Homelift-Concept Based on New Techniques and Materials

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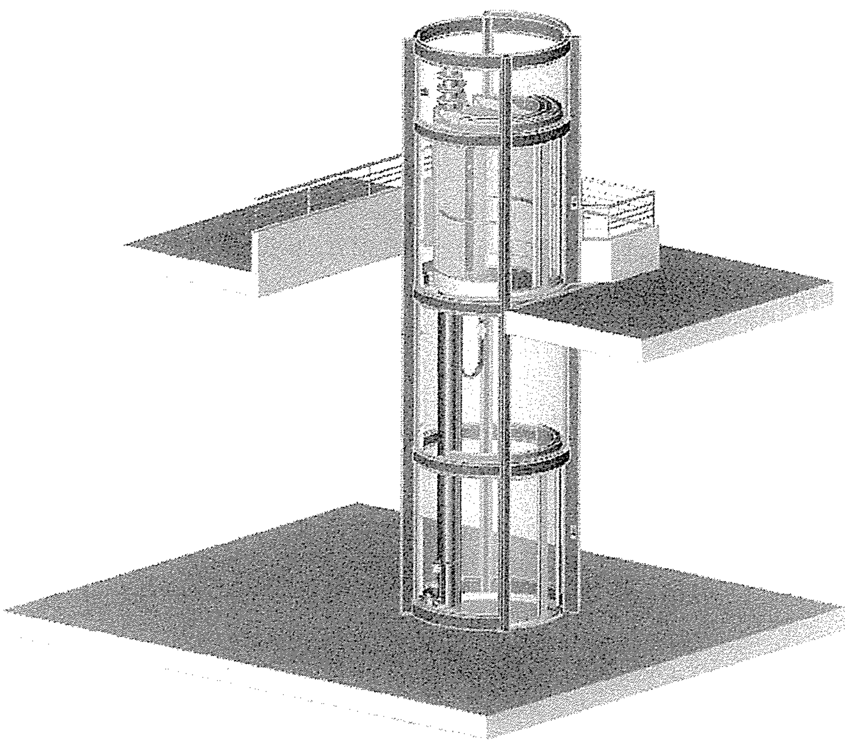
ABSTRACT

A growing demand for elevators in private homes and offices is requiring space saving technology, fewer environmental risks and more aesthetic design. Activities of different elevator manufacturers confirm that this market is steadily growing. Particularly interesting is a new elevator design requiring no machine room and minimal pit space. With such a design the architecture of a new building is minimally influenced and installations in an existing structure simplified. This presentation introduces a new visionary approach (technically and aesthetically): It describes a supportive column and a spindle drive system with entirely new performance data. When a prototype was presented at Interlift '99 to an international audience of experts, it received much attention. Since then, an officially approved (TÜV-certified) version has been installed for a number of private and commercial uses. TÜV is an agency authorized by the German government to approve the safety of elevator systems.



1. STARTING POINT

The requirements of the Homelift-Concept are many sided. The manufacturer must satisfy the customer's wishes and yet develop an elevator that is easily and efficiently produced.

Requirements from the customer's viewpoint:
- Small space requirements
- Minimal organization effort (permits and certification)
- No environmental regulations
- Easy installation
- Cost effective
- Very few requirements on the structure (building)
- No machine room and minimal pit space
- Individual adjustment wishes (customisation)

Requirements of the manufacturer:
- Need to standardize technical components
- New dealership structures
- No compromise on safety requirements
- Low installation costs
- Low logistic expense

This elevator system has been designed in a revolutionary manner, successfully utilizing innovative techniques. Following, is a description of a drive system with a central supporting column and an inner pre-tensed spindle. The central supporting column is the backbone of the elevator and contains the new spindle drive system.

The spindle and an inner rod are pre-tensed for stability and are driven by an electric motor that is located on top of the column. The column, spindle and rod are manufactured in modular segments that accommodate easy installation.

Other elevator manufacturers use hydraulic and cable lift systems which leave hydraulic cylinders and cables visible to the eye when their systems are encased in glass. The column drive system presented here conceals all the inner workings of the system. Hydraulic and cable systems require much pit space for needed equipment. This column drive system has an extremely small pit space and makes installations in existing structures easy.

2. TECHNICAL CONCEPT

2.1 System Description

Based on experience with spindle drive systems (comprehensive technical analyses), the following system has been defined:

Features of the Column-Drive-System (CDS):

Column:

- Self-contained construction

- Compact design and layout containing the spindle
- With guiding function for the cabin (drive cylinder)
- Attachment options on the shaft and floors
- Modular construction for easy handling and installation
- Elegant design for use in glass wells (shafts)

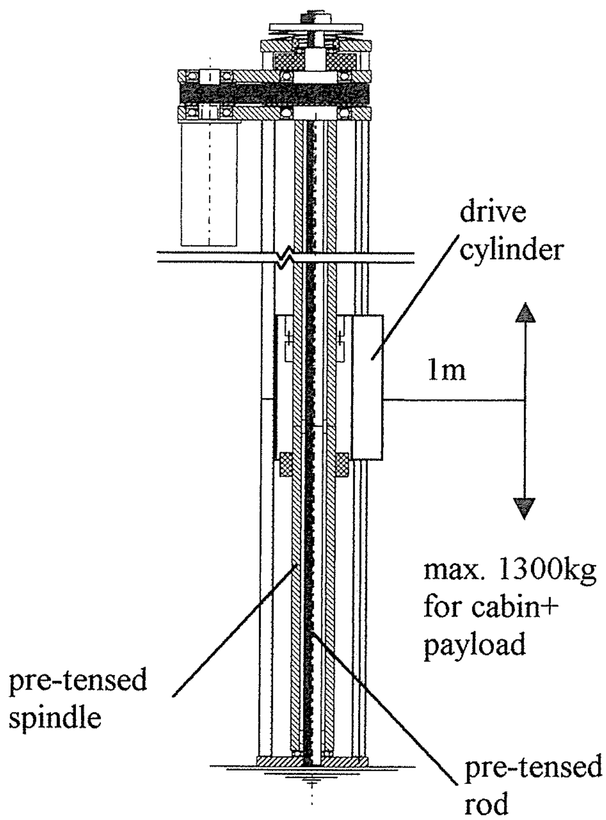
Spindle:

- Revolving spindle rotating around a pre-tensed rod
- Electric motor located on top of the column
- Cabin and a drive cylinder are attached to the spindle with a nut system
- Spindle is driven by a belt drive
- Spindle is not self-locking, it has automatic mechanical and electric release functions
- Two-circuit brake system
- No sinking down or environmental problems as in hydraulic systems

CDS-Drive (Column-Drive-System)

Photo

Drawing



2.2 Development Emphasis

A fundamental goal for the development team was to abtain a highly marketable product. The team concentrated on developing a spindle drive system that is superior to any previous spindle system designs by other manufacturers. The development team also focused on efficient production, easy installation and high reliability.

Focus on development:

Spindle:

- Developing a fast spindle drive system
- Eliminate vibration
- Development of modular construction
- Increase transportation height (number of floors)

Column:

- Selection and verification of optimal materials
- FEM-analysis with geometric conversion of results
- Modular construction (easy installation)
- Comprehensive new manufacturing procedures

This system uses, as much as possible, components that are already available on the market. Only where necessary, the electric motor, controller, brakes, belt system and door system were altered. Also a cabin was developed with optimal attachment to the column drive system and the construction of the cabin floor is designed for minimal thickness. This allows for an extremely small pit space.

3. SYSTEM COMPONENTS

3.1 Spindle

3.1.1 Technical Description

Criterion for the selection of a suitable spindle type were:

- Spindle r.p.m. for transportation speed 0.4-0.6 meters per second
- Segment (modular) construction up to 12 meters (for four or maximum five stops)
- Availability of the production process
- Acceptable production costs
- Wear and tear and level of efficiency
- Easy and safe installation
- Meeting safety requirements
- Low noise level
- Meet European safety codes (EN Codes)

As a result, a hollow spindle with an inserted pre-tensioned rod has been developed with the following characteristics:

- Thread pitch 50mm
- Special profile meeting all requirements
- Effective engagement of spindle segments

The pre-tensed rod – inserted into the spindle – is used to stabilize and effectively angeage the spindle segments.

3.1.2 Spindle Buckling

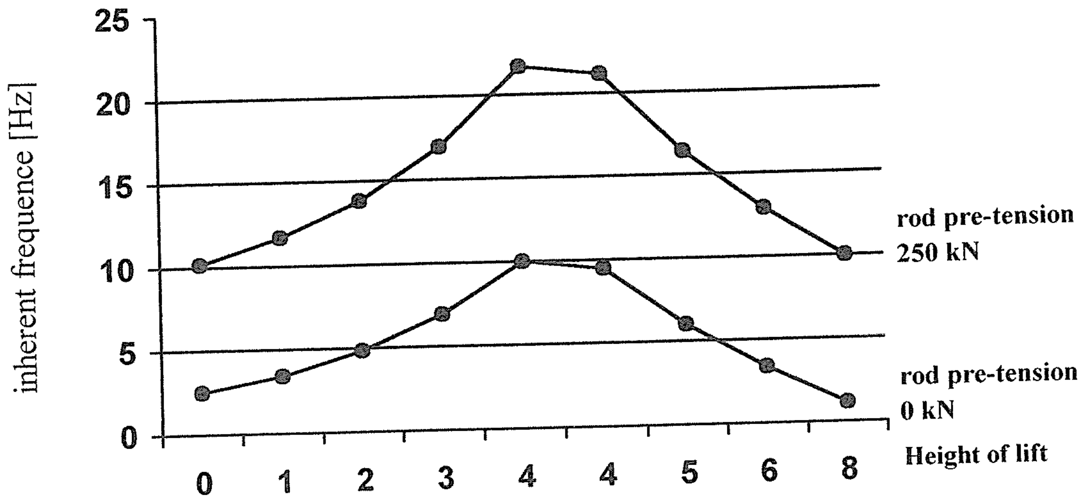
Bearings on each end of the pre-tensed rod are necessary and allow the spindle to revolve without buckling. It is easy to recognize that this design clearly has advantages over a non-segmented spindle because the bearing distance is squared in the calculation of the buckling examination.

3.1.3 Vibration Analysis

The pre-tensed rod – inserted into the spindle – eliminates vibration. Any possibility of vibration was analysed by observing the options below:

- The spindle and inserted rod without tension
- The spindle and inserted rod with tension

The following diagram shows the effect of the inserted rod with and without tension. Results proved that with a pre-tensed rod we have a much faster elevator without noticeable vibration. (Much higher inherent frequency of the spindle)



3.2 Column

3.2.1 Technical Description

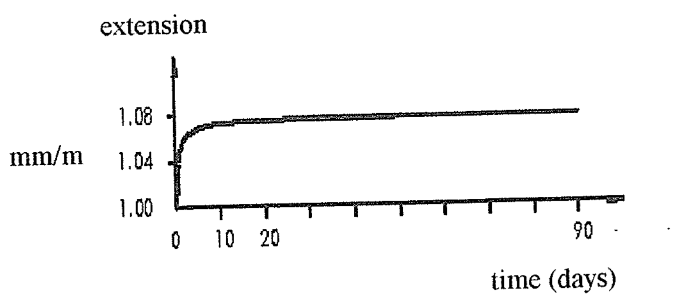
A basic requirement of standard specifications is not to place too much stress on the building. Therefore, standard specifications must be taken into consideration when installing this system into existing buildings. Also a compact main structure was needed to carry the cabin weight and support the pre-tensed spindle and rod. Suggested was a pipe-shaped column out of metal. Examination showed, however, that the technical demand and cost goals were unattainable if a metal column was used. Therefore, the development team researched and reached a decision to use a mineral cast column similar in strength to high performance concrete. The mineral cast column offers the additional advantages of transmitting less noise and weighing less.

3.2.2. Strength Analysis, Distortion

Mineral casting and concrete have similar material characteristics and both are limited to tensile stress. Taking this into consideration, we designed a mineral cast column that is similar to pre-stressed concrete. To create the column pre-tension, tension rods are inserted into the column during installation. The design of the geometric shape of the column is supported by FEM-Analysis (Final Element Methods) and proven through testing.

In long-term research, asymptotic creeping behavior has been observed and proven to meet TÜV- safety requirements.

The following diagram shows an asymptotic creeping behaviour of the column material.



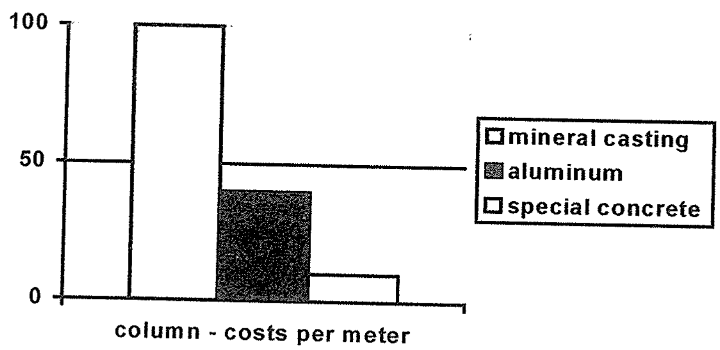
4. OUTLOOK

To assess the Column Drive System for marketability on the international market, the column, spindle and spindle nut system were examined to see if the system has potential for improvement. The goal is to continually optimize the system technically and economically. Thus far, the following has been established:

- Proved the functionability of the entire system
- Proved that large scale production can be done
- Proved that further efficiency can be accomplished
- Proved that production costs can be further reduced

4.1 Column

The most expensive column is a mineral cast column.. A mineral cast has excellent material and performance data and can be produced with high precision. A less expensive column can be manufactured out of aluminum, but an aluminum column can only be produced with less precision. There is another alternative: A new high performance concrete that has been developed with similar material characteristics to the mineral cast column presently produced. A column cast of this concrete can be manufactured with high precision and at a much lower cost. The following diagram shows the relative costs of columns made from these various materials.

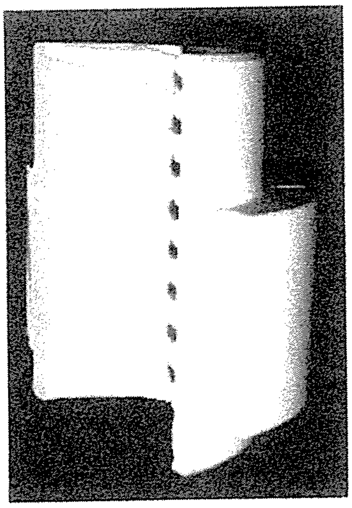


The new and high performance concrete mentioned above is considerably simpler to produce than a mineral casting. This special concrete has excellent pouring ability and a shorter curing time. A large manufacturer in Germany uses this special concrete to manufacture railway ties and these ties are proven to be highly durable.

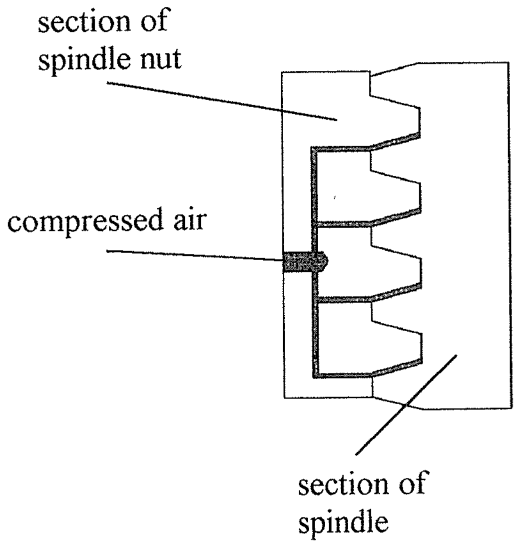
4.2. Spindle Nut System

The existing Column-Drive-System is a new elevator system developed with new technology and in the future it is the goal to develop a guidance and spindle nut-system that has virtually no friction. To do this, an air-cushioned spindle nut-system and drive cylinder are being considered. A small and extremely silent compressor located on top of the cabin would supply the necessary air pressure to cushion the spindle nut and drive cylinder. With this cushion friction would be virtually non-existent. Tests have confirmed this. Following is a drawing of a section of the air cushioned spindle nut system engaged with the spindle and a spindle nut used at present time.

Spindel Nut
made out of High-Performance Compound



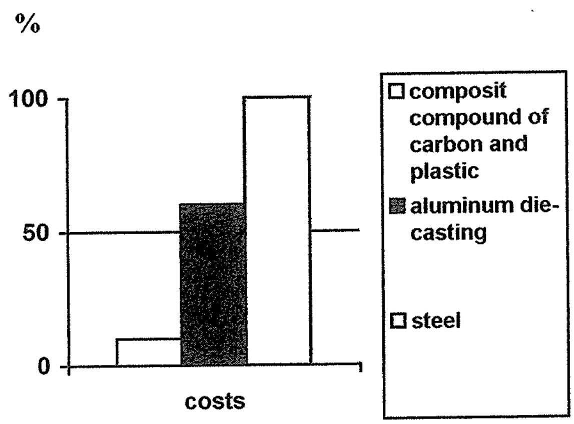
air cushioned
spindle nut system



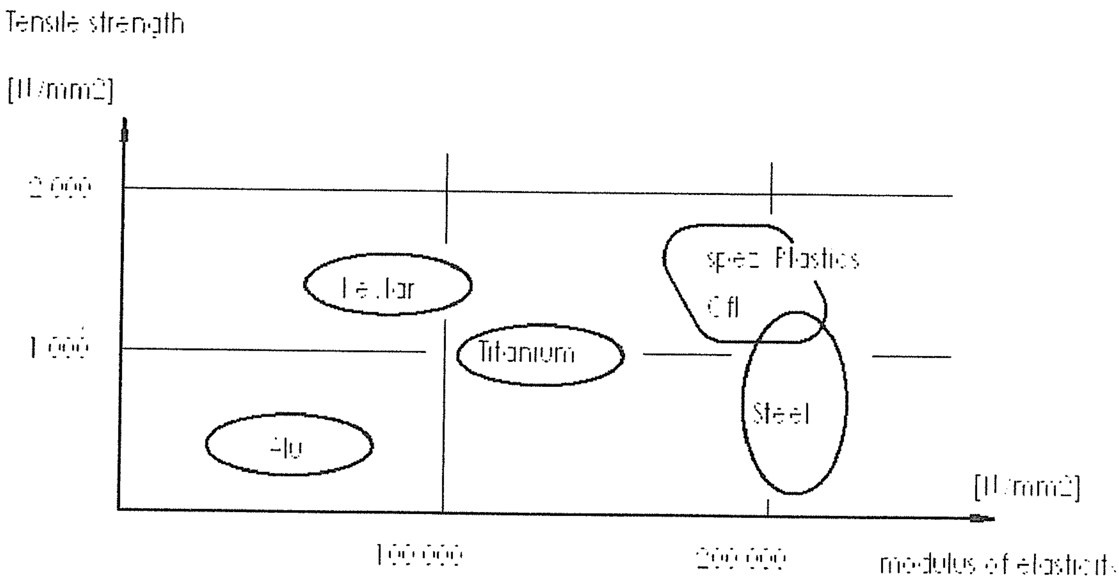
4.3 Spindle and Electric Drive System

Aluminum, plastic coated aluminum or a composit compound of carbon and special plastic are attractive alternatives for spindle material. A light-weight spindle that operates in conjunction with an air-cushioned spindle nut system and drive cylinder reduces the size of the motor and drive-belt system. The speed of the elevator could also be increased by using a light-weight spindle.

The cost comparison diagram below shows the potential for these alternative materials as compared to a spindle made of steel.



In addition, please see the diagram below showing various material data. The following diagram shows that the best alternative for spindle material is a composit compound of carbon and special plastic. A spindle made of such a material and manufactured by injection molding would also dramatifcally reduce costs.

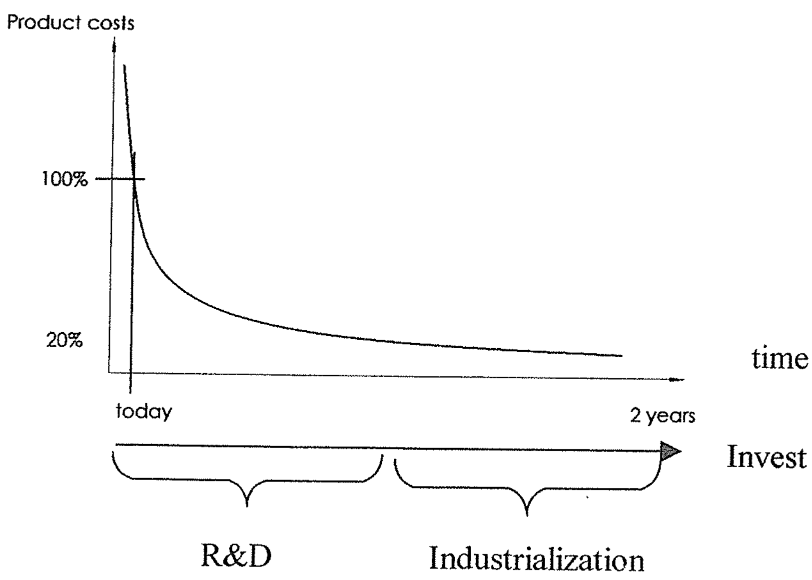


5. Summary

To truly optimize this elevator system, further investment in research, development and production is necessary.

The attention this elevator received at Interlift '99, approved certifications and the sales that have been realized since then confirm that the potential of this new system is strong.

Please see the diagram below that illustrates how costs decrease as investment increases.



Biographical Details

F.W. THIELOW, Managing Director and Engineer in charge of development for LOGOS-INNOVATIONEN, is intrusted with the development of the Homelift. Over the years, a variety of sophisticated projects in the area of elevator development have been carried out by this company. Together with Harald FEISTENAUER, Mr. THIELOW founded LOGOS-LIFTSYSTEME in 1997. Mr. FEISTENAUER is Managing Director and Develomental Engineer of LOGOS-LIFTSYSTEME and directly responsible for development in this capacity.