KISSsoft
Calculation programs for machine design

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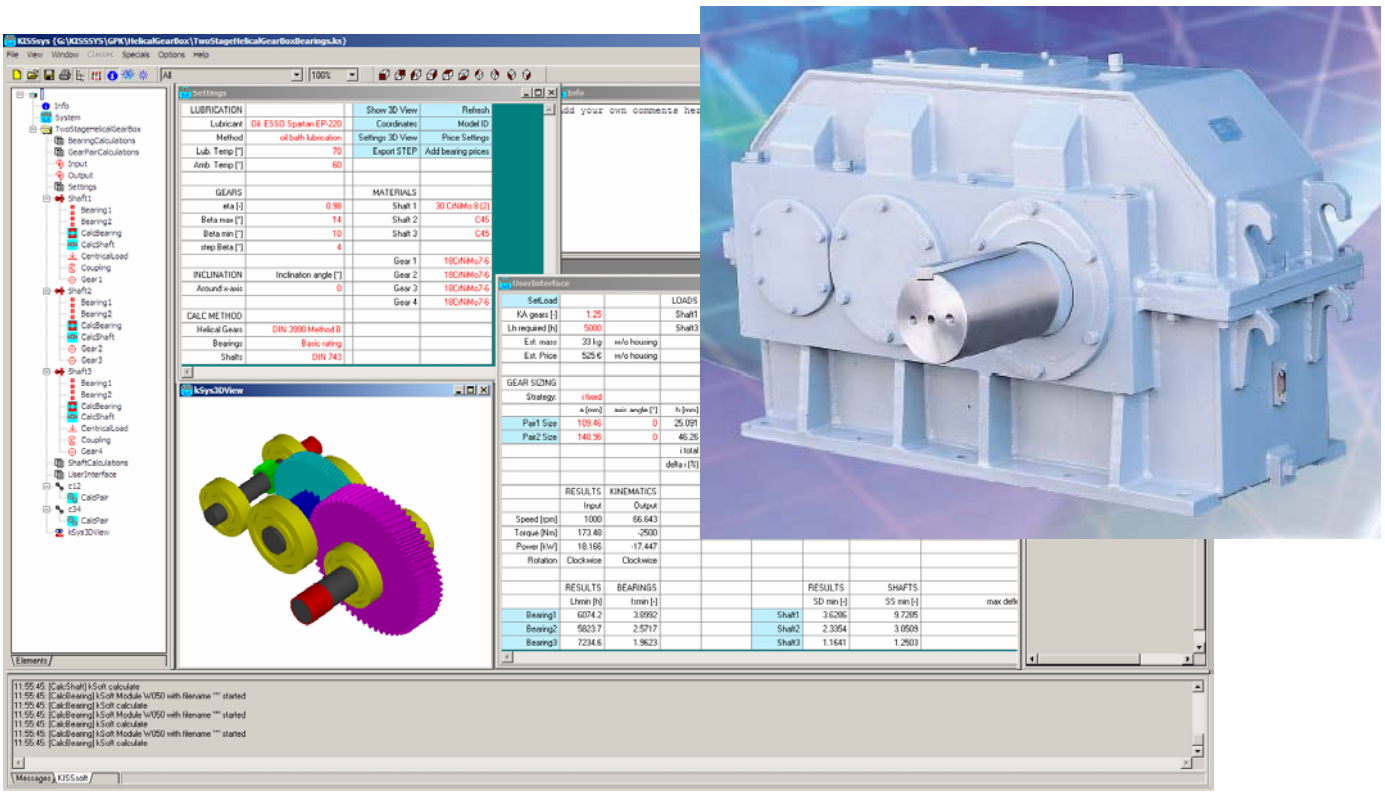

KISSsys models:

For two to five stage helical gearboxes, including automatic presizing, fine sizing of gears, settings, cost estimation, maximum torque calculation, rating, bearing load export and documentation.

Supplier:

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Product Manager KISSsys

Document:

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Table of content

1 Task

Based on the required power rating, lifetime and a desired reduction, a two stage helical gearbox shall be proposed automatically by KISSsys, including the gears, shafts and bearings. The distribution of the total reduction to the stages, gear width and shaft centre distances can either be pre-defined or a sensible value is proposed by the KISSsys model.
After an automatic dimensioning of the gearbox, the user can then modify and optimise the elements (e.g. the gears) and request a complete lifetime calculation, calculation of maximum torque and reports. The time required to design a gearbox is thus greatly reduced.

2 Solution

Using KISSsys, models of two, three, four and five stages gearbox is provided and the kinematics is calculated automatically. Using tables, the gearbox can be configured and basic results (e.g. lifetimes) are presented. The sizing functions provided by KISSsoft are being run automatically in order to obtain a first proposal for gear pairs with just a few steps. The model allows an access to the KISSsoft gear calculations so that optimising them is supported.

Note that for the following description, the two stage helical gearbox is used. Same functions and methods are valid for each model as well.

3 General remarks

The housing is not considered at all.
The manual has been written using the model for a two stage helical gearbox as example and can also be applied correspondingly to other types of helical gearboxes.
For the bevel-helical gearboxes, a separate manual exists.

4 Preparations

Before starting to work with GPK models first time read following instructions through to be able to work with the models in the way that you are able to find results and exported files easily in the correct place.

4.1 Creating project folder

KISSsys uses projects to manage the files. Projects are simply folders where GPK models and the respective KISSsoft files are saved. Before a GPK model can be opened the project folder is to be defined.
Create new project folder called e.g. “GPK” where to download GPK library models and to work. This project folder can be located to any place into your hard drive. It is not recommended to use network drives for working with GPK.

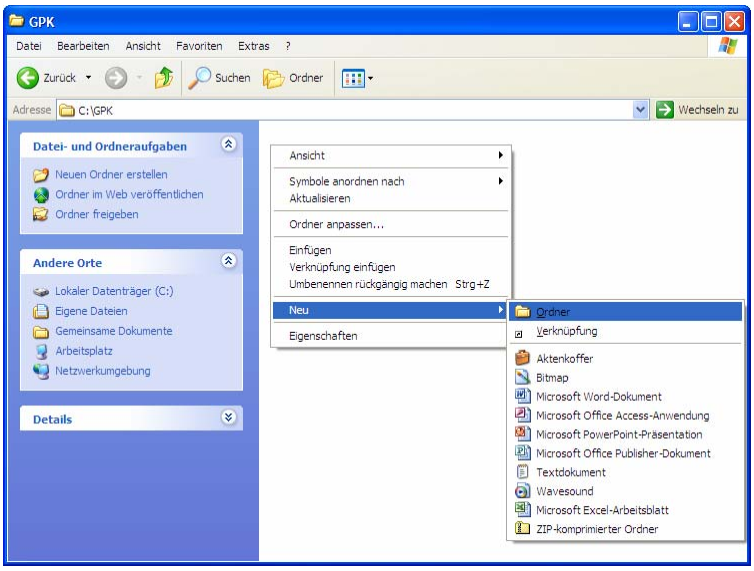


Figure 4.1-1 Creating a project folder.

4.2 Unzip / Download GPK library models

Unzip all necessary GPK library models and save them to your project folder.

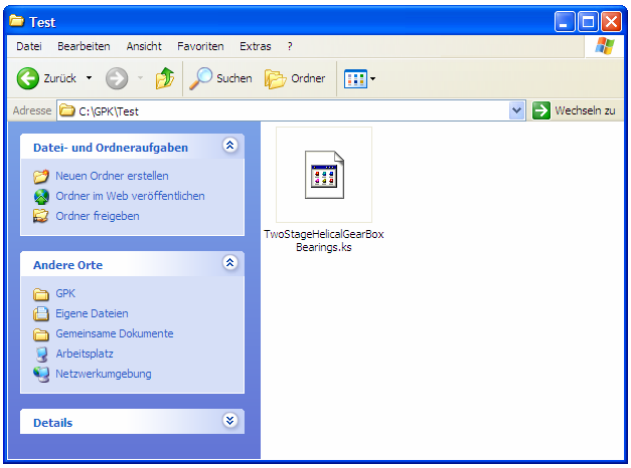


Figure 4.2-1 Load library models to project folder

GPK library models are also available in KISSsoft homepage for downloading. User may select to download single models just for your needs or whole package of all available models.

4.3 Other preparations

It is also possible to rename models before starting to operate with them. Go to your project folder and rename file as any windows type file. Remember that file extension (".ks") must be correct. Also make sure that you have write access to your project folder.

5 Starting the program

Start KISSsys with double click on icon in your desktop or start KISSsys through Windows-Start/Programs/KISSsoft-Hirnware 04-2006/KISSsys. KISSsys will open and dialog to select project folder will appear.

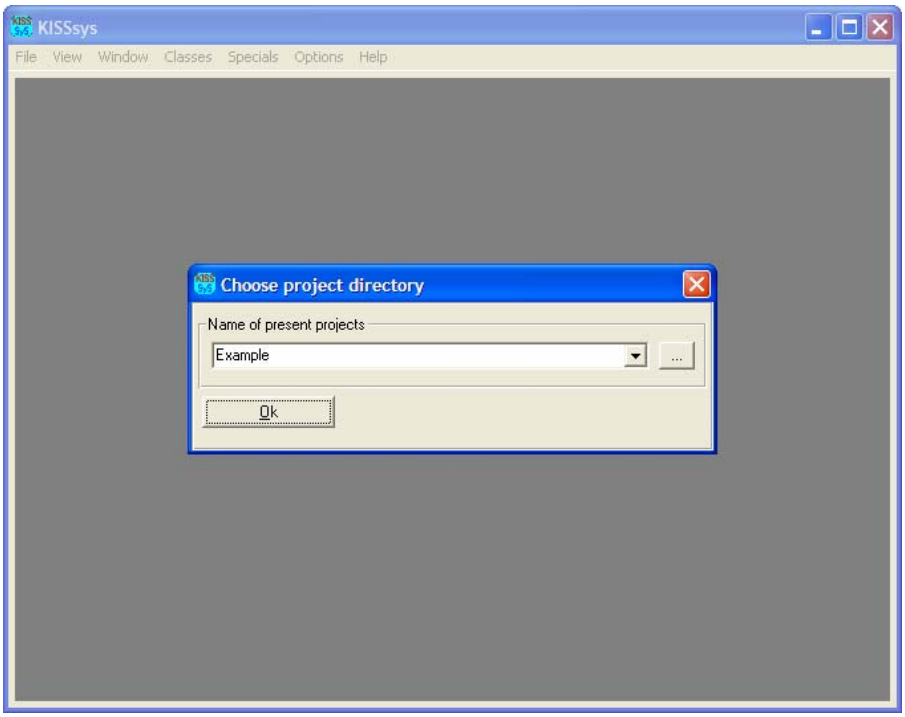


Figure 4.3-1 Dialog to select project folder.

5.1 Opening project folder

From list of project folders you may not find correct project folder. Pressing button with three dots (...) you can select any project directory to work with. Select folder you have created and where you have saved your model(s). Select desired folder and select "Open" and then choose "Open" for selecting folder and opening KISSsys.

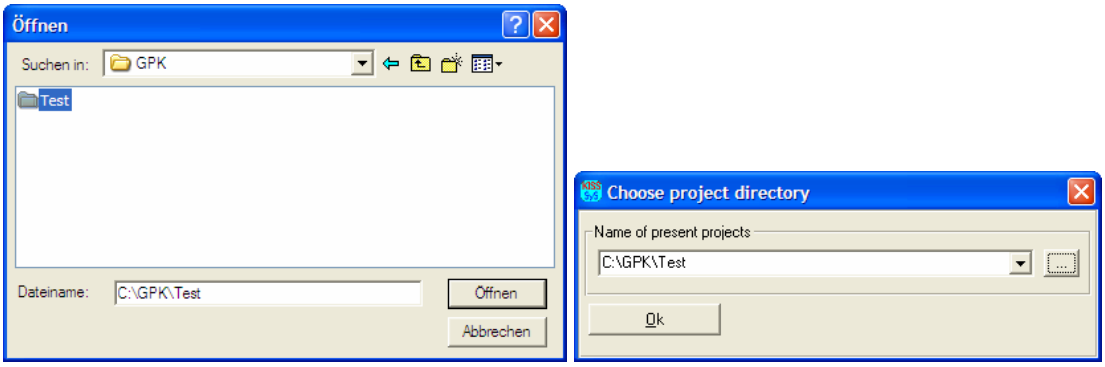


Figure 5.1-1 Select project folder to work with.

Now you will work in selected folder and all information that you need goes to that folder and it is easy to find those files later.

5.2 Selecting model for working

KISSsys will always open with empty file (no any file selected).

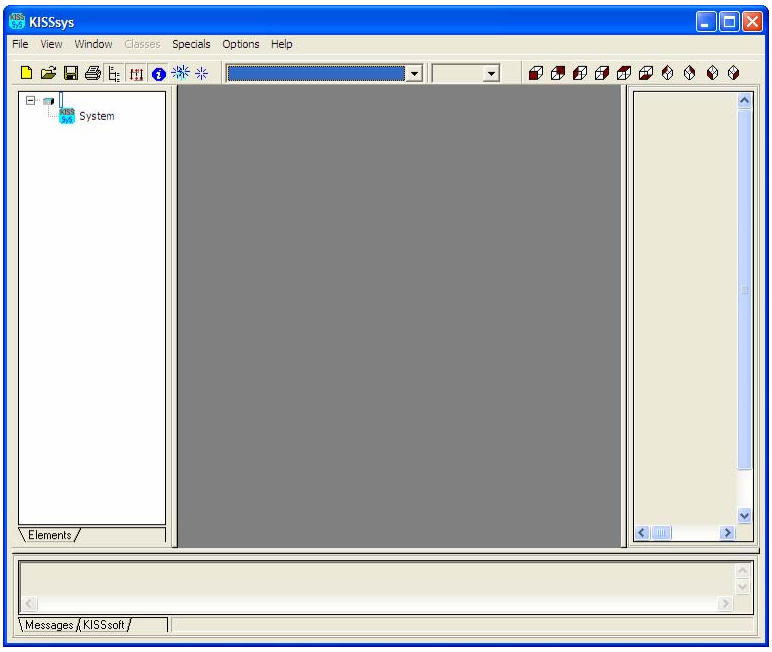


Figure 5.2-1 KISSsys opened without file selected.

After having selected the project, the GPK models available in this project can be opened. Before you can start to work with the model you need to open correct model from your project folder. Open file with Menu – File – Open or select ( ) button from menu bar to open file. Note! Models should be opened only from the current project.

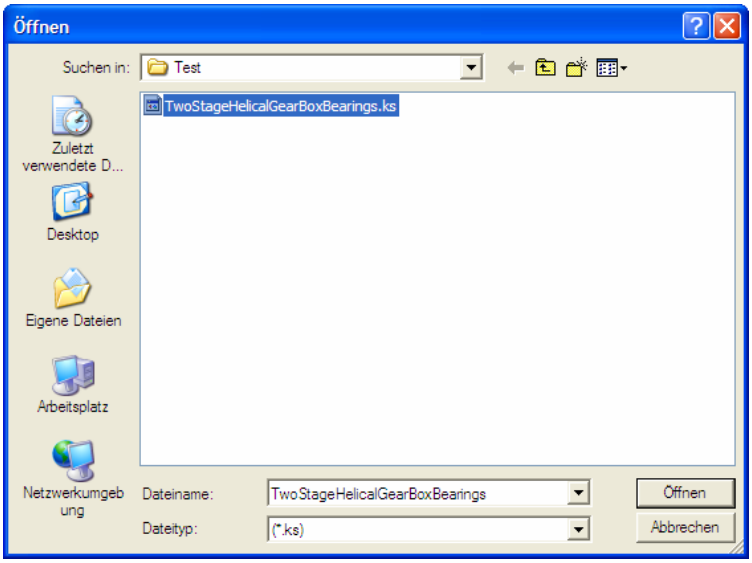


Figure 5.2-2 Select GPK model to work with.

Select file you want to work with and press “Open”. GPK model is now opened and ready for use.

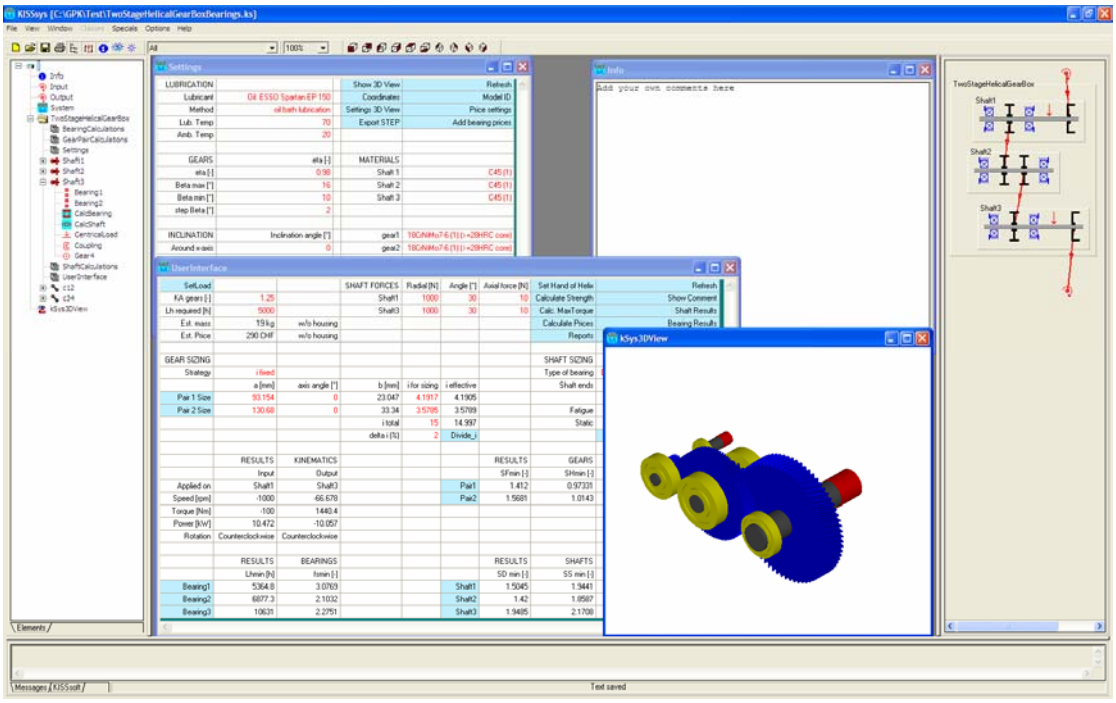


Figure 5.2-3 Selected GPK model open in KISSsys.

6 Working with GPK

6.1 Working with model

Detailed information how to work with models can be found from instructions of following chanpetrs on this file. This file is also downloadable from GPK sections of KISSsoft homepage.

6.1.1 Operation sequence

- Adjust settings via “Settings” window
- Select loads (SetLoad) from “UserInterface”
- Select total ratio and divide it to the gear pairs
- Select gear sizing method and set other variables
- Do initial sizing for all gears in order
- Set bearings and shaft sizing criteria
- Do initial sizing for the shafts and bearings
- Make final sizing for all components via individual KISSsoft masks
- Calculate Strength do modifications if needed
- Calculate max torque
- Create reports
- Do final checks (Detailed cost analyzes…)
- Accept your model and save results.

6.1.2 Operating interfaces

Five operating interfaces are provided:

1. Tree structure
2. Schematic window
3. Interface for automatic sizing and analysis of the gearbox: „UserInterface“

4. Interface for definition of global parameters: „Settings“
5. 3D view of the gearbox: „kSys3Dview“

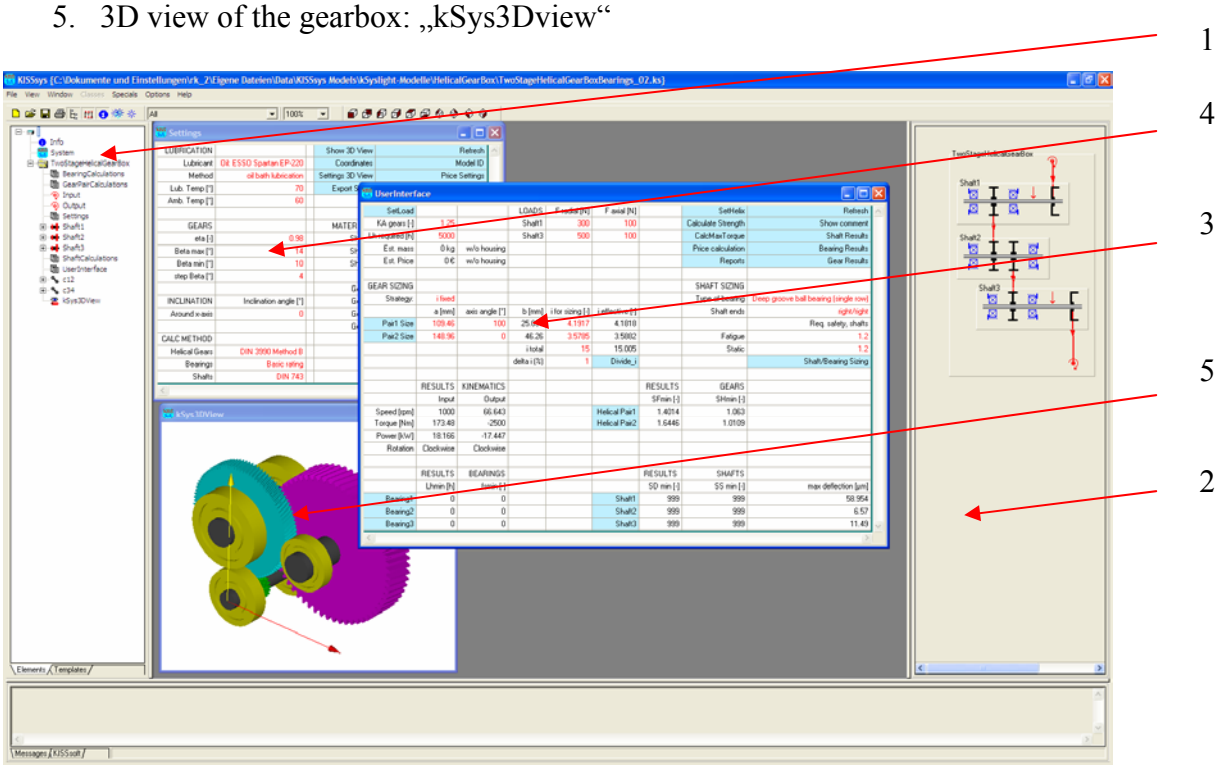


Figure 6.1-1 Left: Tree structure of the model, Centre: Three main windows, Right: Schematic.

The blue fields in the interfaces are functions to be executed by a double click. Fields in red are inputs to simply overwrite or list to select from by double click. Values in black are information or results from calculations.

6.2 Saving strategy

It is recommended to make safety copies (Save as) of you model every now and then, to be able to avoid any unnecessary remodelling in case of errors. Use indexes to keep older version e.g. Model_01_01.ks. After finishing your model with correct data old versions can be deleted. You may also use initial library model as your final model also and save modifications directly in that model with File –Save or save ( ) – button.
It is also possible to save model to as “Save as” to make a separate copy of original model. In this way you can keep library models to be untouched for next project or for later use. This way you don’t also need to download template files again from internet.

7 Description of the model

7.1 Structure of the gearbox

The two stage gearbox as shown below uses three shafts (dark grey), each supported by two roller bearings (yellow). On the last and first shaft, a coupling (red) is attached. Both couplings can either be on the same side of the gearbox or on the different sides, see Figure 8.5-2. On the input and output shafts, an external load/force is applied (green arrow). The three shafts are initially arranged in a horizontal plane, but can also be placed at an angle. The bearings again lie in a plane but can be positioned freely on the shafts.

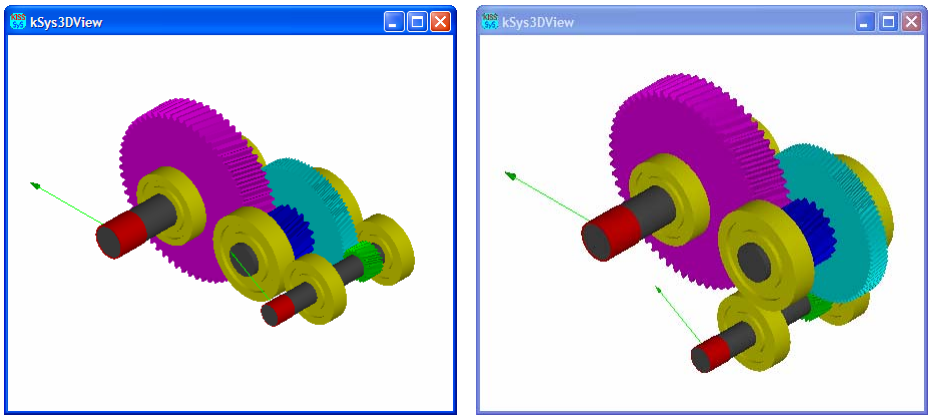


Figure 7.1-1 Left: Gearbox with horizontal arrangement, Right: with angles between axis.

7.2 Global coordinates

The global co-ordinates can be displayed by double-click on function “Coordinates” in Window “Settings”. Then, the absolute length of the arrows can be defined and the display of the global coordinates system can be activated by pressing “Ok”.

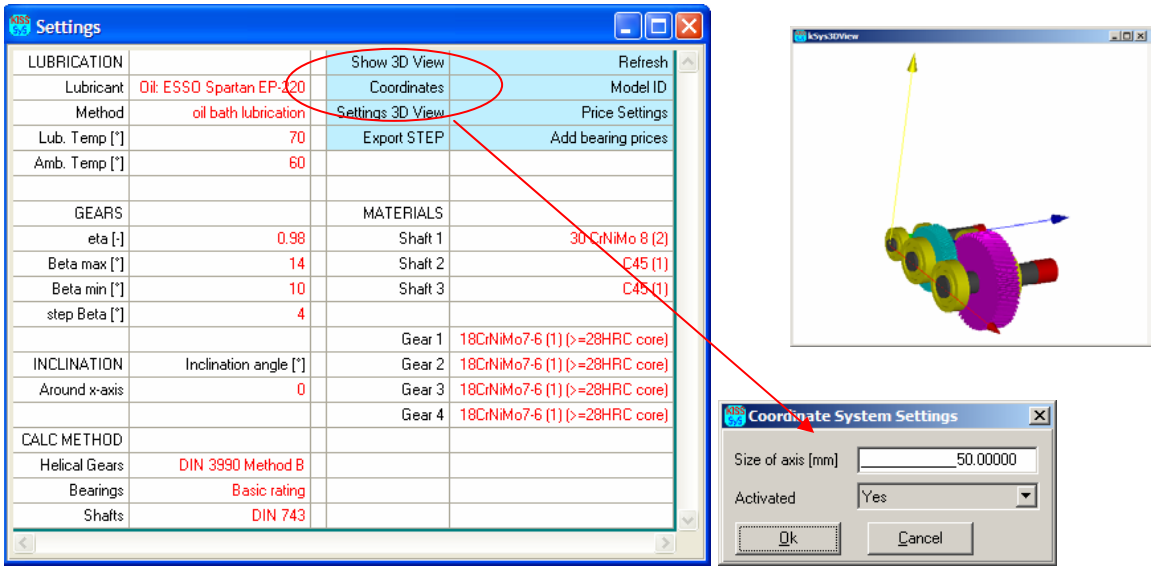


Figure 7.2-1 Function to activate coordinate system, coordinate system in 3D view.

7.3 Window “Settings”

This window is used to define the settings for the calculation and the 3D view.

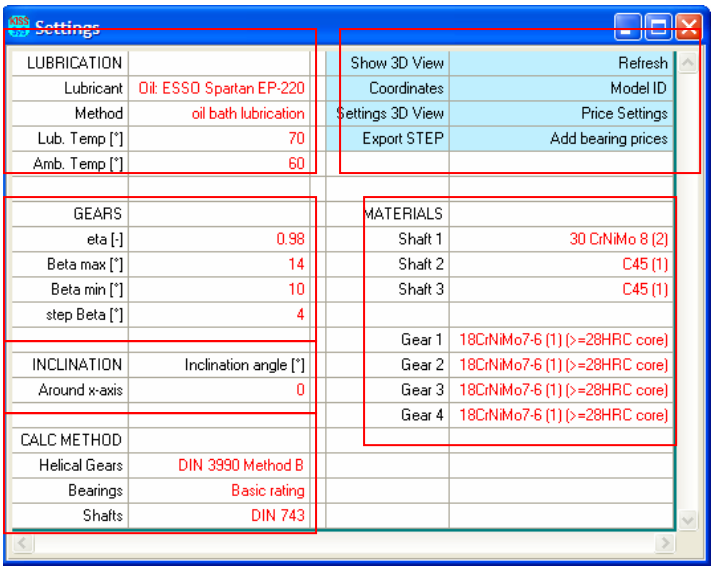


Figure 7.3-1 "Settings" window, for general settings of the model, different sections as explained below are marked.

Section	Cell name	Use	Description
LUBRICATION	Lubricant	Double click on the right text, a drop down list will show up, chose from the list	Chose Oil from KISSsoft lubricant database
	Method	Double click on the right text, a drop down list will show up, chose from the list	Chose type / mode of lubrication
	Lub. Temp [°]	Type in real value	Define lubricant temperature
	Amb. Temp [°]	Type in real value	Define ambient temperature (for plastic gear analysis only)
GEARS	Eta [-]	Type in real value	Enter efficiency of helical stage
	Beta max [°]	Type in real value	Enter maximum value for the helix angle for sizing
	Beta min [°]	Type in real value	Enter minimum value for the helix angle for sizing
	Delta_beta [°]	Type in real value	Enter desired step for the helix angle for sizing
MATERIALS	Shaft 1	Double click on the right text, a drop down list will show up, chose from list	Chose material for shaft 1 from KISSsoft material database
	Additional shafts	identical	identical
	Gear 1	Double click on the right text, a drop down list will show up, chose from list	Chose material for gear 1 from KISSsoft material database
	Additional gears	identical	Identical
CALC METHOD	Helical gears	Double click on the right text, a drop down list will show up, chose from list	Chose calculation method for helical gears
	Bearings	Double click on the right text, a drop down list will show up, chose from list	Chose calculation method for bearings
	Shafts	Double click on the right text, a drop down list will show up, chose from list	Chose calculation method for shafts
INCLINATION	Around x-axis	Type in real value	Rotate gearbox in space
FUNCTIONS	Show3DView	Double-click	Use to show 3D window

	Coordinates	Double-click	Use to show / define global coordinate system
	Settings 3D View	Double-click	Use to define settings for 3D representation
	Export STEP	Double-click	Use to export model according to 3D representation into *.stp file
	Refresh	Double-click	Use to confirm data changes and update all data
	Model ID	Double-click	Type in information for gearbox name, drawing number, user and date of modification
	Price Settings	Double-click	Use to define prices for shafts and gears [EUR/kg] and pinion type shafts
	Add bearing prices	Double-click	Use to add new bearing prices into file “bearinglist.txt”

7.4 Window “UserInterface”

This is the main window, allowing for control of gearbox sizing and gearbox analysis. The window has five different regions:

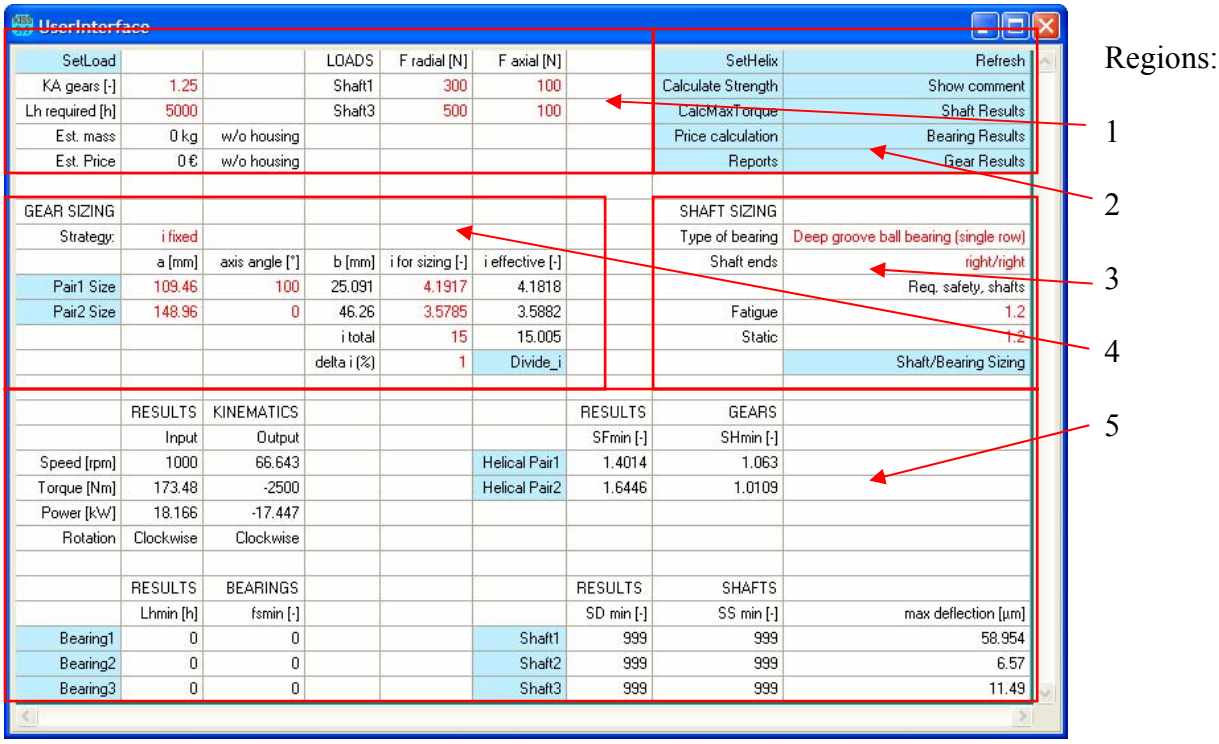


Figure 7.4-1 Regions of "UserInterface" window

Region	Name	Purpose
1	Loads	Define loads on gearbox Show approximate mass Show approximate costs
2	Functions	Execute different functions
3	Shafts, Bearings	Sizing and input of shafts and bearings

4	Gears	Sizing and input of gears
5	Results	Display of most important results

7.4.1 General functions

The following functions will be explained below:

Note: Functions should be operated in the same order as explained.

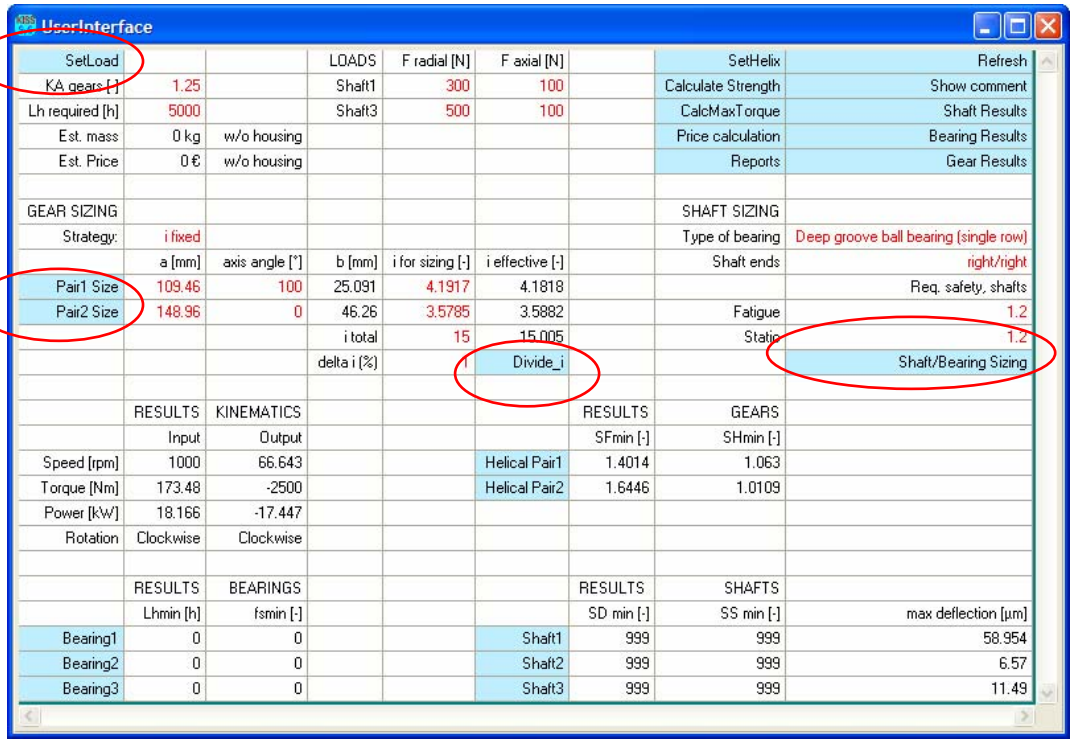


Figure 7.4-2 Functions explained in next sections

7.4.1.1 Function “SetLoad”

The dialog that appears with function “SetLoad” allows for definition of the loading condition on the input / output side as well as Centrical loads on the shafts.

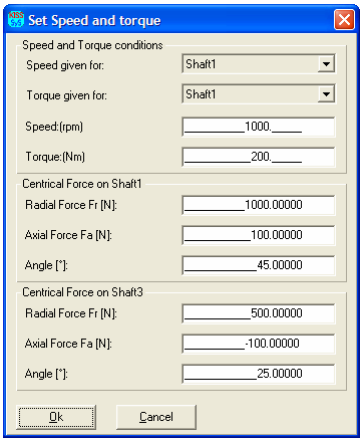


Figure 7.4-3 Dialog to define input or output speed and input or output torque and external loads on the shafts.

7.4.1.2 Function “Divide_i”

Once a desired total ratio for the gearbox has been given in the field “i total” (in this example, a value of 15 is used) and a permissible error defined in the field “delta i(%)”(in this example, a value of 1 is used), the function “Divide_i” will divide the total ratio to individual ratios for each stage.
Desired ratios for each stage can be changed by simply overwriting the values listed in column “I for sizing [-]”.

Note: The function „Divide_i“ is based on a formula given in the literature (G. Niemann) yielding a higher reduction for the first stage. Hence, shaft centre distance for stage 1 and stage 2 are similar.

7.4.1.3 Function “Pair1 Size” / “Pair2 Size”

Once the target ratio has been defined for each gear pair (using e.g. function “Divide_i”, double-click on these buttons will have KISSsys proposeing suitable gearing data. This is similar to the rough sizing function in KISSsoft to get a gear pair proposed.

7.4.1.4 Function “Shaft/Bearing sizing”

Based on the settings given in the cells above (“Type of bearing”, “Shaft ends”, “Fat. safety shafts”, “Static safety shafts”), this function will define an approximate shaft diameter and will choose bearings automatically. Note that shaft geometry and bearings types should afterwards be confirmed / modified. The proposal should be considered as a very first step.

7.4.2 Functions for access to KISSsoft

The following functions will be explained below:

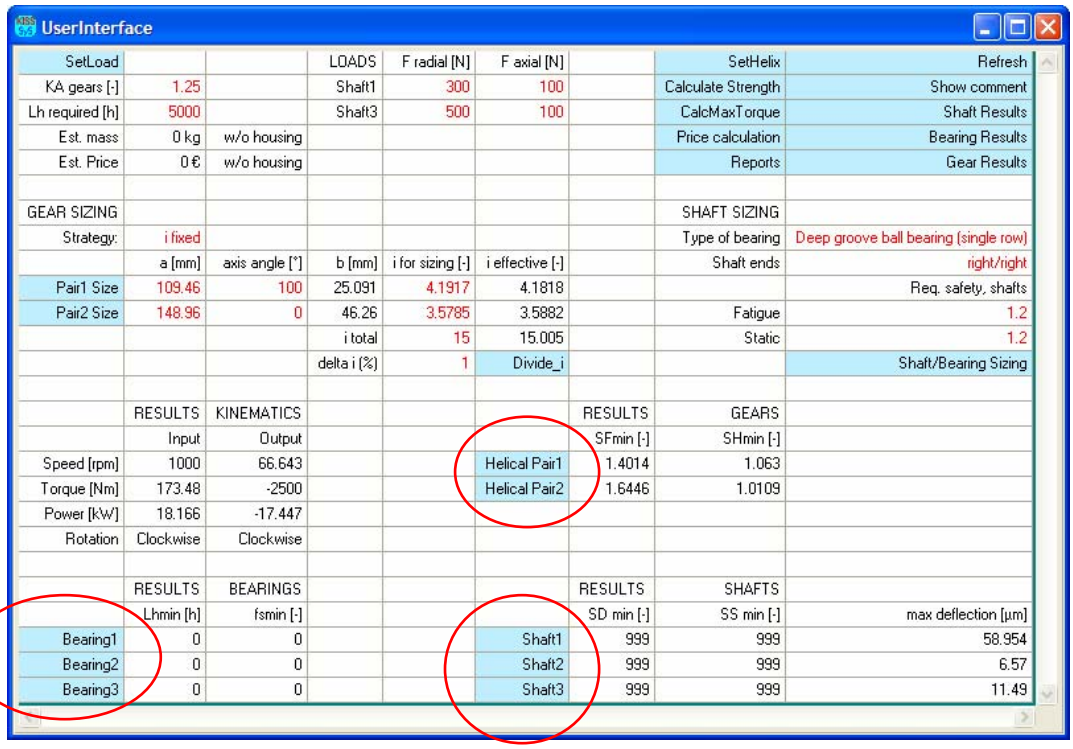


Figure 7.4-4 Functions explained in next sections.

7.4.2.1 Access to KISSsoft for gears

Double click on either “Helical Pair1” or “Helical Pair2” to get to the KISSsoft user interface for the respective gear pair. There, data can be changed as usually done in KISSsoft. After you have modified any data in KISSsoft, press “Calculate F5” before your close KISSsoft again.

7.4.2.2 Access to KISSsoft for bearings

Double click on either “Bearing1” or “Bearing2” or “Bearing3”to get to the KISSsoft user interface for the respective bearing calculation module. There, data can be changed as usually done in KISSsoft, also the fine sizing function can be used to find an optimised gear pair. After you have modified any data in KISSsoft, press “Calculate F5” before you close KISSsoft again.

7.4.2.3 Access to KISSsoft for shafts

Double click on either “Shaft1” or “Shaft2” or “Shaft3” to get to the KISSsoft user interface for the respective shaft definition. There, data can be changed as usually done in KISSsoft. After you have modified any data in KISSsoft, press “Calculate F5” before you close KISSsoft again.
However, no gears, couplings, bearings or forces must be deleted or added.

7.4.3 Functions in Region 2

The following functions will be explained below:

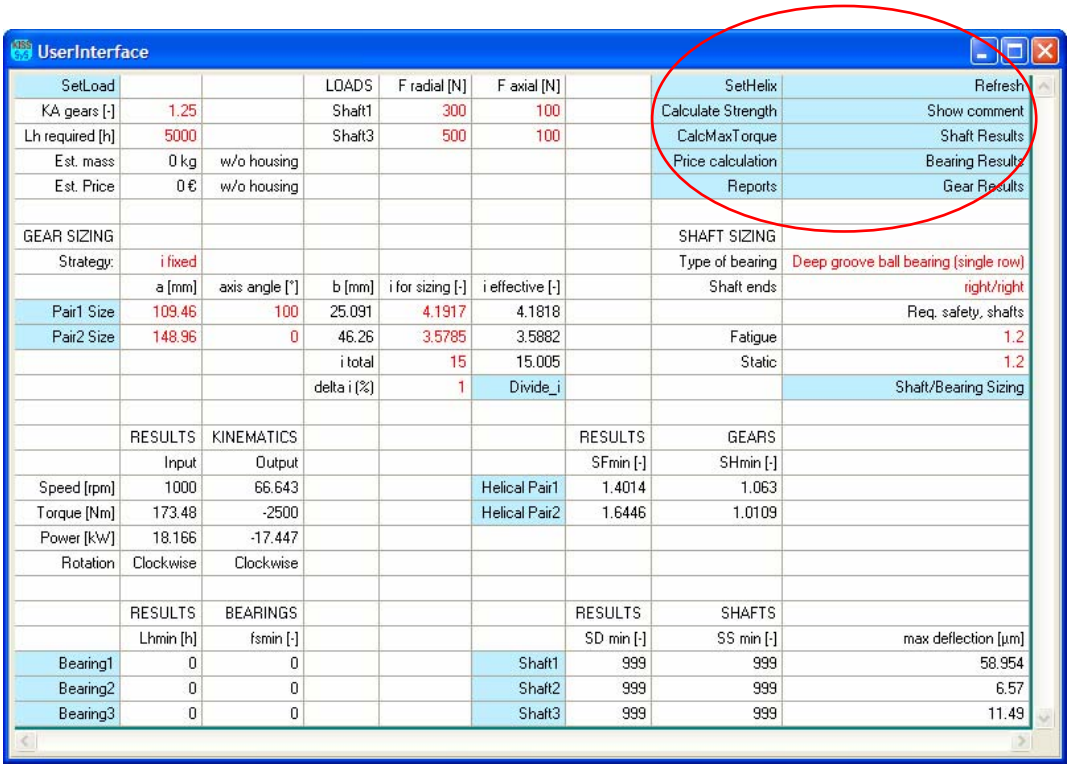


Figure 7.4-5 Functions explained in next sections.

7.4.3.1 Function “SetHelix”

This function will change all helix angles of the gears. The helix angle can be seen in the 3D graphics. Reference helix angle is given for a gear in the last shaft.

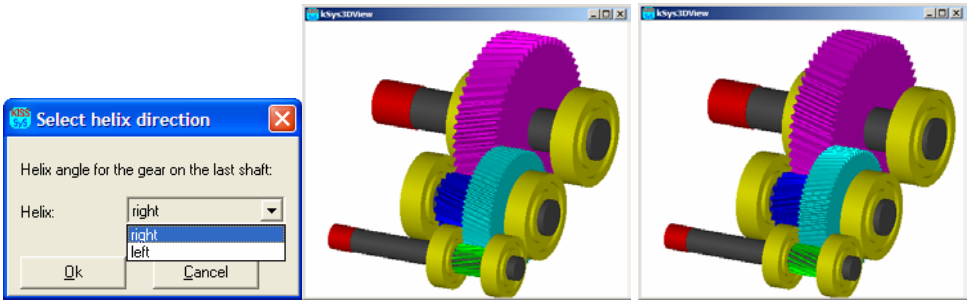


Figure 7.4-6 Changing helix direction.

7.4.3.2 Function “Calculate Strength”

This will execute the calculation of speeds and torques and strength / lifetime of the gearbox. Also estimated price (settings as given in function “Price settings”, see Figure 7.4-1, will be used).) and weight are calculated.

7.4.3.3 Function “CalcMax Torque”

This calculation will find the torque that the gearbox can transmit such that a certain safety factor / bearing life is achieved.

Note: The conditions for this function as follows:

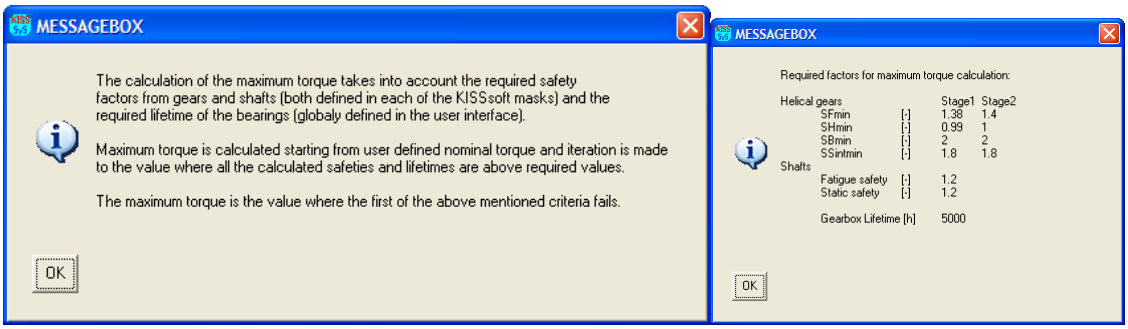


Figure 7.4-7 Conditions for function “CalcMax Torque”.

The target lifetime for the bearings is taken from Window “User Interface”, the target shaft safety factors and target gear safety factors are taken from the KISSsoft calculations of each element.

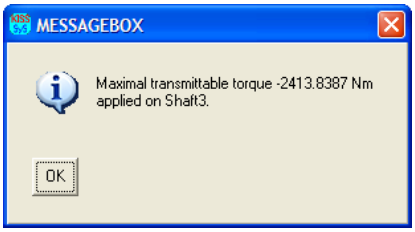


Figure 7.4-8 Output of permissible torque.

Note: This can either be output or input torque, depending on configuration set using Function “SetLoad”

7.4.3.4 Function “Price Calculation”

This function will estimate the cost of the gearbox based on user defined prices for shafts, gears and bearings.

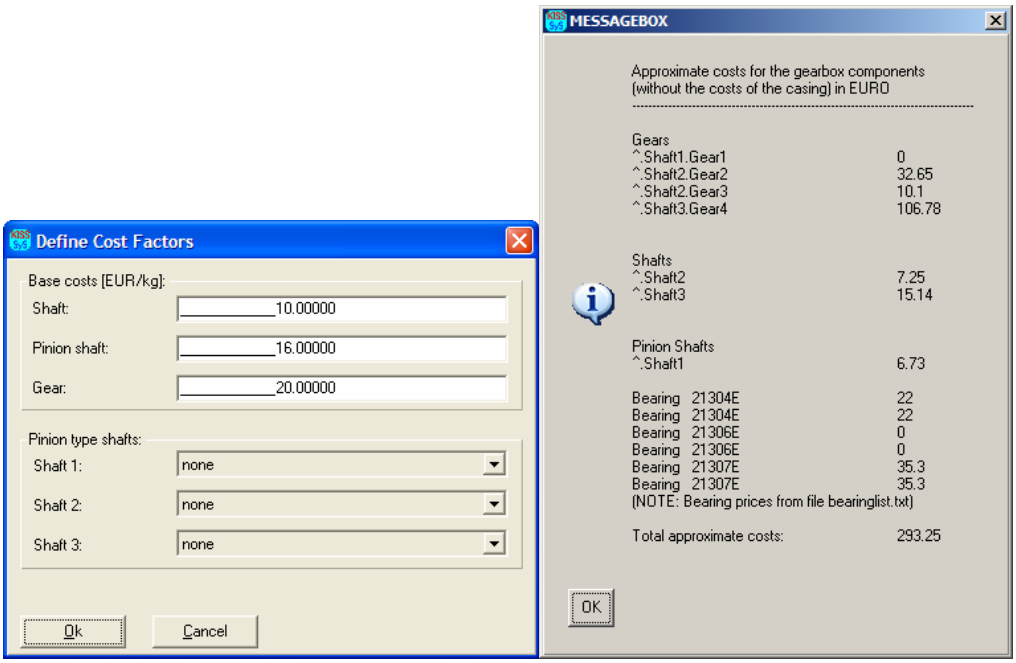


Figure 7.4-9 Input and output for price calculation.

Note: The bearing prices should be given in a text file “bearinglist.txt” and the file must be saved in the same directory as the KISSsys model. If any bearing price is missing on the list during cost calculation price will be assumed to be 0.00€. If user wants to add bearing prices into “bearinglist.txt” file, it can be done using function “Add bearing prices” in window “Settings”. Function will ask and store prices for bearings in the file bearinglist.txt, if user defines the price. Prices can be also added directly in the file, using a text editor.

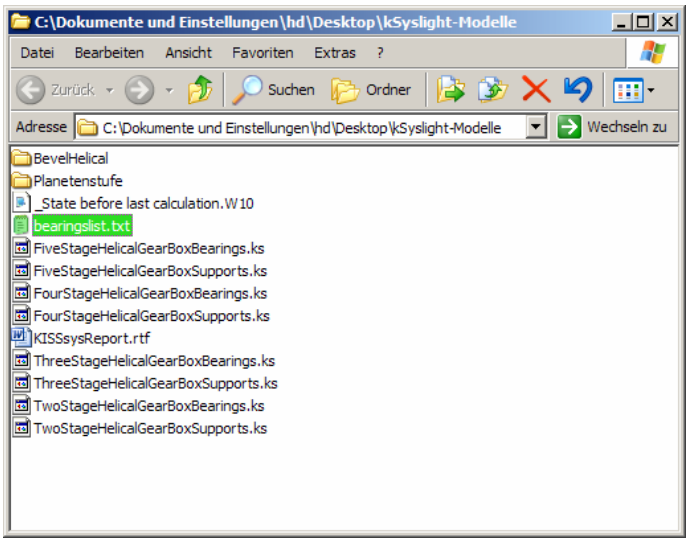


Figure 7.4-10 Location of text file with bearing prices in same folder as KISSsys model.

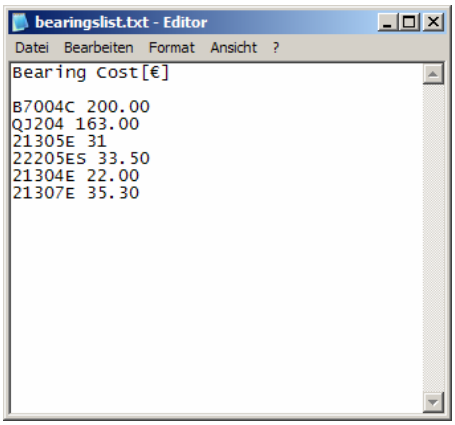


Figure 7.4-11 The format of the text file bearingslist.txt.

7.4.3.5 Function "Reports"

This function opens a drop down list to select what kind of report user wants to get. User can select one of the following reports from drop down list.

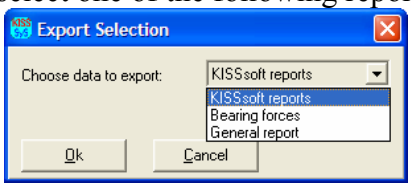


Figure 7.4-12 Dialog to select desired report.

"KISSsoft reports" will return a complete report on the gearbox with the data and results created before. Function adds all individual KISSsoft reports to one long report. Each individual KISSsoft report will be identified by its path:

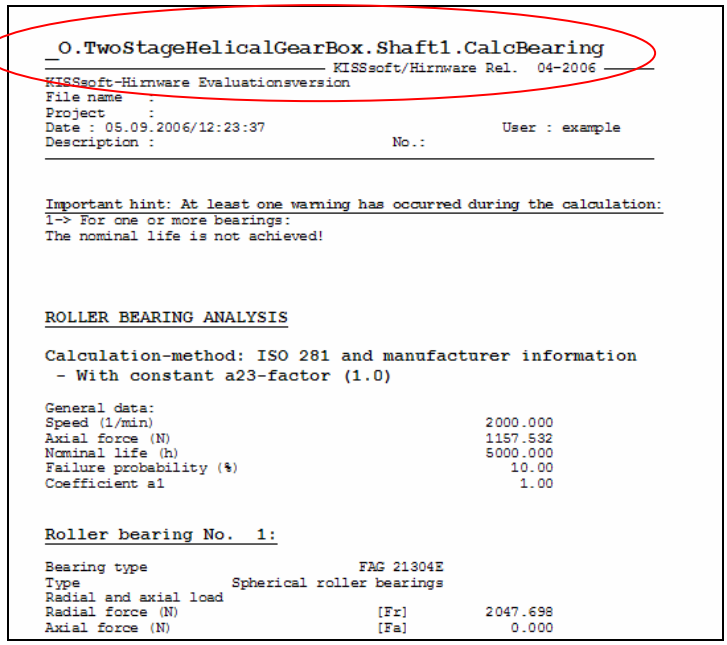


Figure 7.4-13 Identification of report by name as used in tree structure of KISSsys model.

The length of the report can be adjusted from the KISSsoft calculation modules.

"Bearing forces" will export list of bearing forces acting on the gearbox housing. Forces are given in global x, y and z co-ordinates and corresponding directions in space. Values can be

easily used e.g. in FEM- analysis. User can also select exported file type from the drop down list. File is stored on KISSsys model directory with given name.

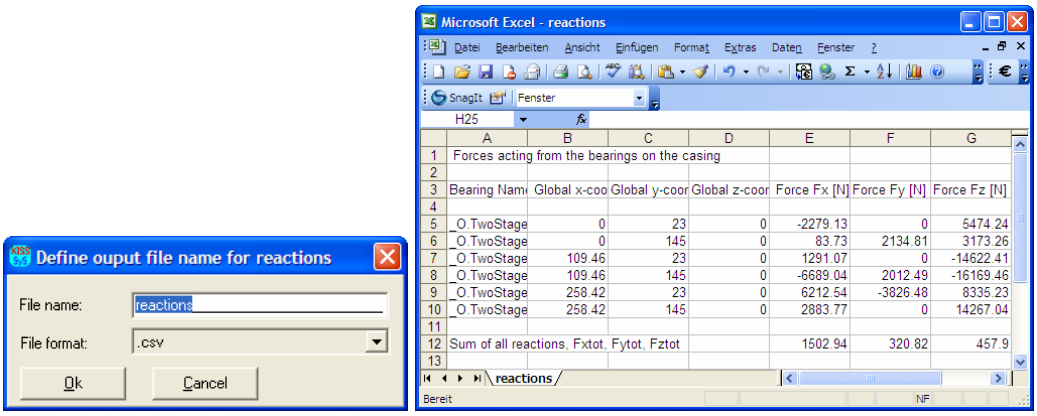
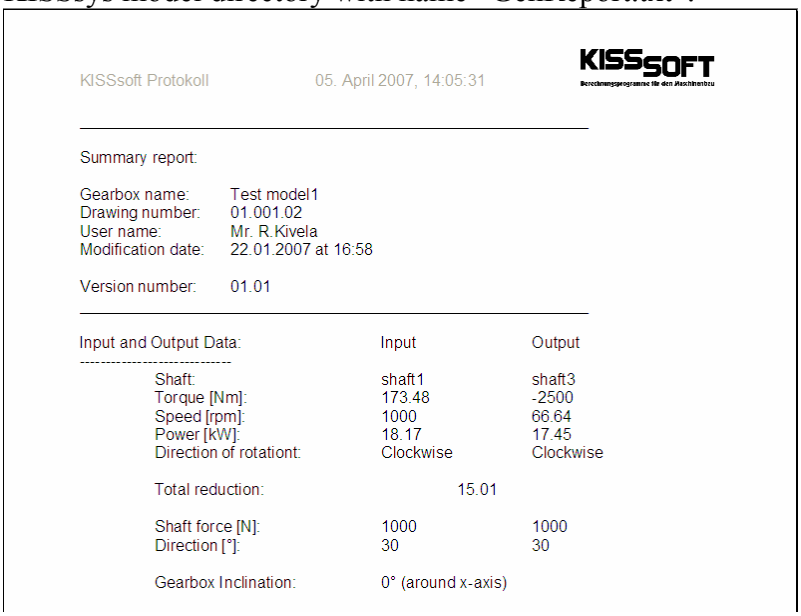


Figure 7.4-14 Bearing force file identification and exported file opened with Excel.

"General report" will create a file with the most important results of the gearbox sizing. This report can be used e.g. as a check list. User can select what kind of information will be displayed in the report. Report is opened automatically with "KISSedit" and is stored on KISSsys model directory with name "GenReport.txt".



KISSsoft Protokoll 05. April 2007, 14:05:31

Summary report:

Gearbox name: Test model1
Drawing number: 01.001.02
User name: Mr. R.Kivela
Modification date: 22.01.2007 at 16:58

Version number: 01.01

Input and Output Data:	Input	Output
Shaft:	shaft1	shaft3
Torque [Nm]:	173.48	-2500
Speed [rpm]:	1000	66.64
Power [kW]:	18.17	17.45
Direction of rotationt:	Clockwise	Clockwise
Total reduction:	15.01	
Shaft force [N]:	1000	1000
Direction [°]:	30	30
Gearbox Inclination:	0° (around x-axis)	

Figure 7.4-15 General report shows most important results of gearbox.

7.4.3.6 Function "Refresh"

Use this function once data has been inputted to update model and the graphics.

7.4.3.7 Function "Show comment"

This function will appear window "info" to be able to type in any comments user wants to have.

Figure 7.4-16 Comment window.

7.4.3.8 Function “Shaft Results”

Execute this function by double click to add a table to the KISSsys model displaying relevant shaft data / results as shown below:

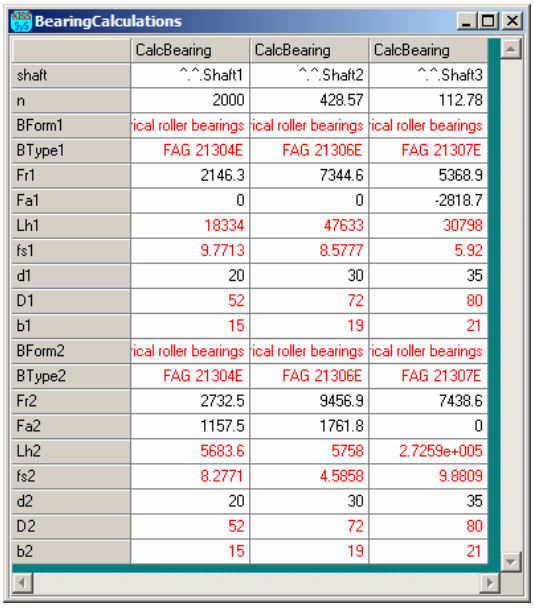
ShaftCalculations

	CalcShaft	CalcShaft	CalcShaft
shaft	^.^.Shaft1	^.^.Shaft2	^.^.Shaft3
n	2000	428.57	112.78
dn	0	1	0
material	C45 (1)	C45 (1)	C45 (1)
xmin	-0.005909	-0.006159	-0.016352
xmax	0.060961	0.004356	0.007595
zmin	-0.013861	-0.029189	-0.033483
zmax	0.004008	0.017158	0.011352
SDA	3.9535	2.0419	1.7257
SSA	5.2833	2.6687	1.8326
RDA	329.46	170.16	143.81
RSA	440.27	222.39	152.72
SDB	6.0956	5.4586	1.775
SSB	6.1963	11.93	1.8395
RDB	507.97	454.88	147.92
RSB	516.36	994.2	153.29
SDC	6.1701	7.2737	1.8866
SSC	6.218	13.826	1.8194
RDC	514.17	606.14	157.22
RSC	518.16	1152.2	151.61
SDD	0	0	1.9541
SSD	0	0	1.8348
RDD	0	0	162.85
RSD	0	0	152.9
SDE	0	0	0
SSE	0	0	0
RDE	0	0	0
RSE	0	0	0
SDF	0	0	0
SSF	0	0	0
RDF	0	0	0
RSF	0	0	0
SDG	0	0	0
SSG	0	0	0
RDG	0	0	0
RSG	0	0	0

Figure 7.4-17 Display of relevant shaft data like speed and safety factors.

7.4.3.9 Function “Bearing Results”

Execute this function by double click to add a table to the KISSsys model displaying relevant bearing data / results as shown below:



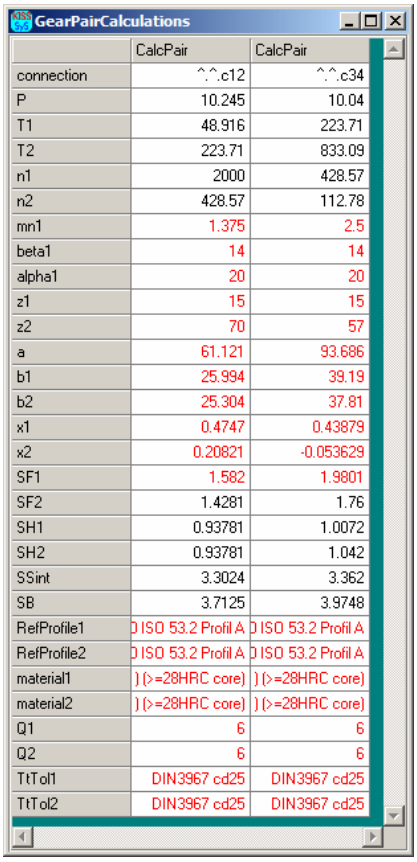
BearingCalculations

	CalcBearing	CalcBearing	CalcBearing
shaft	^.^.Shaft1	^.^.Shaft2	^.^.Shaft3
n	2000	428.57	112.78
BForm1	ical roller bearings	ical roller bearings	ical roller bearings
BType1	FAG 21304E	FAG 21306E	FAG 21307E
Fr1	2146.3	7344.6	5368.9
Fa1	0	0	-2818.7
Lh1	18334	47633	30798
fs1	9.7713	8.5777	5.92
d1	20	30	35
D1	52	72	80
b1	15	19	21
BForm2	ical roller bearings	ical roller bearings	ical roller bearings
BType2	FAG 21304E	FAG 21306E	FAG 21307E
Fr2	2732.5	9456.9	7438.6
Fa2	1157.5	1761.8	0
Lh2	5683.6	5758	2.7259e+005
fs2	8.2771	4.5858	9.8809
d2	20	30	35
D2	52	72	80
b2	15	19	21

Figure 7.4-18 Relevant bearing data like lifetime and other.

7.4.3.10 Function “Gear Results”

Execute this function by double click to add a table to the KISSsys model displaying relevant gear data / results as shown below:



GearPairCalculations

	CalcPair	CalcPair
connection	^.^.c12	^.^.c34
P	10.245	10.04
T1	48.916	223.71
T2	223.71	833.09
n1	2000	428.57
n2	428.57	112.78
mn1	1.375	2.5
beta1	14	14
alpha1	20	20
z1	15	15
z2	70	57
a	61.121	93.686
b1	25.994	39.19
b2	25.304	37.81
x1	0.4747	0.43879
x2	0.20821	-0.053629
SF1	1.582	1.9801
SF2	1.4281	1.76
SH1	0.93781	1.0072
SH2	0.93781	1.042
SSint	3.3024	3.362
SB	3.7125	3.9748
RefProfile1	ISO 53.2 Profil A	ISO 53.2 Profil A
RefProfile2	ISO 53.2 Profil A	ISO 53.2 Profil A
material1	(>=28HRC core)	(>=28HRC core)
material2	(>=28HRC core)	(>=28HRC core)
Q1	6	6
Q2	6	6
TtTol1	DIN3967 cd25	DIN3967 cd25
TtTol2	DIN3967 cd25	DIN3967 cd25

Figure 7.4-19 Gear data.

7.5 Export model

Whole designs can be exported to step file "*.STEP", to be able to open in any other CAD program. Exported model is based on 3D view and can be used e.g. as a starting point for housing designs.
That can be done under "Settings" window with double click on "Export geometry", see also section 7.3

8 Basic sizing procedure

8.1 Settings

Define global parameters in „Settings", see 7.3. Parameters once defined can be changed at any time. Confirm changes by double click on "Refresh".

8.2 Load condition

Define power rating (speed and torque) using function "SetLoad".

- ✓ Define either input or output speed
- ✓ Define either input or output torque
- ✓ Define external loads

See also section 7.4.1.1

Enter application factor KA (applicable for gears only) and target lifetime of gearbox.

Define/modify external forces on input and output shaft using the fields shown below:
Note: External forces can be also defined in function "SetLoad".

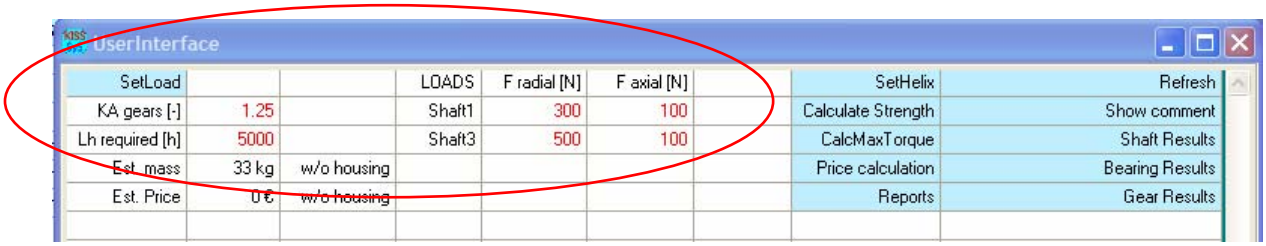


Figure 8.2-1 Definition of external forces on input and output shaft, KA and required lifetime.

The external forces will be represented as shown below (use function "Settings3DView" from "Settings" window to activate / scale arrows).

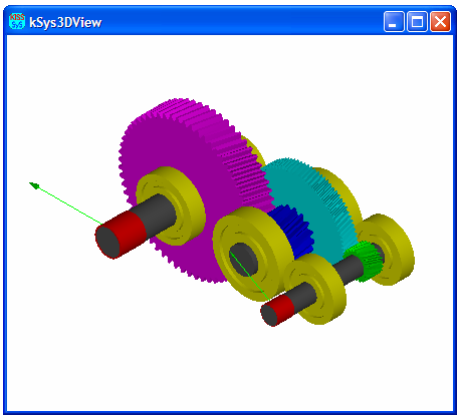


Figure 8.2-2 Arrows showing external forces.

8.3 Define gear ratios

First, enter target total ratio of the gearbox in the field “i total”. Also, enter allowable error in the field “delta i (%)”. Then, execute function “Divide_i”, see 7.4.1.2 resulting in a proposal for the ratio for each stage. This proposal may be modified by directly entering values for the ratio of each stage (i for sizing [-]).

ngle [°]	b [mm]	i for sizing [-]	i effective [-]
0	15.543	4.7138	4.7273
0	37.81	3.8186	3.8
	i total	18	17.964
	delta i (%)	2	Divide_i

gle [°]	b [mm]	i for sizing [-]	i effective [-]
0	15.543	6	4.7273
0	37.81	3	3.8
	i total	18	17.964
	delta i (%)	2	Divide_i

Figure 8.3-1 Left: Input of target ratio, error, automatic distribution of total ratio to stage ratios, Right: Overwriting ratio for each stage manually.

Note: The effective (based on current number of teeth) ratio per stage is shown in the column “i effective [-]”. It may vary slightly from the target value.

8.4 Chose gear sizing strategy

Initial dimensioning of the two stages, based on the power rating and the global parameters defined, for both stages, a total of four gears are proposed (using the KISSsoft function for sizing of gears, for two pairs, each having two gears). For this, the respective selection from the list „i fixed, a small / i fixed, a large / i fixed / i,a fixed / i,a,b fixed“ is to be made. Usually, in the first dimensioning step, choose „i fixed“. If the shaft centre distance however is also given, choose „i,a fixed“ and define the centre distance in the column “a [mm]”. If the face width is also fixed, then define the face width in both gear modules in advance separately and choose “i,a,b fixed”, Using the function „Pair1 Size“ and “Pair2 Size”, gear data for the four gears are proposed.

The axis angle will define the angle between first and second and second and third axis respectively:

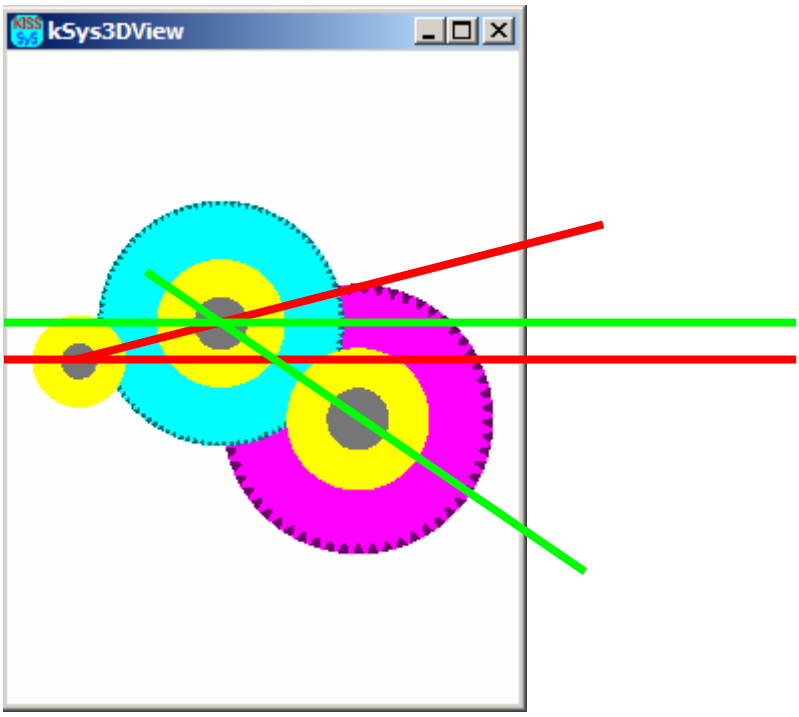


Figure 8.4-1 Angle between axis: axis angle pair 1: between red lines, axis angle pair 2: between green lines.

Note: Some of the values (e.g. the gear width) resulting from the sizing functions are analytical values and may require rounding.

8.5 Shaft and bearing sizing

Based on the required safety factors for the shafts (defined using input for fields “Req. safety shafts” -static and -fatigue) and the lifetime of the bearings (defined using the field “Lh required [h]” in window “UserInterface”) strength or lifetime, a shaft geometry is proposed and suitable roller bearings are selected by executing function “Shaft/Bearing Sizing”. Desired bearing types should be selected from list “Type of bearing” before that.

Shaft ends: The shaft ends can either be arranged either both on the same side or on different sides of the gear box. This is defined through the list shown below:

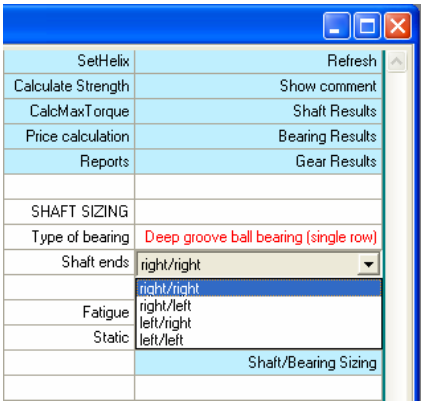


Figure 8.5-1 List to define configuration of input/output arrangement

Depending on the choice made here, the configuration will change once the function “Shaft/Bearing sizing” is executed.

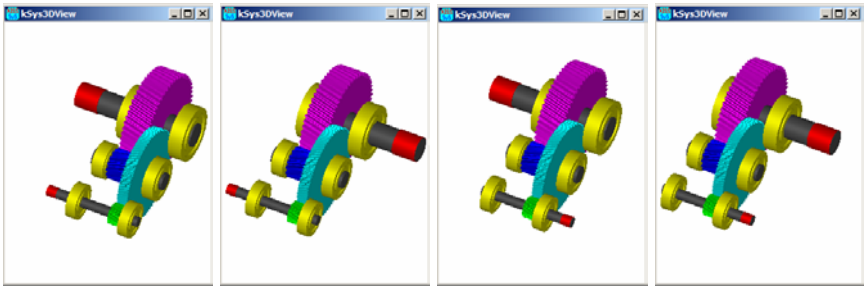


Figure 8.5-2 Coupling configuration: right/right, right/left, left/right

Only once all these settings have been defined, the shaft/bearing sizing should be executed by double click on “Shaft/Bearing Sizing”.

8.6 Price calculation setup

In order to be able to calculate gearbox approximate price without housing, use function “Price Settings” to define base prices for components. It is also possible to define whether any of shafts in the model is pinion type shaft.

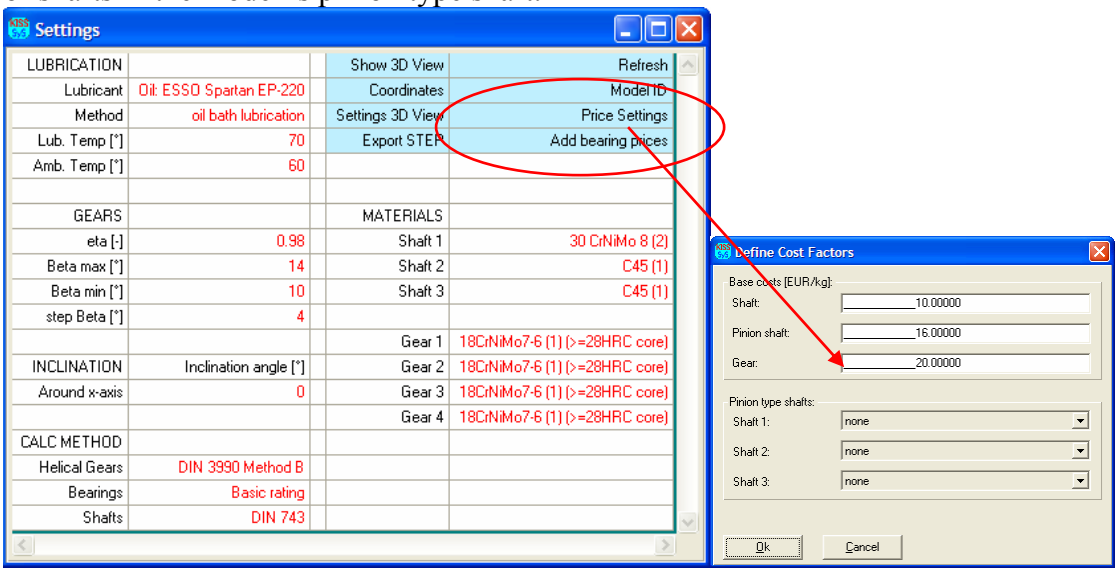


Figure 8.6-1 Price calculation settings dialog.

Use also function “Add bearing prices” to add additional bearings into bearing price list (bearinglist.txt). Function will go through all bearings in the model and checks if the price already exists in list “bearinglist.txt” or not. In case of bearing price is not into list, dialog will appear to type in bearing price and save it to the file. Any changes for bearing prices into list can be done with opening the file in editor and typing in new value. Similarly unnecessary bearings can be removed from the list by deleting lines.

8.7 Strength calculation of preliminary design

With the above steps, a first proposal for the gearbox is established. Using the function „Calculate Strength“, see 7.4.3.2, a strength analysis of the shafts, gear pairs and bearings is executed.

The results are shown in the lower part of the window “UserInterface”. Resulting kinematic data is shown, the minimal gear safety factors (minimum per stage), minimum shaft safety factor and minimum bearing lifetime (per shaft).

For detailed results, create detailed tables using functions “Shaft Results”, “Bearing Results”, “Gear Results”. See sections 7.4.3.8, 7.4.3.9 and 7.4.3.10.

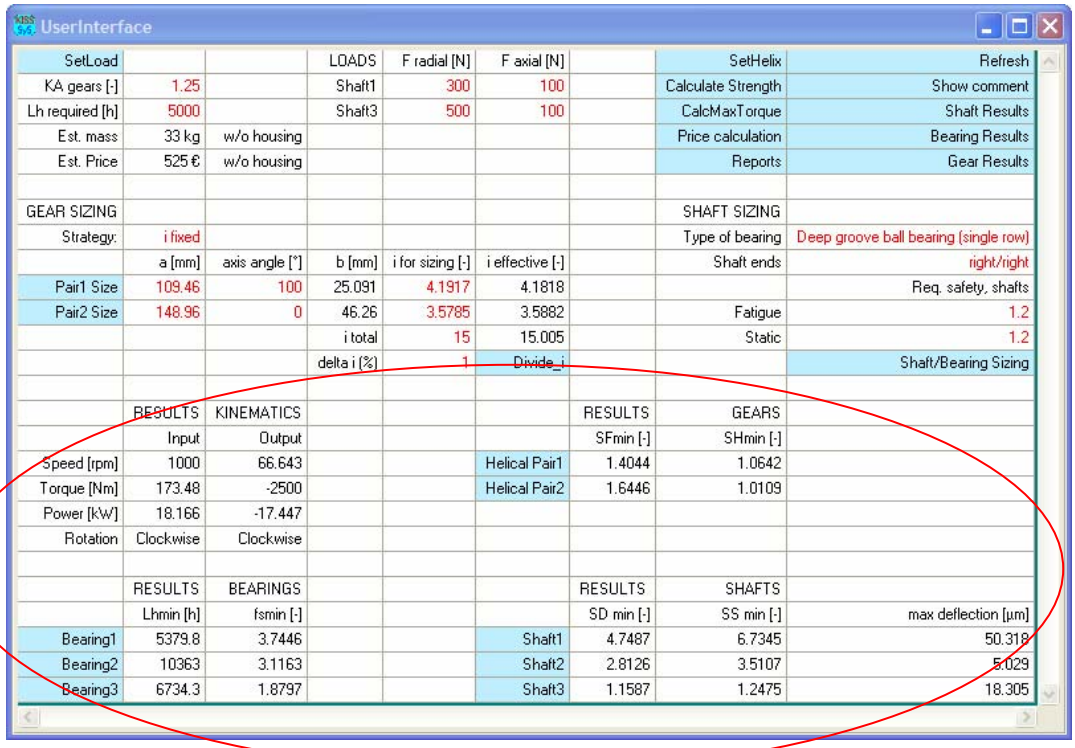


Figure 8.7-1 Results overview.

9 Final design of gears, shafts and bearings

9.1 Finalising gear, shaft and bearing data

Using the functions „Helical Pair1“/„Helical Pair2“, the gears can be further modified and optimised. The shaft geometries and strength analysis can be accessed using the buttons „Shaft1“/„Shaft2“/„Shaft3“ and the bearings selected can be modified either in the graphical shaft editor or in the KISSsoft bearings analysis modules.
The axial position of the shafts is based on the centres of the gears. All positions of the elements (gears, couplings, bearings) on their respective shaft can be modified in the graphical shaft editor. However, no gears, couplings, forces or bearings can be added or removed.

9.2 Results

After final design user may use “Reports” function to create documentation of gearbox dimensioning.

9.3 Important notes

1) Design of the shafts: On dimensioning the shafts, a simple geometry considering relevant constraints is proposed. Using a strength analysis recognising notches, the required diameter is calculated. However, the detailed design of the shaft has to be done by the engineer. It is hence important to modify the shaft geometry before the final lifetime calculation is performed.
2) Function „CalcMaxTorque“: After having finalised the design, the maximum permissible power rating (based on the required life times and safety factors) is calculated using an iteration.
3) The lead angle of the gears has a high influence on the bearings lifetime. Using the function „SetHelix“, the direction of the lead angle on the output shaft can be defined. The direction of the lead angle of the other gears is then set accordingly. On intermediate shaft both gears have the same direction in order to compensate the axial forces.

10 Conclusion

Similar to the sizing functions as used in KISSsoft to generate a pair of gears for a given power rating, a model has been established in KISSsys with a similar functionality but for a complete gear box including all relevant elements. Using this model, a proposal for a two, three, four or five stage gear box based on a required power rating and lifetime is established in a very short time. Using the fine sizing option in KISSsoft, this first proposal can then be optimised. The time required for the design of a complete gear box is greatly reduced and the engineer can compare different gear options easily.