HEAVY MACHINERY - HM 2011, 111-116
ISBN 978-86-82631-58-3 Paper accepted: 30.05.2011

Special Design Of Freight Elevator With Diagonal Guiding And Instantaneous Type Eccentric Safety Gear

Mile Savković[1,]*- Milomir Gašić[1] - Nebojša Zdravković[1] - Goran Marković[1]
[1]University of Kragujevac, Faculty of Mechanical Engineering Kraljevo

The paper presents special design of freight elevator, customized to the particular characteristics of the embedding space and user requirements. Forklift three-sided access during operation is achieved by diagonal guiding concept of the elevator car along channel guides by means of cylindrical and tapered wheels. This guiding concept has imposed special design of car frame, which is made of two X-frames connected by columns. The instantaneous type eccentric safety gear is applied. Self-locking condition is ensured due to the existence of teeth on the eccentric disc.

Keywords: freight elevator, diagonal guiding, eccentric instantaneous safety gear

1 INTRODUCTION

Elevator, as typical example of mechatronic machine (mechanical electronically controlled executive), is inevitable part of modern multistorey buildings and make their exploatation pratictal and economic. Generally, elevators are hoists with periodical action that lift people and/or freight in a car upward and downward in such way that the car moves along rigid parallel guides, with maximum vertical inclination of 15° [1].

For lower lifting heights, hydrocylinders can be used for drive, while for higher lifting heights (few tenths of meters) traction system with the suspension cable and drum or pulley operated by an electric motor is used (Fig. 1).

Fig. 1. The most common elevator drive types
a) pushing up from below by hydrocylinders
b) pulling up from above by electric drive and traction cables

Common concept of an electric drive elevator for higher lifting heights is shown in Fig. 2. During designing new multistorey architectural objects, a separate space for elevator shaft, machine room and pit must be considered. Also, each storey level must have a slot for an elevator entrance. Besides, basic parameters, such as load capacity and rated speed, are to be defined in very early phase of building planning, in order to properly calculate space and support structures. In other words, with these predefined conditions in new objects, elevator design is very much reduced to combination and selection of existing standardized subassemblies and components out of assortment of numerous elevator equipment manufacturers.

On the other hand, within embedding into already built objects, in which no particular space is predefined for elevator operating purposes, it is very often the case that designer is forced to deviate from typical solutions and find a customized solution, usually only possible, according to situation. This kind of situation was handled in the case of customer requirements for designing, manufacturing and installing the freight elevator for overhaul purposes in existing industrial multistorey crushing mill facility Drmno in Kostolac, Serbia. Figure 3 shows the model of the facility building section where freight elevator was intended to be installed.

The building has five storeys, with a slot in each one, framed by steel columns and reinforcement girders. Storey slots cuold not be

*Corr. Author’s Adress: Faculty of Mechanical Engineering Kraljevo, Dositejeva 19, Kraljevo, Serbia, savkovic.m@mfkv.kg.ac.rs

cosidered as common elevator shaft with concrete walls, which makes elevator car guiding more difficult. Transportation of overhauled equipment need to be carried out from fourth storey and ground floor and vice versa. Additionally, user required that elevator loading and unloading had to be done by forklifts, through three-sided access, in order to achieve easier manipulation of freight. The lifting height is 16m, and the load capacity is 8 t. Maximum dimensions of the elevator car are limited by embedding space. Figures 4 and 5 are photos of workspace for this freight elevator.

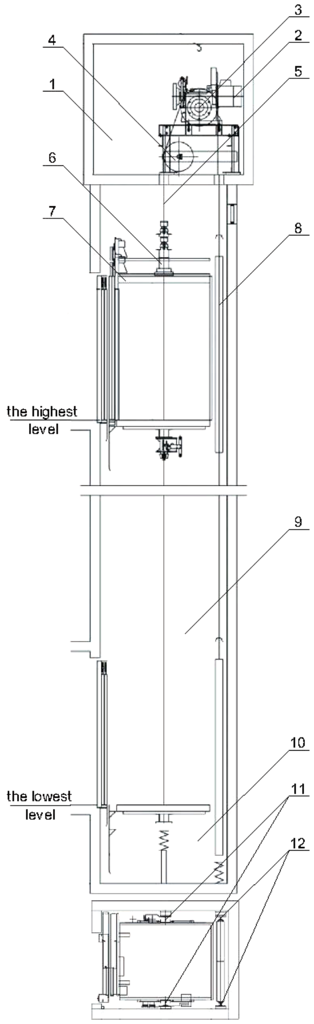

Fig. 2. Common concept of an electrical elevator 1-machine room, 2-electric motor, 3-drive pulley 4-auxiliary pulley, 5-traction cable, 6-suspension assembly, 7-car, 8-counterweight, 9-elevator shaft, 10-pit, 11-car guide rails, 12- counterweight guide rails

The concentration of particles and coal dust is increased in operating ambient air, due to the nature of coal crushing process.

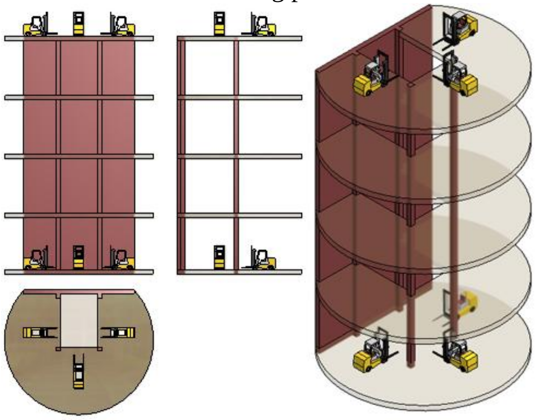

Fig. 3. Model of the facility building section with enforced storey slots

Fig. 4. Elevator embedment space - bottom view

Fig. 5. Elevator embedment space - top view

2 FREIGHT ELEVATOR DESIGN

2.1. Car Guiding

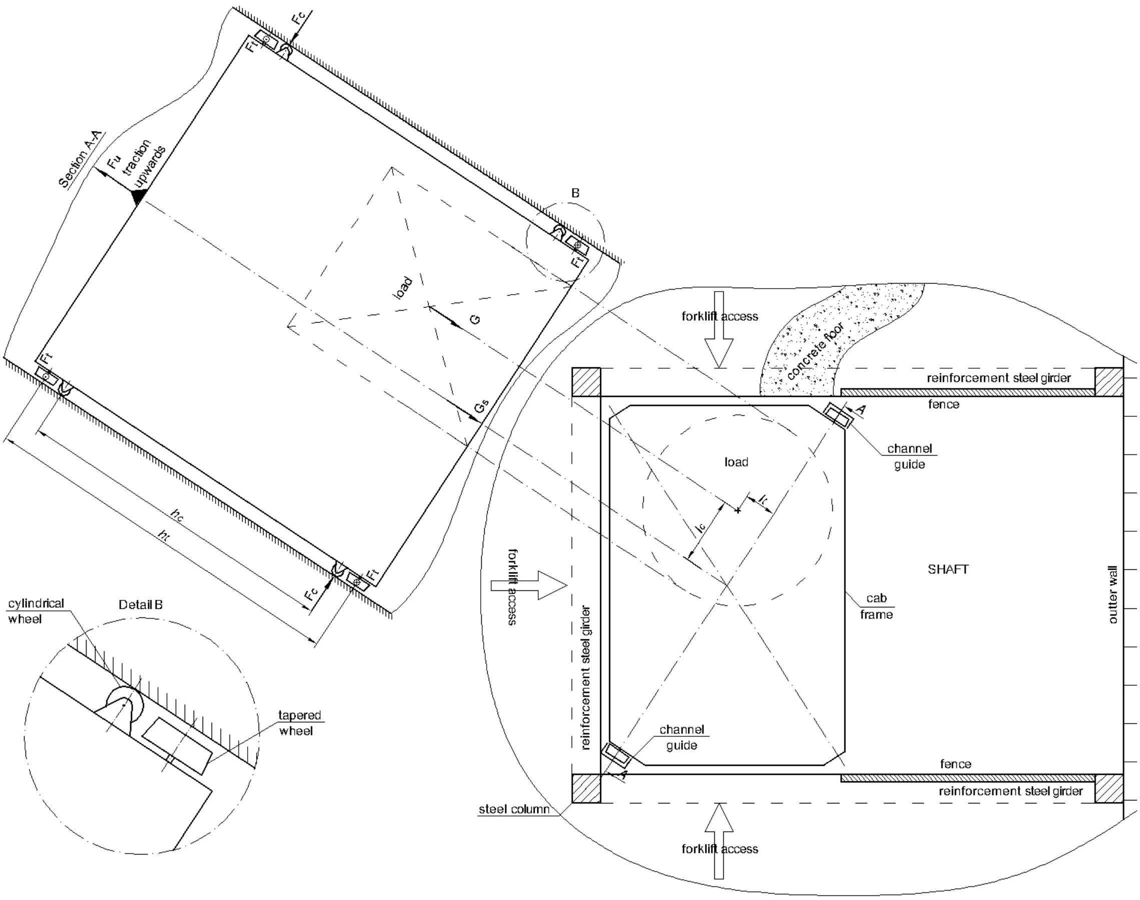

Fig. 6. Car guiding concept

Car guiding concept which meets user requirements and installing conditions is shown in figure 6.

In order to ensure three-sided forklift acces to the elevator car, the elevator car guiding was solved diagonally relative to the car frame by means of two pairs of tapered and two pairs of cylindrical guiding wheels and channel rails as guides. Cylindrical guiding wheels roll on the channel web and tapered ones roll on inner side of flanges. The channel guides are bolted via flange plates to the horizontal steel girders incorparated in concrete storey floors.

According to figure 6, eccentricity of load weight relative to the traction axis makes following forces onto the cylindrical and tapered guide wheels:

$$F_c = G\frac{l_c}{h_c} \quad (1)$$

$$F_t = G\frac{l_t}{2h_t} \quad (2)$$

Figure 7 shows realized design of the freight elevator car frame. The car frame 1 is welded structure made of standard steel shapes and plates. It consists of upper and lower X-frame, connected by columns. Suspension assembly carries the car frame through contact area on bottom side of the upper X-frame. Traction rope and suspension frame are connected by pulley. Both upper zones of car frame are equipped with eccentric safety gears 3.

Subassemblies of cylindrical and tapered guide wheels, 4 and 5, are mounted to the car frame by bolted connection and flange plates.

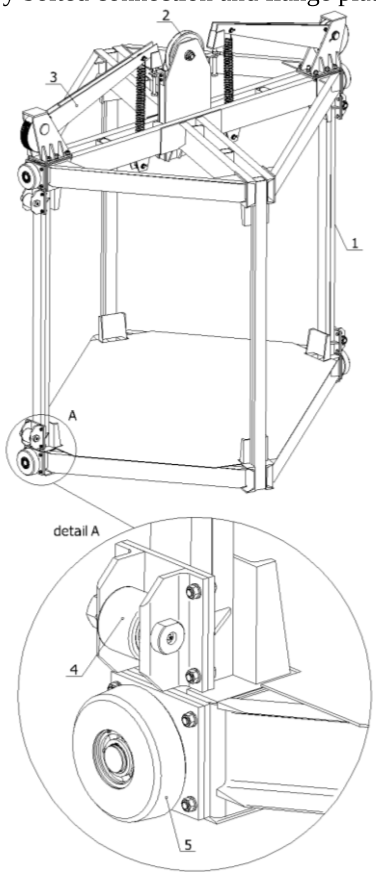

Fig. 7. Car design with guiding wheels detail 1-car frame, 2-suspension assembly, 3-eccentric safety gear, 4- cylindrical guiding wheel, 5-tapered guiding wheel

2.2. Eccentric Safety Gear

Elevator car must be equipped with safety gear, e.g. gripping device for stopping, and maintaining stationary on the guides the elevator car in case of over speeding in the downward direction or breaking of the suspension ropes [2]. In other words, every elevator cab has a clamping device that is activated if downward speed of the cab reaches certain limit [3].

The functions of the guide rails are to [4]:

(a) guide the car and counterweight in their vertical travel by controlling horizontal movement,

(b) prevent tilting of the car under eccentric loads,

(c) stop and restrain the car when safety gear is applied.

In relation to elevator rated speed as well as to the way of acting, there are three types of safety gear: instantaneous type safety gear, instantaneous type with damping effect safety gear and progressive type safety gear. Instantaneous type safety gear is used for rated speeds less or equal to 0,63 m/s and it can be with wedge, balls, rollers or eccentricity [1].

Figure 8 shows applied design solution of an eccentric safety gear, attached on upper side of car frame. Executive part is eccentric disc with small teeth 1, which rotates about pin 2. The pin accomplishes the joint connection between eccentric disc and shoulder frame 3, which is mounted by bolts 4 to the welded structure of car frame. An arm 5 is firmly fixed to the eccentric disc. Tension spring 6 is strained while arm is rotating by tightening the adjusting screw 7.

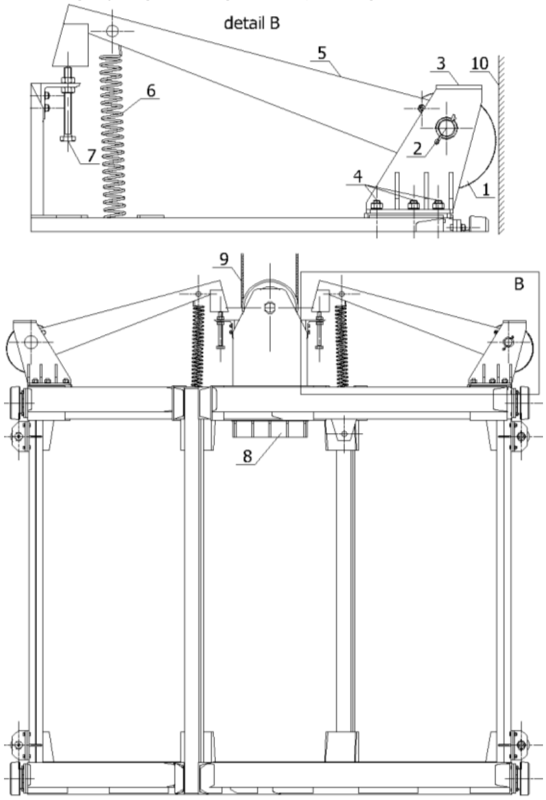

Fig. 8. Special design of eccentric safety gear 1-eccentric disc with teeth, 2-pin, 3-shoulder, 4-bolted connection, 5-arm, 6-tension spring, 7-adjusting screw8-suspension assembly, 9-suspension cable, 10-guide channel

During normal working regime, safety gear is unblocked because of gap existing between eccentric disc teeth 1 and guide channels 10. The arm is rested on the adjusting screw, which is a part of the suspension assembly with pulley 8. Suspension cable 9 is bent around the pulley. In case of suspension ropes breakdown or some other reason for loss of the suspension force, suspension assembly 8 with adjusting screw 7 fall downwards on the top of the car frame. The arm 5 loses its support and, forced by tension spring, rotates altogether with eccentric disc 1 about pin 2. The eccentric disc teeth approach and make contact with guide channels and embed into the channel material and so stop the car moving downwards. Condition for contact realization between eccentric disc and guides is (figure 9):

$$e \cdot \sin\varphi = \Delta \tag{3}$$

where

e - rotation pole eccentricity in relation to center of the disc,

φ - safety gear rotation angle at realized contact,

Δ - starting distance between the disc and the channel guide.

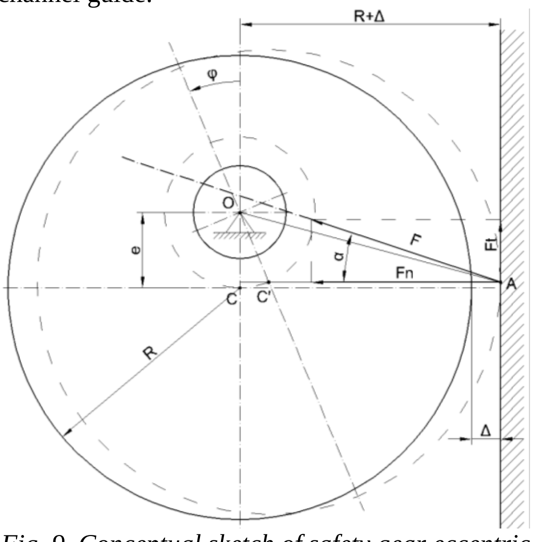

Fig. 9. Conceptual sketch of safety gear eccentric disc

The contact is being established in point A where perpendicular force Fn and tangent force Ft occur:

$$F_t = \mu \cdot F_n \tag{4}$$

where μ stands for friction coefficient.

In order to fulfil self-locking condition, the resultant of Fn and Ft must make such moment in relation to rotation pole O that additionaly pushes eccentric disc towards channel guide. Mathematical formulation of this condition is:

$$tg\alpha > \frac{e \cdot \cos\varphi}{R + e \cdot \sin\varphi} \tag{5}$$

Considering equation (5) and following expression

$$tg\alpha = \frac{Ft}{Fn} = \mu \tag{6}$$

it is obtained

$$\mu > \frac{e \cdot \cos\varphi}{R + \Delta} \tag{7}$$

After trigonometry transformation, final expression for self-locking condition is:

$$\mu > \frac{\sqrt{e^2 - \Delta^2}}{R + \Delta} \tag{8}$$

As elevator stops, direction of resultant F goes through rotation pole O. The values of friction force and perpendicular force are:

$$F_t = \frac{G + G_s}{2} \tag{9}$$

$$F_n = \frac{R + \Delta}{\sqrt{e^2 - \Delta^2}} \cdot \frac{G + G_s}{2} \tag{10}$$

where: G - load weight , G_s - self-weight.

2.3. Freight Elevator Drive

Freight elevator drive is shown in fig. 10.

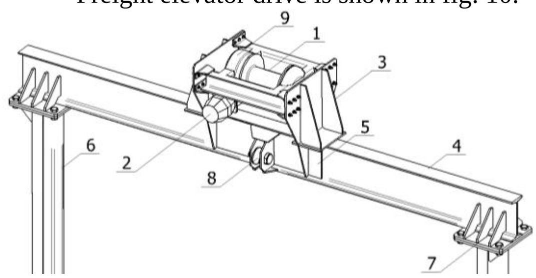

Fig. 10. Freight elevator drive
1-drum, 2-hydromotor, 3-drum frame,
4-top girder, 5-girder reinforcement, 6-guide channels, 7-bolted connection,
8-anchor point, 9-worm gear

The traction of the freight elevator is done by cable reeving on the drive drum 1, which is connected to hydromotor 2 via worm gear 9. Drive drum and hydromotor have own frame 3, which is welded to the girder 4. The girder is I-section beam, reinforced with steel plates 5 in the middle. It is placed at top of the elevator shaft and connected by bolts 7 to the end guide channels 6. Free end of cable is fixed to anchor point 8.

Hydromotor gets power from hydraulic set which is placed beside top girder, on highest storey floor. Hydraulic installation layout is shown in figure 11.

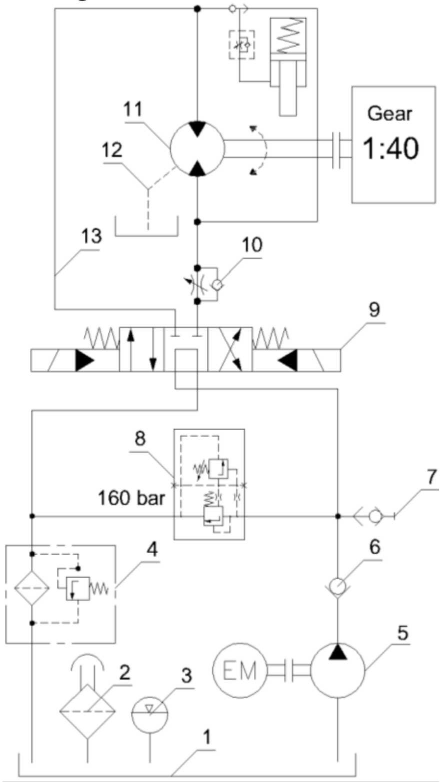

Fig. 11. Hydraulic installation layout
1-oil tank, 2-instil with vent, 3-level indicator, 4-filter, 5-oil gear pump, 6-blocking valve, 7-measuring port, 8-relief valve, 9-slide valve, 10-throttle-blocking valve, 11-hydromotor, 12,13-pipelines

3 CONCLUSION

The features of people and freight vertical transportation as well as the numerous embeddings of freight and passenger elevators in new multistory residential and industrial objects, made this type of hoists design most automated and reduced it to a procedural calculation and selecting standardized subassemblies and parts. Purpose, type, rated load and elevator embedding space which consists of elevator shaft and machine room if existing, are defined in the early phase of construction plan development. Yet, sometimes occures that customer requirements are such that elevator design must have particularities which, more or less, sort it out from common concepts. This paper presents one such freight elevator construction with diagonal guiding concept and eccentric instantaneous safety gear, designed to meet specific exploatation and embedding requirements

4 REFERENCES

[1] Tošić, S. “Liftovi”, Mašinski fakultet, Univerzitet u Beogradu, 2004
[2] Ostrić D. “Dizalice”, Mašinski fakultet, Univerzitet u Beogradu, 2004
[3] Menjić, M., Tošić, S., Bošnjak, S., Vasiljević, N. “Contribution to the solving of problem of noise and vibrations transfer of the personal elevator’s rail and cabin vibrations by using the elastic supports”, XIV International Conference on Material Handling and Warehousing, Faculty of Mechanical Engineering in Belgrade, 1996
[4] Bangash M.Y.H., Bangash T. “Lifts, elevators, escalators and moving walkways/travelators”, Taylor & Francis e-Library, 2007, ISBN 0-203-02076-6
[5] Галиченко, А.Н., Гехт А.Х. “Строителъные подъемники”, Высшая школа, Москва, 1984
[6] Волков, Д.П., Ионов, А.А., Чутчиков, П.И. “Атлас конструкций лифтов”, Машиностроение, Москва, 1984
[7] New Orona TDS, Technical Catalogue
[8] Schindler Freight and Special Elevators, Technical documentation, Schindler lift Ltd.

ACKNOWLEDGMENT

A part of this work is a contribution to the Ministry of Science and Technological Development of Serbia funded Project TR35038