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15th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2011, Prague, Czech Republic, 12-18 September 2011

ANALYSIS OF VELOCITY AND CAPACITY OF MATERIAL TRANSPORTED BY MODERN ELEVATOR

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ABSTRACT
The paper presents guidelines for designer work in the field of elevator and offers some original solutions in the field of automated calculation of modern elevator installation equipment, kinematics analysis of car door mechanism and car frame construction. Based on the analysis of previous researches in this field, considerable influence of characteristics of elevator loose material on operational velocity and capacity is noticed during vibratory elevating. Principles of loose material motion along the vibrating surface are briefly lamed in the paper. The influence of basic factors defining the operational velocity and capacity of the modern elevator is quoted. In order to determine necessary parameters, appropriate mechanical model defining the modern elevator and loose material is formed. Finally, recommendations for determination of basic parameters of modern elevator are given in order to achieve the maximal capacity that is the optimal elevating effects in general. Mathematical model, which defines system's motion, is given and experimental installation is designed.
Keywords: velocity, capacity, modern elevator, mathematical model

1. INTRODUCTION
Today's modern elevators are not fundamentally different from the Otis original. Practically all are electrically propelled and are lifted between two guide rails by steel cables that loop over a pulley device called a sheave at the top of the elevator shaft. They still employ the counterweight principle. The safety mechanism, called the overspeed governor, is an improved version of the Otis original. It uses centrifugal force that causes a system of weights to swing outward toward the rails should the car's speed exceed a certain limit. Although the travel system has changed little, its control system has been revolutionized. Speed and automation now characterize elevators, with micro-processors gradually replacing older electromechanical control systems. Speeds ranging up to 1,800 ft (550 m) per minute can be attained. Separate outer and inner doors are another essential safety feature, and most now have electrical sensors that pull the doors open if they sense something between them. Most also have telephones, alarm buttons, and emergency lighting. Escape hatches in their roofs serve both for maintenance and for emergency use[1]. This paper gives more detailed explanation of one such model that can be used for the study of the motion of loose material along a modern elevator. Quoted numerous and complex demands can not be satisfied by a single model, so, several complementary methods are offered. Numerous drawbacks were noticed in analysis of mathematical models proposed by some authors in their research in the field of vibration transportation [3].

2. MATEMATICHAL MODEL
Using the good characteristics of already existing models, a multilayer mathematical model was formed and it must satisfy following conditions:

• To enable the monitoring of dynamic state in every point of loose material,

• To treat the loose material mass as a set of finite number of masses, that is layers of equal thickness parallel to the plate, while these masses can move relatively to each other,
• Layers have inertial characteristics equal in both perpendicular directions as well as elastic characteristics regarding compression and squeeze,
• Resistance that originate from direct contact between material and working organ should be taken into consideration as well as resistances that originate from motion of loose material and parts of the modern elevator through surrounding environment, i.e. the air,
• Other forms of energy dissipation should be taken into account in order to monitor and determine energy consumption, i. e. driving-unit power, more exactly,
• To enable all influencing factors to change in broad enough diapason of values which allows the monitoring of the influence of one or more parameters of motion, while the motion of the elements of mechanical model can be described by linear differential equations.
Proposed model is more complex than previously used models, but contemporary computers provide the solution of very complex mathematical tasks set by this model. Basic characteristics of the model modern elevator are:
• Inertial properties of elevator plate and layers of material are described by masses m_0 (of the plate) and m_i (i= 1, 2... n - layers of material),
• Elastic properties of material are described by- elastic elements having stiffness coefficients c_{xi} and c_{yi} (i=1, 2... n), where the subscript denotes the (i) mass to (i-l)-mass ratio, and the superscript (x or y) denotes that the property is related to mass motion in the direction of given coordinate axle,
• Appropriate damping coefficients due to the air resistance are b_{xi} and b_{yi},
• The relations between masses, m_i and, m_{i-1} (i=l, 2, 3... n) are one-sided, i. e. in certain conditions, mass m_i can separate from mass m_{i-1},
• The connection between the plate and the foundation is achieved through elastic and damping elements and it is not separable,
• Disturbance force acts upon the plate in the direction which makes angle β with the plate surface.
Where is:
- m_0, m_i, m_{i-1}, masses,
- b_{xi} and b_{yi}, damping coefficients,
- c_{xi} and c_{yi}, stiffness coefficients.

The law of change of disturbance force can be freely chosen in analytic or in numerical form [2].
The circular motion of loose material provides that the equipment achieves real flow with only 1m^3 of given loose material.

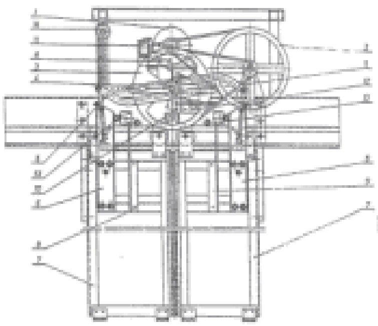

Figure 1. Door opening mechanism modern elevator

3. EXPERIMENTAL EQUIPMENT

In order to perform planned experiments, experimental equipment was designed at the laboratory of the Faculty of Mechanical Engineering in Skopje. It has been taken care of that this equipment can provide conditions for further investigations in the field of vibration transportation. All basic parameters can be changed broad enough limits. This enables the establishment of the law of velocity change of loose material as a function of different influences. The equipment has devices for circular motion of loose material, so the conditions of the experiment are close to reality. Tested structure (elevator), consists of: a modern elevator, a belt elevator, a bunker and a worm elevator. The modern elevator is designed in such a way that different tests regarding the conduct of loose material during vibration transportation can be done. The tub is leaned on supports through the plate springs, massive frame and rubber rings. Elevator sides are made of steel plates, which, depending on the choice of supports, can form the rectangular or trapezoidal tub [4]. When there is a need, steel plates can be replaced by Plexiglas plates in order to achieve the translucency. The heritage value of the Kenaston A elevator lies in the form, design and engineering and its status as one of two all steel elevators built using an experimental construction method tested by the Saskatchewan Wheat eriment to reduce maintenance costs, the Saskatchewan Wheat Pool buil only two all steel elevators. Constructed of distinctive corrugated weight-bearing steel panels, the elevator's innovative design did not need the structural framework that was necessary in most tall buildings. The twenty bins in the elevator were fully hoppered, featured an all-steel elevating leg and a steel boot tank features that were new innovations in grain elevator design in Western Canada. The elevator's steel construction gives it a unique appearance, sharply differentiating it from the wood crib country elevators which were once common in many prairie communities. Construction required the complex assembly of many number of precision-fit steel panels, and the installation of thousands of bolts and weather sealing washers. Despite difficulties, the Kenaston elevator was completed, but the loss of the experienced foreman during the construction of the Saskatoon elevator led to over-expenditures causing the Saskatoon steel elevator to be built significantly smaller.

3.1. Character Defining Elements

The heritage value of the Saskatchewan Wheat Pool Kenaston "A" Steel Grain Elevator lies in the following character-defining elements [5]:

-The width and length of the structure is narrower than wood crib elevators of similar capacity built at the time,

-The use of 676 deep-break corrugated steel panels measuring 12 feet by 4 feet that form the structure's weight-bearing walls,

-The steel bands that encircle the elevator every 4 feet to secure the steel panels in place,

-The 104,000 steel bolts used in assembly that are sealed with a plastic washer to prevent the penetration of moisture,

-The substantial steel beams over the work area that measure 36 inches high and extend the width of the structure,

-The light weight of the elevator. This 60,000 bushel structure weighs 335,000 lbs whereas a wood crib elevator of this capacity weighs 670,000 lbs,

-The all steel elevating leg and underground boot tank were new innovations in Western Canadian elevators at the time of construction,

- Trackside loading leg and overhead shipping scale, drive shed, dust collector, 57 tonne receiving scale and 70 foot unloading deck and new office,

-Those elements that contribute to the property's landmark status and its significant role in the community, including the location of the elevator, annex and office on their original site on the railway right-of-way.

Fig. 2. Bucket modern elevator

3.2. Experimental results of the velocity and capacity

Diagram in Figure 3, illustrates the variation of modern elevator's capacity in relation to layer thickness of material, for different material granulation. This means that curve Qm (h) is in the shape of parabola of the second degree, with the concave part turn downward, so the curve has its maximum. Experimental data have shown that the maximum is in area of real layer thickness of the elevator material.

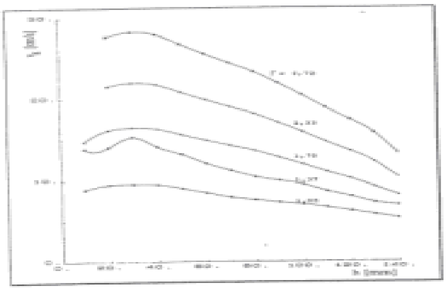

Figure 3. Dependence of the velocity

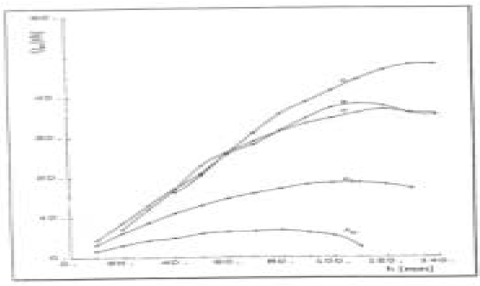

Figure 4. Dependence of the capacity Qm

Relation between velocity of the particle from the free surface, v_g, and operation regime characteristic, F, is presented in Figure 4, in the case of material B.

Analyzing the diagram, the following can be observed:

-Velocity of the particle from the free surface increases with the increase of characteristic F and decreases with the increase of the layer thickness h of the material from the tub.

- Measured velocities deviate from theoretical velocity (v_{teor}). In the area of greater values of F (in this case F >1.7) these deviations are more important and the practical velocity is, as a rule, smaller than theoretical velocity. In the area of smaller values of F ($1 \leq F \leq 1.7$) measured velocities approach the curve v_{teor}.

By further following of the dependence Qm (h), diagrams of this dependence are formed with characteristics T as parameter. Similar to previously discussed diagram, here we can notice that the capacity for given class of granulation increases with the increase of the layer thickness of the material from the tub, but it reaches its maximum for values between h=l00 mm and h=150mm, and then decreases. Obvious that capacity increases with the increase of the value of characteristic F.

4. CONCLUSIONS

Measurements have confirmed conclusions given in theoretical part. Complexity of the operation process of the modern elevator and similar devices made the question of the loose material conduct during this kind of transportation very relevant. It has been observed that the velocity of the particle from the layer of the loose material is a function of particle's position and changes by certain law. Based on experimental results, an analytical expression for the velocity change in relation to the height of the layer has been proposed [1]. The decrease of the velocity from the tub's bottom to the free surface and near the tub's sides induces the decrease of the capacity of transportation. It is possible, for previously determined allowed deviation of the capacity, to determine the smallest width of the tub by which the influence of friction between the material and the tub's sides can be neglected. Considering that the decrease of particle's mean velocity is especially distinct for greater layer thicknesses and for materials with smaller grains, the introduction of mentioned mechanical model is justified and confirmed by experimental results. Regarding the nature of change of some quantities, a high agreement between calculated and experimental results has been reached.

5. REFERENCES

[1] Anne A. F.: Elevators, Mc Grew Hill Book, New York, 1960.
[2] Gojni G.: Vertical transport, Traffic Faculty, 1990.
[3] Timošenko S. P., Jang D. H.: Vibration problems in engineering, Stanford University, New York, 1955.
[4] Hamidi B.: Design and calculation elastic and dynamic stability of light constructions, Plovdiv, 2006.
[5] Harti V., Rubinstein M.: Dynamics of structures modern elevators, New York, 1964.