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SELECTED ASPECTS RELATED TO THE OPERATION OF PASSENGER ELEVATORS

Key words: comfort, passenger elevators, guide shoes.

Abstract: The most common problems related to the operation of lifting devices installed both in residential and public buildings are presented in the article. Selected design solutions of lifting devices that are the most susceptible to wear and tear as well as the symptoms of that wear are analysed in the paper. The methods to observe the processes of progressing wear and tear are proposed based on conducted tests for a chosen group of elevators. The purpose is to identify emergency conditions early enough to have the possibility to reduce the time of maintenance when a device is out of service.

Wybrane zagadnienia eksploatacji dźwigów osobowych

Słowa kluczowa: komfort, dźwigi osobowe, prowadniki.

Streszczenie: W artykule zaprezentowano najczęstsze problemy eksploatacji występujące w urządzeniach dźwigowych instalowanych zarówno w obiektach mieszkalnych jak też użyteczności publicznej. Przedstawione zostały wybrane zespoły konstrukcyjne urządzeń dźwigowych które najczęściej i najszybciej ulegają procesom zużycia eksploatacyjnego, jak również symptomy ich zużycia. Na podstawie przeprowadzonych badań wybranej grupy dźwigów zaproponowano metody obserwacji postępujących procesów zużyciowych w celu wczesnej identyfikacji stanów awaryjnych i możliwości skrócenia czasu serwisu podczas którego urządzenie jest wyłączone z eksploatacji.

Introduction

The passenger elevators belong to the group of vertical transportation systems operated both in residential and public buildings. In spite of the variety of available configurations, several criteria can be used to classify those mechanisms. In relation to the type of drive system, we distinguish the elevators with the following:

– An electric drive (a hoisting winch does the work),
– A hydraulic drive (a hydraulic pump and a servo-motor do the work), and
– Other (e.g., helical drives).

Regardless of the drive type, each passenger elevator is a complex construction equipped with many mechanical, electrical, and electronic systems. When the elevators are operated, there are many side effects involved. Heat, vibrations, and noise are the accompanying processes. Vibrations and noise are particularly negative, because they have strong influence on the passengers' comfort. All unwanted accompanying processes are the source of energy dissipation. In addition, operating costs are increased in consequence. The elevator elements for which wear and tear increases and reduces the users' comfort are presented in Fig. 1. These are the following:

– The drive system (a hoisting winch) – generates noise especially when it is installed in the elevator shaft (i.e. elevators without an engine room);
– Hoisting ropes – they transmit vibrations coming from the rope pulleys, the amplitude of which depends on the rope length (a variable during the operation);
– Cabin guide shoes and counterweights – vibrations caused by the guides' irregularities are transmitted through the guide shoe system on the frame and the cabin. Additionally, the rolling bearings also can generate vibrations and noise; and,
– Cabin walls – in the case of incorrect over-rigidity, the vibrations coming from the guide shoe system make the cabin elements start to resonate.

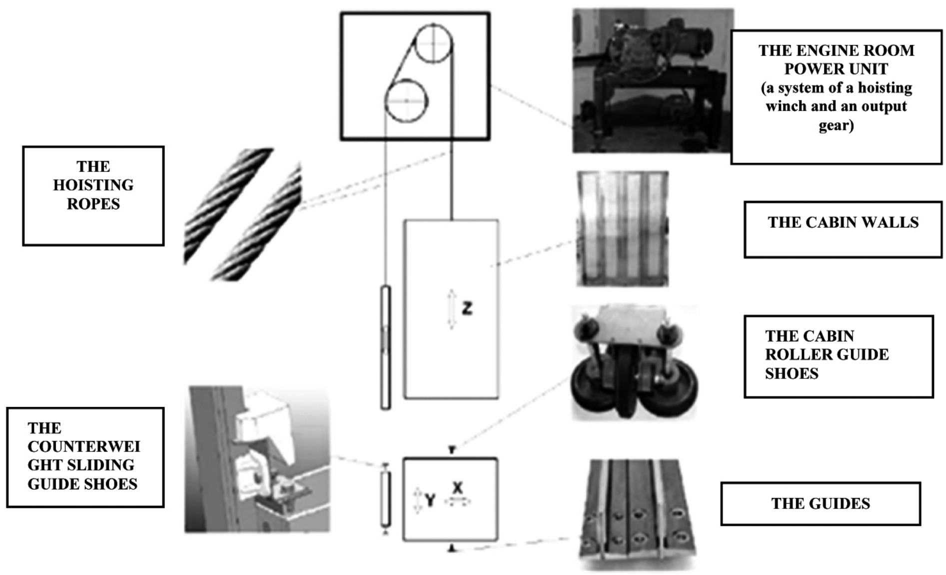


Fig.1. Elevator units susceptible to wear and tear (the individual research study)

Taking all aspects into account, most of the operating problems with an impact on comfort are caused by the suspension system of the lifting device. The suspension system consists of guides along which the guiding system moves (guide shoes). It is installed to the frame where the lift cabin is mounted. To a great extent, correct operation and comfort of travelling depend on the proper match of those elements (or their condition when operated).

In the initial stage of operation when the guiding system is brand new and adjusted in accordance with fixed conditions, the parameters that determine the feeling of comfort are at a quite high level, and the passengers recognize the devices as comfortable ones. The problem appears when the wear and tear increases. Due to the lack of specific rules concerning the frequency of maintenance and repairs during the normal operation and incorrect maintenance, the feeling of comfort may change quite rapidly within an undeterminable period of time. Among others, the time depends on the reliability of maintenance work done. The wear and tear and the increasing clearances between the guide shoes and the guides lead to the situation that when the elevator drives produce accelerations in the Z-axis caused by lift drive system (particularly during starting and stopping) and additional accelerations in X- and Y-axes caused by clearances in the guiding system. These phenomena contribute to the next consequences that deteriorate the machine technical condition. As a result, the cabin fasteners come loose. Most often, the cabin is made of metal thin-walled elements with tendency to resonate. The resonance makes the elevator's acoustic comfort worse. A great number of publications related to the passenger elevators can be found in the available literature. In publications [14, 15] the authors touch the aspects of suitable acoustic insulation, the brake system elements, and safety. Publications [9–12] bring up the evaluation of respective assemblies installed in the lifting devices. The aspects regarding the analysis of vibroacoustic phenomena in lifting devices were partially touched in the available literature. These aspects mainly refer to the following:

– The volume of vibrations and noise coming from different lifting components such as the slides rollers [1, 2, 4];
– Vibroinsulation methods for the lift doors' power drive and the selection of vibroinsulation materials [3, 5, 8]; and,
– Measuring methods and the reduction of acoustic emission in the passenger lifts cabins [6, 7].

In publication [15], the authors refer to the assessment of travelling comfort based on recorded vibroacoustic parameters. A number of publications describing the methods to evaluate the condition of lifting devices based on the signals generated by the devices are not enough.

1. Construction and different types of suspension systems installed in passenger elevators

Each suspension system installed in an elevator has a task to stabilize and counterbalance the cabin (it refers to the elevators with electrical drive) in the vertical movement (along the Z-axis) and also to transmit the loads generated by the loads located in the elevator cabin. Regardless of the guiding system type, we can divide its elements into the fixed ones and the elements integrated with the cabin frame (or counterbalance frame). The guides are the fixed elements and the guide

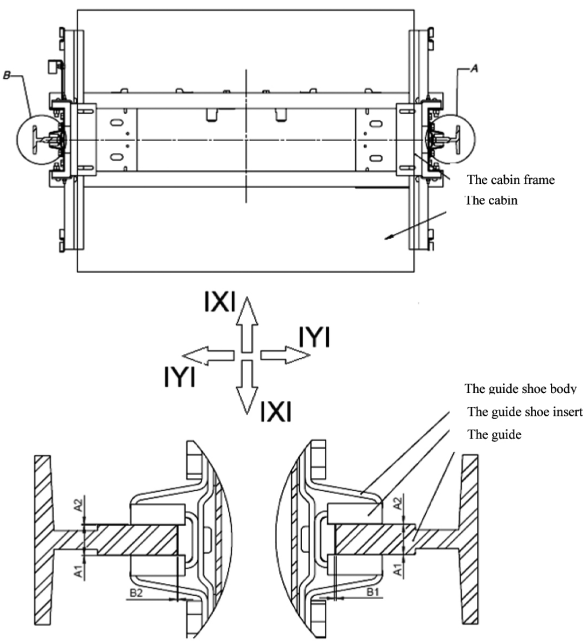


Fig. 2. Suspension system of passenger elevator with sliding guide shoes (an individual research study)

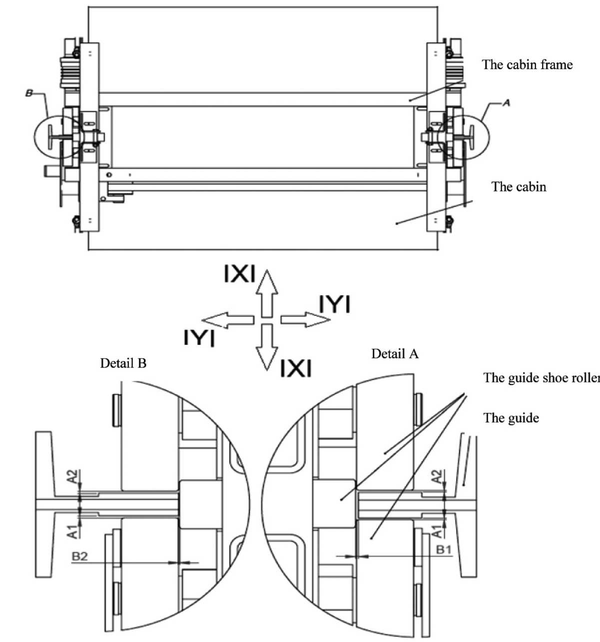


Fig. 3. Suspension system of passenger elevator with roller guide shoes (an individual research study)

shoes are the elements integrated with the cabin frame. The most common shape of the guides is the shape of a tee bar. Depending on the guide type, they can represent slight differences in geometrical dimensions. Surfaces cooperating with the guide shoe are the most important part of the guides. In a colloquial manner, the surfaces are called "a guide sting." Comfort of travelling in an elevator, to high extent, depends on the condition of the sting surface and also on the perfect alinement of all guides in the shaft. For proper machine operation, the condition and type of the suspension system are equally important. The suspension system can be divided into the following two types.

The first is a suspension system with sliding guide shoes as presented in Fig. 2. The guides require lubrication for their proper operation. Generally, the oilers with oil are located on the cabin frame,

The second type is a suspension system with roller guide shoes as presented in Fig. 3. A lubrication is not required, but these guide shoes are more susceptible to the surface condition of the guide sting.

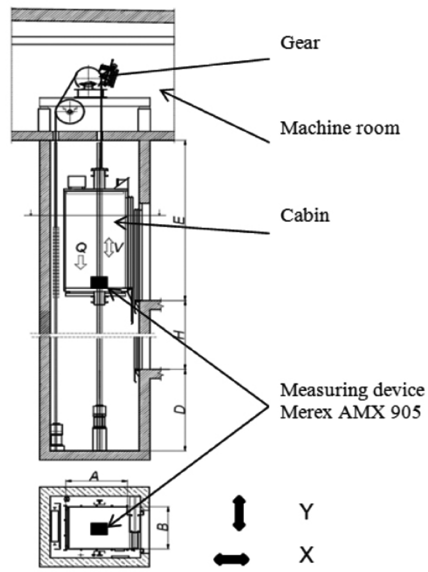
The suspension system, presented in Fig. 2, equipped with sliding guide shoes, has the clearances marked as A1, A2 and B1, B2. If the clearances are too big (not compliant with the manufacturer's recommendations), they contribute to the appearance of unwanted sideways accelerations in directions marked in Figure 2 (A1, A2- direction IXI, B1, B2 – direction IYI). Similarly to the system with sliding shoe guides, the sideways accelerations can also appear in the suspension system equipped with roller guide shoes presented in Figure 3. The only thing that differs is the mechanism of their origin. Control over accelerations in X- and Y-axes gives a reliable piece of information about the scale of clearances in the guiding system. It has a direct impact on the condition of guiding system. To make this information available, tests are needed allowing the correlation of the accelerations recorded in the cabin (or on the cabin) with the scale of clearances in the guide shoes.

2. Purpose, subject of tests and measuring equipment

The tests aimed at checking if measurements of sideways accelerations in the X- and Y-axes recorded in the passenger elevator cabin can give a dependable piece of information about the clearance volumes in the suspension system of a passenger elevator. Therefore, a rough verification of the wear and tear level could be done. Two passenger elevators were chosen to be the object of tests. The obtained parameters are presented in Table 1. Parameters characteristic of tested objects correspond to the majority of machines installed in tall residential and public buildings.

Measurements of the passenger elevator accelerations were carried out with MEREX AMX905 equipment manufactured by AUTOMEX. It is a microprocessor device. The measuring range of accelerometers is ± 10 m/s^2. The measurement resolution is ± 0.01[m/s^2]. The unit was programmed to register data with 10[Hz] frequency and the possibility to record the data in the internal device memory.

Table 1. The parameters of tested objects (an individual research study)



	The elevator 1	The elevator 2
Year of installation	2009	2012
Load capacity Q [kg]	450	
Speed V[m/s]	1.6	1.4
Height of lifting H[mm]	21000	28300
The number of stops N	7	9
The cabin depth A[mm]	1150	1180
The cabin width B[mm]	930	1050
Type of a hoist winch	a single gear hoist winch with an encoder	
Location of the machine room	At the top	
Type of the guide shoes	roller	
Construction of the cabin wall	Panel construction made of stainless steel	

3. Results

Figure 4 presents the course of accelerations in the X- and Y-axes in the form of a diagram. The accelerations were recorded during a measuring sequence (driving distance from the lowest stop to the highest one, stop, and return to the lowest stop). Both from the diagram and the measuring data obtained directly from the measuring equipment, the presence of irregular sideways accelerations can be noticed. These are unwanted phenomena contributing to the appearance of energy dissipation and the negative phenomenon of the cabin vibrations while travelling. The sideways accelerations, caused by the cabin moving along the guide, are generated by the guiding system clearance. The guiding system can be described for each axis with the use of (1) and (2) dependences, respectively. Assuming that the clearance between the guide shoes is a distance covered by the guide "from limitation to the limitation" with initial speed of 0 and the measured acceleration, the distance can be measured with dependencies (3, 4, 5). The obtained value should reflect the volume of the clearance in the guiding system.

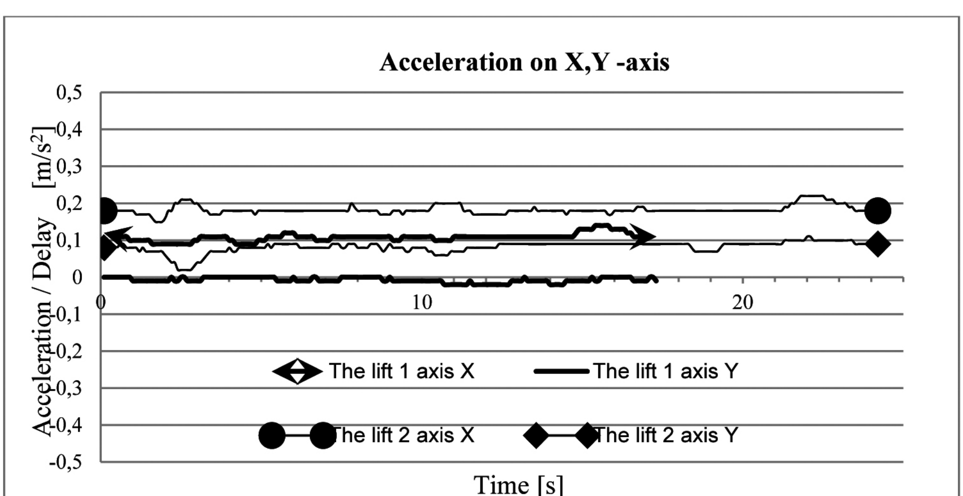


Fig. 4. Compilation of accelerations in X- and Y-axes for tested elevators (an individual research study)

$$L(Y) = B1+B2 \ [m] \quad (1)$$

$$L(X) = A1+A2 \ [m] \quad (2)$$

$$S = V_p \times t + \frac{a \times t^2}{2} \ [m] \quad (3)$$

where
S – covered distance in the measured axis (clearance of the guide shoe) [m],
Vp – initial speed (equals "0")[m/s],
t – time (from the very beginning till the acceleration ends) [s],
a – acceleration measured with an accelerometer [m/s^2].

$$S = L\ (X,Y)\ [m].$$

Table 2 presents the values of clearances for the guiding system. It is a compilation of the values calculated based on measurements done for the cabin accelerations and the values measured with a feeler gauge.

Table 2. A comparison of clearances calculated with those measured directly

	The elevator 1		The elevator 2	
Measured value	Calculated clearance [mm]	Measured clearance [mm]	Calculated clearance [mm]	Measured clearance [mm]
L(X)	0.45	0.5	1.2	1.4
L(Y)	0.0	1	1.3	1.4

Table 2 shows that the volumes of measured clearances are similar to the volumes of clearances received in the calculations based on accelerations parameters measured in the X- and Y-axes. Thus, it can be stated that the method used to measure the parameters of "sideways" accelerations in the X- and Y-axes as data necessary to evaluate the condition of the suspension system is able to give useful results.

Conclusions

Based on conducted experimental tests the following can be stated:

– Accelerations in the axis different from the axis of motion of the elevator cabin, driven by the power system, are a form of energy dissipation increasing the energy consumption of the whole machine and decreasing the comfort of travelling.
– Clearances in the elevator suspension system contribute to the appearance of sideways accelerations experienced by the passenger. They are perceived as vibrations of the cabin and progress together with a degree of the wear and tear of guide shoes.
– Recording the sideways accelerations present in the elevator cabin can provide information about the increase or the volume of clearances existing between the guide and the guide shoe. In addition, it can be referred to the level of wear and tear of the elevator suspension system.

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