FUNDAMENTALS OF MACHINE DESIGN AND DRAWING (A.Y. 2014-2015)

WRITTEN TEXT OF MACHINE DESIGN

The opening and closing device depicted in Figure 1 actuates the leverage system of bus doors. The counter-clockwise rotation of the pinion operates the opening of the doors, while the clockwise rotation operates the door closing.
For geometrical constraints, the distance between the two pitch lines of the racks cannot exceed 80 mm.

As shown in Figure 1, two compression helical springs counterweight the action of the pinion and maintain the racks and pinion in contact. Two ball bearings support the axle rotation.

A maximum torque of 150 Nm may be applied to the pinion under special circumstances.
In regular operating conditions, the torque spectrum (in terms of torque values and percentage in time) is described in Table 1. For all three operating conditions, the opening and closing operation corresponds to 3/4 of a single rotation of the pinion.

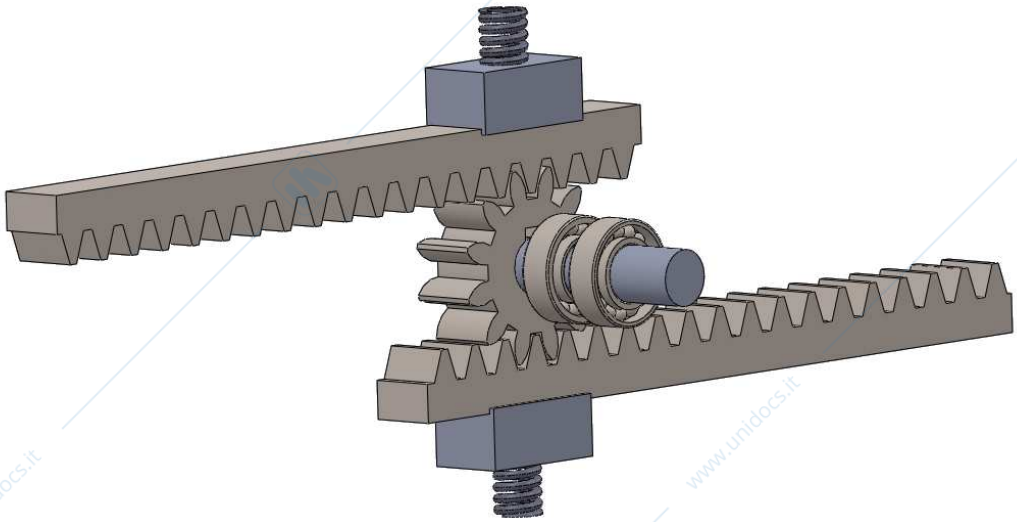

Figure 1: A schematic view of the pinion-rack system used to open/close bus doors. The number of teeth depicted for the pinion is not representative of the effective number.

Table 2: Operating conditions – Torque applied to the pinion and percentages in time.

C (Nm)	% time
80	10
75	40
45	50

In the conservative hypothesis that one of the two racks cannot react to the torque, it is requested to:

- determine a suitable value for the module of the pinion and the rack to ensure infinite life under regular operating conditions. Assume a pressure angle α=20°. For the material take: R_m (ultimate strength)= 1200 MPa and σ_{D-1} (fatigue limit endurance)= 835 MPa;
- define the wire diameter and the mean coil diameter, as well as the number of active coils for the compression helical springs. Consider that the housing where the springs need to be mounted cannot exceed 60 mm in axial size and 56 mm in diameter. Take a steel alloy 50 CrV4 (UNI 3546-68, R_m=1500 MPa, R_{p02}=1250 MPa)
- determine the minimum dynamic load coefficient C_{min} for the two ball bearings to ensure a basic rating life of 200 million cycles of oscillation due to the door opening and closure (reliability 90%).

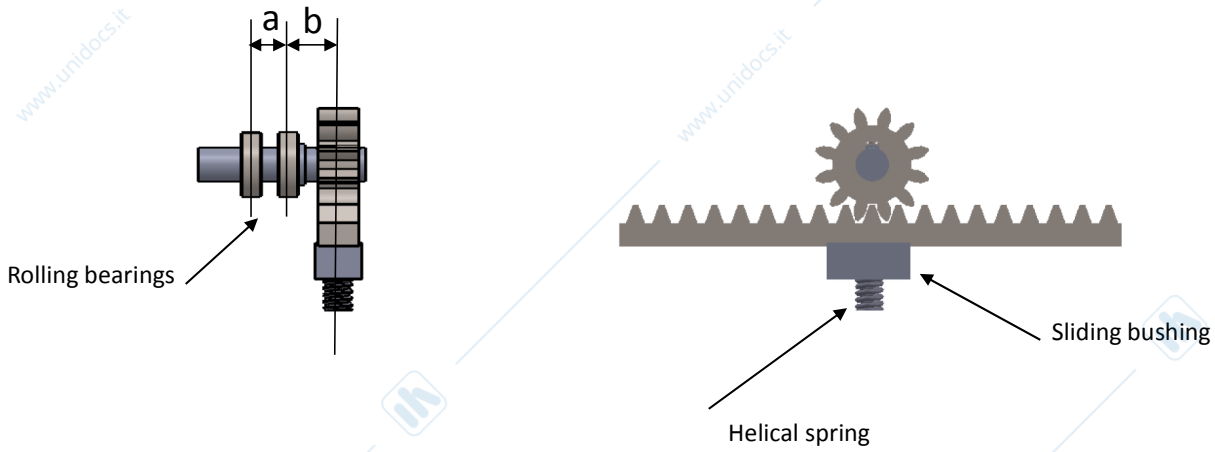

Figure 2: A schematic view of the pinion-rack system to be considered for the design of the parts. Take a= 20 mm; b= 35 mm