INFLUENCE OF THE CHARACTERISTICS OF BULK MATERIALS ON THE DESIGN OF BUCKET ELEVATORS

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1 - REFERENCES

This document forms part of document FEM 2 581 "Characteristics of bulk materials" and is associated with document FEM 2 582 "General characteristics of bulk materials with regard to their classification and to their symbolization".

The method of calculation for designing bucket elevators is dealt with in document FEM 2 122. The latter also refers to the construction and method of operation of the various types of bucket elevators. Knowledge of this document is a prerequisite for understanding the following text.

2 - OBJECT AND PURPOSE OF THIS DOCUMENT

The aim of this document is to describe the relationship between the characteristics of the bulk materials to be conveyed and the designing of a bucket elevator.

3 - GENERAL

The conveying action of a bucket elevator is influenced by the method of filling the buckets at the foot of the bucket elevator and by the method of emptying the buckets at the top of the bucket elevator. In this connection, during filling, the maximum bucket filling with the minimum loading resistance (i.e. minimum power requirements) is aimed at. Emptying must take place at the precise point prescribed for this purpose ; it should be complete and also cause little power loss.

The course of both operations is critically dependent on the characteristics of the bulk material conveyed. Therefore, when planning and designing a bucket elevator, it is necessary to harmonize the shape, the size, the pitch of the buckets and the speed of the buckets very carefully with one another and with the characteristics of the bulk materials.

It is extremely important to know the characteristics of the bulk materials, since they have a decisive influence on the design of the bucket elevator, in particular :

- the method of filling the buckets,
- the method of emptying the buckets,
- the choice of chain or belt,
- the shape of the buckets, as well as details of the bucket design and construction,
- the method of attaching the buckets to the chains or belt,

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- the speed of the buckets and, therefore, indirectly also the size of the buckets, pulleys or sprockets,
- the magnitude of the forces arising,
- the drive power required.

It is necessary that the user shall disclose to the conveyor manufacturer all the relevant information about the material to be handled of which he is aware, and that he shall also point out any items of information he suspects may be relevant the effects of which are not within the scope of his knowledge.

In conveyor engineering manuals, therefore, with reference to bucket elevators, three special items of information in relation with the bulk materials to be conveyed are to be found in most instances : the bucket shape suited to the respective bulk material, the bucket filling attainable with the respective bulk material and the conveying speed of the buckets considered appropriate for the bulk material in question. An example of these details is given in table appendix 1. The description of the bulk materials contained in tables of this type is for the most part general and is quantified in words, but not in figures.

4 - INFLUENCE OF THE CHARACTERISTICS OF THE BULK MATERIALS

The following text deals in turn with the individual characteristics of the bulk materials used in FEM 2 582 for classifying the bulk materials, in the sequence laid down there, with reference to their effects on conveying by bucket elevators.

4.1 - Name of the bulk material

The name of the bulk material to be conveyed can serve the specialist as an indication on the properties of the bulk material, particularly if he can call on earlier experience of conveying this bulk material with a bucket elevator. In most instances, however, the name of the bulk material does not suffice to give a precise description of the bulk material, since bulk materials with the same name can have completely different properties which are also determined by the origin of the bulk material, as well as by previous processing, conveying and storage processes.

4.2 - Grain size

Knowledge of the full grain size analysis (sieve analysis) of the bulk material to be conveyed is useful, while knowledge of the maximum grain size at least is necessary, since this constitutes a very decisive factor for the suitability of the bulk material for conveying by bucket elevators.

It is important for conveying by bucket elevators that the longest edge lenght L of the material to be conveyed should be considerably smaller than the bucket dimensions (one third of the bucket width for instance).

Usual limiting values for the grain size for conveying by bucket elevators are :

$L \leqslant$ 50 mm for belt and bucket elevators
$L \leqslant$ 100 mm for chain and bucket elevators (exceptionally $L \leqslant$ 200 mm)

Normally, the grain sizes of the bulk materials conveyed by bucket elevators are considerably smaller than the limiting values indicated above.

The low limiting values on belt and bucket elevators are based on the fact that the carried material can get between the belt and the drum and that on the slatted pulleys often used for this reason, the distance between the slats can not be as large as is desirable.

If foreign bodies are present, this must be stated and provision made for extracting them if necessary.

4.3 - Grain shape

Grain shapes of classes I and IV according to FEM 2 582 are generally well suited to conveying by bucket elevators. Grains shapes of classes II, III and V are also suitable, but are not quite as good, especially if L is very different from the thickness H and/or from the width B of the grain. The grain shape of class VI according to FEM 2 582 is generally ill-suited or quite unsuited to conveying by bucket elevators.

However, the classification of the grain shape in FEM 2 582 is often inadequate to describe the influence of the bulk material on conveying by bucket elevators since, for this purpose, it is in most cases important particularly on dredging type bucket elevators to know how the bulk material reacts to penetrating edges. The resistance to these penetrating edges is also determined to quite a considerable extent by the grain shape.

In the literature, grain shape factor k_f is proposed for the quantitative description of the grain shape :

$$k_f = k_1 \cdot k_2$$

From the grain size dimensions L, B and H where L > B > H, the geometrical factor k_1 can be determined as follows

$$k_1 = \frac{1}{n} \cdot \sum^{n} \frac{1}{3} \left(\frac{L}{B} + \frac{L}{H} + \frac{B}{H}\right),$$ where n is the number of random samples.

The geometrical factor k_1 has a value of 1 for bodies with the same main dimension L = B = H (e.g. for spheres or cubes) and assumes values which are the greater, the more the main dimensions L, B and H differ from one another.

The shape factor k_2 is intended to take into account the form of the edges and the nature of the surfaces of the individual grains. It is an empirical value which can be estimated, for example, on the basis of table appendix 2.

The grain shape determines to quite a considerable extent the specific dredging work of bucket elevators (specific dredging work is the work done in dredging per unit masse conveyed).

The grain shape factor k_f represents a good comparative value for determining the influence of the material conveyed on the specific dredging work for bucket elevators, which is also determined, to a considerable extent, by the conveying speed and by the relative depth of penetration of the bucket into the conveyed material to be dredged, as well as by the degree of filling of the buckets (see : Ellwanger K.D., "Factor influencing the dredging operation of high-speed bucket elevators", thesis, Hanover University, 1978).

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