FEDERATION EUROPEENNE DE LA MANUTENTION
SECTION II
CONTINUOUS HANDLING

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SCREW CONVEYORS FOR BULK MATERIALS

Recommendations for the design of horizontal and slightly inclined screw conveyors

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1 - DEFINITION

A screw conveyor is composed of a propeller-shaped plate fixed on a shaft and, in the majority of cases, a U-shaped trough inside which the shaft can turn on the bearings.

When the shaft runs, the material introduced into the trough cannot be rotated due to its own weight and friction against the walls of the trough and it is driven along the trough by the lower parts of the propeller. It is discharged either through openings provided for this purpose in the bottom of the trough or at the end.

2 - FIELD OF APPLICATION

This recommendation only applies to the screw conveyor, horizontal or inclined position (up to approximately 20 °), with regular and continuous supply of the bulk material.

Excluded from this recommendation are the special screws for the specific uses such as :
- extracting screws
- calibrating screws
- mixing screws
- moistening screws
- inclined screws (above 20 °)
- vertical screws.

3 - COMMENTS

The rate of flow of the material which may be reached by a screw conveyor as well as the necessary drive power depend upon the operating conditions, the nature of the material conveyed and the design parameters, the most important of which are considered in this recommendation.

The recommendation describes a relatively simple method of calculation and therefore reaches a limited precision only, which is in most cases sufficient

Numerous factors in the formulae are empirical and result from long practical experience.

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4 - SYMBOLS AND UNITS

A	Working section of screw conveyor	m^2
D	Nominal screw diameter	m
F_R	Sum of the resistances due to friction	N
F_{St}	Resistance due to inclination	N
g	Acceleration due to gravity	m/s^2
H	Lifting height	m
I_M	Mass capacity	kg/s
I_V	Volume capacity	m^3/s
L	Conveying length = length of screw	m
m'	Mass of material per unit of length	kg/m
n	Number of screw roundings	1/s
P	Total power of screw	W
S	Screw pitch	m
v	Linear speed of material movement	m/s
δ	Angle of inclination	-
λ	Progress resistance coefficient	-
φ	Trough filling coefficient	-
ρ	Density of bulk material	kg/m^3

5 - CALCULATION OF THE CAPACITY OF A SCREW CONVEYOR

The nominal output is the maximum capacity that may be reached by a screw conveyor.

The volume capacity I_V is the product of the working section of a screw conveyor :

$$A = \varphi \cdot D^2 \cdot \frac{\Pi}{4}$$

by the conveying speed :

$$v = S \cdot n$$

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From which results the equation :

$$I_V = \varphi \cdot \frac{\Pi}{4} \cdot D^2 \cdot S \cdot n$$

The output is very often expressed in the form of mass output I_M :

$$I_M = I_V \cdot \rho = \rho \cdot \varphi \cdot \frac{\Pi}{4} \cdot D^2 \cdot S \cdot n$$

One should not ignore the importance of the filling coefficient φ which gives the formulae all its flexibility.

In fact, with materials that do not flow normally, or when over-filling occurs, there is a large difference between the actual conveying speed and the theoretical conveying speed introduced into the equation ($v = S \cdot n$).

The maximum wise filling coefficients depend upon the friction and adhering properties of the conveyed materials on the screw pitch and the inclination of the screw centre line.

In general, the following are used :

$\varphi \approx 0.45$ for screw without intermediate bearings and for hardly abrasive materials which flow easily, (flour, cereals)

$\varphi \approx 0.30$ for the most current bulk materials, with average abrasive properties, with a grading varying from grains to small lumps (salts, sand, coal)

$\varphi \approx 0.15$ for heavy bulk materials, very abrasive, aggressive (ash, gravel, minerals)

These values should be reduced in the following cases :

- extremely large propeller pitch (normally $S \approx 0.6$ D to 1.0 D),
- screw inclination (approximately 2 % per degree of inclination up to 20 °),
- small diameter screws with cumbersome intermediate bearings.

It should be pointed out that the diameter of a screw should not only be defined by the capacity but also by the dimensions of the largest lumps and their percentage in the material.

The rotation speed of the screw should not be too high or else the material will be thrown upwards which will spoil its transport. It should be chosen in function of the screw diameter, the physical properties of the material and the filling coefficient.

6 - RESISTANCES TO THE MOVEMENT OF THE SCREW CONVEYOR

The movement of the screw conveyor and the material is subject to a number of resistances to the movement i.e.:

- resistance due to the inclination (lift power) to lift the material,
- friction of the material against the wall of the trough,
- friction of the material against the propeller,
- friction of the material against the shaft and the intermediate bearings,
- friction in the bearings and the packing of the shaft,
- internal friction of the material.