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Pneumatic Suspension of Vibrating Conveyors

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Abstract. Vibratory conveyors are used especially within serial productions for the transport of diverse materials and parts for assembling. The desired oscillating movement is accomplished by electromagnetic exciting forces. The exciting force of this dynamic system actuates between the carrying element and the inertial mass. The inertial mass is fixed to the ground by an elastic constraint using a relatively stiff rubber spring. This elastic constraint ensures the conveyor's stability and defines its position towards the assembly line, but does not meet relevant effective vibration isolation demands. One possible solution would be a vibratory conveyor air suspension as is being introduced below.

Introduction

Vibratory conveyors are during the operation as a source of unfavourable vibrations, which is transmitted to the ground. The principle of the material transport depends on the right setting of the carrying element oscillation in the resonance area, where one of the natural frequencies of the system is equal to the frequency of the exciting force. The effort of the operators is to find effective vibration isolation, which reduces the vibration transmitted to the ground. The most effective solution is possible by air springs, which enables to reach a low stiffness of the connection between the conveyor and the ground. That fact is the most important requirement for good vibration isolation, because the natural frequency of the conveyor-ground-connection is much lower than the frequency of the exciting force. The article analyses the right position of the air springs and their influence on the natural frequency of the carrying element.

Current Status

There are two primary ways of constructing vibratory conveyors, based on translational or spiral motions (Fig. 1).

In this case there is the possibility to use a simple two-mass mechanical system (Fig. 1), where the mass *m3* presents the carrying element and *m2* the inertial mass. The elastic and damping constrain between both bodies is defined by leaf springs with given stiffness *k32* and damping coefficient *b32*. The connection of the inertial mass *m2* with the ground is realized with rubber springs with a given stiffness *k21* and the damping coefficient *b21*. The exciting force *F32* of the vibratory conveyor system is created using an electromagnet. As the exciting force *F32* with a frequency of 50 Hz (314 rad/s) impacts on the system, it comes to resonance oscillating on one of its natural frequency and to an oscillating movement of the carrying element.

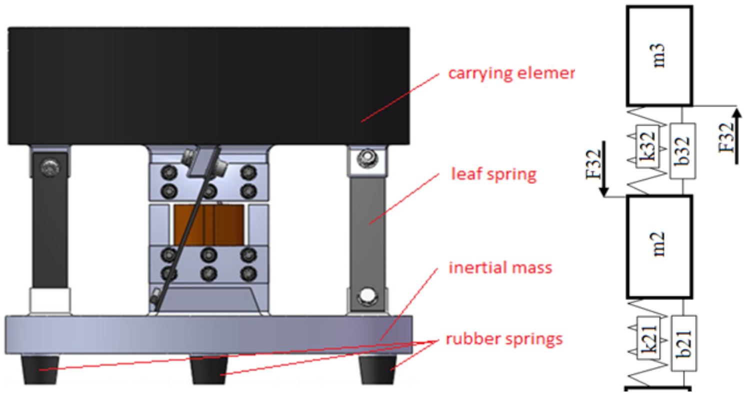

Fig. 1. Current status of the vibratory conveyor and its mechanical model.

$$m2\left(\frac{d^2}{dt^2}q21(t)\right)+b21\left(\frac{d}{dt}q2(t)\right)+k21\,q2(t)+b32\left(\frac{d}{dt}q2(t)-\left(\frac{d}{dt}q3(t)\right)\right)+k32\,(q2(t)-q3(t))=F32(t) \tag{1}$$

$$m3\left(\frac{d^2}{dt^2}q3(t)\right)+b32\left(\frac{d}{dt}q3(t)-\left(\frac{d}{dt}q2(t)\right)\right)+k32\,(q3(t)-q2(t))=-F32(t) \tag{2}$$

There are *q2* and *q3* the general coordinates of the mass *m2* and *m3*.

The solution of these differential equations in the software MAPLE 14 shows the low influence of the rubber spring stiffness *k21* on the natural frequency 314 rad/s of the system (Fig. 2).

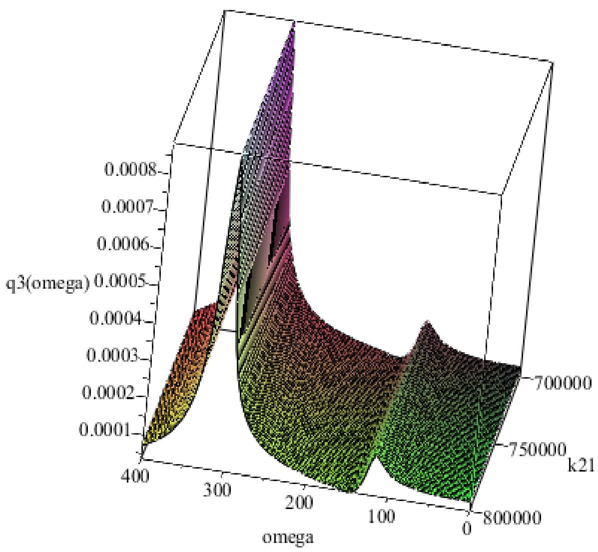

Fig. 2. Amplitude frequency characteristic of pneumatic suspended vibrating conveyor.

Pneumatic Suspension of the Conveyor

The pneumatic suspension of the vibrating conveyor is very effective for minimizing of dynamic forces that are coming from the frame of the conveyor in the floor. This fact is due to the very low stiffness of pneumatics springs. The system obtains other dynamic properties and it is necessary to provide its correct dynamic set-up.

To accomplish the required value of natural frequency 50 Hz of the dynamic system while using pneumatic suspension requires the implementation of an elastic constraint (rubber springs) between the inertial mass *m2* and the horizontal hinged platform with reduced mass *m1* (Fig. 3).

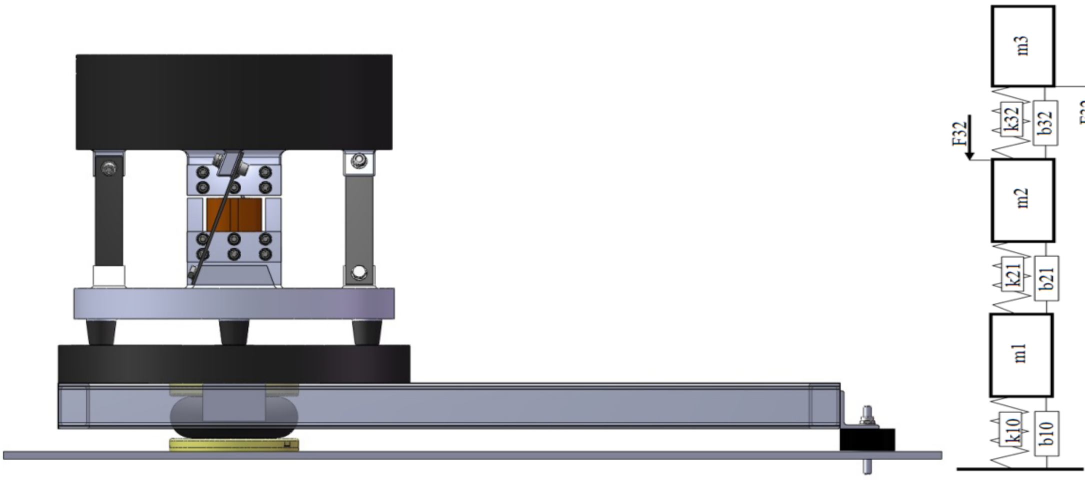

Fig. 3. Vibrating conveyor system with air spring and its mechanical model.

A dynamic triple-mass system (Fig. 3) has been invented and typical amplitude frequencies calculated in accordance to the constrain stiffness between inertial mass and ground (Fig. 4).

$$m1\left(\frac{d^2}{dt^2}q1(t)\right)+b10\left(\frac{d}{dt}q1(t)\right)+k10\,q1(t)+b21\left(\frac{d}{dt}q1(t)-\left(\frac{d}{dt}q2(t)\right)\right)+k21\,(q1(t)-q2(t))=0 \tag{3}$$

$$m2\left(\frac{d^2}{dt^2}q2(t)\right)+b21\left(\frac{d}{dt}q2(t)-\left(\frac{d}{dt}q1(t)\right)\right)+k21\,(q2(t)-q1(t))+b32\left(\frac{d}{dt}q2(t)-\left(\frac{d}{dt}q3(t)\right)\right)+k32\,(q2(t)-q3(t))=F32(t) \tag{4}$$

$$m3\left(\frac{d^2}{dt^2}q3(t)\right)+b32\left(\frac{d}{dt}q3(t)-\left(\frac{d}{dt}q2(t)\right)\right)+k32\,(q3(t)-q2(t))=-F32(t) \tag{5}$$

There are *q1*, *q2* and *q3* the general coordinates of the mass *m1*, *m2* and *m3*.

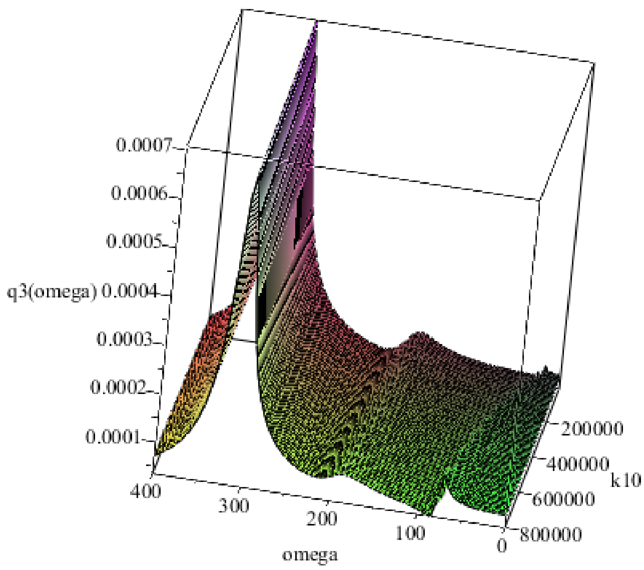

Fig. 4. Amplitude frequency characteristic of pneumatic suspended vibrating conveyor.

The solution of these differential equations in the software MAPLE 14 shows the low influence of the pneumatic spring stiffness *k10* on the natural frequency 314 rad/s of the system (Fig. 4).

The arising typical amplitude on the resonance frequency (Fig. 4) demonstrates that the invented solution is able to ensure a proper resonance oscillation of the carrying element on the one hand, and reaches an effective reduction of the transmitted vibration by using the pneumatic spring with relatively low stiffness on the other hand. This can be proved by various measurements during the working time of the conveyor see below. The acceleration $a = q3''$ measurement of the carrying element shows, that system is oscillating at its resonance frequency and that the transport efficiency won't be reduced at all (Fig. 4).

Conclusion

Pneumatic suspensions of vibratory conveyors have not only to ensure a given stiff position towards the assembly line, but are demanded to provide oscillation in the resonance frequency area of the carrying element - the most important requirement when realizing high transport performance. The typical amplitude frequency of the vibratory conveyor system shows that air suspension of a conventional conveyor depends to its settings. This means to keep the demand on the carrying element resonance oscillating. The requirement was solved by implementing a triple-mass dynamic system as any further experiments to reduce the degree of freedom and using air suspension would lead to enforced changes of the elastic constraint stiffness between both, the carrying element and the inertial mass. This would cause significant structural modifications. This solution minimizes also the transfer of dynamic forces into the floor.

References

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