Advances in Science and Technology Research Journal
Volume 8, No. 21, March 2014, pp. 73–77
DOI: 10.5604/20804075.1091882

Research Article

SELECTED PARAMETERS OF THE WORK OF SPEED LIMITER IN LINE STRAINING SYSTEM IN A FRICTIONAL LIFT

Paweł Lonkwic[1], Kamil Szydło[1]

[1] Lublin Factory of Personal Lifts LIFT SERVICE S.A., Roztocze 6, 20-722 Lublin, Poland, e-mail: pawel.lonkwic@lift.pl

Received: 2014.01.17
Accepted: 2014.02.06
Published: 2014.03.05

ABSTRACT
The article presents the analysis of selected work parameters of speed limiter in line straining system. We analyzed the effect of changing the geometrical conditions of the new solution for the speed limiter in line straining system upon the working conditions in frictional lift braking system. Within the conducted simulations of the work of the system, which is responsible for lift braking with a tension with spring, a test bed was prepared, which simulated the work of tension-rope-limiter system. The tests were performed in the conditions reflecting the work of a lifting appliance. Analyzing the results obtained through empirical calculations, we can conclude that there is a possibility of applying the spring to eliminate the weight.

Key words: frictional lift, speed limiter, weight.

INTRODUCTION

According to the standard [7], the frictional lift car must be immobilized in case of exceeding its velocity by 0,3 m/s of the nominal velocity or breaking all the carrying strings. The main appliances protecting from uncontrolled increase of car velocity are: catchers and a speed limiter [6].

To examine if the braking system works correctly before it is admitted for operation the tests of braking system are performed by enforcing velocity increase by means of controlling system, and thus it is checked if the braking system works correctly. Such a test is performed with the nominal lifting capacity with the load increased by 125% of the lifting capacity. The braking system consists of a speed limiter, brakes (here called: catchers), tension and steel rope clamping all the above–mentioned sub-assemblies. The speed limiter is placed in the highest position of the lift shaft or in the engine room, placed over the lift shaft and it is an appliance controlling the speed of lift car movement. It consists of a cast iron wheel with an indented rope groove, the geometry of which is within the standard [7].

The line trims the speed limiter wheel by the angle of 180 degrees. Inside its structure the wheel has a system of latches, released by the centrifugal force. When the speed is exceeded, the speed limiter wheel revolves faster than the nominal speed, causing the latches to spread outside. The latches pulled apart like that wedge by the line wheel hollows, causing its blocking. The shape of groove and coefficient of friction between the steel rope and cast iron wheel stop the rope. A thorough kinematical analysis of steel limiter work was contained in [4]. It is the tension that is responsible for achieving appropriate friction of the rope on seed limiter wheel. It is supposed to generate the voltage in the rope of the value set by manufacturer of the brakes. The value of rope tension force is closely connected to the friction forces generated on the speed limiter wheel. To secure the speed limiter line tension and not to interfere with the remaining movable elements of the lift, the tension is placed in the lowest point of the lift shaft, which is shown in Figure 1.

In Figures 2 and 3 typical speed limiter (Figure 2) and tension (Figure 3) were shown.

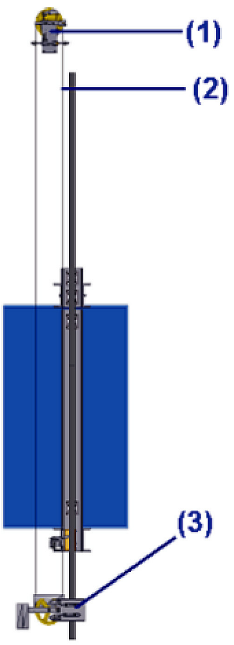

Fig. 1. Position of braking system of a frictional lift: 1 – speed limiter, 2 – speed limiter rope, 3 – tension [1]

Fig. 2. Typical frictional lift speed limiter [2, 3]

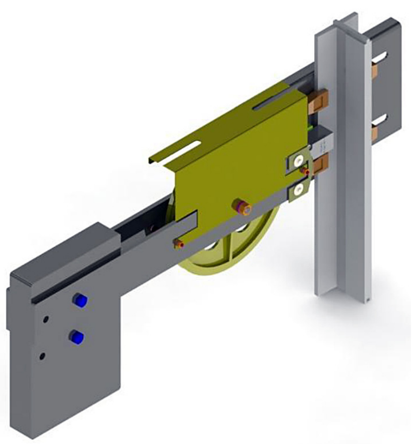

Fig. 3. Typical frictional lift tension [2]

NEW CONCEPT OF ROPE STRAINING METHOD

The main purpose of developing a new solution of tension was a maximum decrease of space available for tension fittings, which is connected with the obligatory trends in construction industry. Another purpose was to minimize the costs of manufacturing the product and improve the ergonomics of the assembly, which was connected with decreasing weight of the appliance by ca. 20 kg.

View of the tension with straining string was shown in Figure 4.

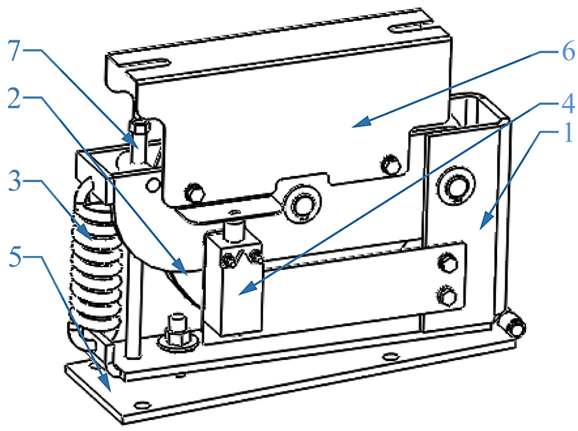

Fig. 4..New solution of frictional lift tension

The appliance consists of body 1, rope pulley 2, spring 3, tension screw 7 and electric connector 4. It is fastened to a base by means of the mount 5. The rope pulley 2 has got a shield 6, protecting from foreign matters permeating between the speed limiter rope and the rope pulley during work. The electric connector 4 is an element of safety circuit of the whole lifting appliance. The spring characterization in the suggested solution was selected so as the rope tension during the normal work of the appliance caused friction force between the speed limiter wheel and appropriate rope for catchers.

To eliminate all the tension structure defects, in the first phase of prototyping model #D was made, with simultaneous analysis of structure kinematical relationships. Structure optimization was performed on the basis of 3D model digitization and then MES simulation. The final stage of designing required calculations checking the correctness on the basis of standard records [3].

ALGORITHM OF SELECTING THE APPROPRIATE WAY OF ROPE STRAINING

The correctly selected braking system should be able to stop the car in motion, loaded with 125% of the nominal weighing capacity. To make it happen, the lift catchers must be selected proportionally to the loading and the tension and the speed limiter must meet the following conditions [7]:

- The tension must strain the limiter rope so as the force needed to make the brakes work do not cause rope friction loss. On the blocked speed limiter wheel. The minimum rope tension force is given by the manufacturer of speed limiter.
- The maximum forces generated in the speed limiter rope must be at least 8 times lower than the force that breaks the rope (specified by manufacturer of the rope).

In the classic solution, with the tension, the rope straining force G_n is the resultant of the force coming from tension G_o, working on arm R. In the solution with the application of straining spring straining force G_n is the resultant of force G_s coming from the stretched spring working on arm R. For that purpose we prepared the characterization of the spring, which is shown in Figure 5.

Considering the application of the spring in structure of the tension, it is justifiable to check what value of stretching force affects the rope. Using the above characterization and geometrical relationships of the braking system shown in Figure 6, we juxtaposed the characteristic working parameters for both types of tensions in Table 1.

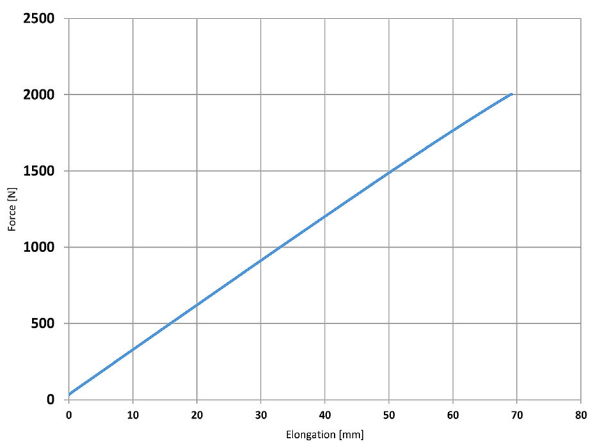

Fig. 5. Characterization of tension spring applied in the tension, drawn up on the basis of data obtained from the testing machine

Weight of the rope resulting from lifting height can be calculated from the relationship (1):

$$Q_l = g \cdot q_l \cdot H \text{ [N]} \quad (1)$$

where:
g – gravity force [m/s²],
q_l – rope unit mass [kg/m],
H – distance between limiter wheel and tension pulley (wheel) calculated from formula [m]:

$$H = H_p + H_n + H_d \text{ [m]} \quad (2)$$

where:
H_p – lifting height [m],
H_n – shaft top height [m],
H_d – shaft bottom height [m],

The stretching force in the rope for the tension with a weight can be expressed by means of an empirical relationship (3), and for the tension with a spring-by means of a relationship (4)

$$Gn = g \cdot [(\frac{R}{r} \cdot G_o) + ((0{,}5 \cdot \frac{R}{r}) \cdot G_r) + G_k] \text{ [N]} \quad (3)$$

$$Gns = g \cdot [(\frac{R}{r} \cdot Gs) + ((0{,}5 \cdot \frac{R}{r}) \cdot G_r) + G_k] \text{ [N]} \quad (4)$$

where:
G_r – weight of the tension arm [kg],
G_k – weight of the tension wheel [kg].

On the basis of relationships (3) and (4) speed limiter rope safety coefficient should be calculated, initially calculating the biggest force occur-

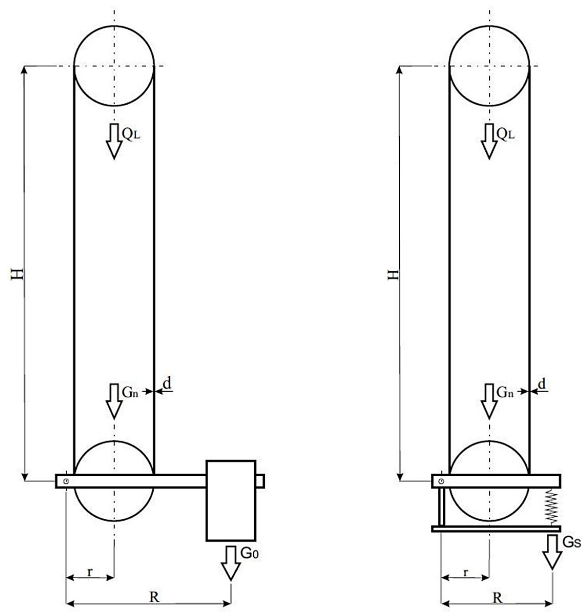

Fig. 6. Geometry of braking system in a frictional lift: R – length of the arm of the effect of force exerted by tension Go (spring Gs) [m], r – length of the arm of the effect of straining force Gn [m],Go – weight of the tension [kg], d – diameter of limiter rope [m], Q_l – weight of the rope resulting from lifting height [kg]

ring in the rope for the considered system, which can be described in relationship (5):

$$S = \left(\frac{G_n}{2} + Q_l\right) \cdot e^{\sin \frac{\mu_o}{\frac{\gamma_o}{2}}} \quad (5)$$

where:
F_z – minimum breaking force in the rope (rope manufacturer's data) [N],

On the basis of mathematical relationships (3), (4) and (5), the values of speed limiter rope safety coefficients must be calculated for both types of the tensions, which is expressed by formula (6):

$$k_{bo} = \frac{F_z}{S} \geq 8 \quad (6)$$

where:
S – the highest force in the rope.

Using the above empirical relationships and catalog charts of the manufacturers of catchers and steel ropes, in Table 1 we have collected the data for a model of frictional lift for the most unfavorable configuration, which is with lifting height H_p of 70 m. In order to perform comparative calculations we have used the characterization chart of speed limiter LK250 manufactured by P.F.B. S.r.l., Italy, for which the nominal rope straining force is G_n = 1020 [N]. The rope was selected on the basis of data contained in the technical charts by BRUGG. For experimental purposes we selected a rope of the structure 8.0 6x19S.

On the basis of relationships described above, in Table 2 we collected values calculated on the basis of data presented in Table 1.

Table 1. Geometrical parameters of the tensions juxtaposed on the basis of the performed project

Factor		Tension with weight	Tension with spring
G_o [kg]	G_s [kg]	22	48
R [m]		0.480	0.265
r [m]		0.114	0.115
G_k [kg]		0.5	
G_r [kg]		6	2
d [m]		0.08	
q_1 [kg/m]		0.25	
F_z [kN]		37.4	
μ_o		0.2	
γ_o [°]		40	
H_p [m]		70	
H_n [m]		3.6	
H_d [m]		1.4	

Table 2. Values of tension parameters obtained by means of empirical calculations

Specification	Tension with weight	Tension with spring
Rope weight resulting from the considered lifting height [N], relationship (1)	184	184
Strain force in rope [N], relationship (3) and (4)	1050	1130
Maximum force in rope [N], relationship (5)	4451	4789
Rope safety coefficient [-], relationship (6)	8.4	8

While the system of the tension with weight is simple to estimate the straining force value in the rope, however, the system with spring requires additional characterization analysis. To estimate the straining force value in the rope larger than that recommended by the manufacturer of speed limiter (in the discussed case: 1020 N), the force in spring should be selected so as the scope of minimum and maximum forces was on one hand larger than the recommended value of 1020 N, and on the other the value of safety coefficient was not higher than 8.

On the basis of the above records, as well as the conditions given in the introduction to point 3 of this study, in the Figure 7 we presented a fragment of characterization of a selected spring, taking into consideration the increased spring elongation, which shows the range of spring work where two conditions described above are met at the same time.

Within the conducted simulations of the work of the system, which is responsible for lift braking with a tension with spring, a test bed was prepared, which simulated the work of tension-

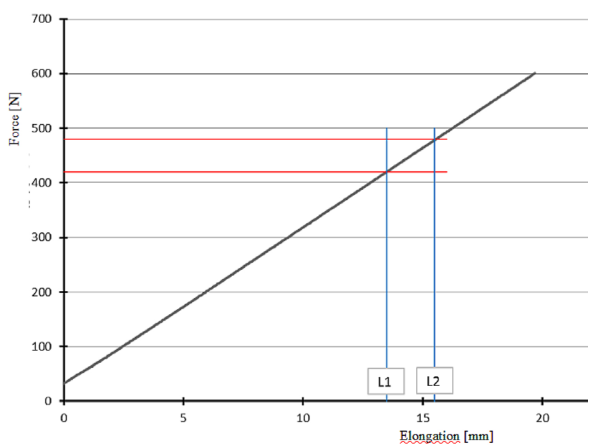

Fig. 7. Fragment of the characterization of spring for the case under discussion

rope-limiter system. The tests were performed in the conditions reflecting the work of a lifting appliance. The tests were performed within 1 year, what was presented in Figure 8.

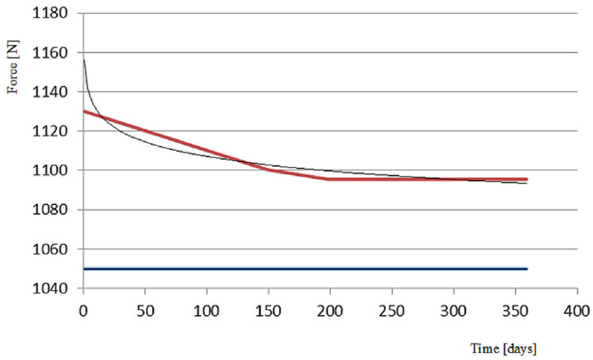

Fig. 8. Value of straining force Gn depending on time for the test performed within the period of 356 days: red line – tension with spring, blue line – tension with weight

Analyzing the above graph, we can notice that during testing in the whole period the spring characterization did not manifest losses of its properties, and at the same time, the value of straining force for the new tension solution did not fall below the value of 1020 N. in the initial testing period there was a visible decrease of straining force value from 1130 N to 1090 N, what is presented in drawing 8. That is caused by elongation of the new rope. This situation, stabilizing after about 200 days (for the conditions of experiment), and the rope tension reaches the value of 1090 N, which remained constant until the end of the experiment.

CONCLUSIONS

The conducted experimental studies and empirical calculations allow for the formulation of the following final conclusions:

- The presented initial studies on the application of tension with spring do not exhaust the subject matter. Subsequently, the dynamic studies should be performed to would take into account sudden impulses of force resulting from the work of lift system as a result of sudden braking.
- Analyzing the results obtained through empirical calculations, we can conclude that there is a possibility of applying the spring to eliminate the weight.
- A certain difficulty in selecting the correct straining force value is caused by the necessity of using the characterization of spring. Thus, it is important to create an appropriate algorithm of selecting the value of the force stretching the spring through changing its elongation.
- The presented concept of speed limiter rope straining appliance has a coherent structure securing appropriate work in the braking system. On the basis of the prepared tension model it is estimated that the manufacturing costs will be lower than these of a traditional solution by about 30%.
- Analyzing the development of construction market, including lift industry, it was therefore justifiable to undertake the subjects contained in the presented study.
- The conducted empirical analysis of spring selection and working conditions for the presented lift model does not exhaust the subject completely. Thus, it is justifiable to perform experimental studies, assembling a tension with a string on the lifting appliance to verify the stated project assumptions.

REFERENCES

1. Autivox brakes assembling instructions.
2. Instruction of operation and maintenance of the tension OB – 200–250 manufactured by Lift Service.
3. Instruction of DYNATECH speed limiter operation and maintenance.
4. Kaczmarczyk S., Andrew J.P.: Systems Engineering of Elevators. Published by Elevator World INC, Mobile, Alabama 2011.
5. Kwaśniewski J: Passenger and Freight Lifts – Structure and Operation. AGH Publishing House, Kraków 2006.
6. Lonkwic P.: Protecting Lift Systems against Uncontrolled Fall on the Example of a Passenger Lift. (in Polish) Narzędziowiec, 4, 2009.
7. Polish Standard PN EN 81.1+A3, Safety Regulations Concerning the Structure and Installation of Lifts, Part I. Electric Lifts.