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KISSsys 03/2016 – Instruction 012
Forces in a model
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1. Introduction

Within one model it is possible to use forces for different purposes, because they are independent components. In this file an explanation for most common type of force usage is given. External load from outside of the model, internal loads between components and internal load generated inside the model.

2. External load

2.1 A load from a component which is outside of the model

![Industrial gearbox](image)

*Figure 2-1 Industrial gearbox*

In this example loads on shaft1 and shaft3 are considered as "external" load, which are acting outside of gearbox, but will have some effect on the shafts. It can be that in the input shaft (shaft1) the power is not coming directly from the engine/motor, but there is e.g. a belt or chain drive before our gearbox. This belt/chain drive will give some extra axial or radial loads to the shaft, which need to be considered to get bending, bearing lifetime and other values correctly in the shaft. But because the belt/chain itself is not of interest in this case, we don’t want to model it. This is why this load is used to demonstrate effect of this “external” component. (Similarly for the “shaft3” output on the belt/chain drive outside of the model).

This can also be any other external component, which has an effect on the shaft. Because there are no any "expressions" in the load the values can be freely selected in graphical shaft editor.
All force components can be changed freely in here. Also the position of the force can be selected freely.

3. Internal loads (Not needed with coaxial shafts)

3.1 Bearing between shafts

When there is a bearing between two shafts, so that two shafts are on top of each other (e.g. loose gear on the shaft), first we need to calculate other shaft/gear and then move all forces from that shaft to the other. Therefore a connection between bearings and loads is created to move forces. This process is iterative, because there may be interaction between shafts.

Green arrows show connected bearings and loads. The force values are transferred from the bearings to the Shaft1. Shaft named “RedShaft1” is only a gear, which is carried by the “Shaft1” and there are two bearings between shafts. First “RedShaft1” is calculated and forces for the bearings are defined. Then these forces are moved to the “Shaft1”. Then “Shaft1” is calculated and deflections can be transferred back to the corresponding force positions on the “RedShaft1”. This loop is then iterated until components are balanced.
Figure 3-2 Shaft “sgr” This is in reality only a gear.

Figure 3-3 Shaft “sa”, forces from the gear are transferred with “centrical loads” and torque with “clutch” (synchronizer)

### 3.1.1 Connections

Iteration during the kinematic calculation is made between the bearings and the forces, because deflection of the shaft has an effect to the forces and vice versa. Connections between forces and bearings need therefore to be defined to make this connection. E.g. force “f_sgrb1” is connected to bearing “b1” on shaft “sgr”.
Figure 3-4 Force connected to the bearing

Position of the force is made to be equal to the position of the reference bearing. If the bearing is moved on the shaft or shafts are moved according to each other, force is still always in the same position as the bearing in the global coordinates.

Figure 3-5 Positioning the force according the corresponding bearing.
Fx, Fy, and Fz values are connected to that bearing force values and are always equal to those.

![Image of force components](image1)

**Figure 3-6** Bearing force components transferred to the force.

### 3.2 Centrifugal force

Sometimes forces can be used to demonstrate some effects inside gearbox e.g. centrifugal forces in planetary gear set. Because of planetary carrier rotation, planet gears and planet shafts have some extra load on. This may have an effect for bearing lifetime and must be therefore considered in some cases.

![Image of centrifugal force](image2)

**Figure 3-7** Centrifugal force in a planetary set

In that case force is generated due the speed of the carrier, center distance of the gears and mass of the planet gears. An expression for load values is given and cannot be changed manually, but is automatically calculated.
Figure 3-8 Planet shaft

Figure 3-9 Definition for centrifugal load