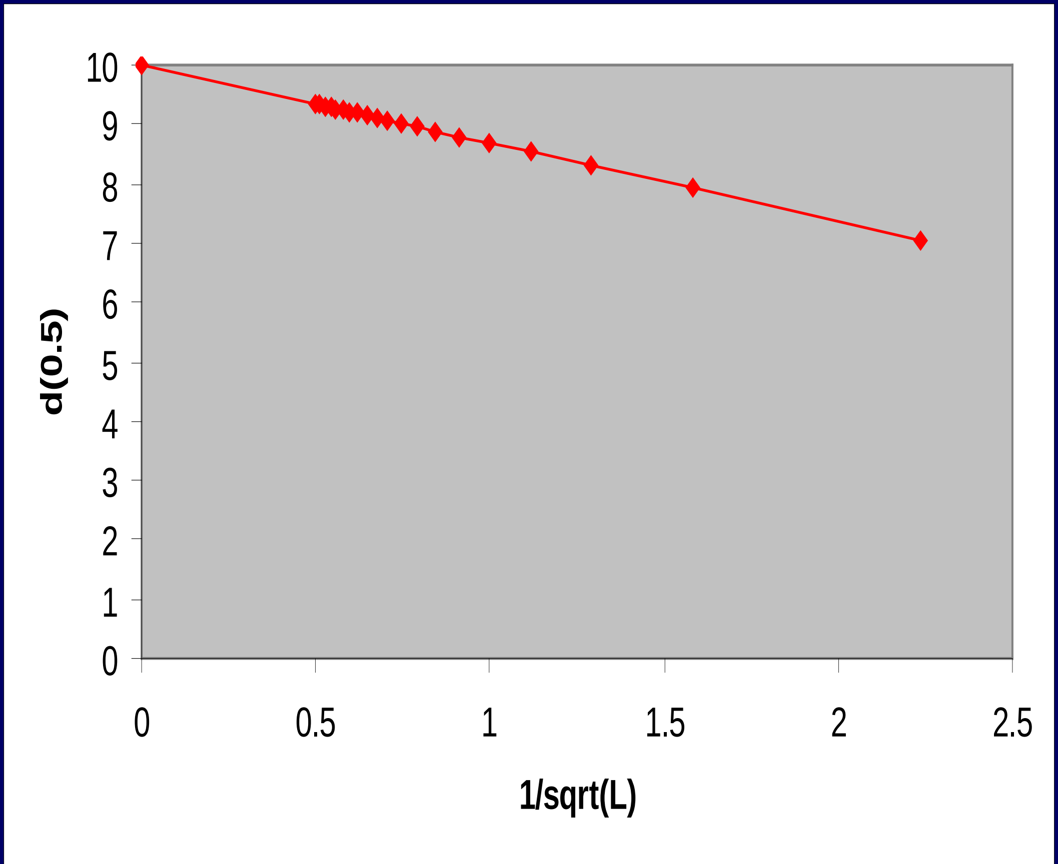
I = passage trials / m = screen index
L = screen length
D = effective screen opening

$$d_{0.5} = D - \frac{1}{\sqrt{L}} \cdot \left(\frac{0.832 \cdot D}{\sqrt{I}}\right)$$

TUDelft

$$d_{0.5} = D - \frac{1}{\sqrt{L}} \cdot \left(\frac{0.832 \cdot D}{\sqrt{I}} \right)$$

D = 10 mm
I = 40 passages/m

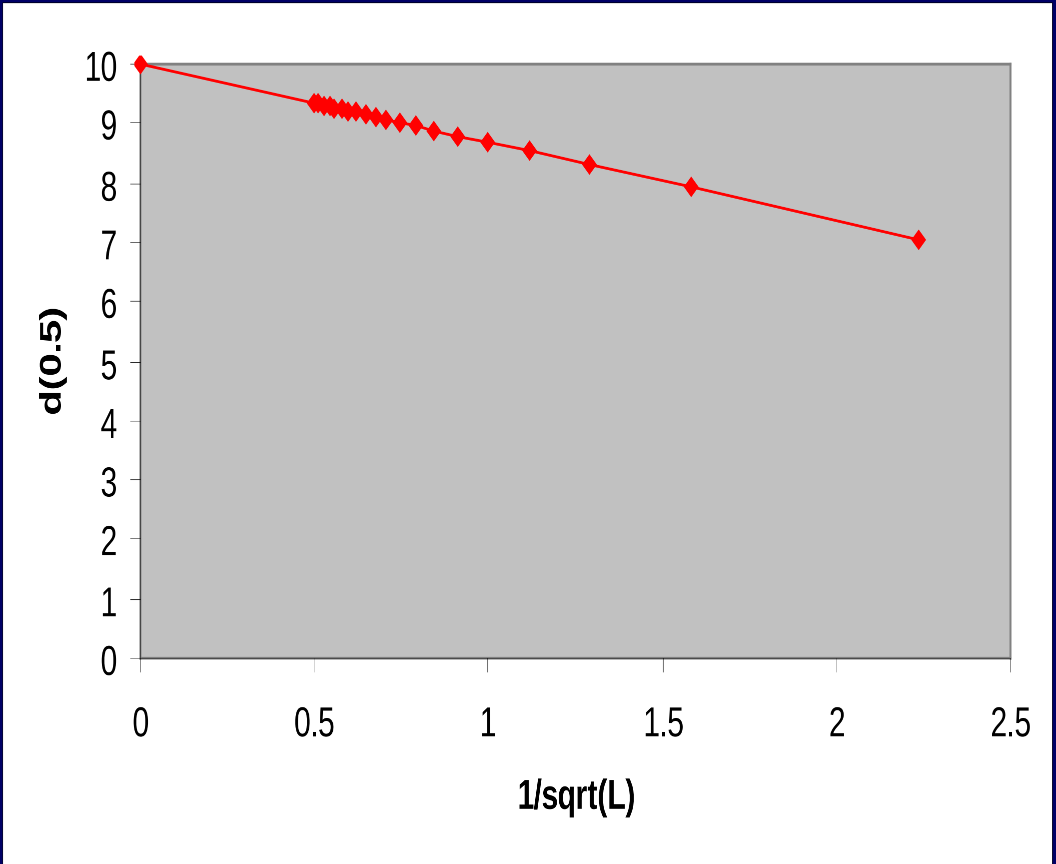


TUDelft

$$d_{0.5} = D - \frac{1}{\sqrt{L}} \cdot \left(\frac{0.832 \cdot D}{\sqrt{I}} \right)$$

D = 10 mm
I = 40 passages/m

i = I*L

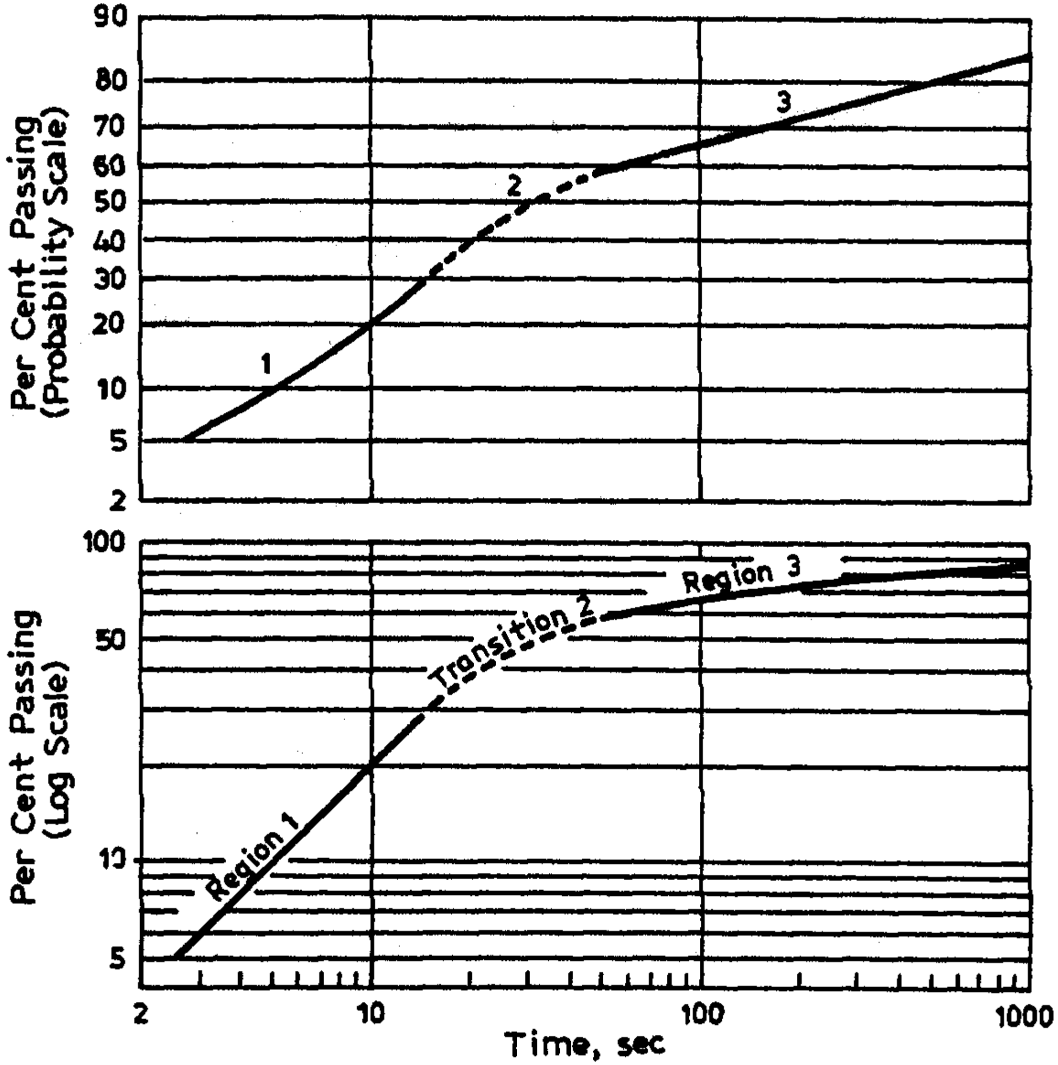


$$r_i = \left[1 - \left(\frac{D - x}{D} \right)^2 \right]^i$$

Predict size distribution under-, overflow

TU Delft

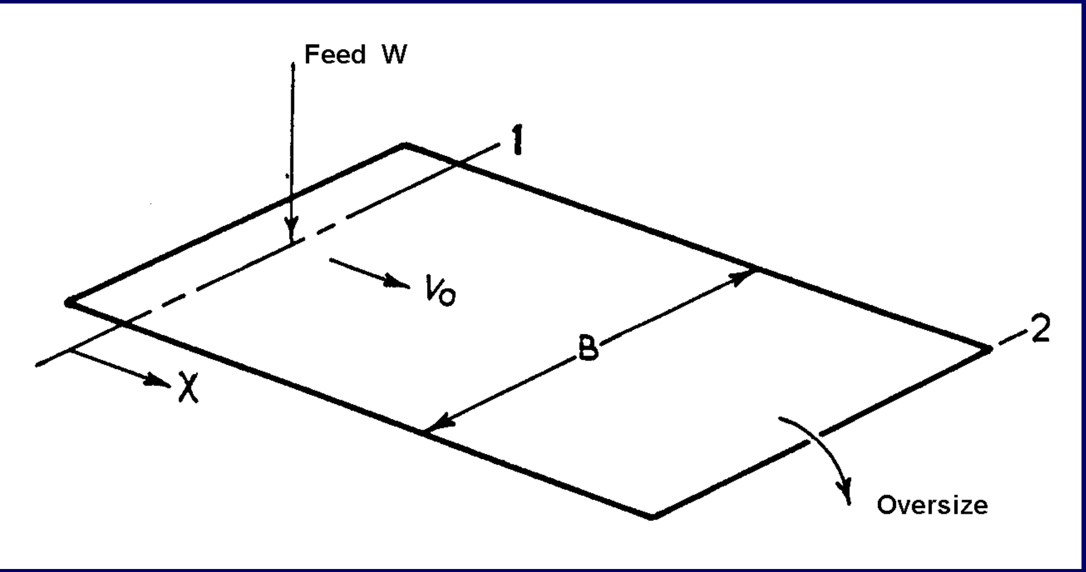
Screening kinetics



Experiments Whitby (1958)

1. Linear relationship between log(undersize) against time
2. Transition
3. Linear relationship between undersize on a log-probability scale against time (also equilibrium zone)

TUDelft



Region 1

$$\frac{dC(W,t)}{dt} = K \cdot \frac{W}{A}$$

Region 2,3

$$\frac{dC(W,t)}{dt} = f(t) \cdot \frac{W}{A}$$

Approximation of kinetics: $C(W,t) = 100 \cdot \left[1 - \exp\left(-kt\right)^n\right] \%$ (n, k = constant)

Taylor's series

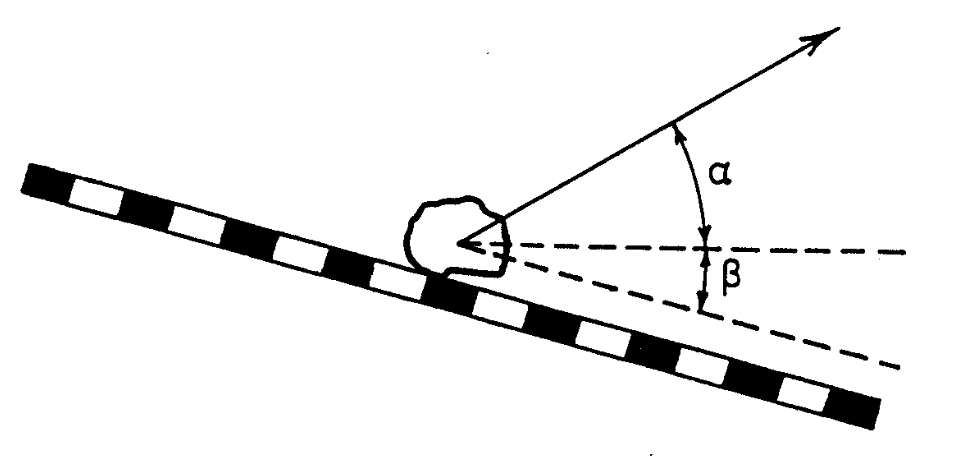
$$C(W,t) \approx 100\left(1 - \frac{1}{1+kt^n}\right) = 100 \cdot \frac{kt^n}{1+kt^n}$$

K, n: Constants

TU Delft

Screening parameters

a	Amplitude of the screen deck	[cm]
n	Frequency	[min^{-1}]
ω	Angular velocity	[s^{-1}]
α	Throw angle	[°]
β	Inclination of screen deck	[°]



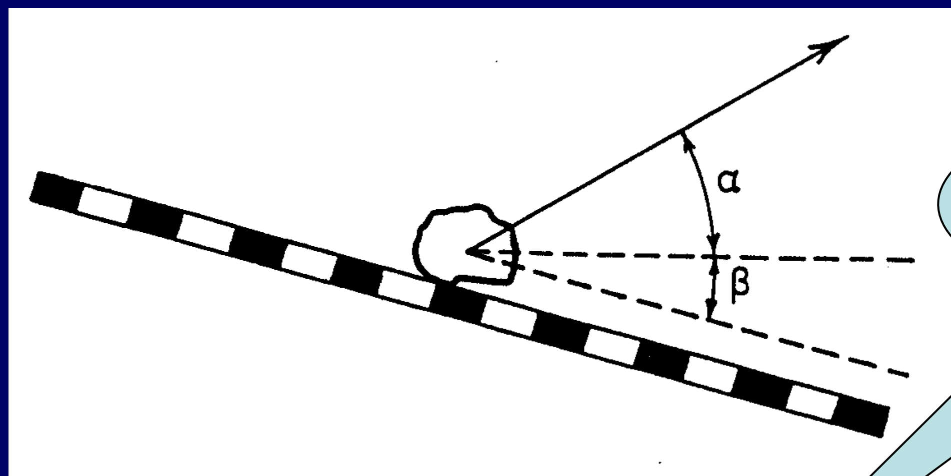
Throw angle α and inclination β.

Machine parameter $$K = \frac{a\omega^2}{g} \approx \frac{an^2}{90000}$$

TU Delft

Screening parameters

a	Amplitude of the screen deck	[cm]
n	Frequency	[min^{-1}]
ω	Angular velocity	[s^{-1}]
α	Throw angle	[°]
β	Inclination of screen deck	[°]



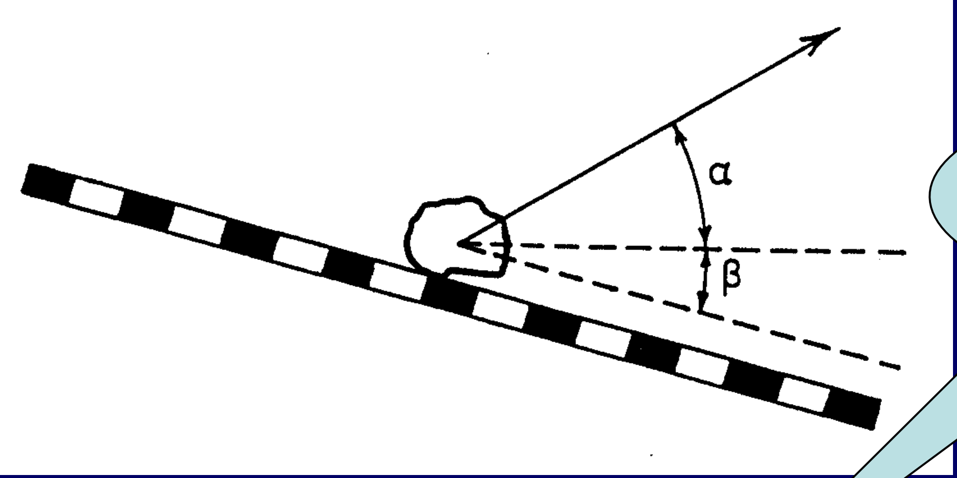
Throw angle α and inclination β.

Generated acceleration

Machine parameter $$K = \frac{a\omega^2}{g} \approx \frac{an^2}{90000}$$

Screening parameters

a	Amplitude of the screen deck	[cm]
n	Frequency	[min^{-1}]
ω	Angular velocity	[s^{-1}]
α	Throw angle	[°]
β	Inclination of screen deck	[°]



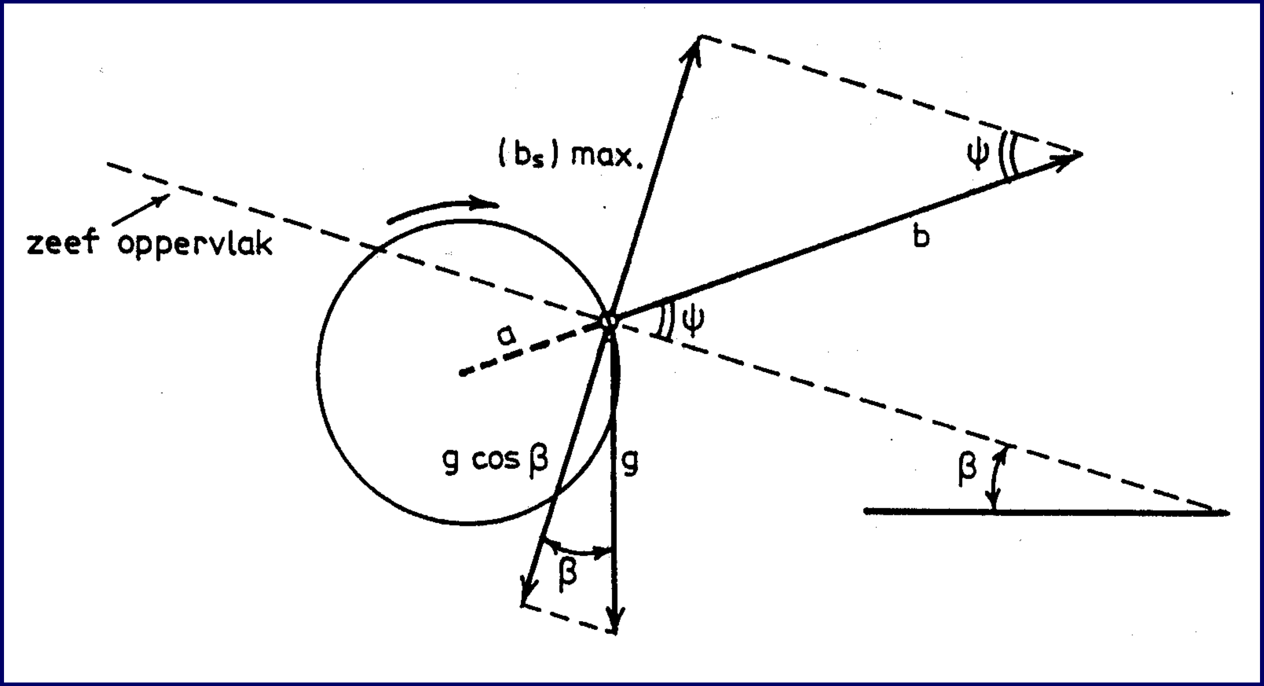
Throw angle α and inclination β.

Generated acceleration

Gravity acceleration

Machine parameter $$K = \frac{a\omega^2}{g} \approx \frac{an^2}{90000}$$

Screen parameter $K_v = \dfrac{(b_s)\max}{g \cdot \cos(\beta)}$

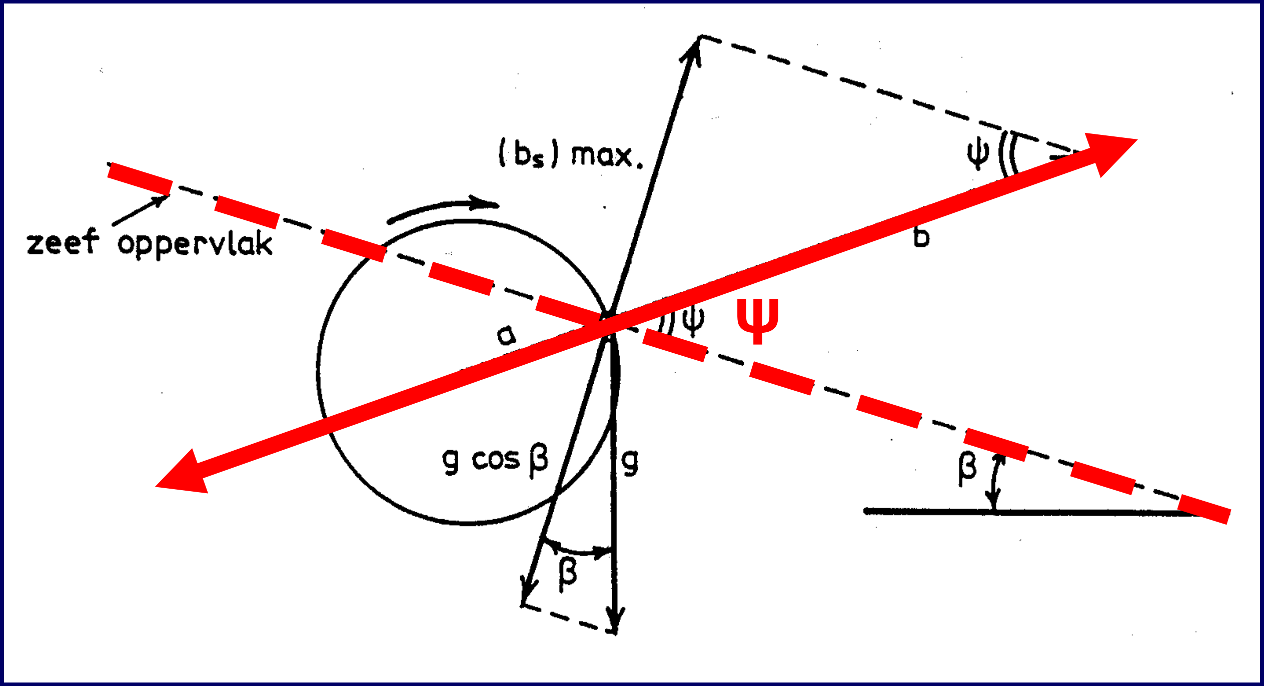


Particle jumps if:

$K_v > 1$

TU Delft

Screen parameter $K_v = \frac{(b_s)\max}{g \cdot \cos(\beta)}$



Particle jumps if:

$K_v > 1$

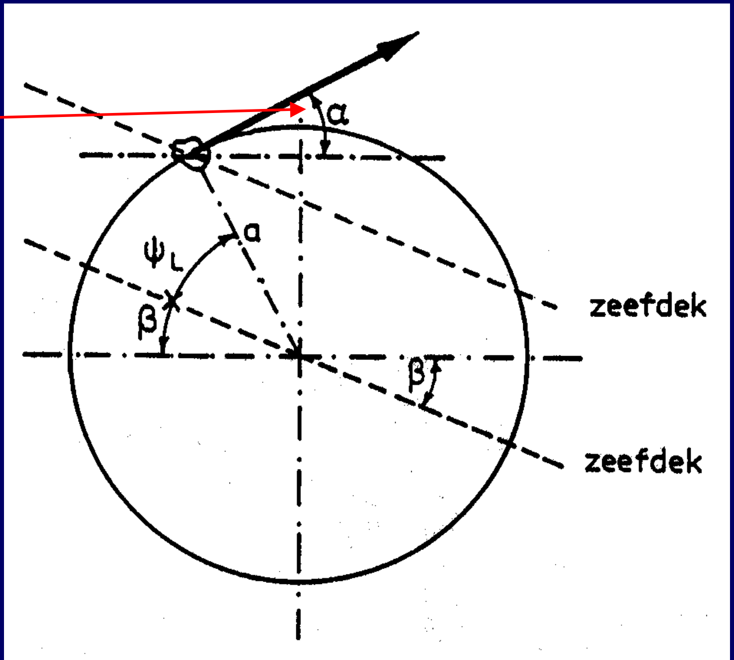
ψ = angle between centrifugal acceleration vector and screen surface

TUDelft

Particle thrown upward for $\Psi = \Psi_L$

$$\sin(\psi_L) = \frac{g \cdot \cos(\beta)}{a \cdot \omega^2} = \frac{\cos(\beta)}{K} = \frac{1}{K_v}$$

Throw angle
$\alpha = 90° - (\psi_L + \beta)$

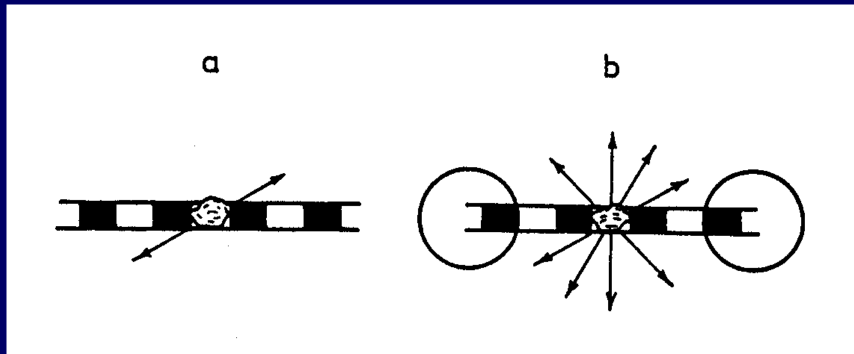


TU Delft

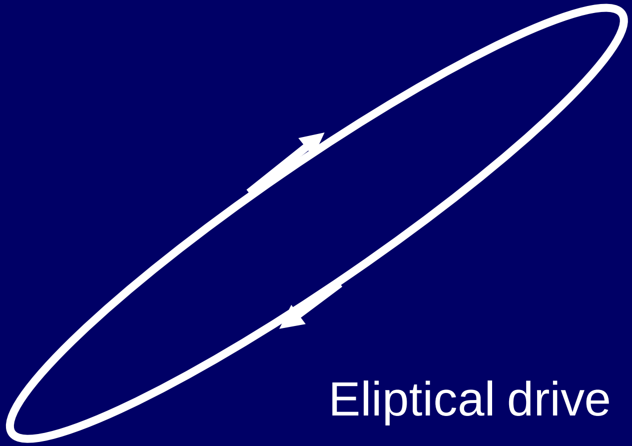
Optimised screening conditions

- Calculate α for different K and β
- Calculate particle trajectory
- Determine impact location
- Optimise
  - Amplitude a
  - Frequency n
  - Angle β

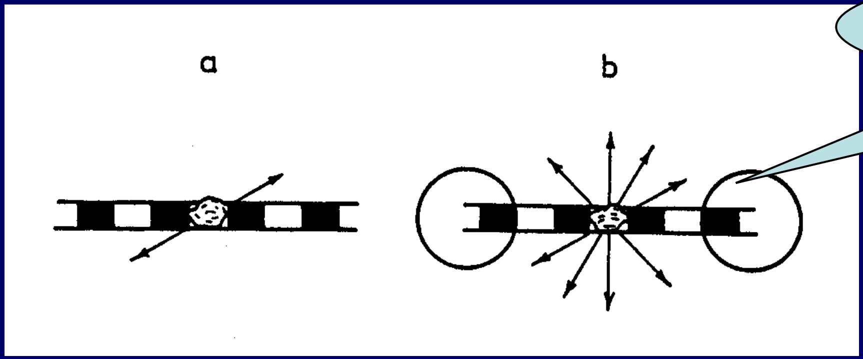
  for a given feed material



Linear, circular drive

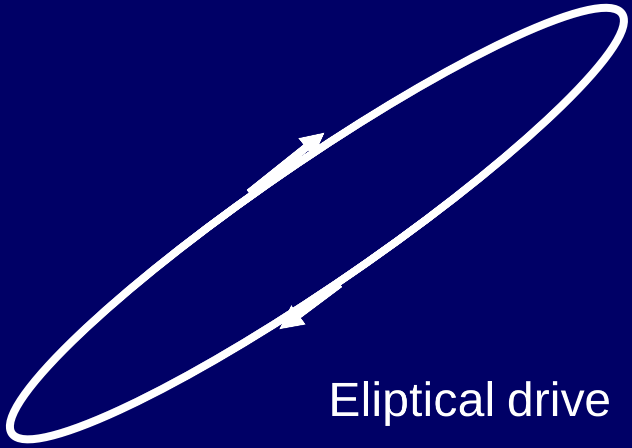


Eliptical drive



Inclination required !

Linear, circular drive



Eliptical drive

Optimised K_v

K_v<1.5 no screening

1.6<K_v<1.8 soft minerals, coal

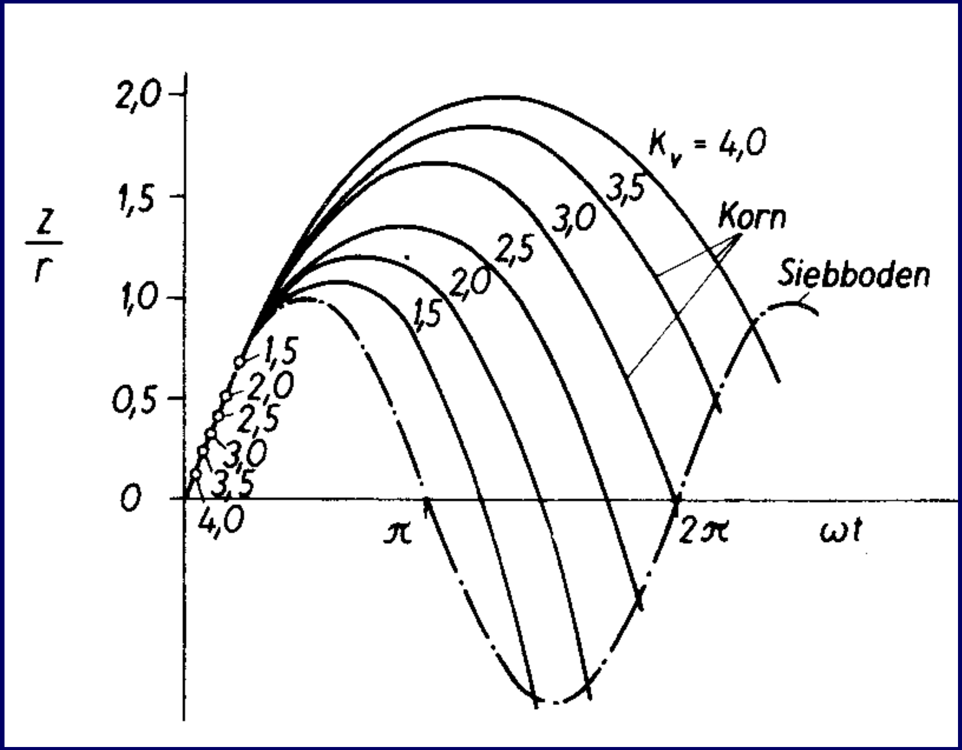
2.1<K_v<2.3 difficult materials, cokes

3<K_v<3.5 easy mat., high capacity

K_v≈3.3 resonance, optimum

$$K_v = \sqrt{1+(n\pi)^2}$$

K_v>>4 transport only



TU Delft

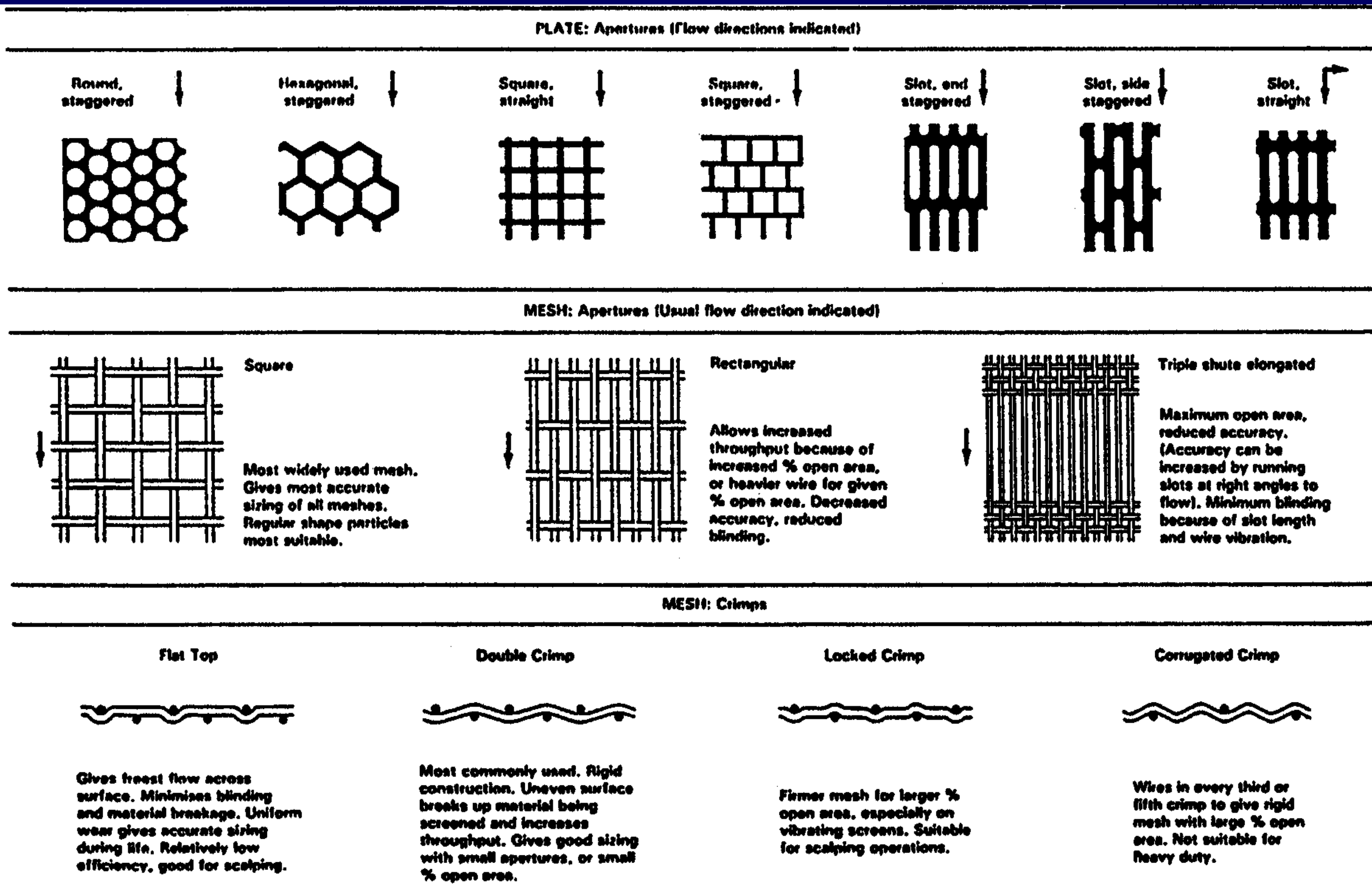
Feed size determines optimised a and n at a given K_v:

- For loosening coarse feed: larger a, lower n
- *For finer feeds it is reverse*.

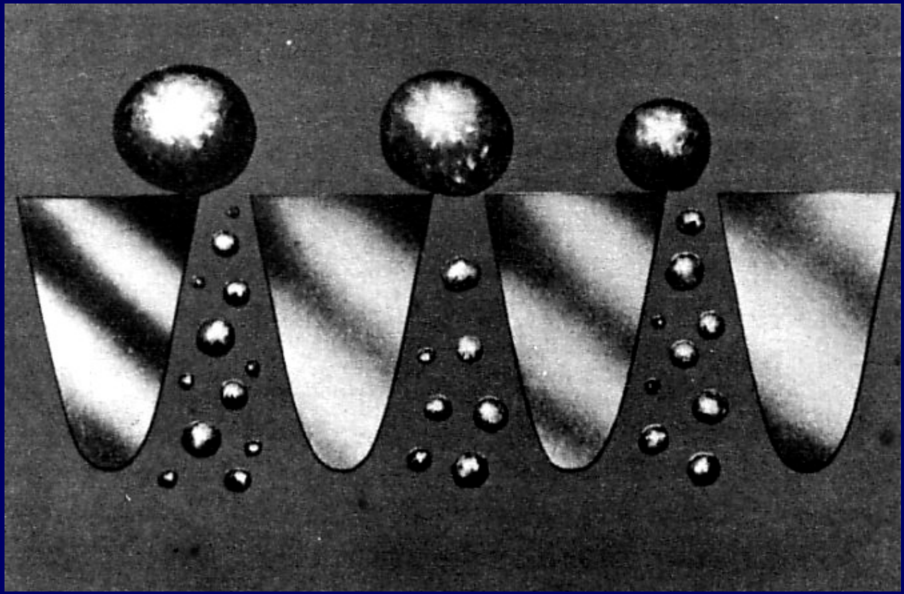
At constant K_v materials are thrown higher at larger a and lower n as reverse.

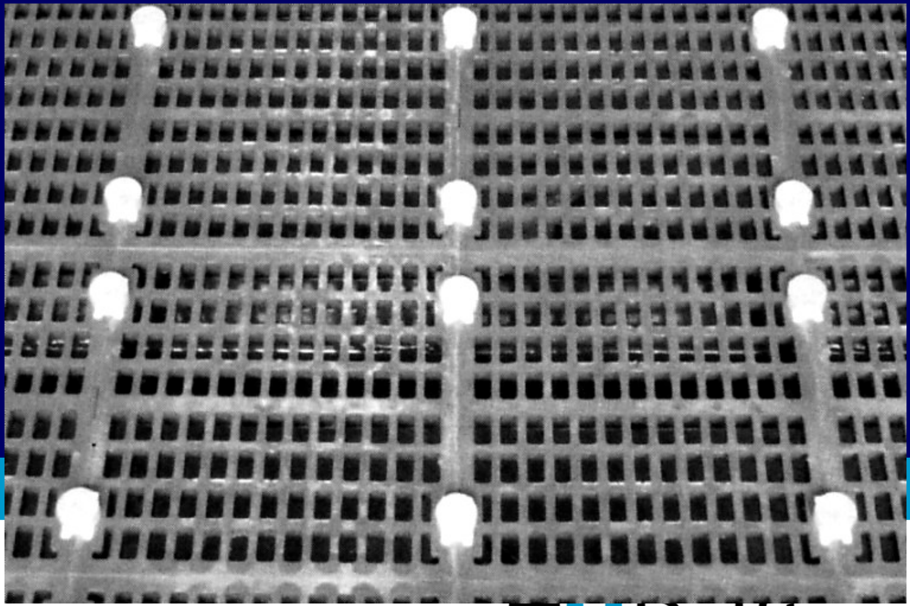
As a consequence for fines screening small a at higher n are used, and reverse for coarse feeds.

Screen decks



- Perforated plate
- Grizzly rod deck
- Bar deck
- Rod deck
- Wedge-wire deck
- Woven wire screen media
- PU screening media
- Rubber screening media





Screening efficiency

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton's screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f) \cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f) \cdot (1 - g_g)}{G_v \cdot (1 - g_v)} \right]$$

TU Delft

Coarse in oversize

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton's screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f)\cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f)\cdot(1-g_g)}{G_v \cdot (1-g_v)} \right]$$

Coarse in feed

TU Delft

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton's screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f)\cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f)\cdot(1-g_g)}{G_v \cdot (1-g_v)} \right] \rightarrow$$

Coarse in oversize

Fine in oversize

Coarse in feed

Fine in feed

TU Delft

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton's screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f) \cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f) \cdot (1 - g_g)}{G_v \cdot (1 - g_v)} \right]$$

Mass balance: $G_v \cdot g_v = (G_v - G_f) \cdot g_g + G_f \cdot g_f$

$\rightarrow$

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton’s screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f)\cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f)\cdot(1-g_g)}{G_v \cdot (1-g_v)} \right]$$

Mass balance: $G_v \cdot g_v = (G_v - G_f)\cdot g_g + G_f \cdot g_f$

$$\rightarrow E_n = 100 \cdot \left[\frac{(g_g - g_v)\cdot(g_v - g_f)}{g_v \cdot (1-g_v)\cdot(g_g - g_f)} \right]$$

TU Delft

	Fractions		
	Mass	*% coarse*	*% fine*
feed	G_v	g_v	f_v
oversize	G_g	g_g	f_g
undersize	G_f	g_f	f_f

Newton's screening efficiency:

$$E_n = 100 \cdot \left[\frac{(G_v - G_f) \cdot g_g}{G_v \cdot g_v} - \frac{(G_v - G_f) \cdot (1 - g_g)}{G_v \cdot (1 - g_v)} \right]$$

Mass balance: $G_v \cdot g_v = (G_v - G_f) \cdot g_g + G_f \cdot g_f$

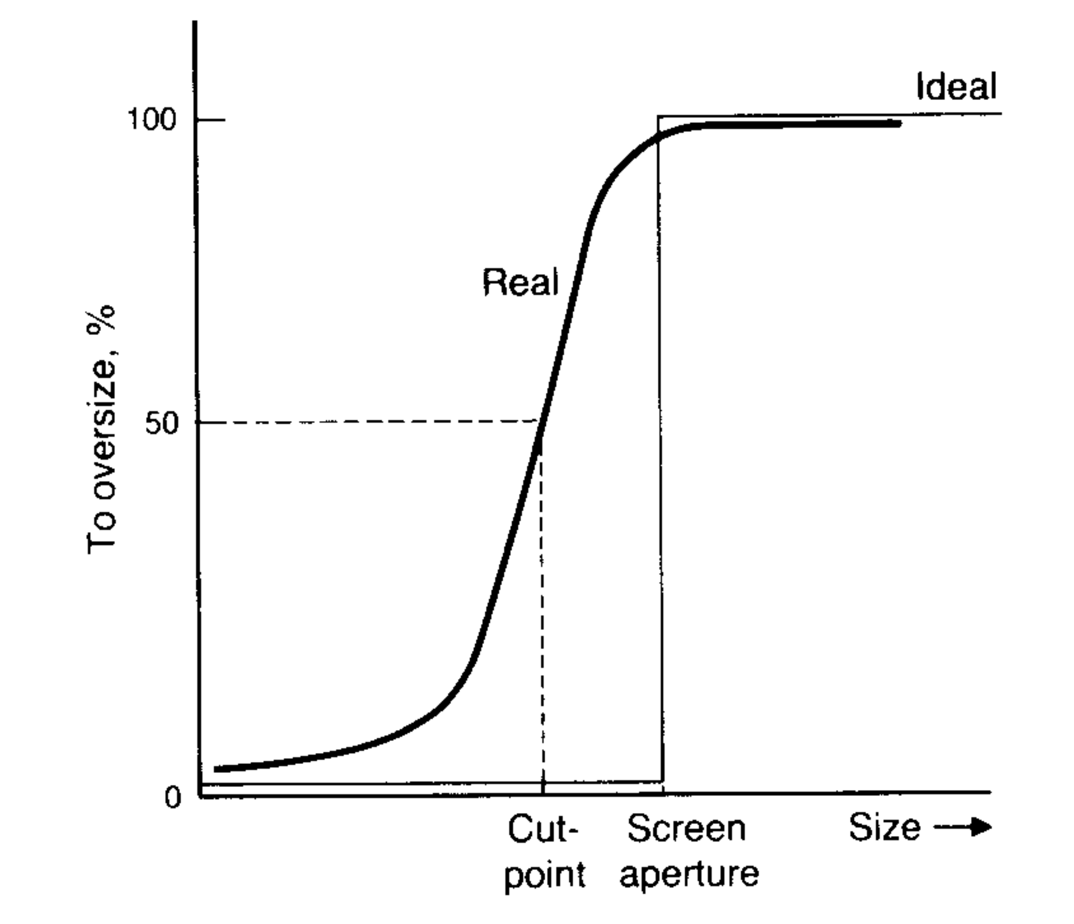
$$\rightarrow E_n = 100 \cdot \left[\frac{(g_g - g_v) \cdot (g_v - g_f)}{g_v \cdot (1 - g_v) \cdot (g_g - g_f)} \right]$$

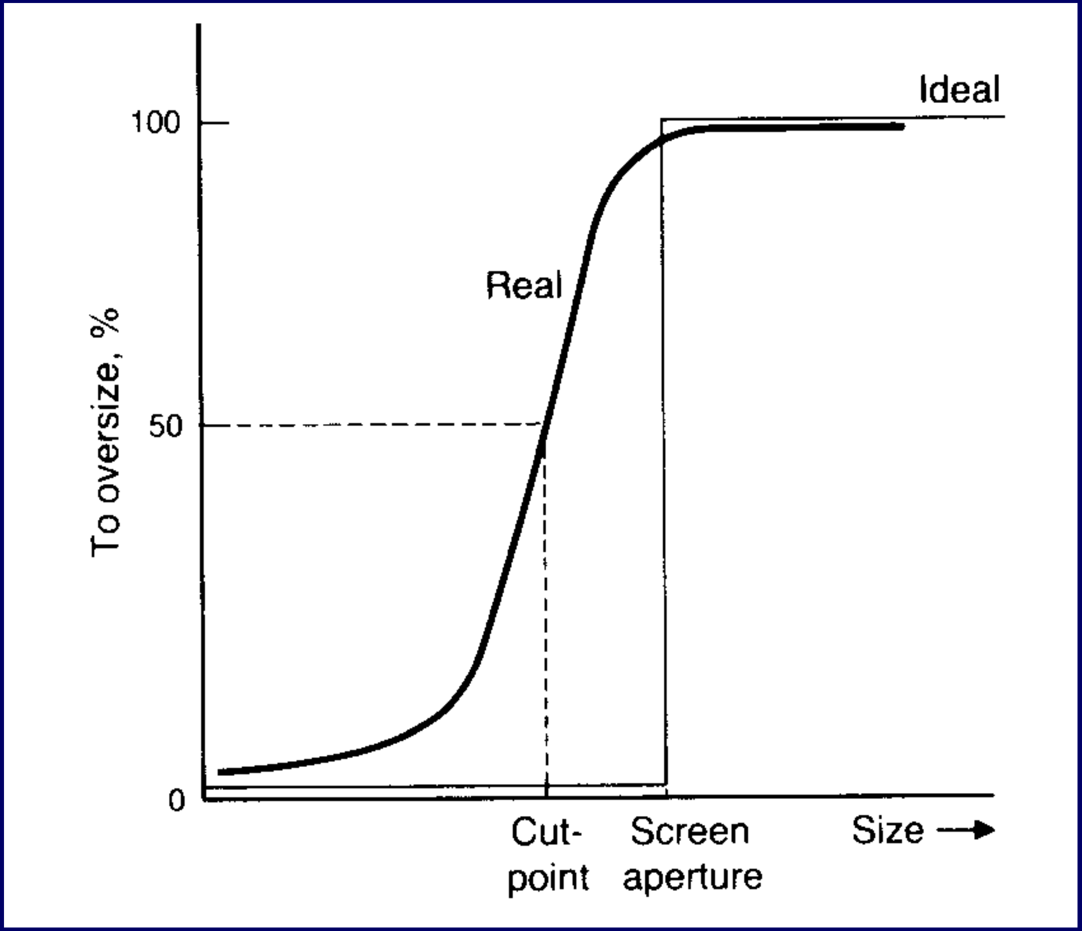
65% < E_n < 75% compromise capacity / efficiency

E_n = 90% dry lab. test

TU Delft

Partition curve





Ecart probable

$$E_p = \frac{x_{75} - x_{25}}{2}$$

Imperfection

$$I = \frac{E_p}{x_{50}} = \frac{x_{75} - x_{25}}{2x_{50}}$$

Particle spread

$$H = \frac{x_{75}}{x_{25}}$$

Separation sharpness

$$T = \tan(\alpha_{x50})$$

Screening capacity

- Capacity ≈ proportional to mesh size
- Wet screening < 0.2 mm rarely economic
- Dry screening < 2 mm rarely applied

Screening capacity

- Capacity ≈ proportional to mesh size
- Wet screening < 0.2 mm rarely economic
- Dry screening < 2 mm rarely applied

Vibratory screen:

Solid density in g/cm³

$$C = 1.4 \cdot \frac{\rho}{\gamma} \cdot D^{0.6}$$ t/hr.m²

"Difficult" fraction 0.5D < x < 1.5D

- Square mesh openings of a deck with at least 50% open surface.
- γ < 15% (otherwise transport becomes a delimiting factor)
- 0.5 mm < (mesh size) < 250 mm

TU Delft

Screening capacity

- Capacity ≈ proportional to mesh size
- Wet screening < 0.2 mm rarely economic
- Dry screening < 2 mm rarely applied

Vibratory screen:

Solid density in g/cm³

$$C = 1.4 \cdot \frac{\rho}{\gamma} \cdot D^{0.6} \quad \text{t/hr.m}^2$$

"Difficult" fraction $0.5D < x < 1.5D$

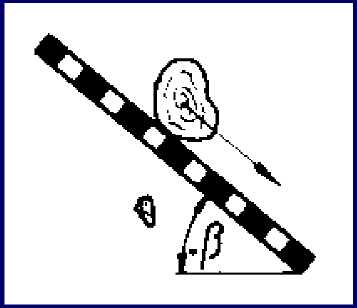
- Square mesh openings of a deck with at least 50% open surface.
- γ < 15% (otherwise transport becomes a delimiting factor)
- 0.5 mm < (mesh size) < 250 mm

Moisture has a major effect on capacity:

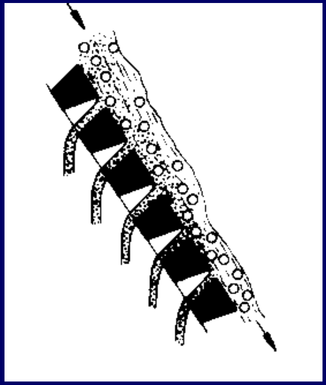
- levels between 8% and 10% reduce capacity down to 0.8C
- efficient spraying may increase it up to 1.25C

TUDelft

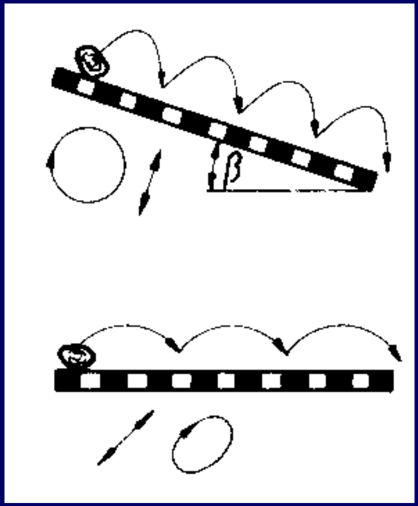
Screening equipment



Static dry

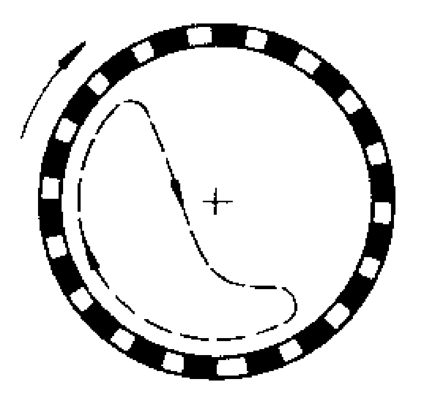


Static wet

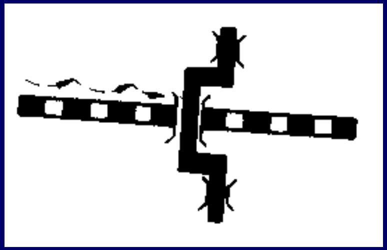


Vibrating

Roller

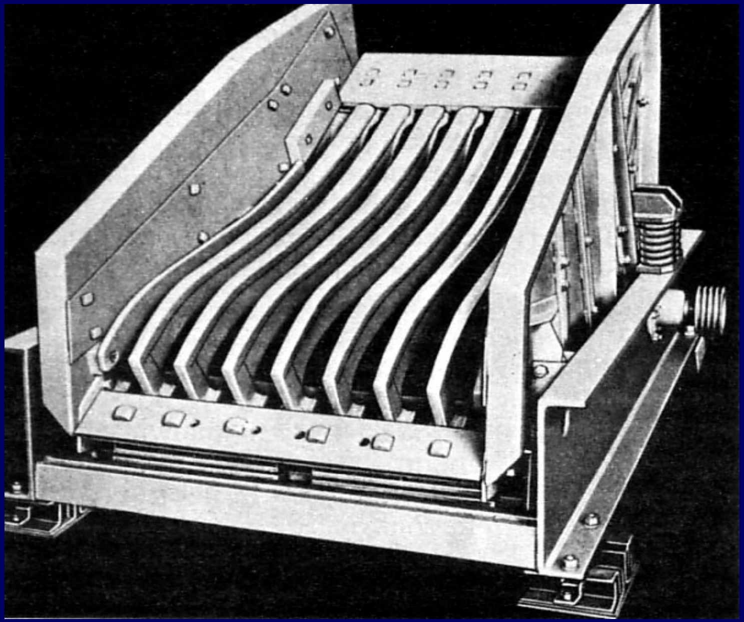


Trommel



Circular inclined

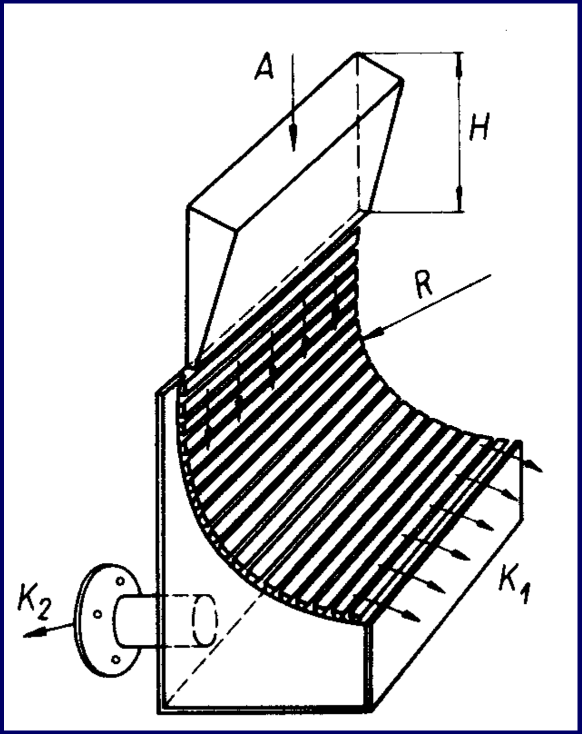
Grizzly / drain panel

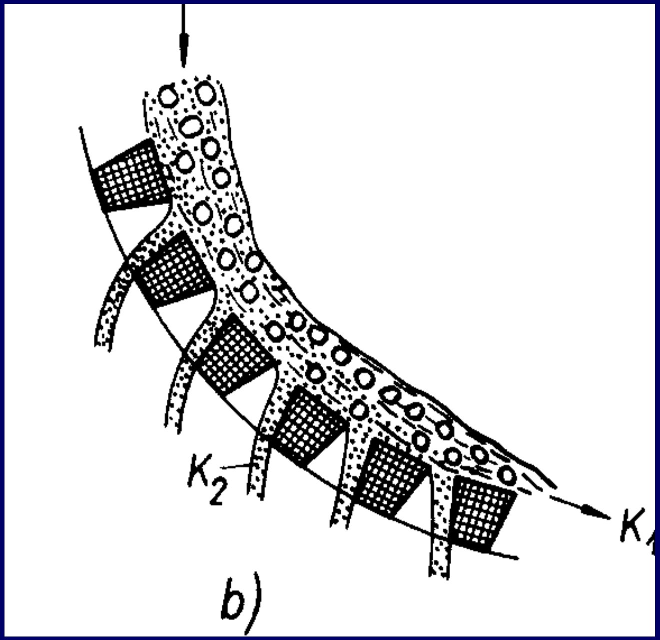


(Ankerpoort N.V.)


(Steenberg Laura)

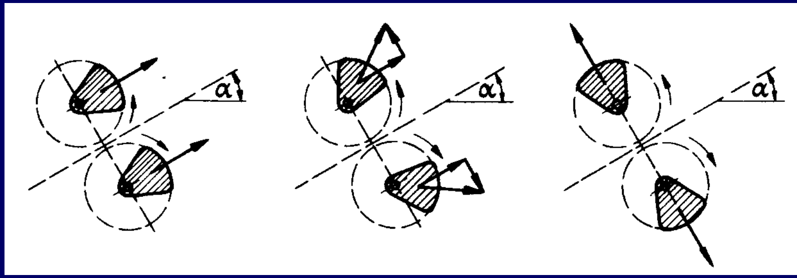
Sieve bend

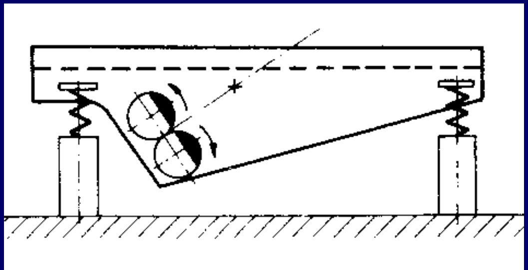




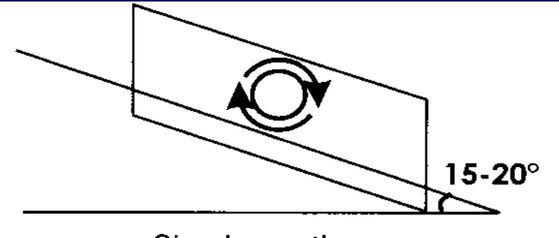
- For dewatering fines
- “centrifugal effect” sweeping off water
- Cut size 0.5 … 1 mm = 0.5 * slot size
- Invented by Staatsmijnen (DSM) in the 1950’s for fine coal

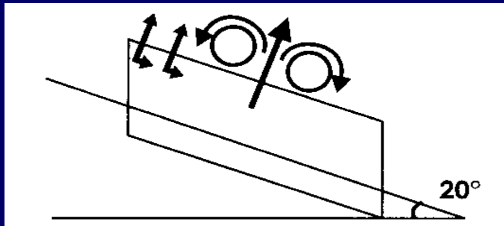
Vibrating screens

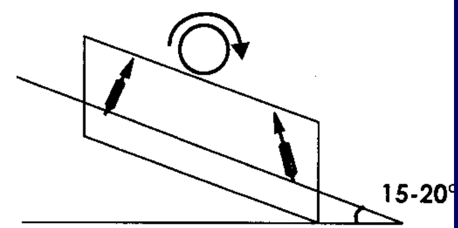




- (Double) unbalance drives (common)
- Electromagnetic drives (0.1 ... 4 mm only)
- Excenter drives (only older installations)







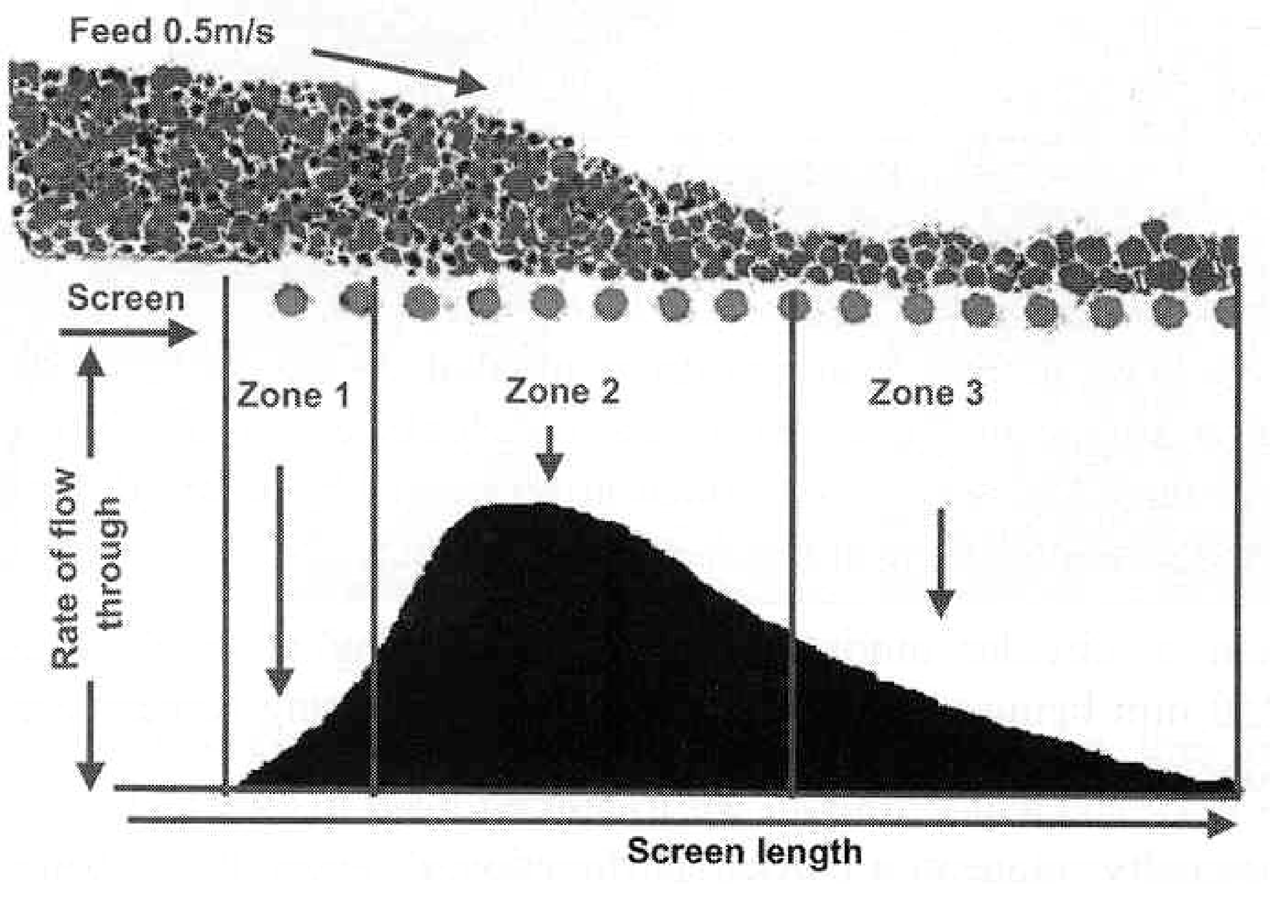
(linear)

TU Delft

Vibrating screens

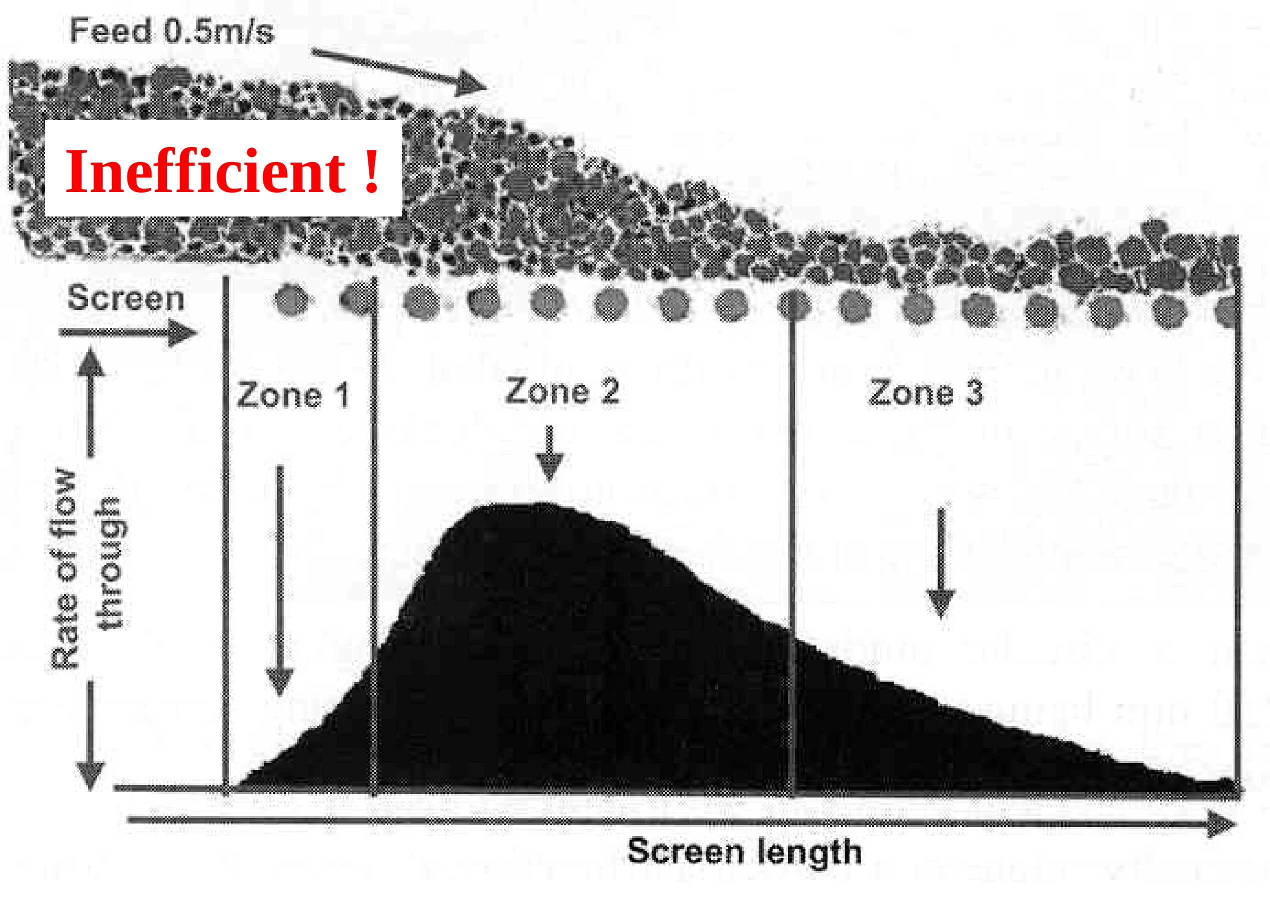
- Linear horizontal
- Linear inclined
- Banana
- Circular inclined
- Elliptical inclined
- Resonance
- Modular, Omni screen
- Multi-deck screen

Horizontal screen



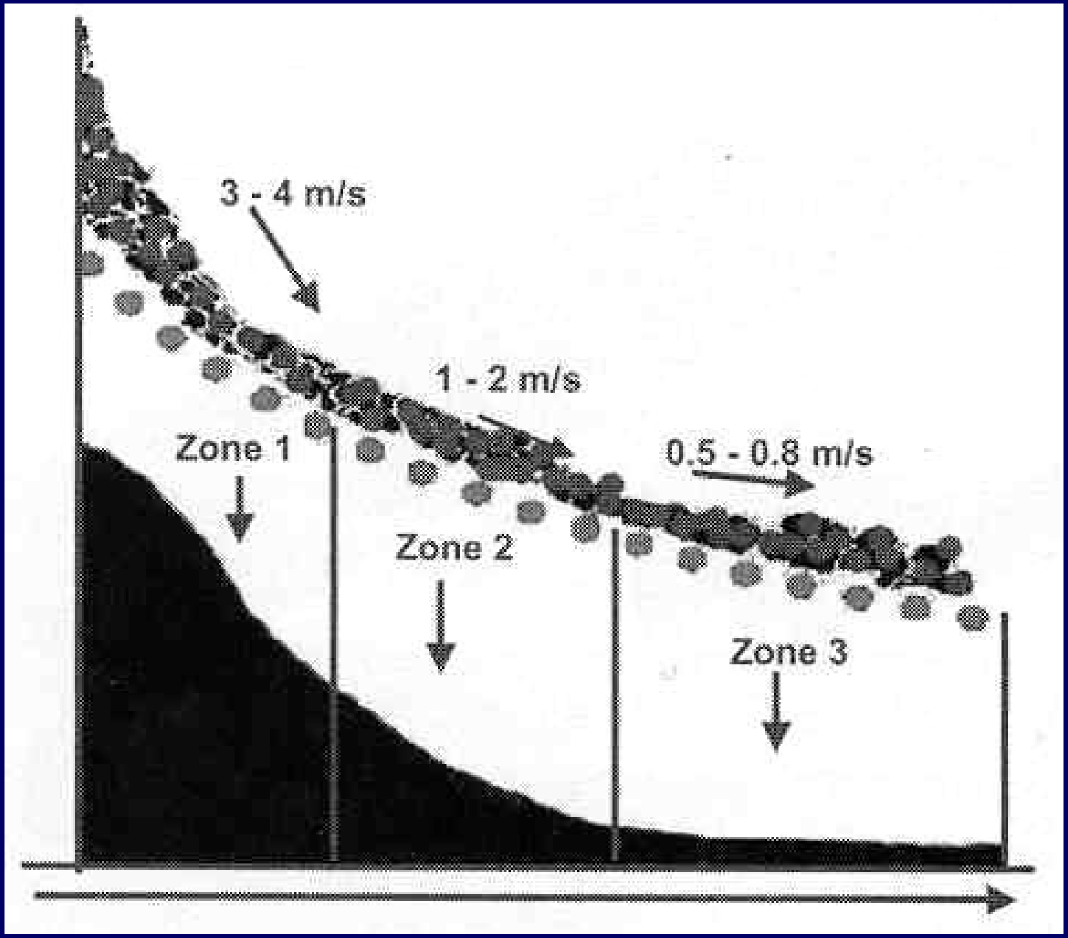
(Limcoal, Genk)

Horizontal screen

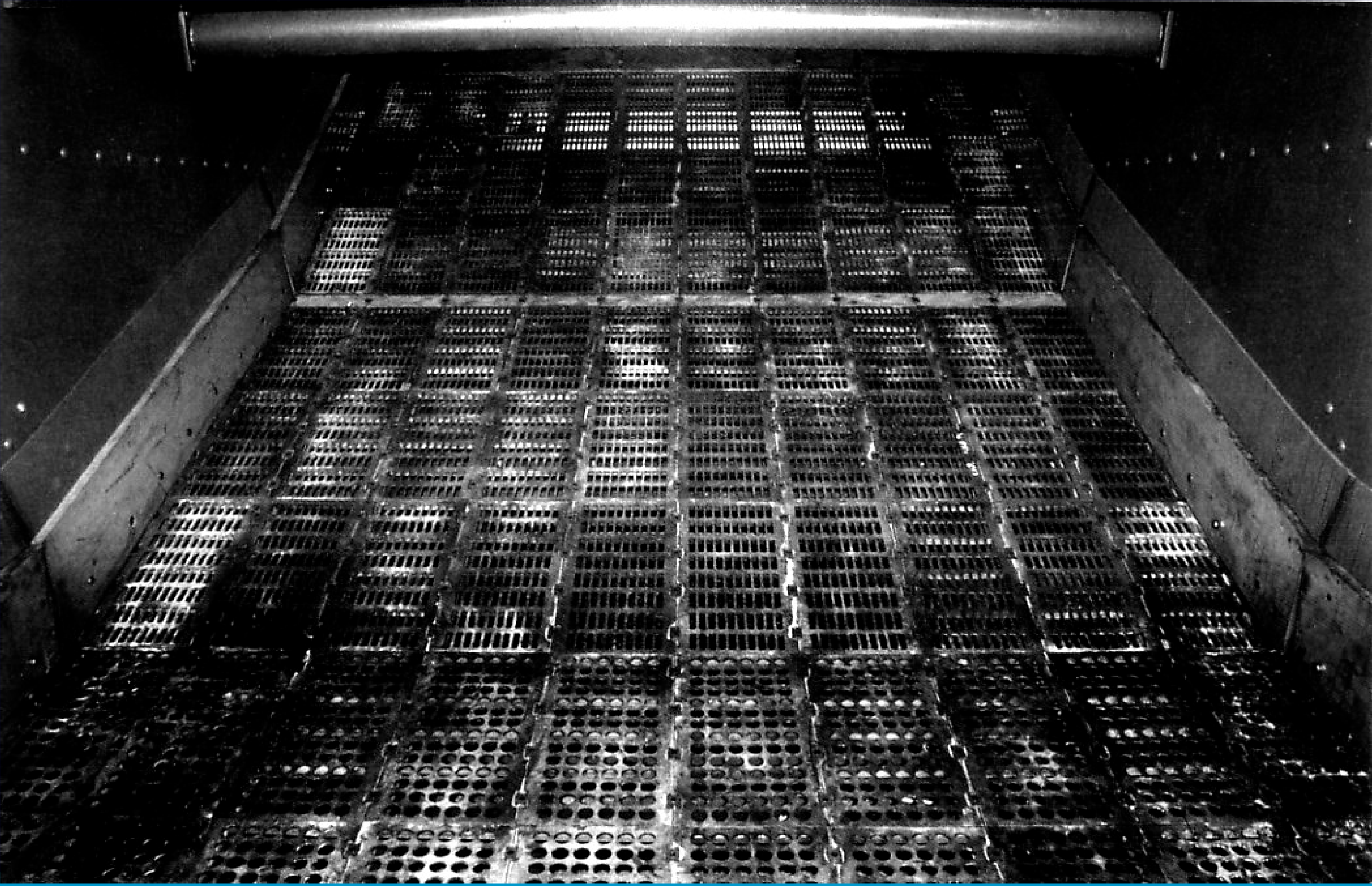


TUDelft

Multi-slope / Banana screen

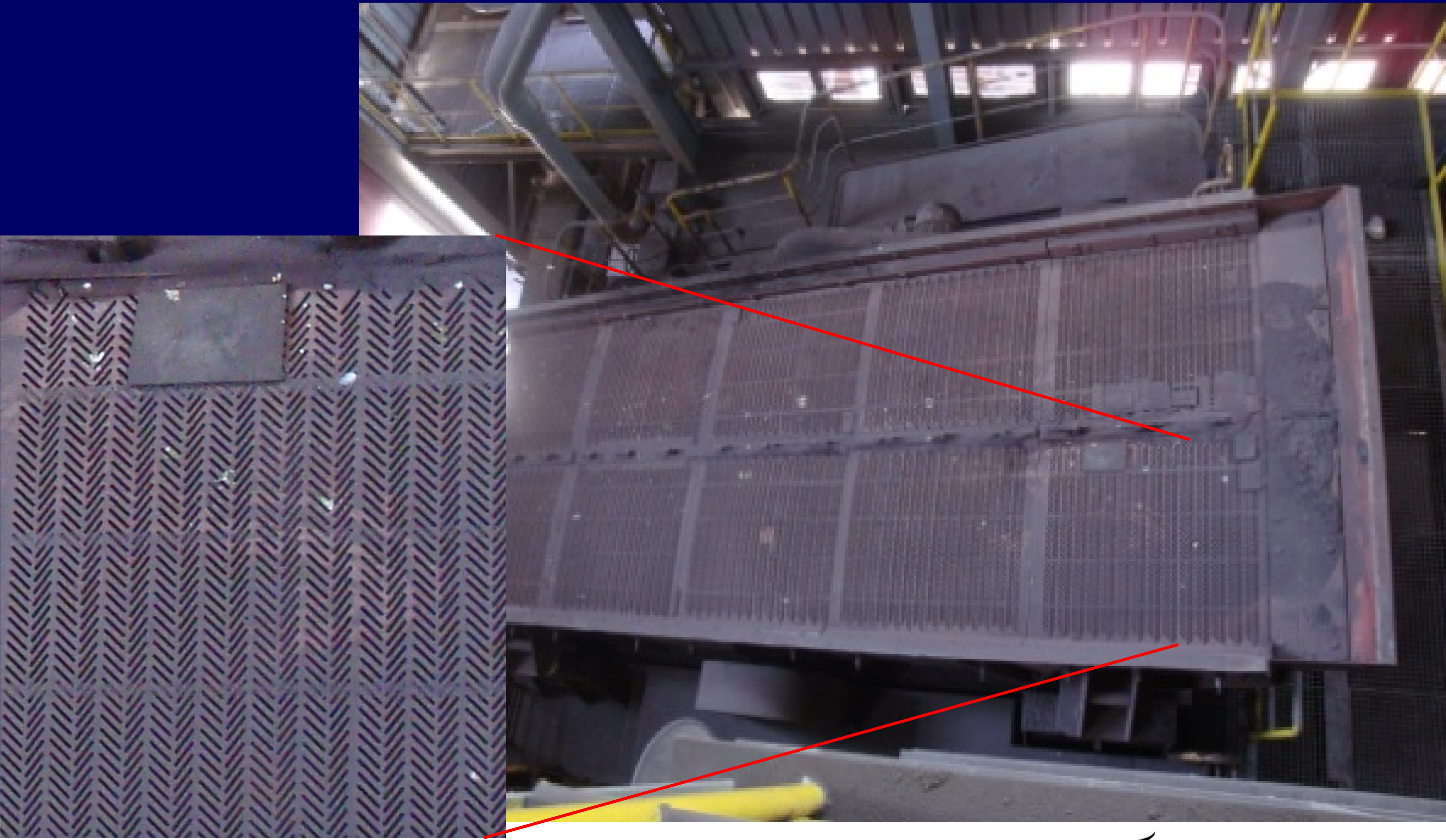


- Better feed distribution
- For high fines content



Vibrating inclined

Vibrating inclined: deck

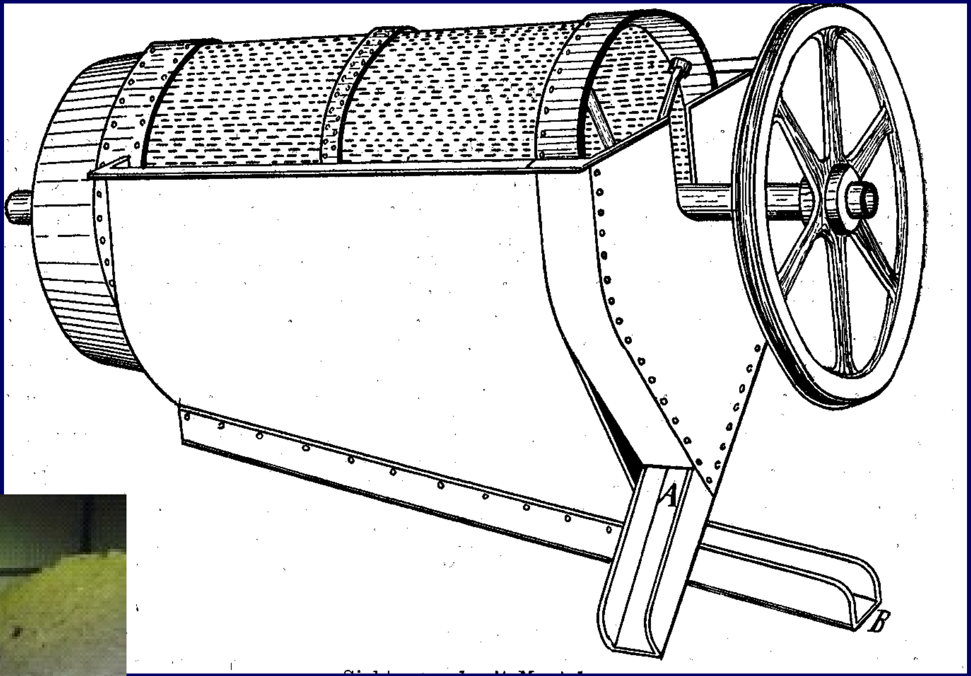


TU Delft

Allgaier screen

- Circular screen deck, central feed
- Compact design
- Extraction of more than 2 size fractions

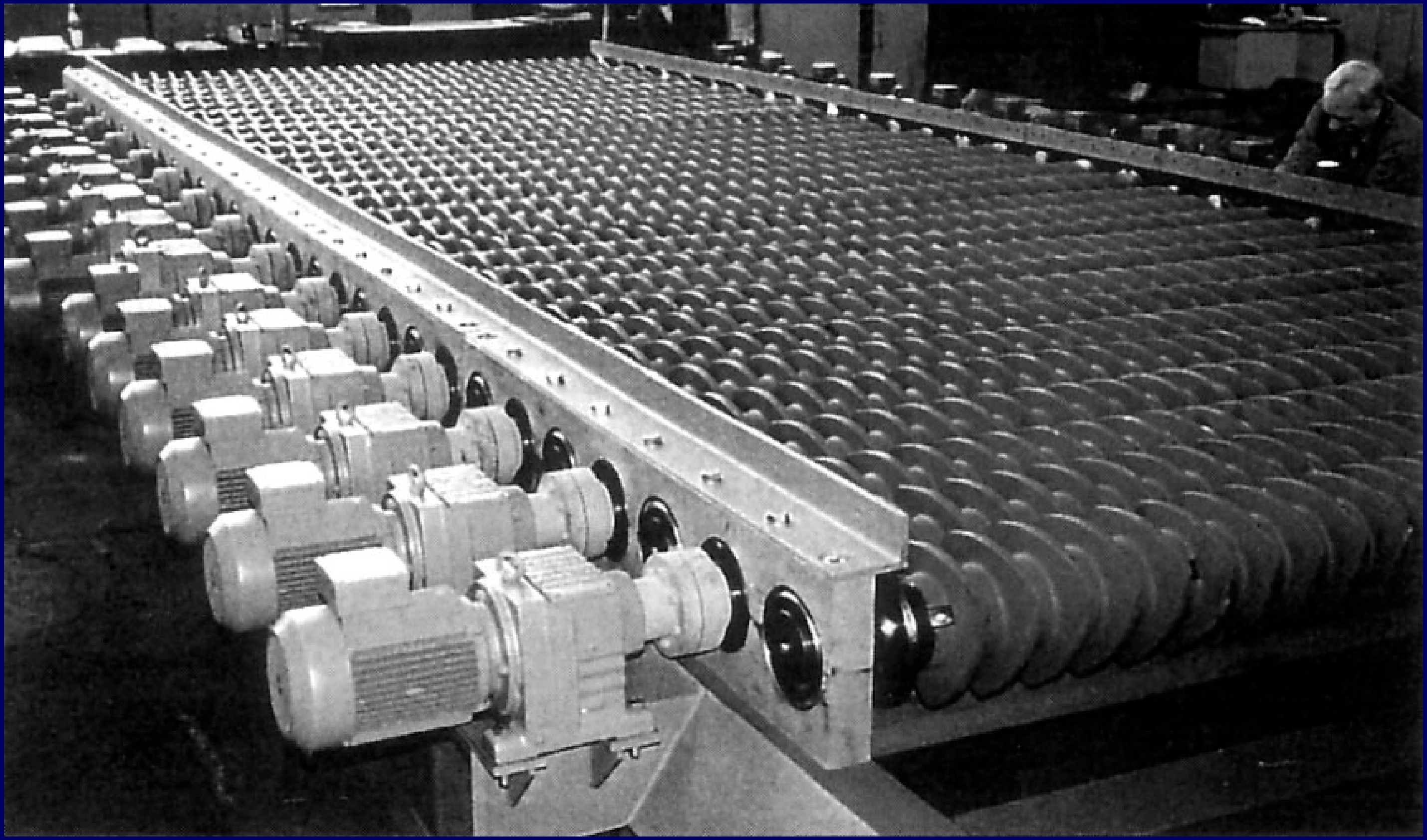
Non-vibrating screens



Trommel screen

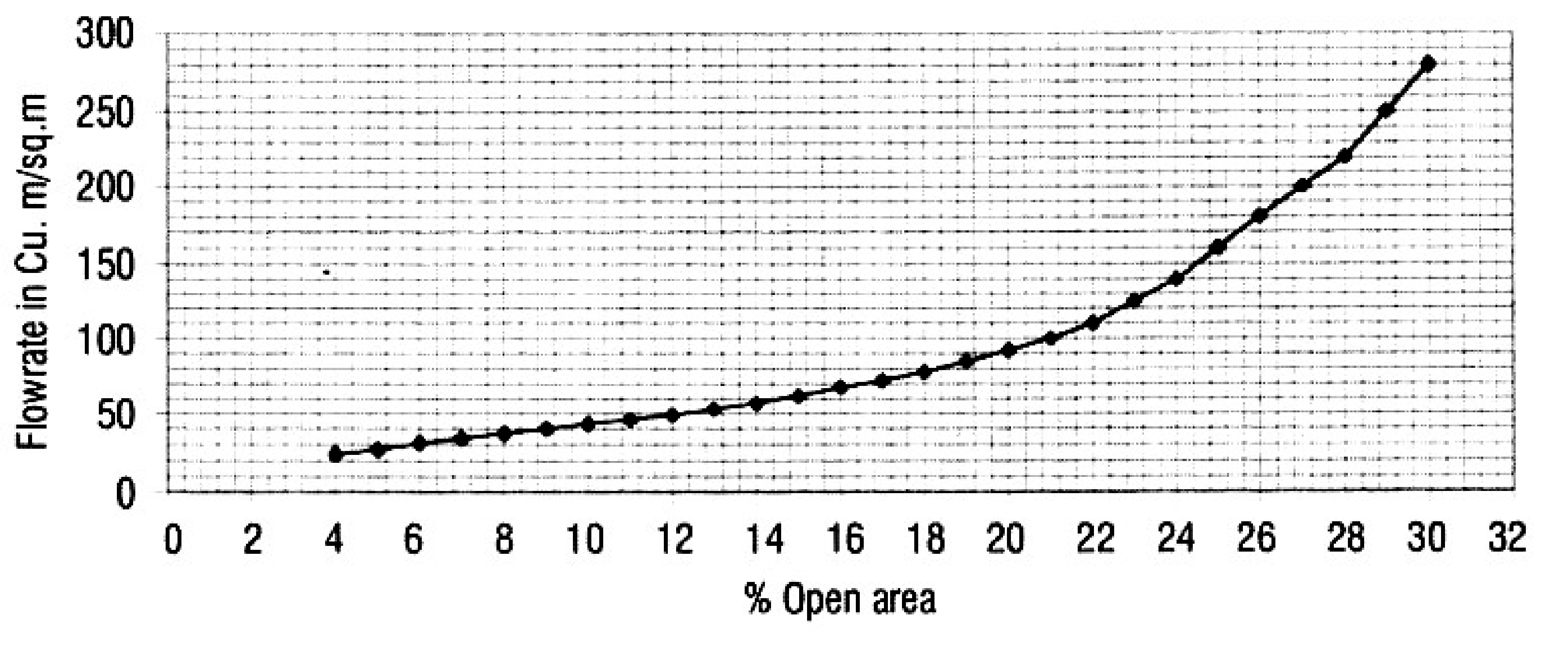
Non-vibrating screens

Roller screen



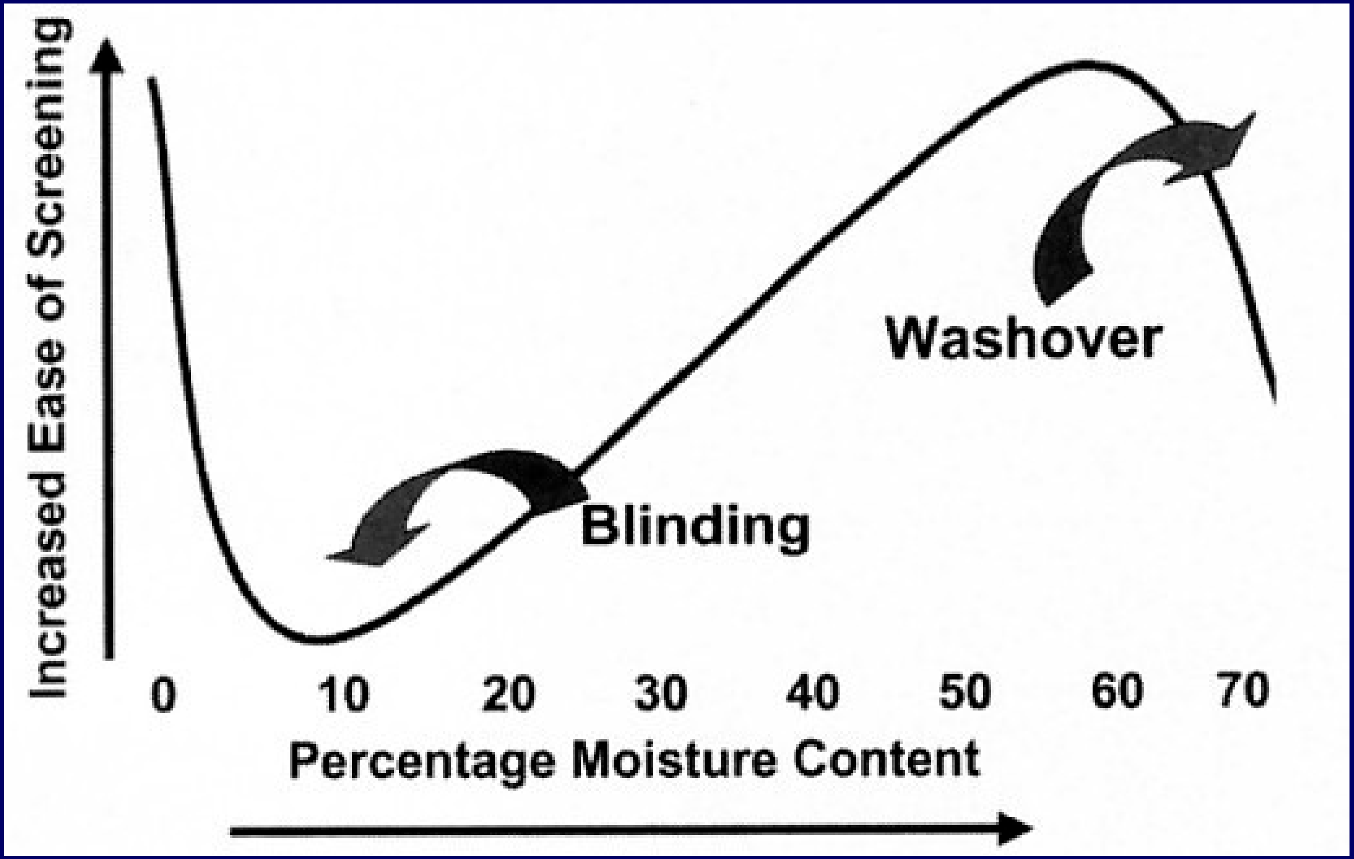
TU Delft

Wet fines screening



TUDelft

Fines screening



Dry fines screening

Problematic moisture content ≈ 10% (for coal) → **agglomeration**

Solution:

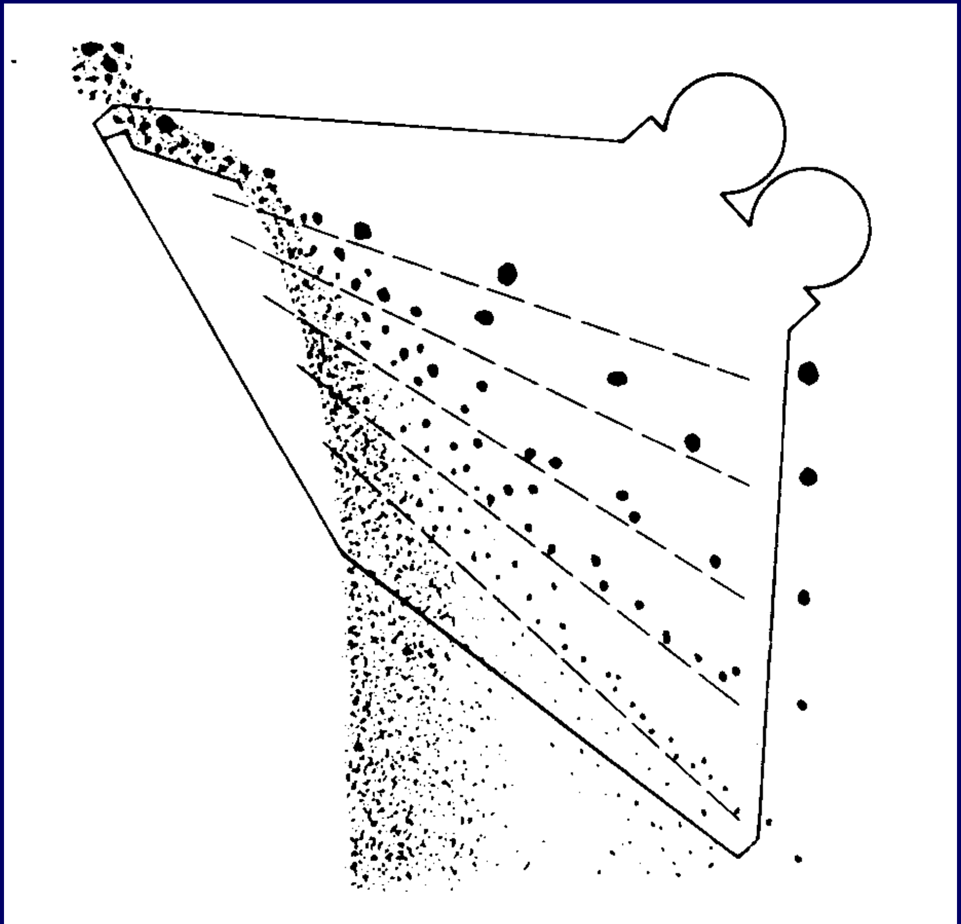
- **Increase the forces** on the particles (increase K_v).
- **Drying** of the feed
- **Adding water** to the feed

TU Delft

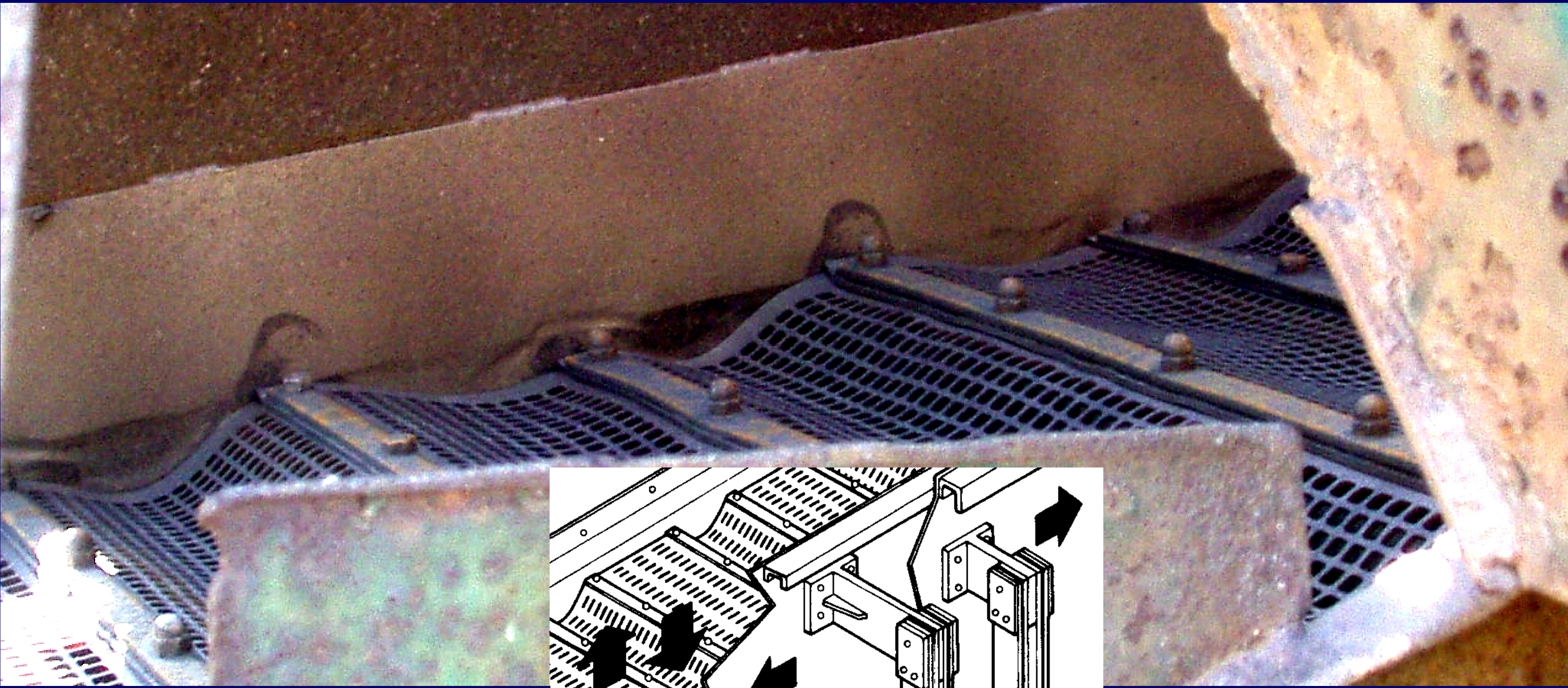
Dry fines screening

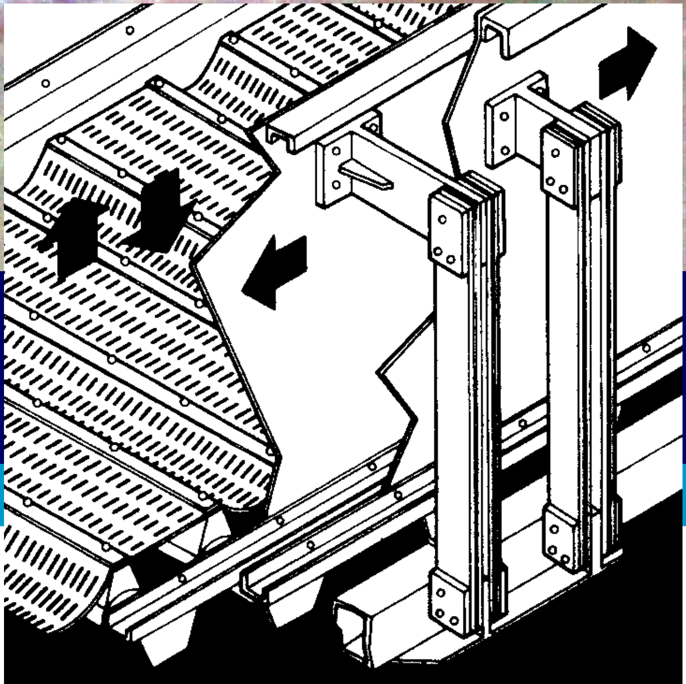
- **Heated-deck screens**: Stickiness is reduced by heating the mesh by electric currents.
- **Piano-wire decks**: Individually tensioned pieces of piano-wire in the direction of flow avoid bridge formation by vibration of the wire.
- **Harp screens**, **duo-sieves** etc. have a corrugated wire shape and rely on the same principle.
- **Sta-Kleen decks**: Captive rubber balls are mounted below a standard mesh. As the screen vibrates, the balls strike the mesh and destroy any bridges.
- **Probability screens** (Mogensen)
- **Flip-flow or Hein Lehmann screen**

Mogensen sizer



Flip-flow /Hein Lehmann

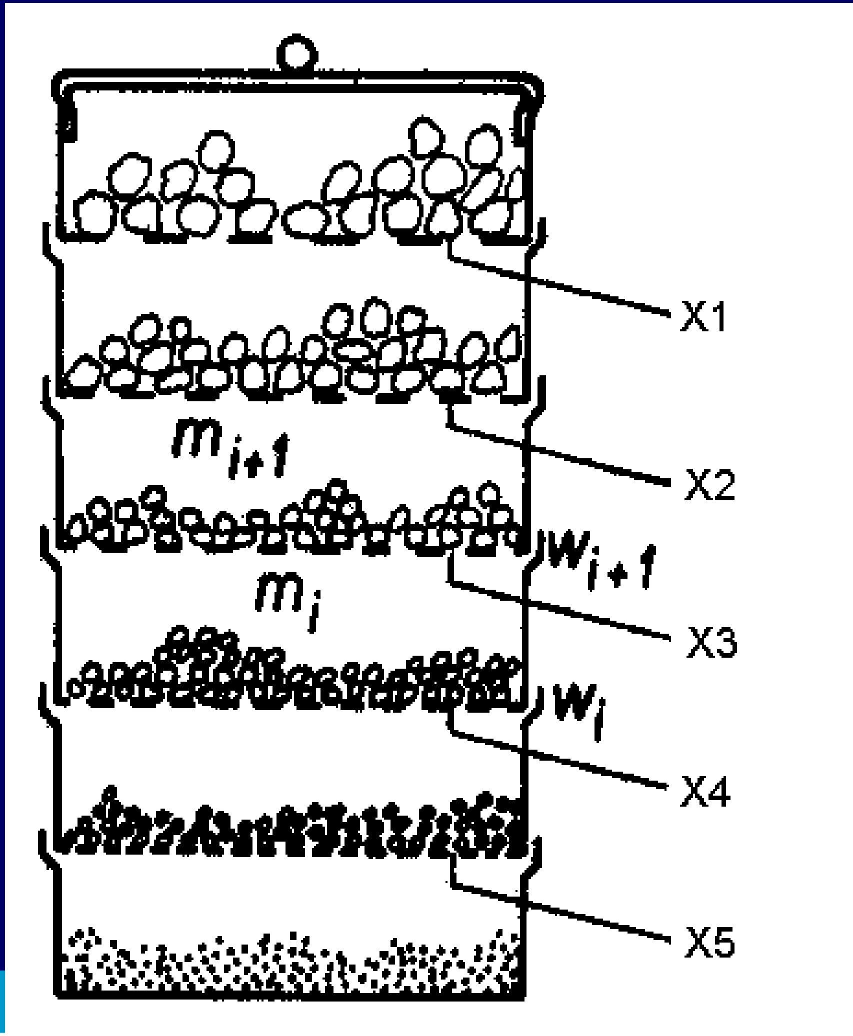


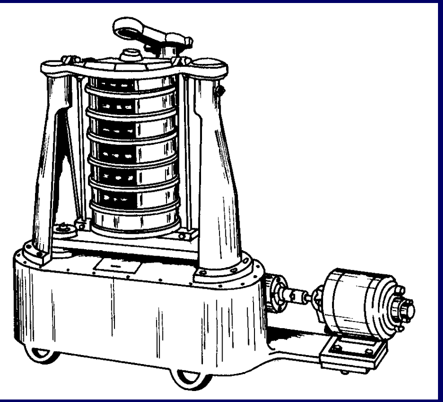


(Steenberg laura)


Dewatering screen
(Anglo coal)

Sieve analysis



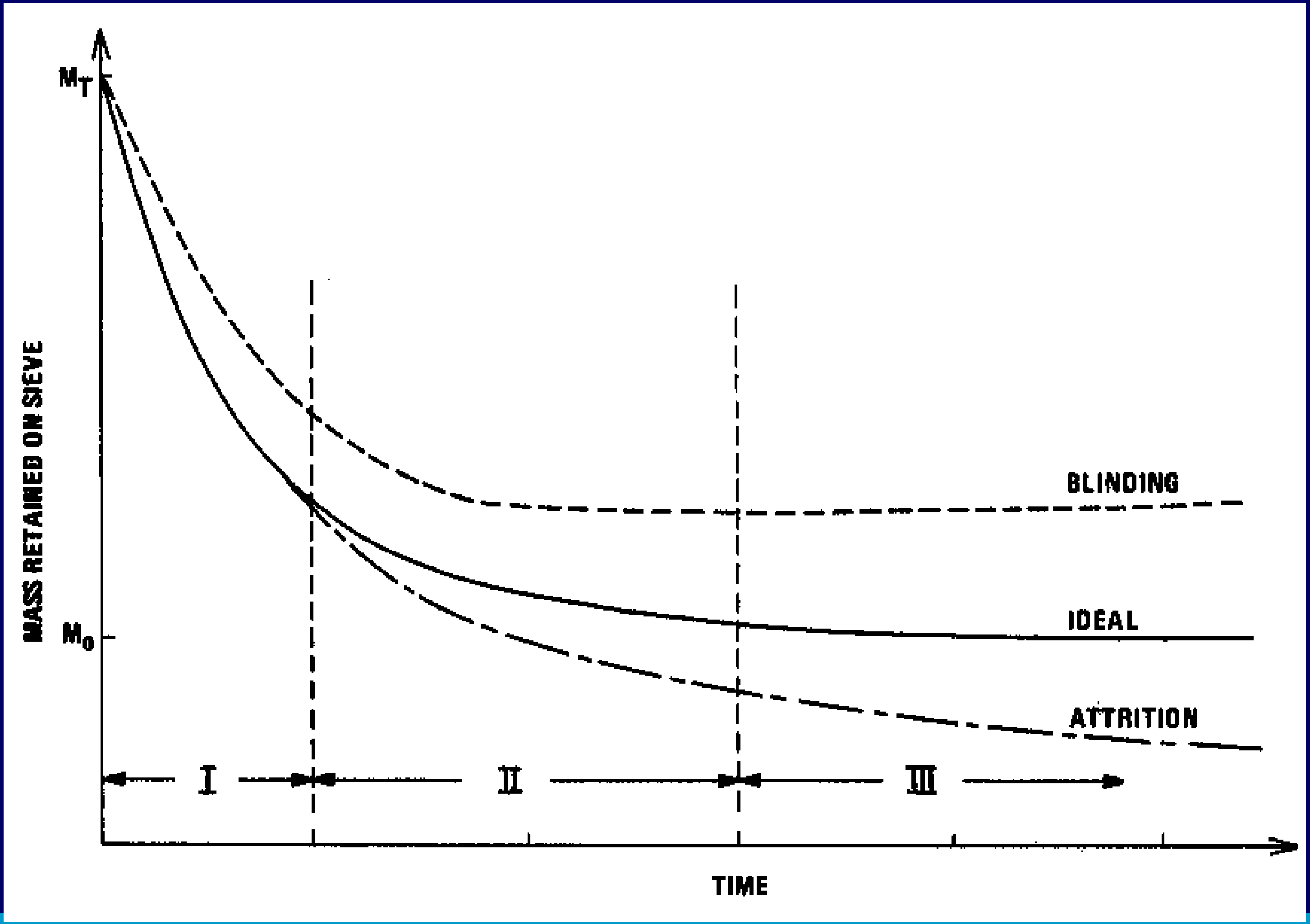


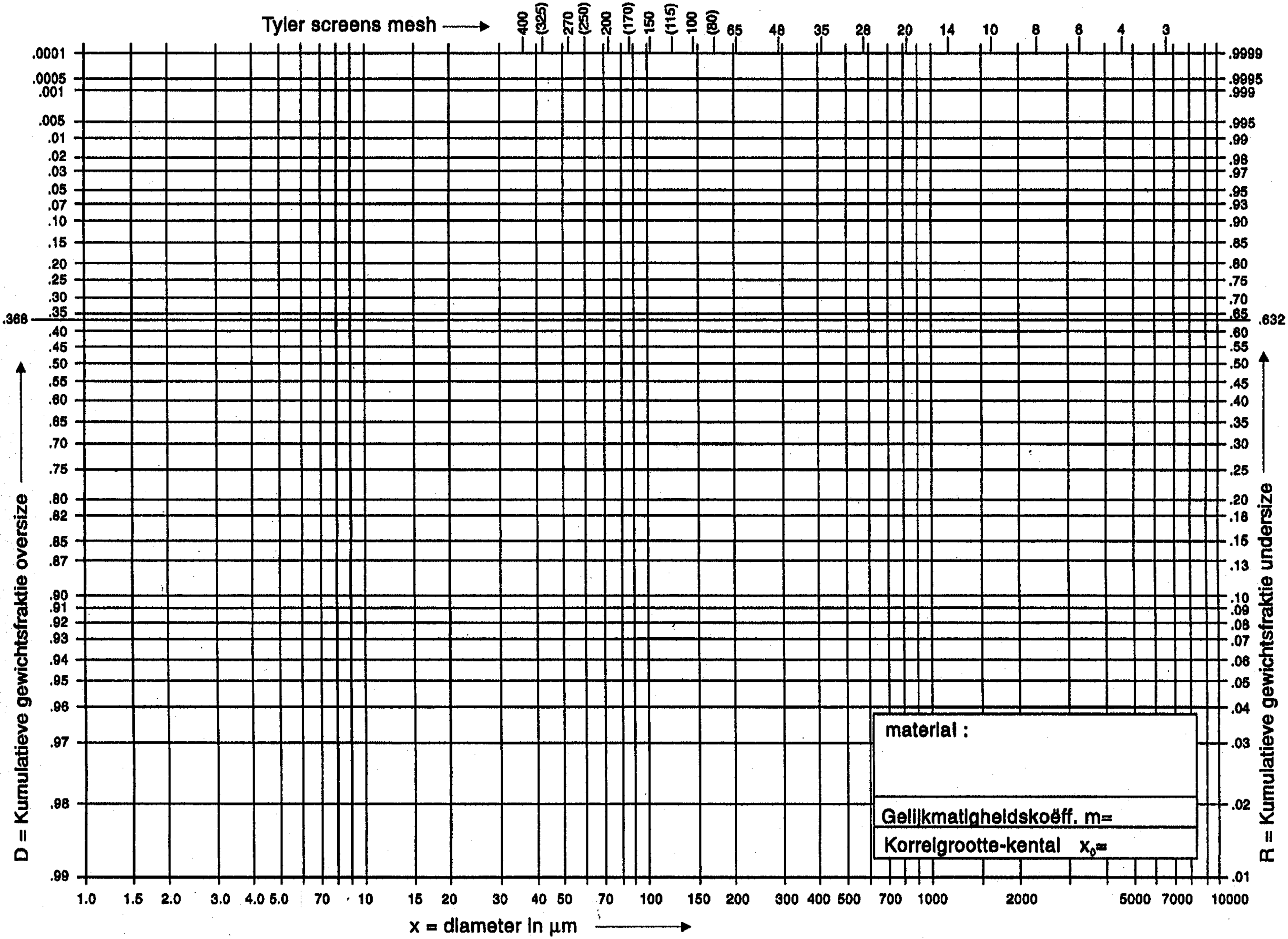
Geometric mean:

$$x_i = \sqrt{m_i m_{i+1}}$$

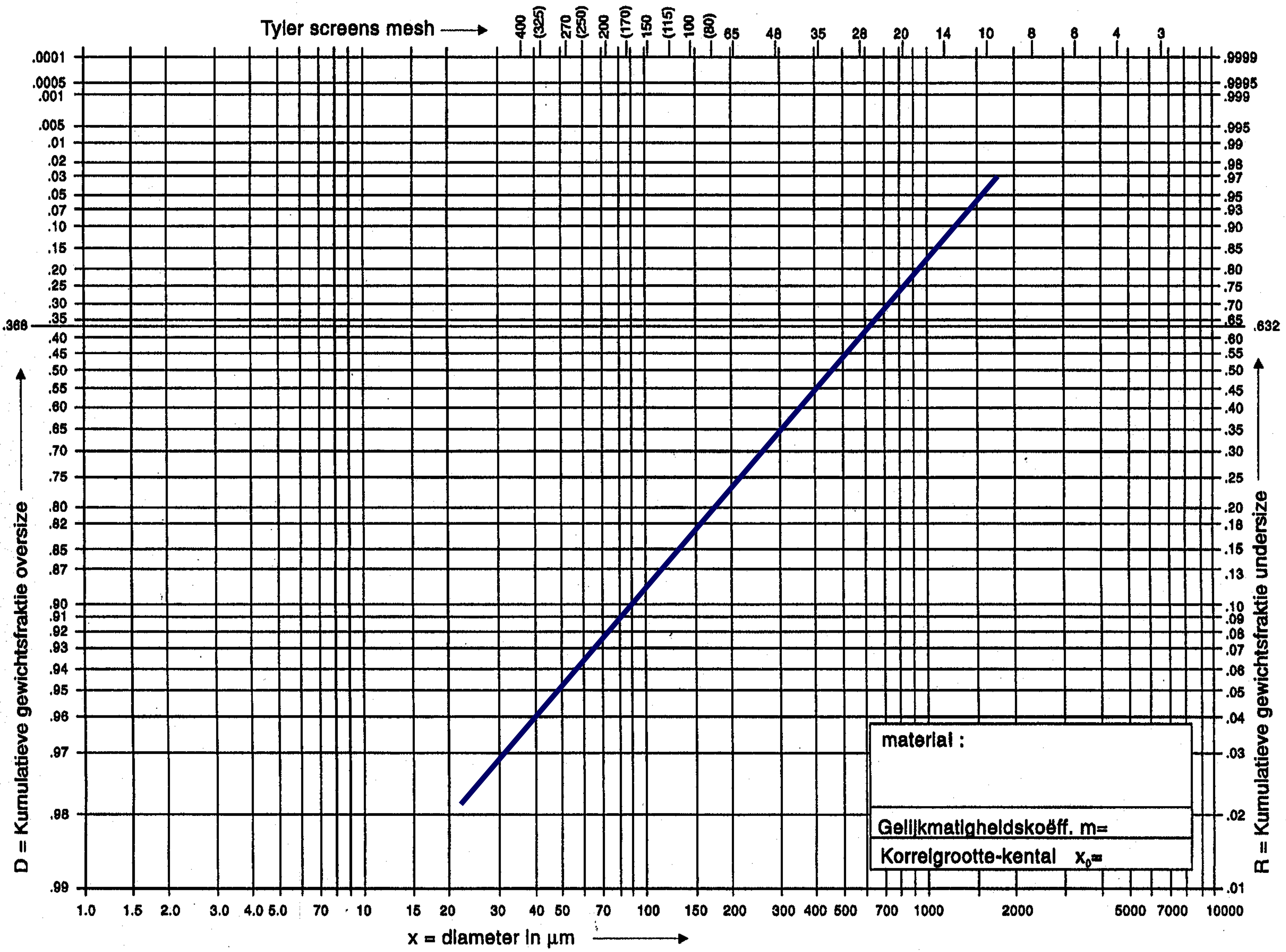
TU Delft

Sieve kinetics

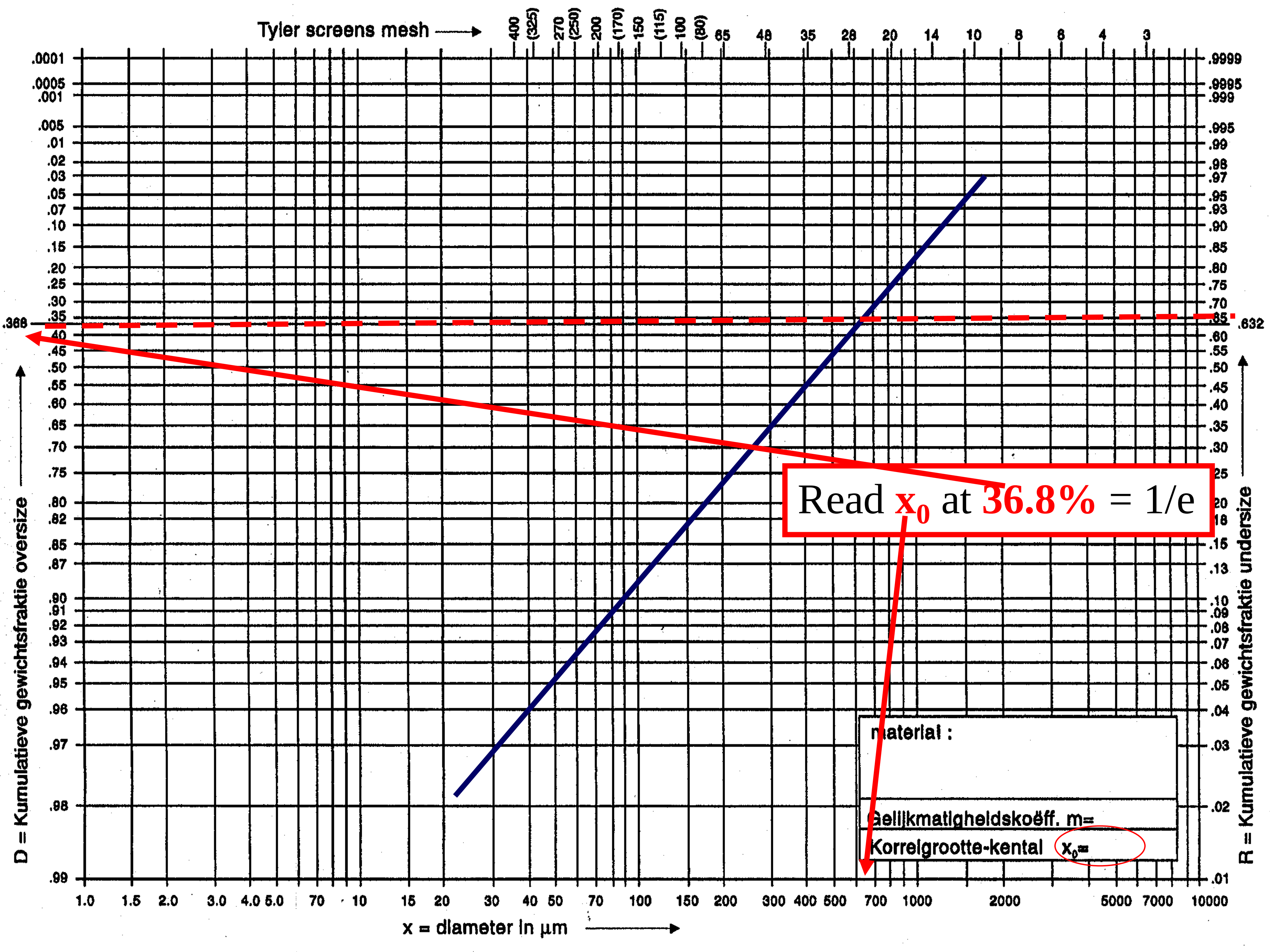


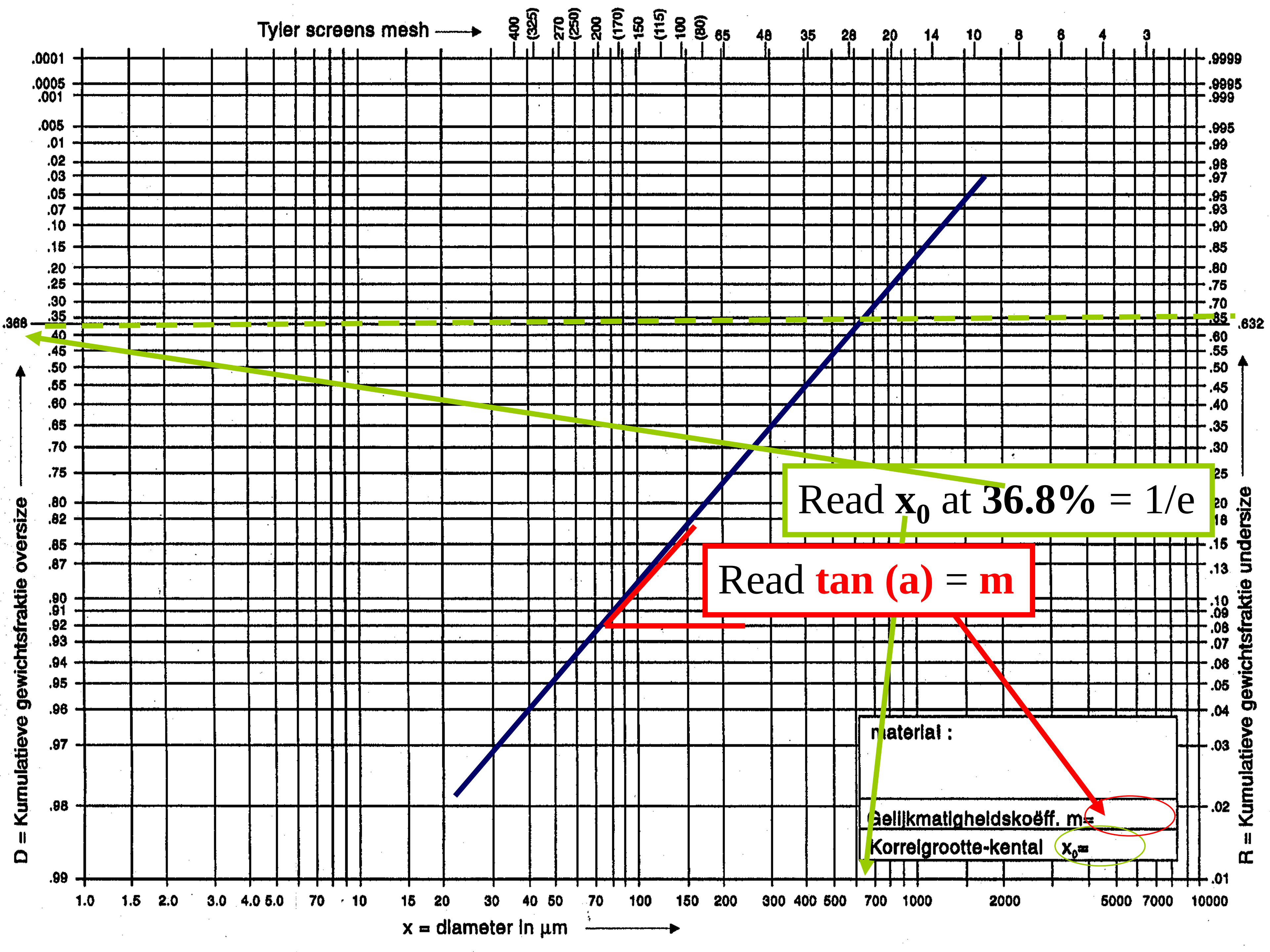


Tyler screens mesh
400 (325) 270 (250) 200 (170) 150 (115) 100 (80) 65 48 35 28 20 14 10 8 6 4 3
D = Kumulatieve gewichtsfraktie oversize
.0001 .0005 .001 .005 .01 .02 .03 .05 .07 .10 .15 .20 .25 .30 .35 .368 .40 .45 .50 .55 .60 .65 .70 .75 .80 .82 .85 .87 .90 .91 .92 .93 .94 .95 .96 .97 .98 .99
R = Kumulatieve gewichtsfraktie undersize
.9999 .9995 .999 .995 .99 .98 .97 .95 .93 .90 .85 .80 .75 .70 .65 .632 .60 .55 .50 .45 .40 .35 .30 .25 .20 .18 .15 .13 .10 .09 .08 .07 .06 .05 .04 .03 .02 .01
1.0 1.5 2.0 3.0 4.0 5.0 70 10 15 20 30 40 50 70 100 150 200 300 400 500 700 1000 2000 5000 7000 10000
x = diameter in µm
material :
Gelijkmatigheidskoëff. m=
Korrelgrootte-kental x₀=



Tyler screens mesh
400 (325) 270 (250) 200 (170) 150 (115) 100 (80) 65 48 35 28 20 14 10 8 6 4 3
.0001 .0005 .001 .005 .01 .02 .03 .05 .07 .10 .15 .20 .25 .30 .35 .368 .40 .45 .50 .55 .60 .65 .70 .75 .80 .82 .85 .87 .90 .91 .92 .93 .94 .95 .96 .97 .98 .99
.9999 .9995 .999 .995 .99 .98 .97 .95 .93 .90 .85 .80 .75 .70 .65 .632 .60 .55 .50 .45 .40 .35 .30 .25 .20 .18 .15 .13 .10 .09 .08 .07 .06 .05 .04 .03 .02 .01
1.0 1.5 2.0 3.0 4.0 5.0 70 10 15 20 30 40 50 70 100 150 200 300 400 500 700 1000 2000 5000 7000 10000
x = diameter in µm
D = Kumulatieve gewichtsfraktie oversize
R = Kumulatieve gewichtsfraktie undersize
material :
Gelijkmatigheidskoëff. m=
Korrelgrootte-kental x₀=


Tyler screens mesh
Read x_0 at 36.8% = 1/e
material :
Gelijkmatigheidskoëff. m=
Korrelgrootte-kental x_0=
x = diameter in µm
D = Kumulatieve gewichtsfraktie oversize
R = Kumulatieve gewichtsfraktie undersize
.368
.632



Tyler screens mesh
400 (325) 270 (250) 200 (170) 150 (115) 100 (80) 65 48 35 28 20 14 10 8 6 4 3
.0001 .0005 .001 .005 .01 .02 .03 .05 .07 .10 .15 .20 .25 .30 .35 .368 .40 .45 .50 .55 .60 .65 .70 .75 .80 .82 .85 .87 .90 .91 .92 .93 .94 .95 .96 .97 .98 .99
.9999 .9995 .999 .995 .99 .98 .97 .95 .93 .90 .85 .80 .75 .70 .65 .632 .60 .55 .50 .45 .40 .35 .30 .25 .20 .18 .15 .13 .10 .09 .08 .07 .06 .05 .04 .03 .02 .01
D = Kumulatieve gewichtsfraktie oversize
R = Kumulatieve gewichtsfraktie undersize
Read x_0 at 36.8% = 1/e
Read tan (a) = m
material :
Gelijkmatigheidskoëff. m=
Korrelgrootte-kental x_0=
1.0 1.5 2.0 3.0 4.0 5.0 70 10 15 20 30 40 50 70 100 150 200 300 400 500 700 1000 2000 5000 7000 10000
x = diameter in µm

2. Classification

Contents

1. Introduction
2. Principle
3. Hydraulic classifiers
4. Pneumatic classifiers
5. Cyclones

TU Delft

Objectives of classification

- Separation on particle size
- (Sometimes)
  - On density
  - On particle shape
  - On a combination of the three
    - Density and shape influence result !

Known as density or shape separation (density and shape)

Why classification ?

Screening:

- Capacity ≈ proportional to mesh size
- Wet screening < 0.2 mm rarely economic
- Dry screening < 2 mm rarely applied

Typical grinding operation:

- 20 – 150 µm

Pneumatic classification

- **Gravity**
  - Horizontal
  - Vertical

  air current

- **Centrifugal force**
  - Cyclone
  - Windsifter

Hydraulic classification

- **Gravity**
  - Sedimentation tank
  - Rising current
  - Thickener
  - Multi-directional water
  - Pulsating

- **Centrifugal**
  - Clarifier
  - Hydrocyclone

Principle

Settling velocity of larger particles in air or water is

- Higher

Trajectory of larger particles is more difficult to change by

- Air flow
- Water flow

See part B

TU Delft

Hydraulic classifiers

1. Clearing cones, settling cones
2. Mechanical classifiers
3. Rising current classifiers

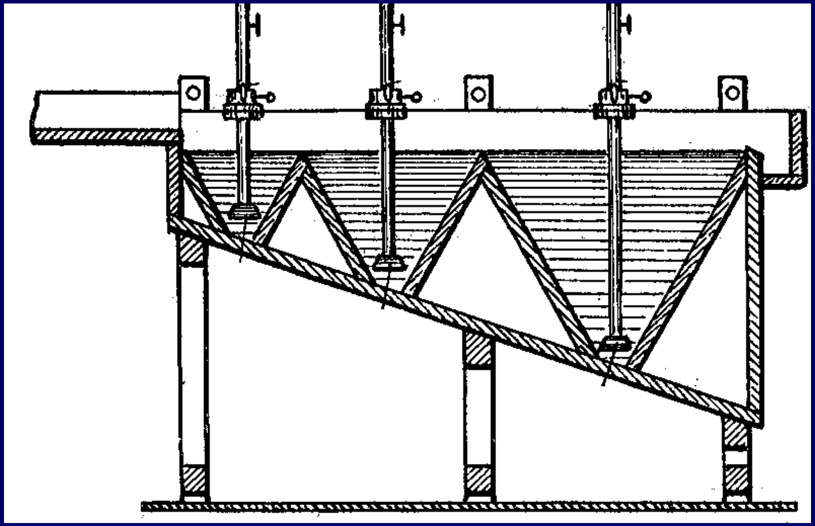
Clearing cones

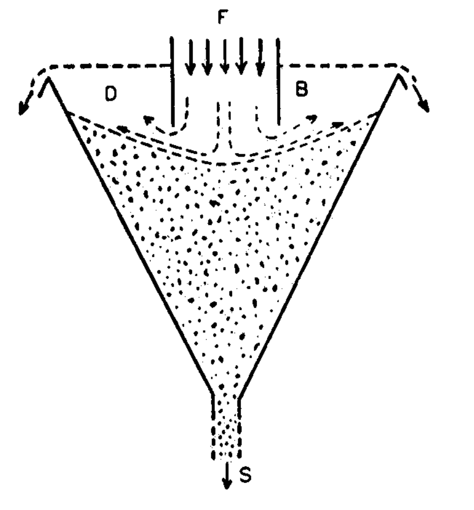
Single stage or **Multi** stage

- Feed < 3 mm
- Cut size 0.25 – 0.1 mm

Applications

- Sand processing
- Coal slurry thickening





TUDelft

Mechanical classifiers

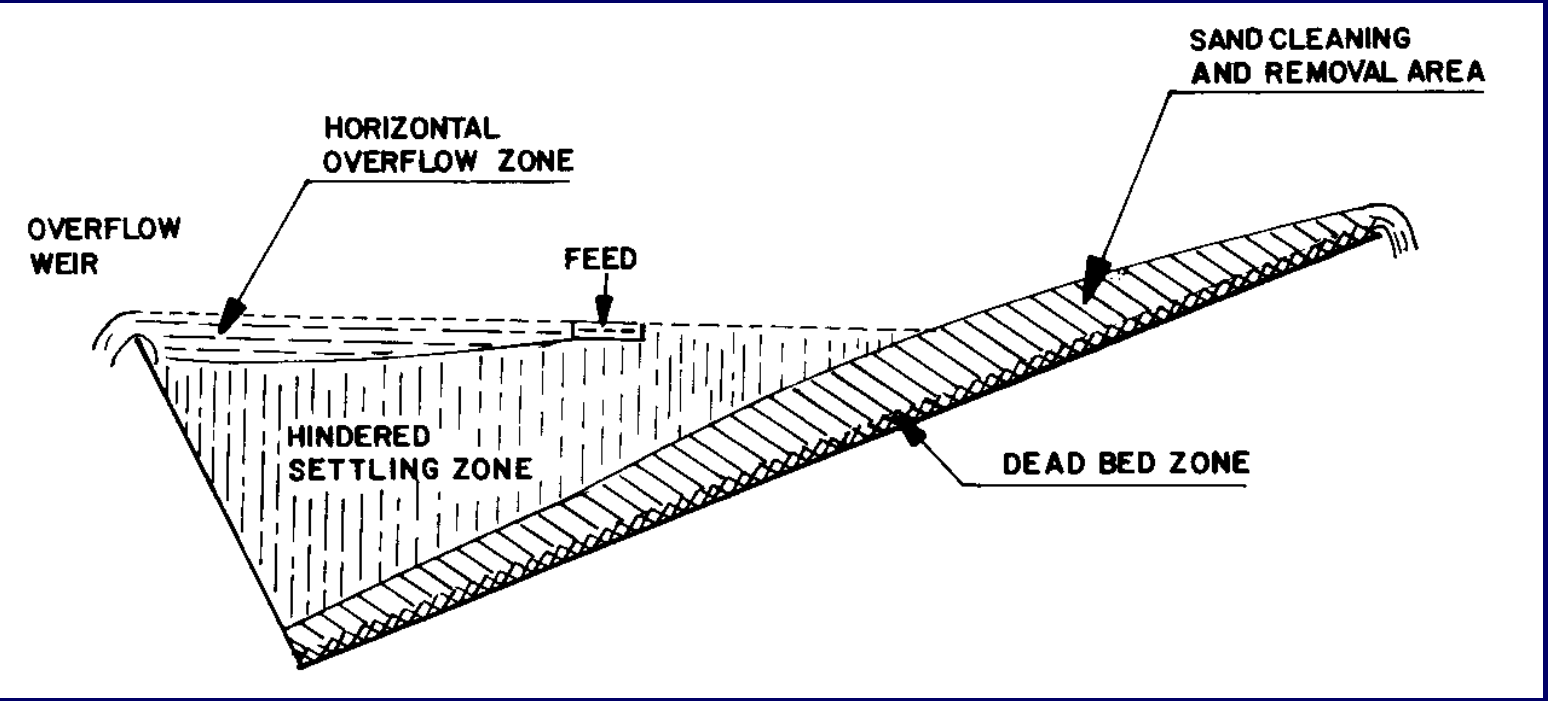
- Rake classifiers
- Screw classifiers

Applications

- Cut sizes in the mm range
- Grinding circuits, but
    - Modern systems: cyclones (50-250 µm) or screens (larger cut sizes)
- Water treatment
- Environmental engineering

Method to estimate capacity on page 38, 39 of course notes

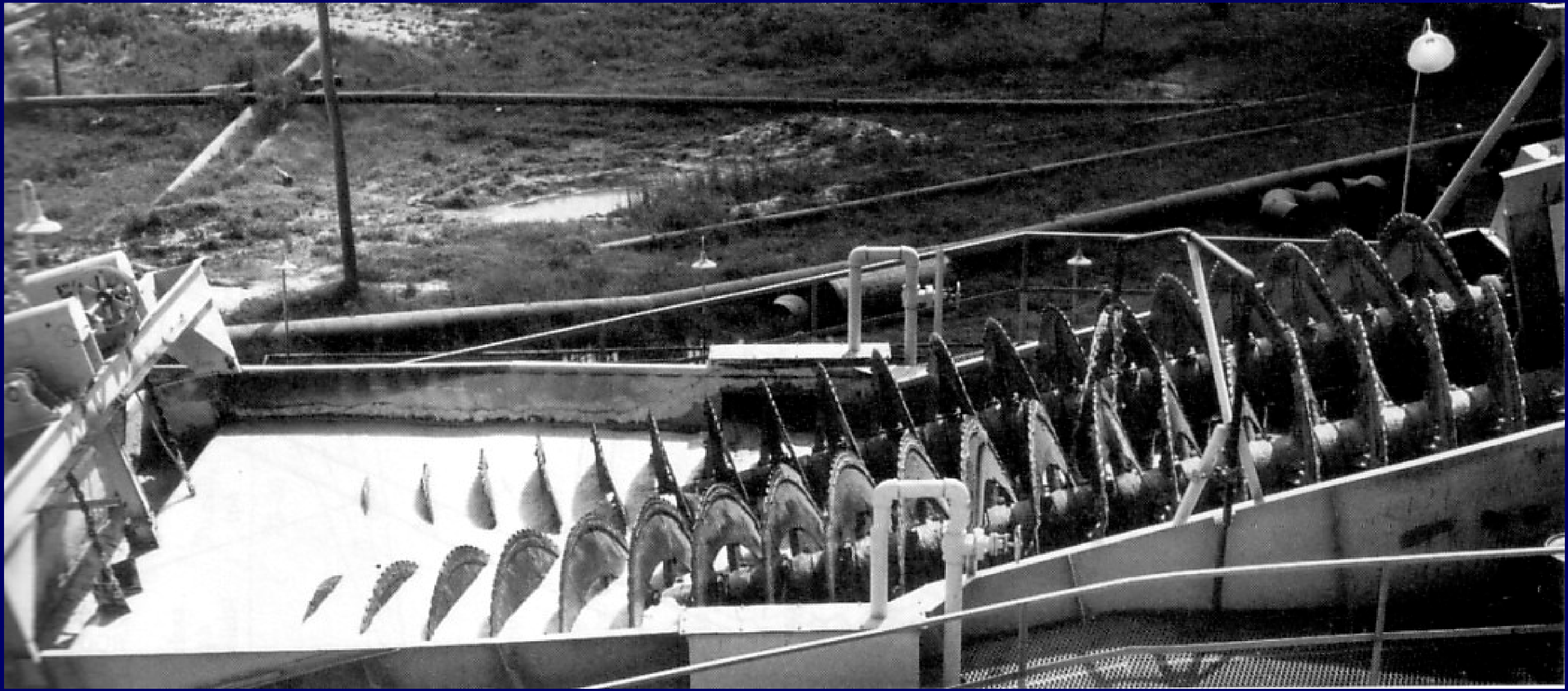
Principle mech. classifier



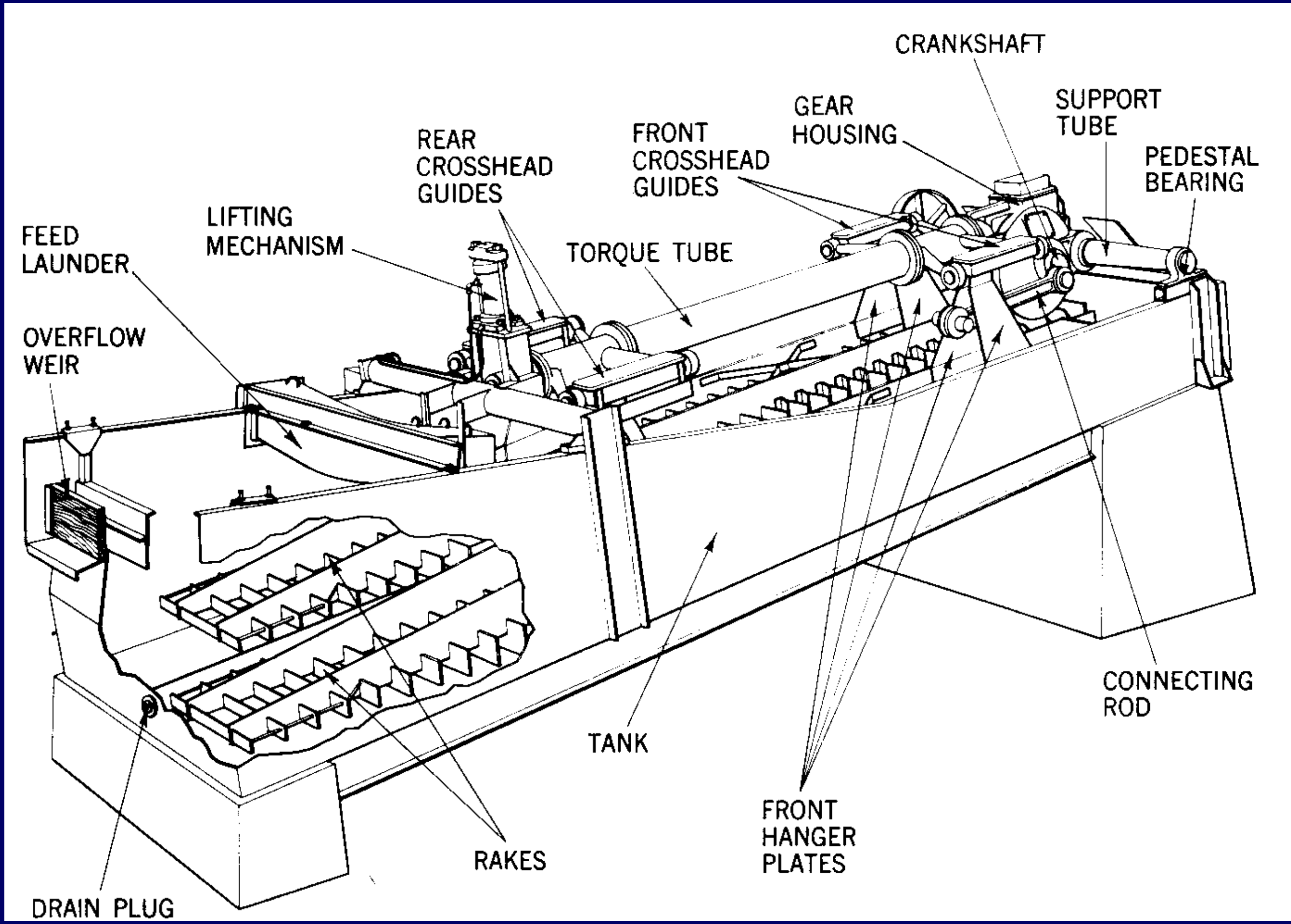
TU Delft

Screw classifier

- Most common



Rake classifier



TUDelft

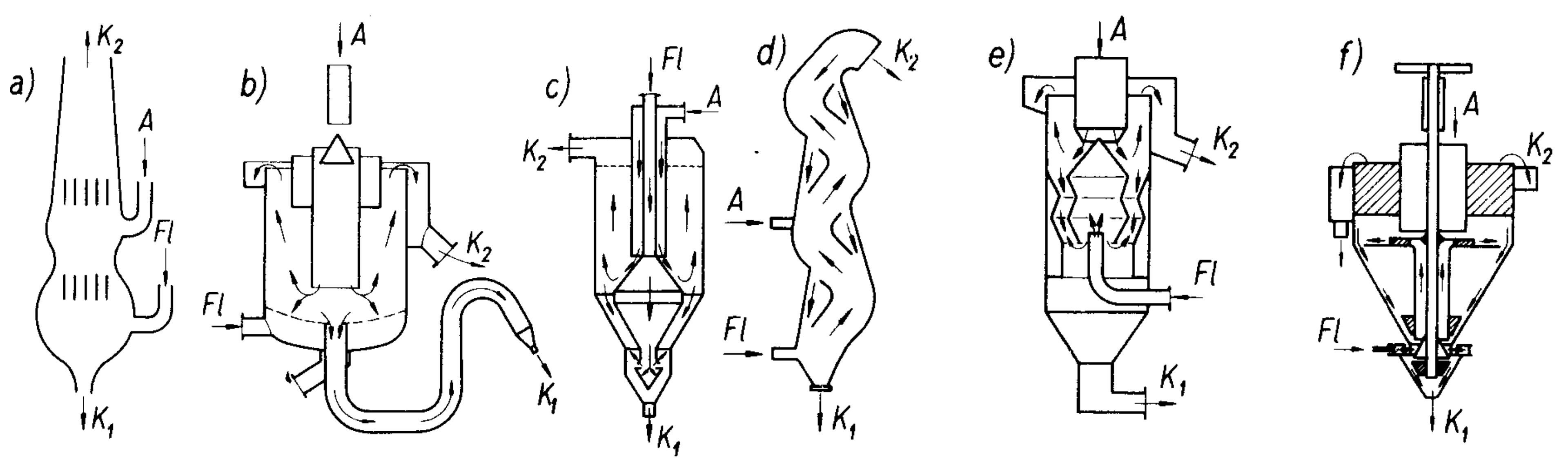
Rising current

- Cut sizes 0.4 – 2.5 mm
- $1.4 < E_p < 2.2$
- Numerous designs exist

$$E_p = \frac{x_{75} - x_{25}}{2}$$

Applications

- Dredging, sand cleaning, industrial minerals



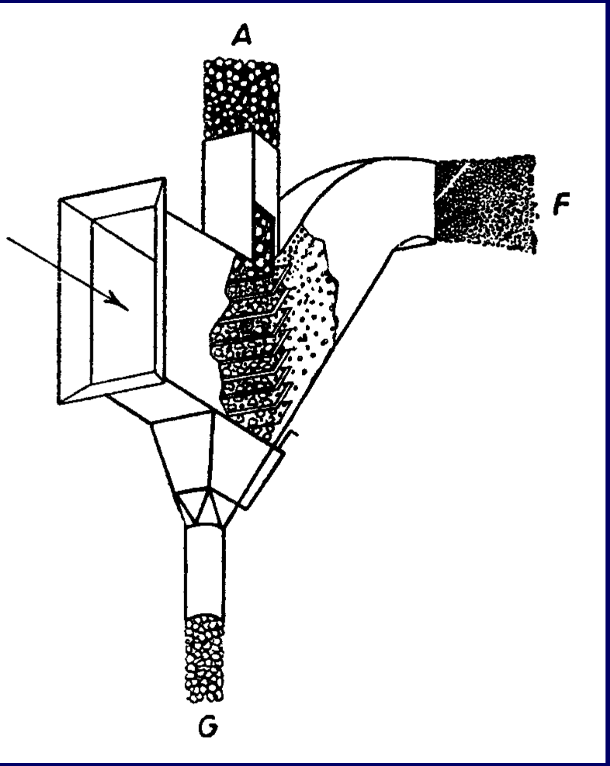
Pneumatic classifiers

- Cut sizes 5 – 500 µm, sometimes more
- Air is:
  - Recycled,
  - fresh,
  - or a combination
- Tasks of the classifier:
  1. Constand feed supply to separation zone
  2. The separation
  3. Separating air from products

TU Delft

Cross flow classifier

- Simple
- Cut sizes 0.2 – 0.6 mm
- Solids concentration < 1.5 kg/m³

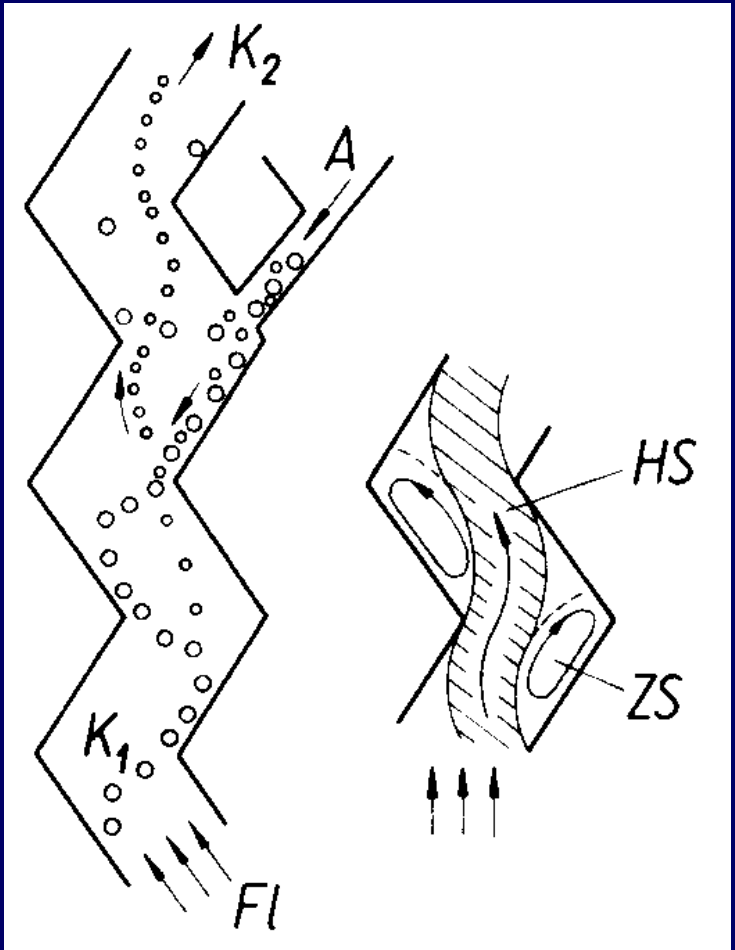


$$C_{sift} = Auc_s = A\partial v_{CS} c_s$$

A=cross sectional area of sifter,
u=air velocity,
c_s=solids concentration of sifter air,
v_{CS} stationary settling velocity of the cut-size particle
$\delta = u/v_{CS}$.

Zig-Zag classifiers

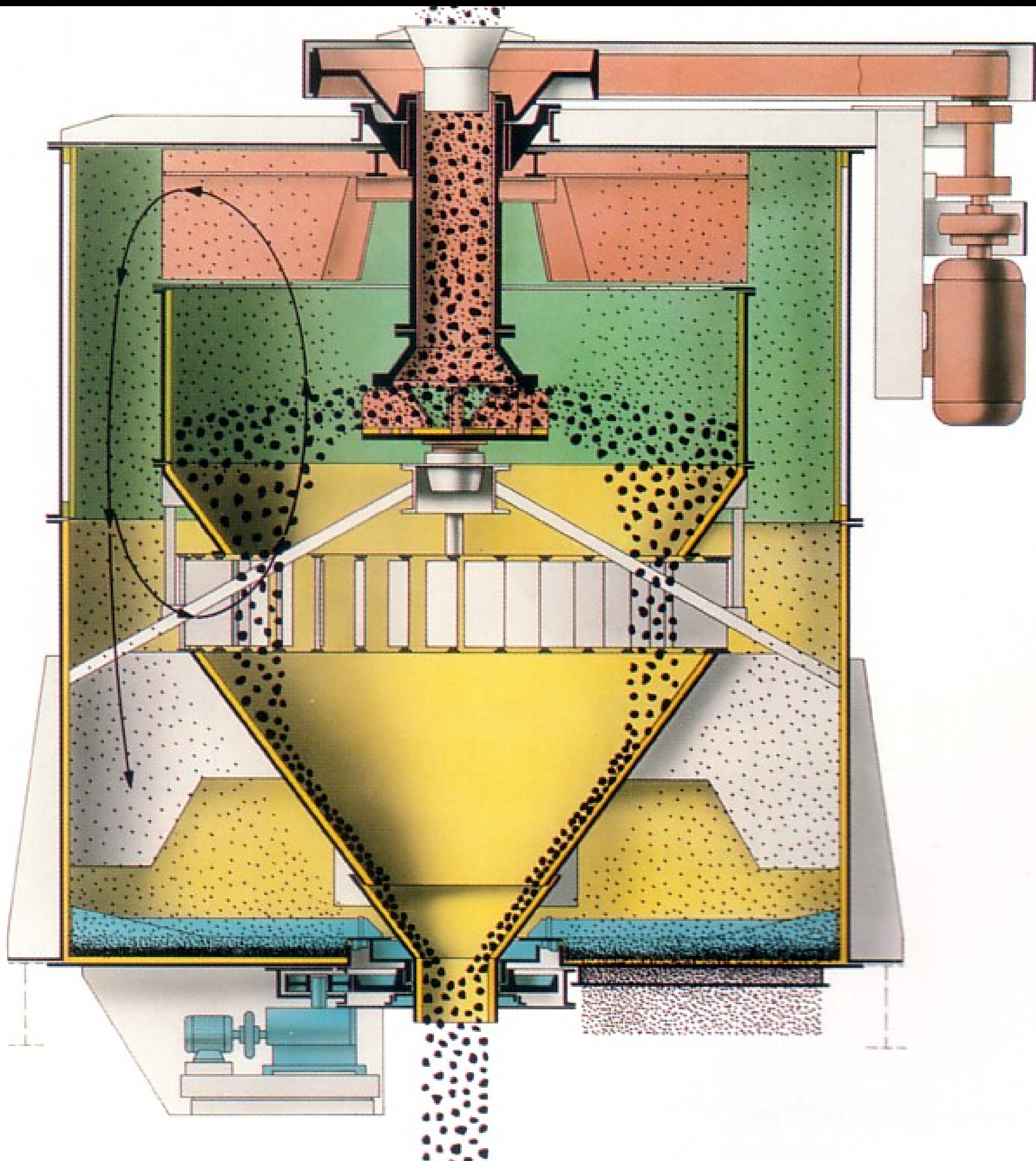
- Cut sizes 0.1 – 10 mm
- $1.2 < E_p < 1.7$
- Multi-stage arrangement



TUDelft

Centrifugal classifier ("Deduster")

- Feed injected in air current from rotating table
- Cut size variable by changing table speed
- Cut sizes 0.05 – 0.6 mm
- $1.5 < E_p < 3.0$
- Diameters up to 8 m, 500 t/h
- Applications: Limestone, cement, coal



Capacity data

Cement	Cut size ≈90µm, 60%<90µm	
Sifter diameter [m]	Capacity [t/h]	Power draw [kW]
1.5	5...6	4...6
2.5	15...20	7...15
3.5	30...60	20...40
5.0	50...120	50...75

Coal	Cut size 500µm, ≈25%<500µm	
Sifter diameter [m]	Capacity [t/h]	Power draw [kW]
1.5	≈14	≈6
2.5	≈75	≈16
3.5	≈150	≈30

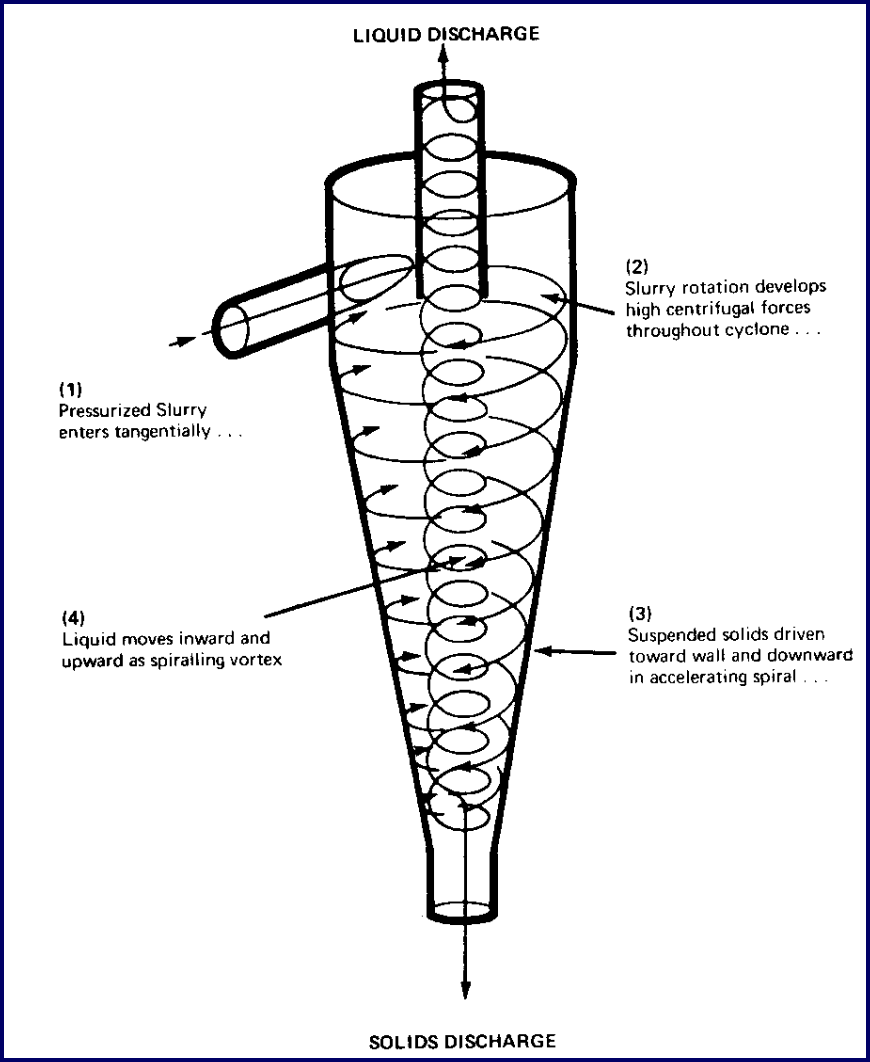
TU Delft


18

Cyclones

- “Wrap-around” settling tank
- Centrifugal acceleration
- Simple and cheap
- **Diameter determines d_{50}**
- Mining industry:
  - Typically 4- - 220 µm
  - Diameter 250 – 830 mm
- High dilution
- Not for viscous fluids

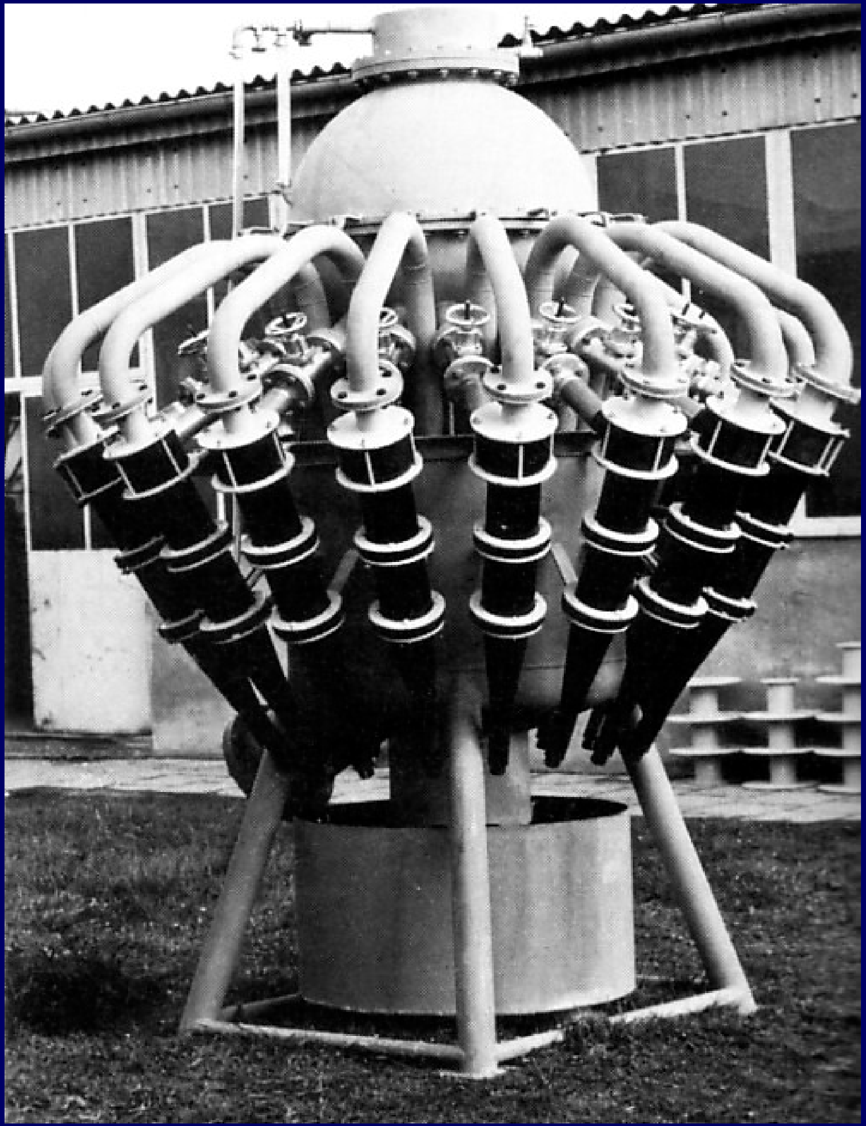
→ *Principles in part B !*

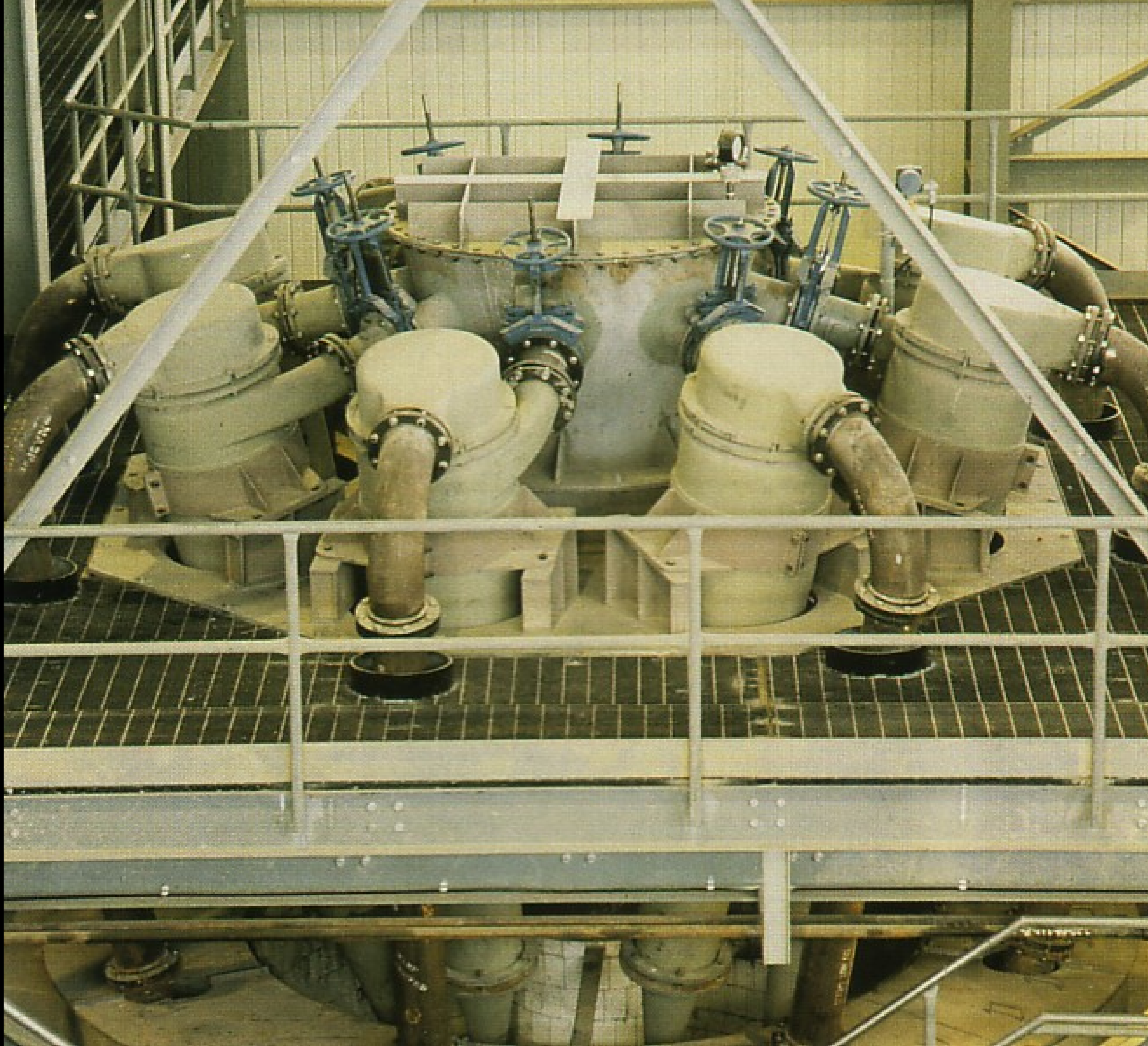


TUDelft

Bank of cyclones

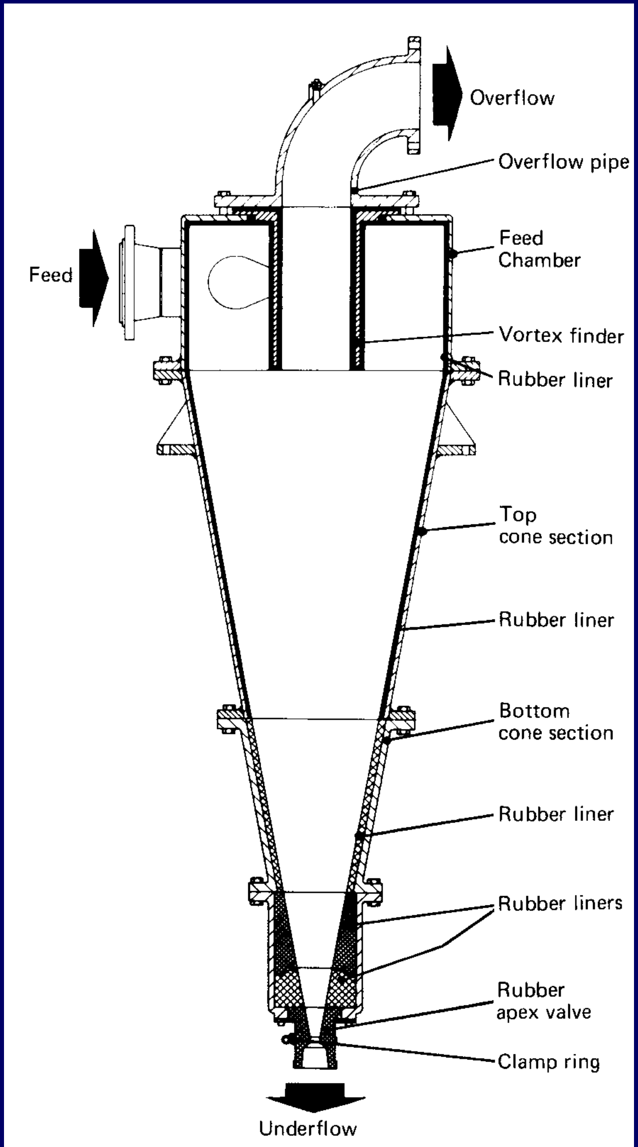
- High capacity
- Small cut size



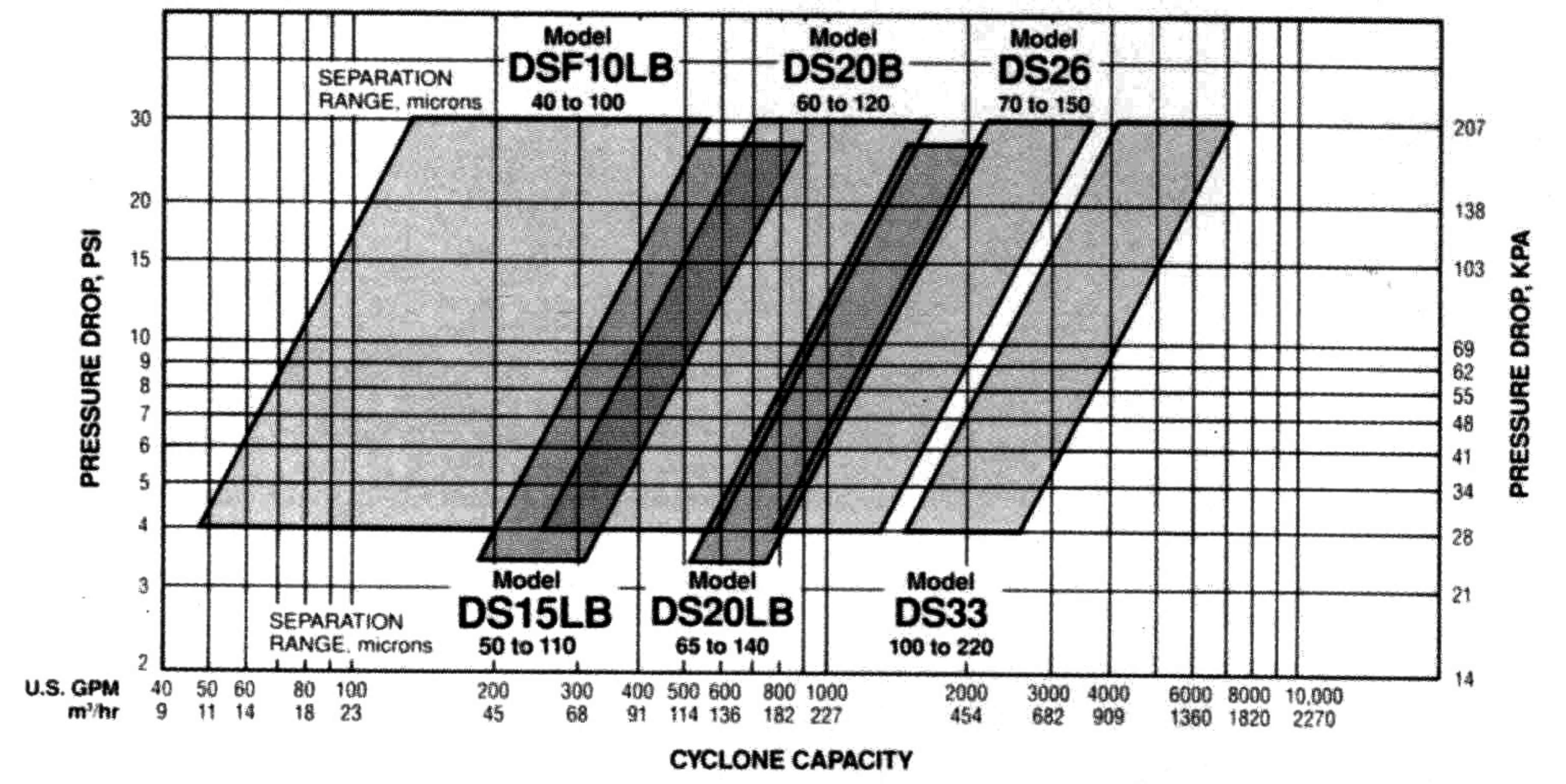


Cyclone design

Wear of liner and
in-, outlets is an issue



Performance chart



?