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Original Research Article

Two stage vibration isolation of vibratory shake-out conveyor

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ABSTRACT

In this paper the effectiveness of two stage vibration isolation on example of a vibratory conveyor has been shown. Vibratory conveyors are used for separating the casting from the mold in foundries. In the considered case the shake-out conveyor has been supported directly on the foundation. Due to that the high amplitudes of vibrations on the foundation has been observed, which are transmitted to the building structure. To reduce the vibration transmission from the conveyor to the foundation, two-stage vibration isolation has been applied. The mathematical model of two stage vibration isolation has been shown. Based on the results of calculations, simulations and measurements a significant reduction of vibrations at the building structure has been achieved.

1. Introduction

The vibratory machines and devices are mounted in the industrial buildings directly on foundations or a metal structure supported on the ceiling. In both cases the vibration is transmitted to the foundation and the supporting structure. To reduce the transmission of vibrations from the vibrating machine to the supporting structures a proper vibration isolation will be required [1–6]. Active vibration isolation systems [7] provide sophisticated solutions for vibration problems mainly in fields of precise technologies such as metrology, optics, manufacturing etc. A multiple-degree-of-freedom active vibration isolation systems was presented in [8]. Active vibration control can also be applied in civil structures [9]. Various types of methods can be used in active vibration control, however the main limitation is the limited amplitude and frequency range of vibration [9]. Due to the operation of shake-out conveyors, high amplitudes of vibrations and forces generated by the accelerated masses, application of an active vibration isolation system is not justified. Another approach to the problem of vibration in case of heavy machinery and structures is the research of various types of passive vibration isolation systems [10].

This paper presents the theoretical background and experimental investigation results regarding the vibration isolation effects obtained by using a two-stage vibration isolation of the vibratory conveyor. Introduction of an additional, frequency tuned ballast mass to a single stage vibration isolation should decrease the vibration outside resonance frequency, resulting in a decrease of forces transmitted to the foundation of the device.

2. Description of the conveyor

Fig. 1 presents the vibratory conveyor (1), mounted to four supporting elements (4) which are fastened directly to the

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Nomenclature

a_1	vibration amplitude of mass 1 (m)
a_2	vibration amplitude of mass 2 (m)
m_1	conveyor's mass (kg)
m_2	frame mass with additional mass attached (kg)
c_1	stiffness coefficient of the conveyor support (N/m)
c_2	stiffness coefficient of the second stage of vibration isolation (N/m)
c_{rel}	relative stiffness coefficient c_2/c_1
b_1	damping coefficient of the conveyor support (Ns/m)
b_2	damping coefficient of the second stage of vibration isolation (Ns/m)
m_{rel}	relative mass coefficient m_2/m_1
F	exciting force (N)
F_0	amplitude of excitation force (N)
F_T	transmitted force (N)
ω	angular frequency (1/s)
Ω	angular frequency of exciting force (1/s)
φ	phase angle (rad)
η	ratio of frequencies Ω/ω
SSVI	single stage vibration isolation system
DSVI	double stage vibration isolation system

foundation (5) of the first floor inside the building. The conveyor is excited by a set of two rotational shafts with eccentric masses (2). Each shaft is driven by an electric motor at the rotational frequency of 25 Hz. The electrical motors are electronically synchronized in order to control the phase shift between the drives and change the impact angle of the conveyor. This frequency provides optimal conditions for castings transportation through the chute. Vibrations caused by the conveyor were measured according to the PN-90/N-01357 standard, at the base frame of the conveyor and its foundation. It was established that the vibration exceeded human perceptibility threshold value sixteen times. Such vibrations are a health hazard for people and may damage the foundation, supporting elements and building structure.

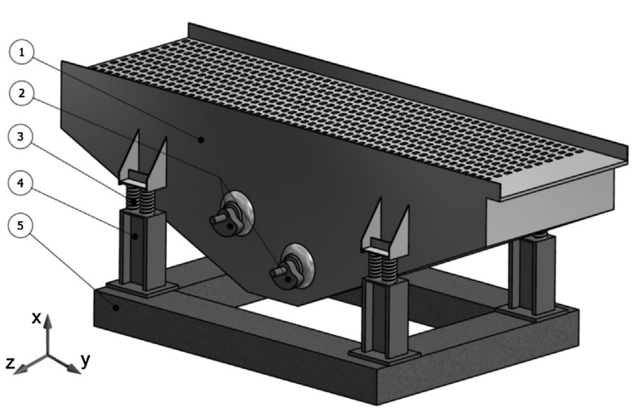

Fig. 1 – Shake out conveyor – factory setup (SSVI).

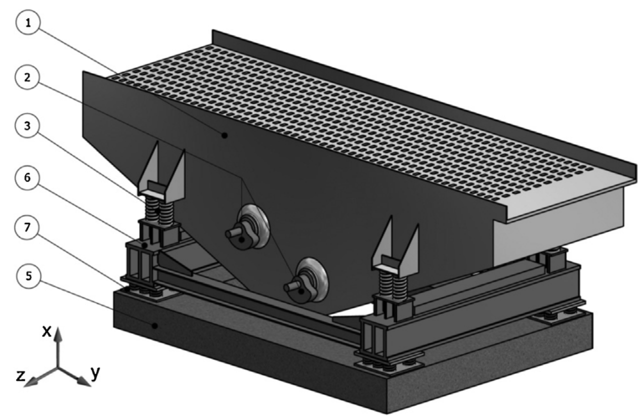

Fig. 2 – Shake out conveyor with second stage of vibration isolation. Frame supported on spring elements (DSVI).

The shake-out conveyor was connected to the mounting frame by four sets of spring elements (3), which forms the first stage of vibration isolation. After the modernization (Fig. 2) instead of rigid connection of the frame to the foundation, four additional spring elements (7) were used. Together with frame (ballast mass) (6) they form a second stage of vibration isolation.

3. Mathematical model

The scheme of the single-stage and double stage vibration isolation has been shown in Fig. 3. Mass m_1 represents conveyor's mass, c_1 is the stiffness of the system connecting conveyor to the base. The b_1 coefficient represents damping of the system. Mass m_2 is the ballast mass included into the conveyor in form of a frame, c_2 and b_2 represent stiffness and damping coefficients of implemented vibroisolators, placed between the frame and the foundation.

According to the technical data of the conveyor mass $m_1 = 11{,}000$ [kg] and $m_2 = 6600$ [kg]. The spring stiffness coefficients were set to $c_1 = 2116$ [kN/m] and $c_2 = 5500$ [kN/m].

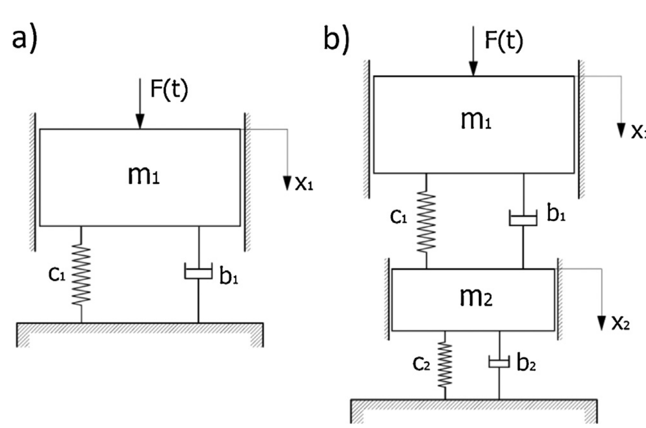

Fig. 3 – Scheme of the single-stage (SSVI) and double-stage (DSVI) conveyor's vibration isolation system.