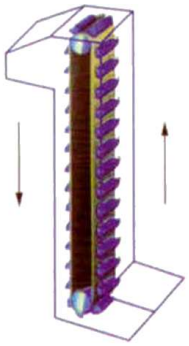
Mechanical Engineering Department
Carlos III University

BUCKET ELEVATOR

TRANSPORTATION

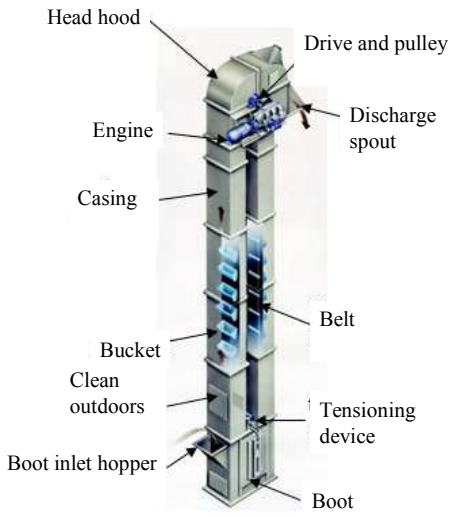
BUCKET ELEVATORS

Bucket elevators are the most used systems for vertical transport of bulk, dry, wet and even liquid materials.



- **Designed with various options of height, speed and constructive details depending on the type of material to be transported.**
- **Are constructed by pieces or units to allow to define efficiently the needed height.**

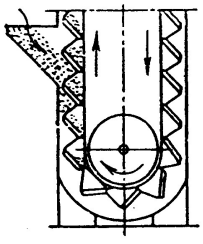
COMPONENTS



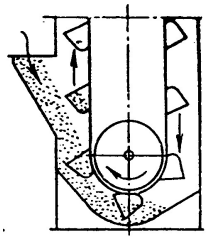
DEPENDING ON THE LOAD

Directly to the input hopper

- **Used for transport of abrasive and big size materials.**
- **Chain/belt travelling speed is low.**



By digging

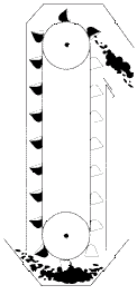


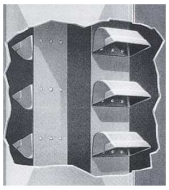
- **Used for transport of materials that offer no resistance to extraction, like fine grain and dusty materials.**

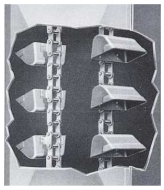
DEPENDING ON THE TYPE OF DISCHARGE

Centrifugal

- **It is the most common.**
- **Great travelling speeds (1.2 and 1.4 m/s).**
- **Loading is carried out by dredging the material at the bottom of the elevator.**
- **The separation distance between the buckets is 2 to 3 times the bucket height.**



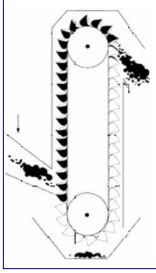


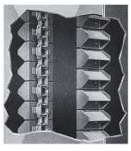


DEPENDING ON THE TYPE OF DISCHARGE

Gravity or continuous

- **Lower travelling speeds (0.5 and 1.0 m/s).**
- **It is taken advantage of self weight.**
- **Classification:**
  - **Free gravity.** It is necessary to change the free branch line or incline the bucket.
  - **Forced.** The buckets are situated one after the other without separation between them. The discharge takes place due to gravity by means of the lower part of the preceding bucket that acts as a discharge spout.

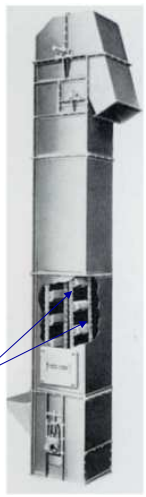




DEPENDING ON THE TYPE OF DISCHARGE

Positive

- Similar to the gravity elevator safe that buckets are fitted at the edges with two cords.
- Bucket speed is low are appropriate for light, aired, sticky materials.



MATERIAL TRANSPORTED FLUX

Bucket volume (l)

Fill in bucket coefficient (0,6 – 0,9)

Material weight (kg)

$$P_c = i \cdot \rho \cdot j$$

Density (kg/l)

Travelling speed (m/s)

Transported material flux (t/h)

$$Q = 3.6 \cdot \frac{P_c \cdot v}{t}$$

Pitch:

Bucket height

Standard buckets: $t \in [2h, 3h]$

Flake bucket: $t = h$

For chains: $t = cte \cdot t_{chain}$

POWER

The force the drive pulley needs to move the belt (kg):

$$F_a = \frac{Q}{3.6 \cdot v} \cdot (H + H_0)$$

Elevating height (m)

Fictitious height (m)

Load system	Material size	Value of H_0 (m)
From the inlet hopper		3.8
By digging	Little	7.6
	Medium	11.4
	Big	15.3

Power of the engine (CV):

$$N_a = \frac{F_a \cdot v}{75 \cdot \eta}$$

Engine efficiency

MAXIMUM TENSION OF THE BELT

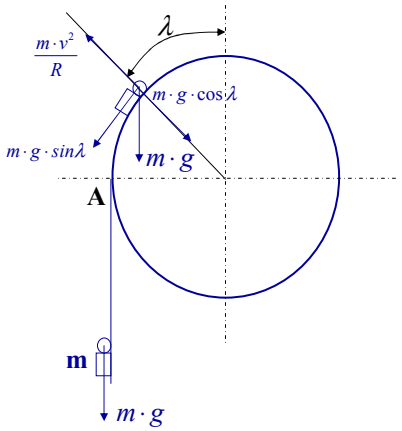
Maximum tension of the belt (kg):

$$T_a = F_a \cdot k$$

Coefficient that depends on the pulley

Pulley conditions	K
Humid smooth	3.20
Dry smooth	1.64
Humid layer	1.73
Dry layer	1.49

MATERIAL DISCHARGING

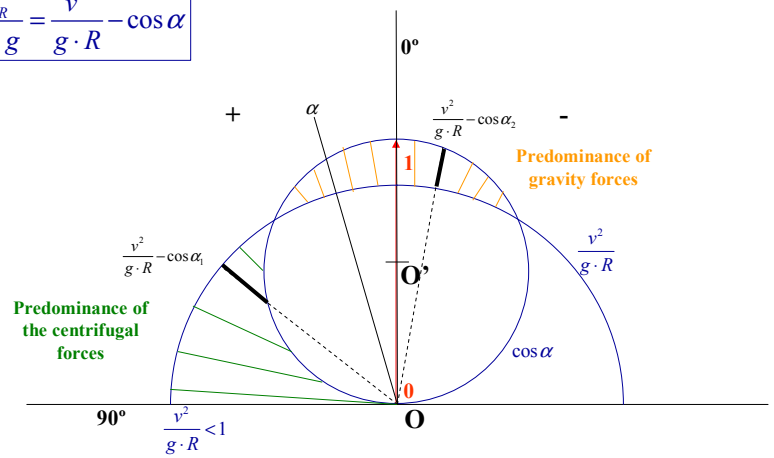


$$F_R = \frac{m \cdot v^2}{R} - m \cdot g \cdot \cos\lambda$$

$$\frac{F_R}{m \cdot g} = \frac{v^2}{g \cdot R} - \cos\lambda \quad \begin{cases} < \\ = \ \mathbf{0} \\ > \end{cases}$$

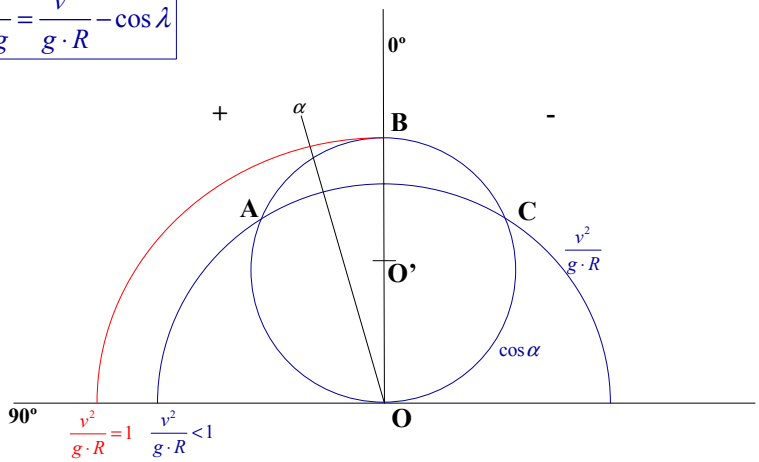
MATERIAL DISCHARGING

$$\frac{F_R}{m \cdot g} = \frac{v^2}{g \cdot R} - \cos\alpha$$

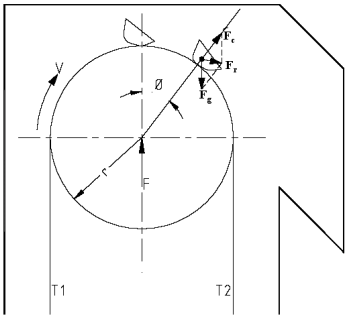


MATERIAL DISCHARGING

$$\frac{F_R}{m \cdot g} = \frac{v^2}{g \cdot R} - \cos\lambda$$



MATERIAL DISCHARGING



Pulley diameter

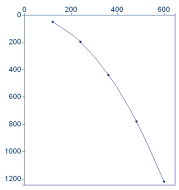
$$F_c = F_g$$

$$m \cdot \frac{V^2}{R} = m \cdot g \Rightarrow R = \frac{V^2}{g}$$

Material path

v = 0.5 m/s

TIME (s)	S_h (m)	S_v (m)
0.1	120	50
0.2	240	195
0.3	360	440
0.4	480	780
0.5	600	1220



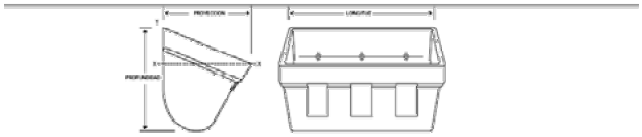
$$s = \underbrace{v \cdot t}_{s_h} + \underbrace{\frac{1}{2} \cdot a \cdot t^2}_{s_v}$$

EXAMPLE

- Design the features of a belt conveyor that has to transport dry clay of density 1700 kg/m^3 with an approximate capacity of 15t/h:
  - Size of the bucket
  - Spacing
  - Belt speed
  - Pulley diameter

BUCKET ELEVATOR

EXAMPLE



CANGILONES ELEVADORES DE PLASTICO MAXI-TUFF® USO AA INDUSTRIAL

Tamaño del cangilón	Longitud (mm)	Proyección (mm)	Profundidad (mm)	Peso (Kg)	100% Capacidad bruta (litros) X—Y
4x3	108	80	80	0.12	0.25
5x4	134	105	105	0.24	0.74
6x4	159	105	105	0.27	0.90
7x4	185	105	105	0.30	1.07
7x5	181	131	134	0.44	1.55
8x5	207	131	134	0.50	1.83
9x5	232	131	134	0.54	1.99
9x6	239	156	156	0.68	2.80
10x6	264	156	156	0.74	3.14
11x6	289	156	156	0.78	3.43
12x6	315	156	156	0.98	4.06
12x7	315	181	181	1.14	5.25
14x7	366	181	181	1.37	6.30
14x8	366	207	207	1.93	7.60
16x8	416	207	207	2.16	8.85
18x8	461	207	207	2.32	10.15
18x10	470	258	258	3.88	15.00

EXAMPLE

- Load weight=(2/3)·bucket· volume·density= (2/3)·0,74·1700=0,84 kg per bucket
- To move 15t/h we need: (15000/0,84)=17857 buckets/h=5 buckets/s
- Spacing
  - Pitch=[2h,3h] if bucket height is 105mm **Pitch=300 mm**
- Belt speed=5 bucket/s · 300 mm=1,5 m/s
- Pulley diameter: $D=2\cdot R=2\cdot(v^2/g)$=460 mm