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KISSsys Instruction: Kinematics calculations

1 Introduction

In KISSsys it is possible to define kinematic conditions of the whole system. E.g. when speed and torque is defined for the input or output side of a simple helical gearbox, torque and speed for all machine components are calculated automatically according to kinematic conditions, efficiencies and power flow.

2 Kinematic calculation

2.1 Explanation

The kinematic boundaries are defined with „kSysKinematicConstraint“ elements. In the example schematic the power flow through the system is presented with red lines. Direction of the arrays shows the direction of the power flow. When component connection is loaded it is presented in red colour. If there is a connection between elements without load it is presented with black line and “open” connection is represented with grey line. Speed difference in open connection is automatically calculated from the speed difference of the connected shafts.

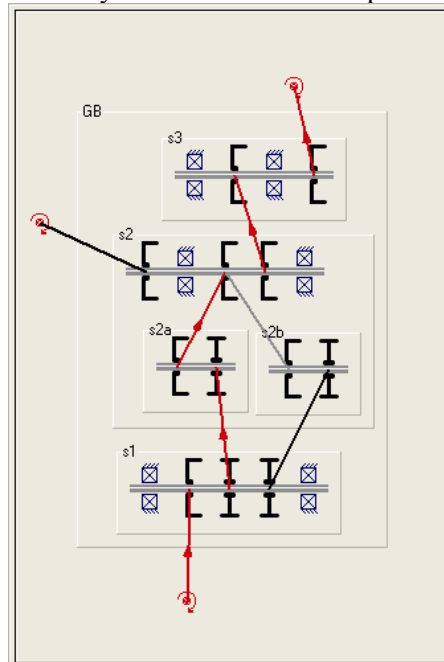


Figure 2.1-1 Schematic view showing kinematics of the model

Normally, when no epicyclical gear connection or power loops are defined speed and torque of the following component is calculated from the previous component. The “kinematic” calculations can be started directly under “System” – “calcKinematic“.

2.2 Boundary definitions

When an error message appears „Error in Calculation of Kinematic!“ indicates that wrong number of boundary conditions are defined or there are wrong number of connection defined inside the model. In the given example there are two gear connections giving different speed for the “Shaft2” and therefore only one of the coupling connections can be active on the time. There are three “inputs”/”outputs” in the model. Only one Speed can be defined, because other speeds can be calculated then from gear ratios. Two torques (or powers) must be defined to tell program how powers are divided between boundaries. It is possible to define both outputs and input will be calculated or input and other output can be defined letting second output to be calculated.

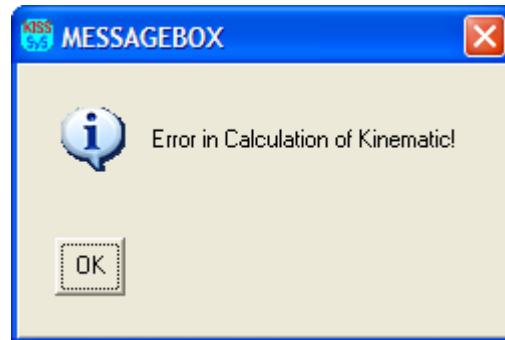


Figure 2.2-1 Error message in kinematic calculation

By activating “Messages” an indication of the erroneous conditions can be looked for.

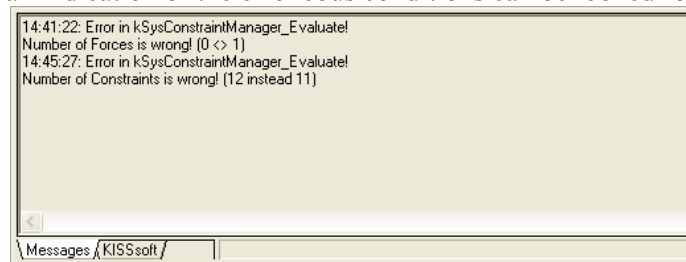


Figure 2.2-2 Message of the erroneous boundary conditions

2.3 Error in “Number of Forces”

If the first number e.g. (1 <> 0) is bigger than the second it indicates that too few conditions for the torques are defined.

If the second number e.g. (0 <> 1) is bigger than the first it indicates that too many conditions for the torque are defined.

This can due the wrong number of boundary conditions or internal connections

2.4 Error “Number of constraint”

If the first number e.g. (12 instead 11) is bigger than the second it indicates that too few speed conditions are defined.

If the second number e.g. (11 instead 12) is bigger than the first it indicates that too many speed conditions are defined.

This can due the wrong number of boundary conditions or internal connections

3 Connection types

3.1 Definition of gear connections

A connection between helical and bevel gears is made with element type „kSysGearPairConstraint“. When this type of connection is selected dialog to select connected gears is shown. Also efficiency of the connection can be defined as a fraction of 1. Ratio of the gear pair is then calculated over the tooth numbers. “Element 1“ is always the 1st element defined in the calculation mask. When bevel gears are defined pinion needs to be always defined as „Element1“ (Fever number of tooth).

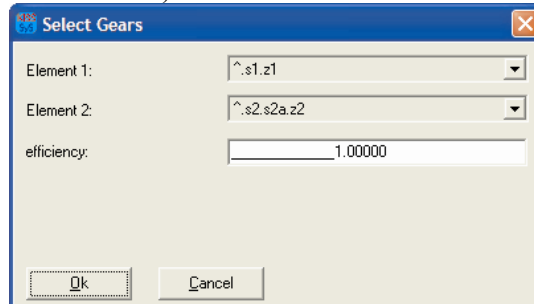


Figure 3.1-1 Definition of gear pair connection

3.2 Planetary gear connection

For the planetary connection use connection type “kSysPlanetaryGearPairConstaint”. Select connected gear pair, select gears and also carrier coupling. “Gear 1” is always the first gear described in configuration. Under “carrier coupling” a variable “NofPlanets” type “Real” needs to be defined, telling how many planet shafts is in the carrier. Configuration can be selected between three gear meshes “sun/planet”, “planet/planet” or “planet/ring”. “kSysPlanetaryBevelGearConstraint” can be used in case of bevel differential application.

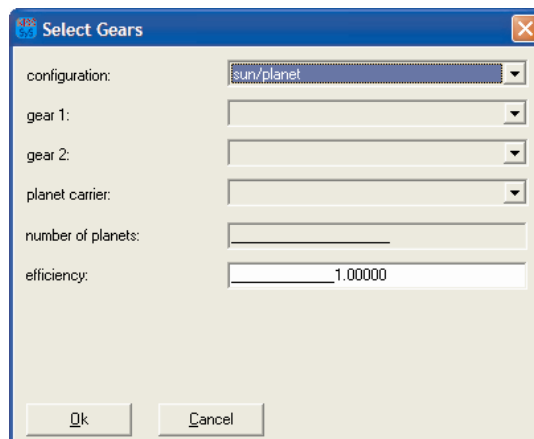


Figure 3.2-1 Planetary gear connection dialog

3.3 Coupling connections

For the coupling connection use element called „kSysCouplingConstraint“ giving connected coupling elements in the dialog. The connection can be activated by defining only speed or torque or both. Also slip speed between connected couplings can be defined. If connection is inactive (Activated =“no“) then slip speed is automatically calculated.

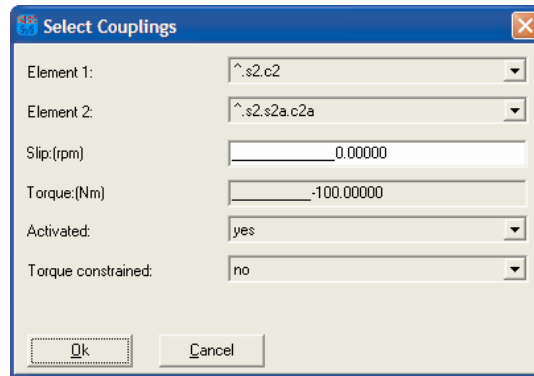


Figure 3.3-1 Coupling connections definition

Coupling connection is used to define different types of connections between machine elements. If connection is not any gear connection then this type of connection is to be used.

3.4 Worm gear connection

A connection between worm and gear can be made with connection type „kSysWormGearConstraint“. This connection type works similarly to the other gear connections. Select correct gears in the dialog and define efficiency. More information can be found from separate instructions for worm gear modelling.

4 Boundary conditions

4.1 Definition of the power

Component type „kSysSpeedOrForce“ is used to define boundary conditions for the transmission. This presents any input, output or fixed points in the gearbox. User can define speed and torque or power in each boundary, taking in the account of calculation freedoms. When boundary condition is pasted in the model dialog appears to select connected component and to constrain desired values.

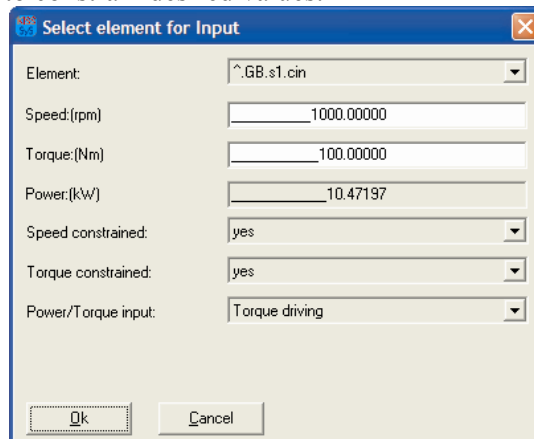


Figure 4.1-1 Boundary condition definition dialog

If torque is constrained user may select if torque or power is given. It is recommended to use “Torque with sign” as definition. If the speed and the torque has the same sign (both either positive or negative) defined boundary point is an input. If the sign are opposite defined point is an output. The sign of the speed defines the direction of the rotation. If sign is positive shaft connected to this boundary rotates in clockwise direction seen from left end of the shaft, if speed is negative rotation is counterclockwise.

4.2 Power/Torque input

Torque with sign	Torque can be given with sign in the input field
Torque driving	Given torque is driving the gearbox (input)
Torque driven	Given torque is driven by the gearbox (output)
power driving	Given power is driving the gearbox (input)
Torque driven	Given power is driven by the gearbox (output)

In cases the torque or the power selected driving or driven sign of the torque is automatically selected from the speed sign.

5 Calculation iteration

5.1 Iteration type

In some cases it may be necessary to change default kinematic iteration type. This may be in case if using e.g. differential gear connections. When “calcKinematic” under “System” is operated first speeds of all components are calculated and after that torques for the components are calculated. Iteration types can be found under “System” – “kSysKinematicMode”.

no iterations	No any iterations for the kinematic calculations are used. This works only in the most simplest cases without efficiencies
iteration for torque	Normal case where speed can be calculated directly from the previous component. Calculation of the torque needs iteration e.g. due the efficiencies and multiple outputs.
iteration for speed and torque	Both speed and torque is calculated with iteration until changes are minimal
iteration for speed and torque with damping	Use this in case if system is instable and doesn't converge. Not used in normal cases.

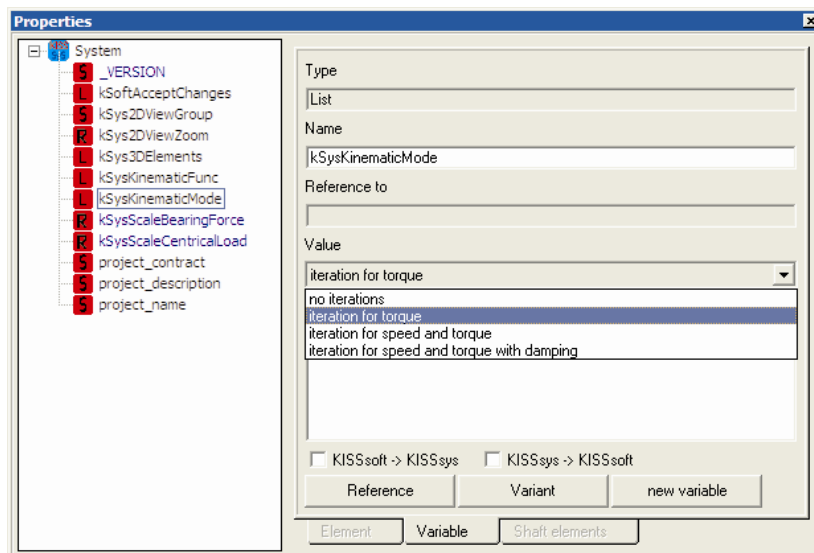


Figure 5.1-1 Kinematic iteration selections

Under “kSysKinematicFunc“ it is also possible to activate calculation of “OnClacTorque”. This means that bearing forces are actualized after every iteration step. This option is to be used if there are overlaid shafts or other connection of forces between two shafts.