Changed Requirements In The International Lift Market Ask For New Pulley Types With Better Tension Equalization Features

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Abstract: There is a clear trend in the lift construction: Due to the changes in the world population's composition as well as the trend toward larger cities the need for new installations as well as modernization is rising.

In these volume driven "standard" lifts total cost is the major driving force. In these lifts, small drives and plastic coated ropes or other traction media and pulleys of innovative character and flexible design are requested. This dimension reduction leads to problems in the suspension systems such as prolonged installation times and reduced traction media life time. In this presentation the newest product, which is developed to comply with these new circumstances is introduced. In practice a new type of deflection pulley is presented which improves installation and life time of plastic coated ropes.

1 INTRODUCTION

Today's situation: World population grows, average life expectancy raises (see figure 1) and people continue to move into cities. This leads to increased and changing requirements for vertical transportation. In most countries there is, driven by legislation, an absolute need to support handicapped persons and to make available the right transportation means for the elderly citizens. The installation of new lifts and the modernization of existing ones is a must.

The task: Public authorities, architects, consultants, lift planners, manufacturers and service companies have to design, produce, install and service lifts which offer more space, a higher level of ride comfort and cost benefits. Driven by the fact that elderly people stay at higher age in their own house, modernized lifts with a larger car space to accommodate wheelchairs and other mobility aids are required.

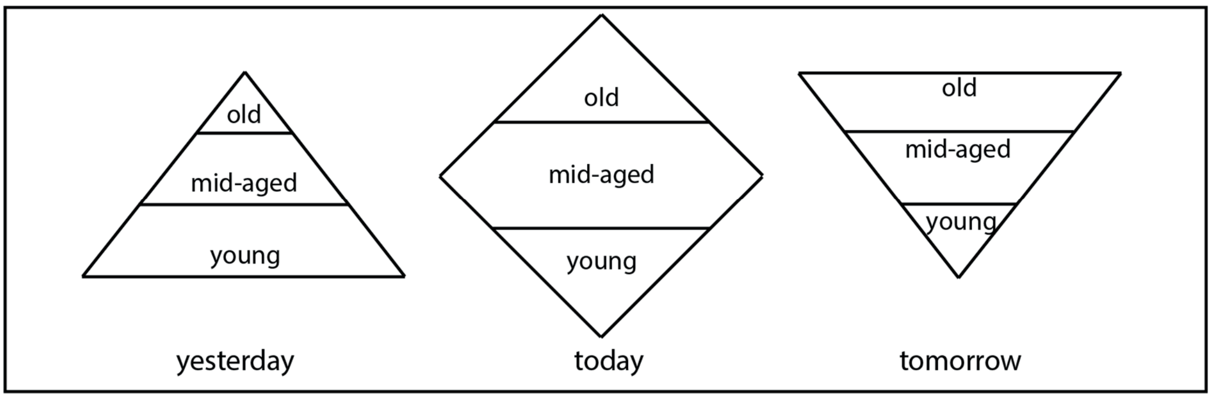

Figure 1: Today's demographic change.

That means in terms of lift engineering that cars need to have a larger floor space to be accessible for people with restricted mobility. As a result, counterweight and further parts traveling in the shaft need to be especially space saving. 'MachineRoomLess' does no longer mean "No machine room" but best shaft space utilization possible. In combination with smaller drive units (Figure 2) to reduce costs, these facts lead to traction media like belts and plastic coated ropes with smaller steel rope diameters, smaller gearless drive units and finally to smaller pulleys of 240, 160 or even as small as 120 mm diameter.

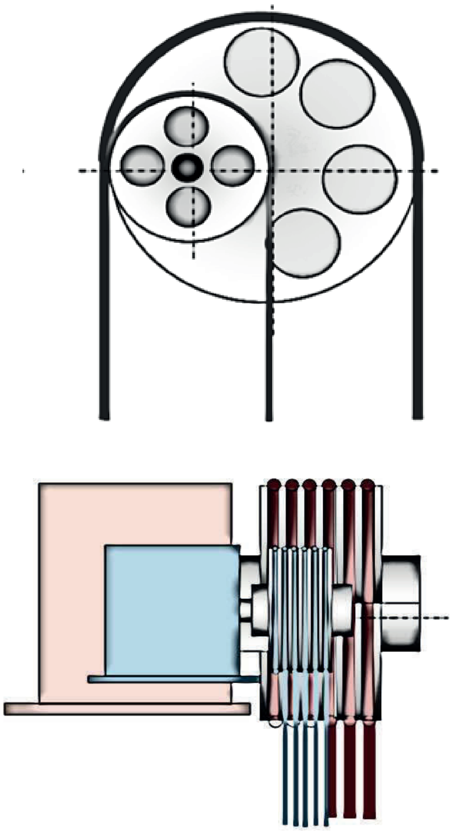

Figure 2: Reduction of sheave diameter

This dimension reduction in the traction system leads to unwanted effects in the suspension of the lift. Due to the growing amount of deflection / support rollers in a system as well as the growing amount of ropes the effects of small dimensional changes can lead to reduced life time of the traction media.

2 THE PROBLEM

2.1 Installation and Rope tension

In smaller traction systems typically a higher number of ropes are used in order to retain the same payload. This is often done in combination with a higher number of deflection, car and counterweight pulleys in order to distribute the loads over more shafts to remain the required life time for the smaller diameter bearings.

This creates several problems in the installation, as well in the operational phase of the lift. The modern traction media such as plastic coated ropes bring higher trip numbers but are more complex in installation and servicing. Due to their design, which is focused on creating high friction between the surface of the traction sheave and the rope outer surface, the complexity is mainly to achieve and maintain a good equal rope tension over the life time of the ropes. As a general rule all traction media in a set should be tensioned equally (+/- 5%). This tension needs to be checked right after installation of the ropes and it needs to be rechecked after some weeks or a maximum of 3 months after bringing the lift into service. This can be done with the help of electronical tensioning devices or continuously balancing end termination (hydraulic) devices.

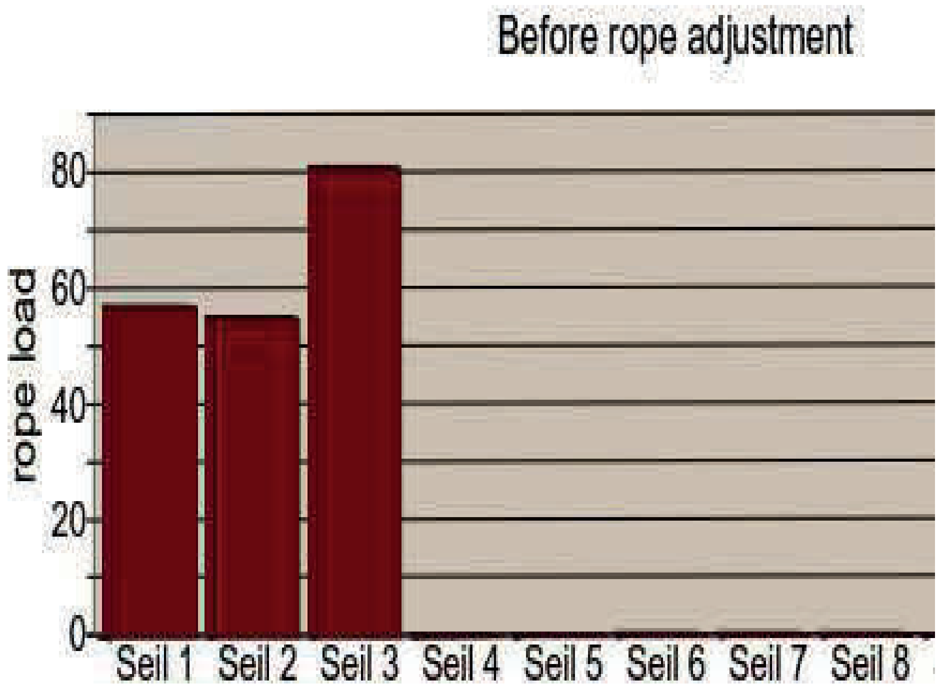

Figure 3: Typical plastic covered rope tension deviation after 100-500 hours of operations for a 3 rope suspension system in classic rope suspension system.

However due to the high friction surface of the rope (or belts) it is already difficult to install all ropes equally in a short time since all pulleys will be blocked by the friction between the pulley and the first rope after this has been pulled through the system. This leads to extended installation times (and cost) and to problems in equalizing the rope tension - even between section of the same rope.

Experience in the field shows that not only the rope tension of all ropes in one set needs to be checked and equalized, but also that the tension of one and the same rope in this set can vary significantly in 2:1 or higher suspensions between pulley and traction sheave, pulley and neighboring pulley or pulley and end termination. In daily practice it is seen that the equalization is generally not done properly due to the complexity of these systems.

Between the ropes in a section tension differences can exist (figure 3) as a result of these friction forces which are directly related to the tension in the two sections on either side of the pulley for a specific rope and its friction coefficient between the pulley and the rope surface. Especially when operating with a steel rope tension differences can lead to extra wear in the traction sheave grooves where the highest loaded ropes are running.

2.2 Length differences

With a classic drive of 320 mm and a 8 mm rope, the wear induced groove diameter reduction of 1 mm in combination with the tolerance in rope diameter of -1/+5% can already lead to a run length difference of 4.65 mm per rotation (Table 1). With a smaller pulley of 160 mm this effect is the same, but this pulley has 2x the rpm to follow the same car speed. For 10 meter height the 320 mm pulley can "give" a run length difference of 42.77 mm, for the 160 mm pulley this will be 83.68 mm max.

			rope length difference per 10 meter movement per pulley compared to nominal											
			320			160			240			120		
			319	320	320,1	159	160	160,1	239	240	240,1	119	120	120,1
effect of pulley diameter									-30,58	0,00	3,05	-59,88	0,00	5,95
rope diameter in mm														
nominal	tolerance	effective												
6	-1%	5,94							-2,45	-2,44	-2,44	-4,79	-4,76	-4,76
	5%	6,3							12,23	12,20	12,19	23,95	23,81	23,79
	max pot. delta										**42,77**			**83,67**
effect of pulley diameter			-30,58	0,00	3,05	-59,88	0,00	5,95						
8	-1%	7,92	-2,45	-2,44	-2,44	-4,79	-4,76	-4,76						
	5%	8,4	12,23	12,20	12,19	23,95	23,81	23,80						
	max pot. delta				**42,77**			**83,68**						

Table 1: Rope length differences /10 m. movement per pulley compared to nominal diameter of pulley and rope

These effects can be increased due to the fact that there are more pulleys in the system however the grove diameter differences are typically only to be expected at steel pulleys such as the traction sheaves.

These potential extreme length differences between the different ropes in a section of the suspension will lead to tension differences, especially when the traction media have no possibility to “slip” over the pulleys to compensate.

This effect can be extra damaging at so called double wrap sheaves. The diameter differences can lead to an extreme loss of traction due to “loose” ropes.

If the tension is out of balance there will be different forces on each rope, on the rope structure and on the outer coating. Depending on the rope constructions unequal tension may lead to protruding wires or strands or cracking of the plastic coating before the end of the expected life time is reached. Additionally extra loads on the traction media are to be considered which may occur from design and installation quality out of buffer movements, wrong alignments or high deflection angles.

3 NEW PULLEY SOLUTION

The solution for the abovementioned problems is to create pulleys which neutralize the friction and/or the length differences. The smart technique combines the traditional pulley with the benefits of polyamide. Groove segment rings are mounted on a polyamide-basic body (figure 4) with good sliding characteristics. The separated rings with grooves on the support body allow each and every rope to move independently from each other.

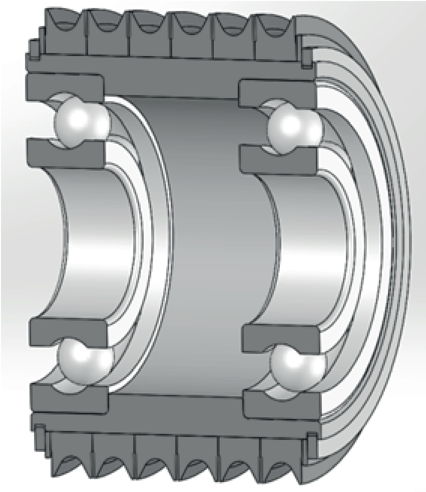

Figure 4: Cross section new pulley solution

This design brings a number of benefits to elevator producers and service companies.

The installation is far easier, especially in a lift with multiple pulleys. Due to the separate independent movement it is possible to tension each rope from each end termination to the traction sheave without the effects of the friction on each pulley. During the operation the independent rings (figure 5 and 6) allow each rope to move over the pulley with slight speed differences compared to the average speed of the rope set. This way rope tensions and/or length differences are neutralized.

Due to this compensation in the rope tension differences the life time of the ropes are increased up to 1,8 times. It also supports the lift ride comfort and reduces the lift Life Cycle Costs.

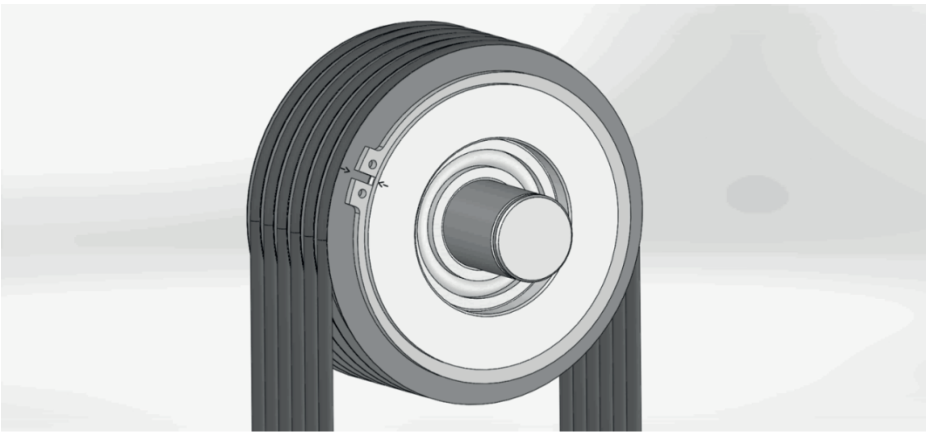

Figure 5: New pulley solution with plastic coated ropes

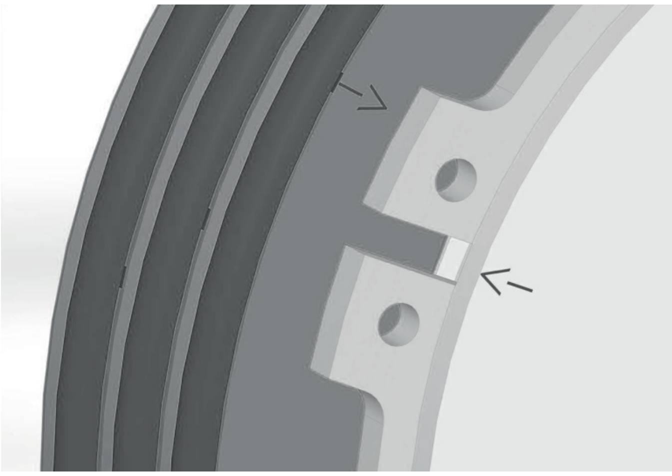

Figure 6: Segments moving the basic body

The new pulleys are running in various test installations, in house and in demanding field applications. Test in lifts which have been equipped before with solid pulleys show that the ropes run within a closer tension tolerance field and do compensate the length between the end termination and the traction sheave.

At present a standard program with grooves for 6.5 and 8.1 mm are used.

In Figures 7 and 8 the marks on the pulley grooves indicate the movement of the different grooves when in operation. In figure 9 it is shown that the tension deviation between the three ropes is clearly better than in the classic system as is shown in figure 3.

Figure 7 / 8: New solution before at installation / after 1 week operation

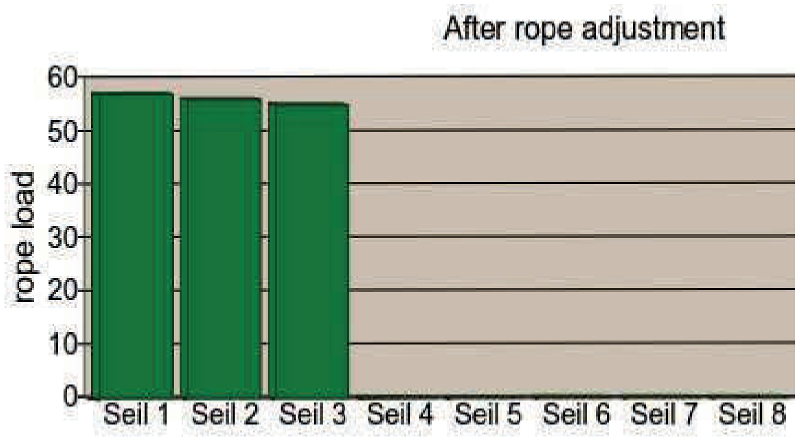

Figure 9: Typical plastic covered rope tension equalizytion after 100-500 hours of operations for a 3 rope suspension system in a rope suspension system with new pulleys installed.

4 CONCLUSION

Well tensioned ropes are one of the major steps in creating a good drive system. Due to the trend to use smaller diameter traction and support pulleys and at the same time increase the amount of these pulleys per system the tension and length equalization problems increase. This leads to a decreased life time of the traction media, longer installation times and reduced ride comfort. A pulley which allows speed differences between the different ropes in a set is introduced.

The new solution supports an easy installation, and allows to ropes to compensate for length and tension differences. This light pulley will not only reduce total life time cost but also improve the whole elevator behavior and ride comfort.

5 REFERENCES AND FIGURES

[1] Design and drawings by Thomas Schonlau, Jawk Meijer, Karl-Heinz Bosmann, Lothar Sieber / all Schwartz GmbH Technical Plastics, Xanten/Germany

[2] Figure 1: Demographic change: c.f. Wahlgang (2013): http://www.wahlgang.de/wahlgang13/?p=1889; 10.02.2016

[3] Figure 2: N.Imbimbo (2004)

[4] Figure 3 and 9: out of Henning Weight Watcher Readings

[5] Table 1 / Figure 4, 5, 6, : Table and drawings by Schwartz GmbH Technical Plastic, 46509 Xanten/Germany

[6] Figure 7,8, : Pictures by Schwartz GmbH Technical Plastic, 46509 Xanten/Germany

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