NEW DEVELOPMENTS IN LIFT DOORS

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Abstract:

The aim of this presentation will be to reveal in a brief exposition the most recent developments connected with the lift doors, both car doors and landing doors. A great emphasis will be put on those advances directed to help with the fulfillment of the COMMISSION RECOMMENDATION 95/216/CE. The reason of this special accent is the important implications that this will have in the lift industry.

An explanation of the set of tools used in the development of these products will be provided as well, illustrating in detail the work of a mechanism simulation software called COMPAM.

Introduction:

In the European Commission Official Bulletin, N° L 134/37 dated 20.6.95, was published the COMMISSION RECOMMENDATION of 8th of June of 1995 about the safety increase of the existent lifts, 95/215/CE.

This commission recommends to the Member States:

1.-That if the legislation in force is not enough to meet the requisites of this Recommendation, they should approve the necessary dispositions:

- To guarantee the satisfactory maintenance of the existent lifts,
- To increase the safety of this lifts applying the legal dispositions based on the principles of the appendix of the mentioned recommendation.

2.- The application of additional measures to those of the appendix, if the safety requires so.

That is, and as was declared in the meeting held on the 22nd of November of 1995 between the European Community Lifts Associations, which took place in Brussels organizated by the E.E.A. (European Elevator Association):

- The recommendation (95/216/CE) is complementary to the Directive on Lifts (95/16/CE).
- Its application to the different countries, in part or as a whole, is not compulsory, but with the publication of the recommendation, no country can ignore it and therefore its responsability is involved.
- Nevertheless, in order to achieve an homogeneous quality level in the European lifts and facilitate the product circulation and free trade, it is asked to act as if it were compulsory.
- It is established that during two years, up to 6/97, the countries will take in a gradual way and in accordance with its own priorities the appropiate measures. When this period is finished, and in accordance with the results, the Recommendation will be published or not as a Compulsory Directive.

Taking into account that the number of lifts installed in Europe is close to 3 millions, the 70% of which are more than 10 years old and the 45% more than twenty, it is possible to conclude that the volume of car doors to install will be of 475,000 units.

Obviously, the challenge to the lift components manufacturers, and more specificly to the door manufacturers is a clear one.

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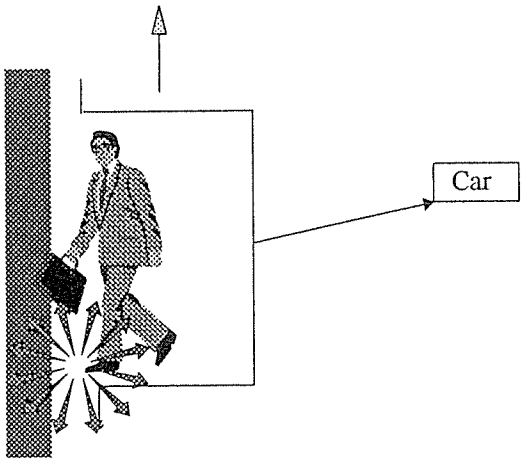
Pnt. A: Analysis of the first section of the recommendation:

The first item of the Recommendation of the E.U. contains the double requirement of installing doors in the car and, inside of them a system showing the floor in which the lift is.

Evidently, obvious reasons of security advocate for the fulfillment of the reforms involved in this point. Particularly, in Spain, the statistic of accidents shows that the want of doors have supposed for a long time the 50% of the whole number of accidents. Today, the incidence of this risk has decreased to a 33%, as much as because of the regulation on lifts which forces, since 1980, to install doors in the car, as for the measures dictated by a good part of the Autonomical Communities compelling to install doors.

This fact was tragically famous among the people in charge of buildings, since the use of rigid litter containers provoked their beheading when they introduced the container into the lift car. Once the container was introduced and with the person in charge leaned on the rear wall of the car, the movement of it caused the pivoting of the container and the subsequent squashing.



Rules applicable for new elevators: EN 81, next amendment: 8.5.2 will be removed, and cars without door will no longer be considered. In present version, 8.5.2. reads:

"Although the presence of a door is preferable in all cases, it may, however, be permitted for goods passenger lifts, for one car entrance or two opposite car entrances not to be fitted with doors if in addition to the provisions of 8.2.1, the following conditions are simultaneously fulfilled:

* *the lift is reserved for authorized and instructed users;*
* *the rated speed does not exceed 0.63 m/s;*
* *the depth of the car, measured perpendicular to the doorless sill, is greater than 1.5m.;*

** the number of passengers is calculated as laid down in 8.2.4., disregarding, however, for each doorless car entrance an area of 0.1 m depth and of width equal to the width of the doorless car entrance;*
** the buttons or switches for car control, stop and alarm are at least 0.4 m from the car entrance."*

Proposal for a Council Directive on the aproximation of the laws of the Members States relating to lifts: 3.1 (Annex 1) (92/C62/05)

Lifts cars must be completly enclosed by full length walls and equipped with full length doors. These doors must be so designed and installed that the car can not move, except for the levelling movements referred to in the first indent of the paragraph 2.3; unless the doors are closed and the elevator comes to a halt if the doors are opened.

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Pnt. B: Characteristics of the products to develop:

As was said in the introduction, the products that must be developed have to comply with a serie of precise specifications in order to maintain the competitivity of the product without a loss in the quality, and also to facilitate the mounting and subsequent maintenance.

Perhaps, this is one of the points that, in spite of its obviousness, the engineers of desing miss the most when they begin the development of a new product, that is, the existence of a technical specifications, complete, closed, and with a broad consensus among the whole committee of the product.

Along this paragraph I will expound the characteristcs that in my opinion must be basic in the design of a product intended to be used as CAR DOOR, FUNDAMENTALLY FOR MODERNIZATIONS:

1.- Space
2.- Re-openig and reclosing system.
3.- Lightness, robustness.
4.- Peep-hole system.
5.- Cam for driving the locks.
6.- Hermetic sealed, easy to mount.

1.- One of the main problems that a lift fitter finds in the moment of installing a door in the car of an existent lift with several years of working, is the room available in the shaft to place the door. As a general rule:

- If the shaft is wide and the counterweight is placed behind the car:
Center parting car door with two panels.
- If the shaft is narrow and the counterweight is on a side of the car:
Two speed car door with two panels.
- If the shaft is very narrow and the counterweight is placed behind the car:
Center parting door with four panels.
- If the shaft is narrow and the counterweight is on a side of the car:
Three speed car door with three panels.
- If there is NO room in the shaft: DOOR WITH FOLDING PANELS.

The last situation is the most usual, as the architects usually reduce the room available in the shaft to a minimum to save spaces. For this reason and from here we will center the exposition on this type of doors.

Other problem referred to the space, appears when the car is replaced. Obviously, the new car should have the widest usable surface and because of this our operator should be as narrow as possible. This fact, seeming banal, will condition absolutely our desing, since we will only have a space of 100 mm. to situate The whole opening mechanism (motor, transmission, control board, etc...)

If the door to use in the modernization is a "folding" door, is evident That there is an additional risk of being caught in the case of the opening of the door. For children this risk increases, since they can be entrapped between the lintel of the car and the panels of the door. For this reason, the door must incorporate a re-opening and re-closing system.

3.-Another important aspect to take into account is the weight of our system of car doors. If we achieve an optimum weight, the total weight of the existent lift will not change probably and by this there will not be need of any other modifications, for example the replacement of the lift traction system.

In consecuence, the concepction of the desing of the operator must be based on compact mechanical elements, without either complex transmisions or electrical wires in movement. An special attention should be payed to this point, hence in our pledge in order to reduce weight, we might make a design without robustness enough and therefore we do not comply the point 8.6.7. of the EN-81.

4.- Finally we should note the desing of the peep-holes in accordance with the point 8.6.5. and 7.6.2.2 of the EN-81. We should also make a stand on designing them to be of y and fast replacement in the building.

We should also pay attention to the design of the cam for driving the locks of the semi-automatic door, both in frontal and lateral way.

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Pnt. C: Development tools:

COMPAMM, Computer Analysis of Machines and Mechanisms, is a software tool to analyse mechanical systems that was used for developed a car door.

COMPAMM has been designed for the kinematic and dynamic simulation of mechanical systems. It is a three dimensional program (not only for calculations but also for visualisation of solids) capable of simulating a wide range of open and closed loop mechanisms containing revolute, spherical, cylindrical, prismatic, universal, helical, gear, pinion-rack joints, etc

One of COMPAMM's main features is the high quality motion visualisation module and the interactive response to user inputs. COMPAMM includes advanced functionalities such as collisions detection and interactive geometric measurements.

The main types of joints that COMPAMM supplies are:

Revolute
In a revolute joint two points share one point and one direction on the axis, as show in figure 1.1

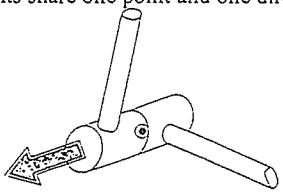


figure 1.1

Spherical
In a Spherical joint one point is shared between the two bodies, as show in figure 1.2

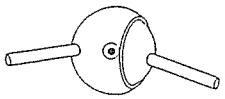


figure 1.2

Cylindrical
In a Cylindrical joint there is a direction shared between the two bodies and two additional points, one belonging to each body, aligned with the axis' direction, as show in figure 1.3

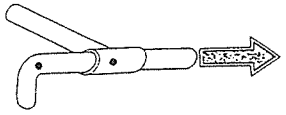


figure 1.3

Prismatic
In a Prismatic joint there is a direction shared between the two bodies and two points, one belonging to each body, aligned with the axis' direction, as show in figure 1.4. In addition, there are two directions, one on each body, which must maintain a constant angle.

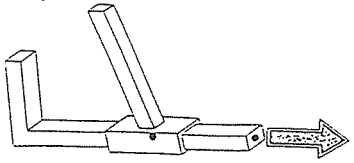
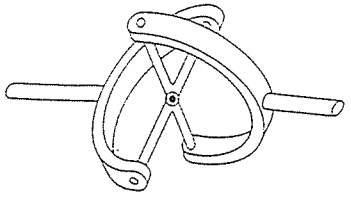


figure 1.4

Universal
In a Universal joint two bodies share one point and, at the same time, one direction of each body remain perpendicular, as show in figure 1.5

figure 1.5



Helical
A Helical joint is similar to a cylindrical joint. The two bodies share one direction and, at least, one point of each body must be lie on the axis. In addition, it is necessary to define explicitly the relative angle and the relative displacement shown in figure 1.6

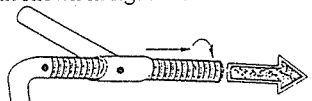


figure 1.6

Gear
In a gear joint, the two bodies are linked to a third body by a revolute joint. The relative angles of rotation must be defined explicitly to specify the ratio of angular velocities. See figure 1.7

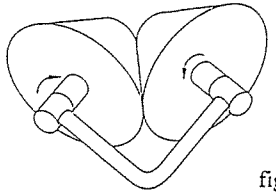


figure 1.7

Pinion-Rack
In a Pinion-Rack joint, the two bodies are linked to a third body, one by revolute joint and the other by a prismatic joint. The relative angle of rotation and the relative distance must be defined explicitly to specify the ratio of angular velocity to linear velocity.

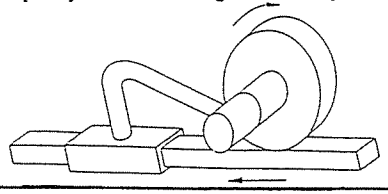


figure 1.8

COMPAMM is based on natural coordinates, which describe the position and orientation of bodies through the Cartesian components of points and vectors located at the joints. The immediate physical meaning of points and vectors, as well as the simplicity of the formulation, lead to an efficient implementation of kinematics and dynamics which allows near real-time response to small and medium size mechanical systems.

Modelling

A mechanism is defined as an assembly of two or more imperfectly connected rigid bodies, with the possibility of relative motion among them. A kinematic joint, or simply a joint, is the imperfect connection between two or more rigid bodies that form part of the mechanism. A joint allows certain relative motions and constrains others.

An especially important concept in the analysis of mechanisms is the number of degrees of freedom, which is the number of parameters required to define completely the position, velocity or acceleration of the mechanism. The parameters themselves are called generalised coordinates, degrees of freedom or independent variables for a given mechanism there are several different sets of independent variables equally acceptable for COMPAMM.

Interactive use

COMPAMM is an interactive program which, in addition to its kinematic and dynamic capabilities, offers a flexible user interface. Among its interactive functions are:

- Configuration changes (only in kinematics)
- Change of the point of view
- Change of lighting conditions
- Selection of cameras
- Playback analysis of a previously computed motion
- Change of colours, textures, transparency, etc.
- Motion smoothing

Simulation

Once the geometry and the mechanical system has been defined, a simulation can be carried out.

COMPAMM solves the kinematics, forward an inverse dynamics and the position of static equilibrium of a multibody system.

In some cases a complex mechanism is naturally divided into smaller systems which have things in common. A subsystem can also include smaller subsystems with no depth limit.

For the simulation there are necessary some inputs to be introduced by the user, i.e. force, torque, displacements, angles, etc.

The output of the simulation is a file which contains forces, torques, reactions, contacts, displacements and angles of every solid.

Visualisation

The visualisation module of COMPAMM is capable to handle not only figures made in the program itself but also solids created using specific drawing programs such as I+DEAS.

The movement can be shown in real time (if the hardware is able to)

Several cameras can be put all over the system: attached to one object, overall view. The features are the same as a professional camera: zoom, translation, rotation, light effect, etc.

Simulation of the opening and closing movement of a door.

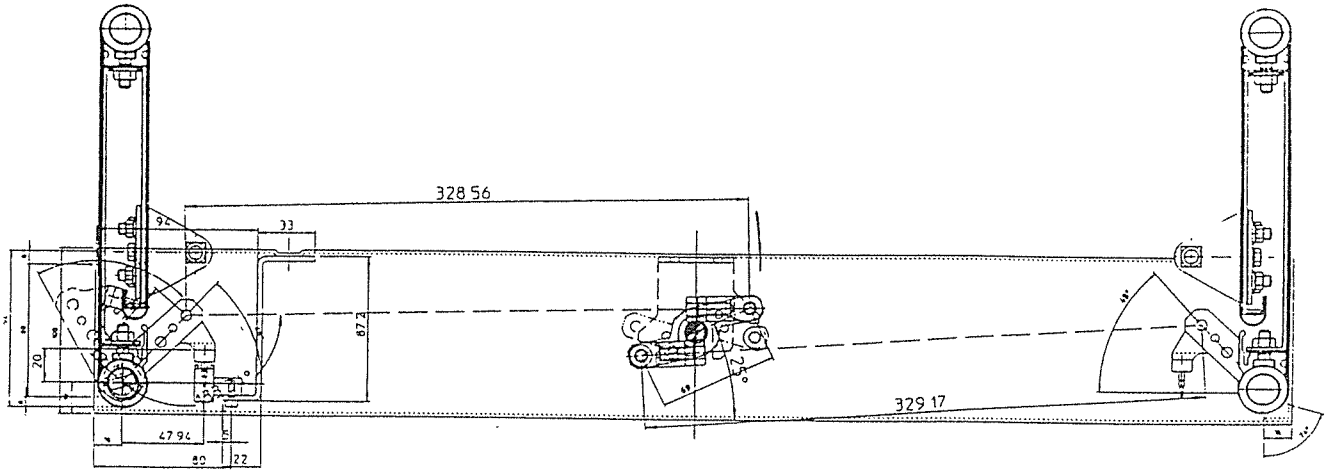
One important application of simulation programs is to verify the behaviour of a mechanical system before any prototype has been made.

ITA, Instituto Tecnológico de Aragón (Technological Institute of Aragon) was the research centre chosen by SELCOM to modelize a new product: a door with an electronic obstacle detector.

COMPAMM was used to simulate the door behaviour.

Description of the door and mechanism to modelize.

There is an electrical motor in the centre that generates the movement (rotation). The motor is fixed to a crank, the crank is connected by rods to the first part of the door, this part receives the movement from the rod and pushes/pulls the second part of the door.

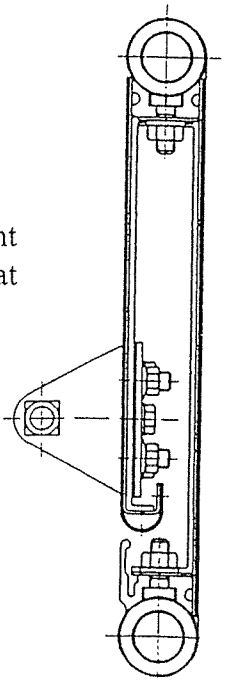


Objectives of the project

There were made a project with the following steps:

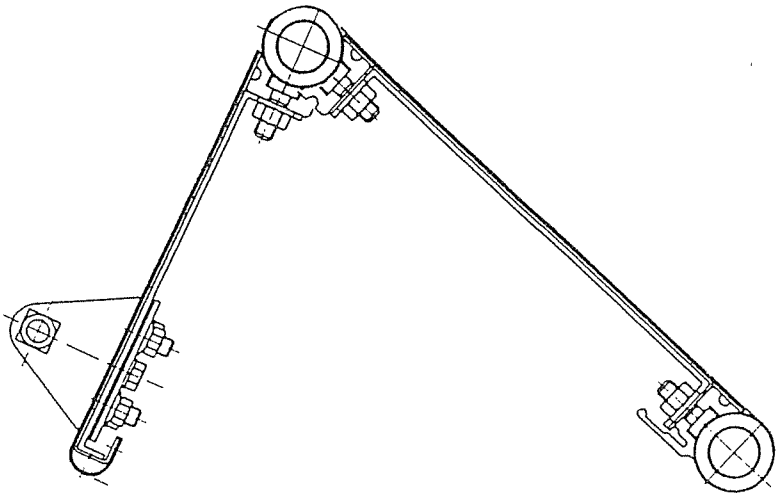
- Solid modelling of all the solids to determine masses, centres of gravity, and moments of inertia. The program used in this stage was I-DEAS
- Generation of a model for kinematic and dynamic analysis

1) Door is open and passengers can get into the cabin or get off the cabin.

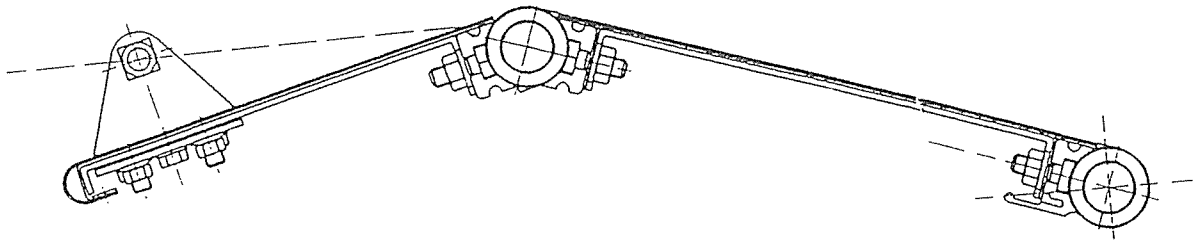


2) Door is closing:

The motor spins, the crank-rod mechanism transmits the rotary movement to the first piece of the door. This part pushes the second piece of the door, that has motion and rotation.



3) When the entrance is closed the movement finishes.



4) Door is opening:

The motor spins, the crank-rod mechanism transmits the rotary movement to the first piece of the door. This part pulls the second piece of the door, that has motion and rotation. When the entrance is open the movement finishes.

5) Had any person been trapped by the door, it would change the movement. There is a torque detection system that identifies if an obstacle (usually a person) is in the door trajectory. Then an electronic switch changes the spin of the motor and it re-opens if was closing or re-closes if was opening.

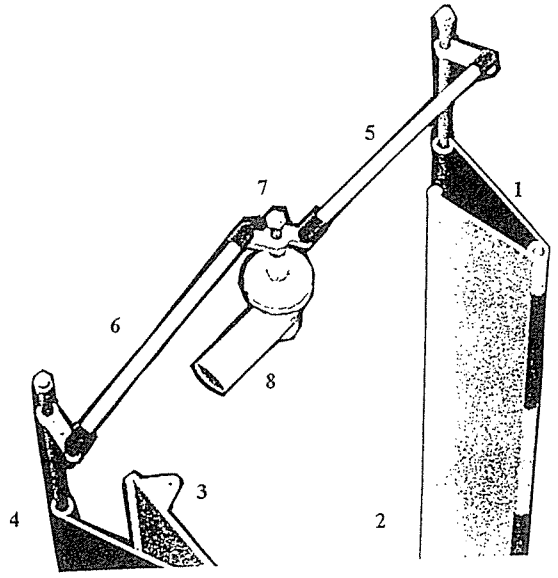
- Simulation of the process of re-opening and re-closing to obtain the following information:
  - kinematics of every element
  - torques and forces in the joints
  - motor power and torque
  - maximum power to be transmitted by the motor depending upon the force done by the obstacle

Generation of a model:

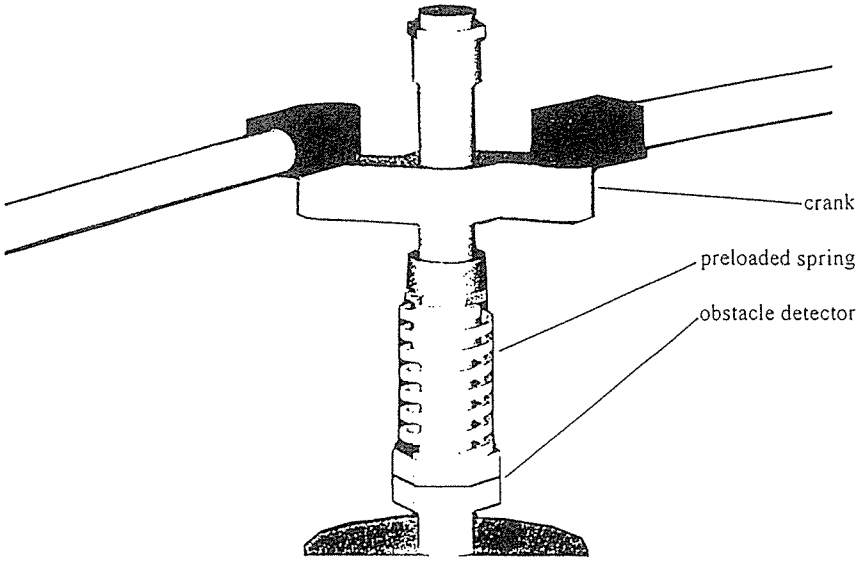
After the solids drawings were carried out, a model was prepared. The model had four solids for the doors, two solids for the two connecting rods (to connect the doors to the crank), one solid for the crank and one solid for the motor. All the solids were properly linked using revolute joints.

Modelization of the mechanical set:

Solid 1: door
Solid 2: door
Solid 3: door
Solid 4: door
Solid 5: connecting rod
Solid 6: connecting rod
Solid 7: crank
Solid 8: motor



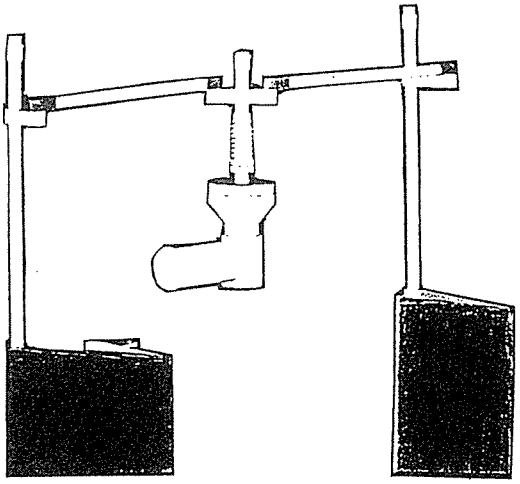
The obstacle detector is connected to the crank and adjusted by a preloaded spring:



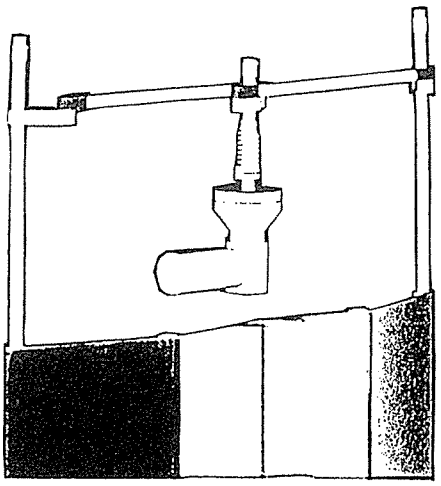
Simulation:

In the simulation process a rotary movement in the motor was the input for the system to verify the kinematics. It was checked that no abnormal contacts happened and the door had a smooth movement.

Simulation. Doors in the closing movement



End of simulation. Doors closed.



A movie of the doors movement was made: The kinematic simulation was run on a Silicon Graphics console, the images were directly recorded in a video tape (VHS) with a common video tape recorder connected to the computer video output.

To analyse the dynamics, the input was the torque/rpm curve of the motor and the friction force in the guide rail of the door. It was also added the effect of the force of an obstacle in the door.

With this simulation it was obtained the relationship between motor's torque and force produced by an obstacle. These data were used to adjust the obstacle detector. With these calculations and simulations, the number of prototypes and tests to be done were dramatically reduced.

Author biographical details.

The engineer Fernando Artero is the present Engineering Manager of SELCOM Aragón S.A., a company specializated in door lift manufacturing, both landing and car doors. He took his degree in Industrial Engineering at the University of Zaragoza in 1987. In the same year he started to work in Madrid as Engineer responsible of mechanical equipments in several Nuclear Stations, as well as making seismic qualifications by means of MEF, untill 1990 when he began to work in Schindler S.A.

In the company Schindler S.A. he held the post of Manager of the Mechanical Engineering Department during the years 1991 and 1992, leading diferent projects in the lift world, essencially mechanical. In October of 1993 he enters the managing equipment of SELCOM Aragón as Manager of the Engineering Department.

He is a founder member of IAEE España, as well as of the Organizer Committee of ELEVCON96.