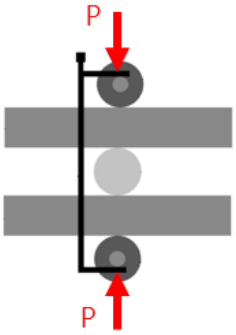
How to open a door with friction

The door blades in an automatic door can be driven back and forth by taking advantage of the friction between components. Similar to a train on a track, cylindrical shafts and rods can be combined and used as a transmission system for moving the door blades in horizontal direction. This concept can be used when driving the night closing doors placed on the outside of a revolving door. However, due to high loads and high constraints on the dimensions, it is easily worn out and will eventually fail. In this Master's thesis, the friction drive is investigated and several improvements, such as a change of forces, dimensions and material are evaluated. The goal is to improve the friction drive to the extent that it is not worn out when the doors are opened and closed repetitively.

A night closing door is in general placed on the outside of a revolving door and is used to close the area between the door blades during the night. The reason for this is to prevent unwanted guests or litter to enter area of the revolving door.

Night closing doors attached to a revolving door

The friction drive, which is used for moving the door blades horizontally, consist of five main components. Two rods, which are bent to follow the curvature of the main door, are attached to curved door blades on each side. Over and under these rods are two cylindrical shafts connected to bearings, which are there for support and guiding. A force is applied, with a compression device, to these shafts in opposite directions to compress all the components. The fifth component is placed between the two rods. It is a cylindrical driving shaft which is connected to a motor. The motor rotates the driving shaft, which the drives the rods.



Two-dimensional illustration of the five main components in the friction drive.

Two main problems exist in the current design of the friction drive. The first problem is that it is unknown which compression fore is needed to obtain the correct horizontal force. The horizontal force needs to be at least 150 N, because this corresponds to the acceleration of the heavy door blades if they must open quickly for safety reasons. This compression force, P, can be determined by using Coulomb's law of friction, $F_x = \mu_s P$, where μ_s is the static coefficient of friction and F_x is the horizontal force. Usually the static coefficient of friction for a contact between steel and steel is approximately 0.2.

The second problem is that the high loads, that are required to obtain the correct horizontal force, creates very high stresses on the surface of the material. During opening or closing the driving shaft is rolling over the rods and stresses occur repetitively on each point of the components. This leads to that the material is worn down, either by *fatigue*, where cracks are formed, or by *ratcheting*, where craters are formed. This problem can be solved by increasing the dimensions of the components so that they have a larger contact area. However, the friction drive cannot be too large due to lack of space. The problem can also be solved by increasing the material hardness. This can be done with different surface treatments.

Practical tests were performed to explore how the change of material affected the wear and fatigue life. Firstly, tests were made with a basic steel material without surface treatment and the results showed large deformations and an uneven surface, which is bad for the functionality of the friction drive. In the second test, the new and improved material with a surface treatment called Corr-i-Dur was used. It showed large improvements. After approximately 217 000 cycles of repetitive loading there was almost no signs of cracks, craters or scratches.

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