

APM Drive

User's Guide

APM Drive

System for complete design and calculation of 3D drive unit

Version 9.2

User's Guide

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Introduction

General regulations

System APM Drive is the tool for complete calculation and design of drive unit. Using APM Drive, You can get geometry of gears, worm gears and necessary sizes of frictionless bearings and shafts. Changing of construction according to intermediate results is made in interactive mode. Upon the completion of calculations an assembly drawing of drive unit is automatically generated (in 2D graphics editor APM Graph). Following APM WinMachine modules are used for calculation and design of drive unit: APM Trans, APM Shaft, APM Bear, APM Data, APM Graph. You can use their possibilities entirely. APM Drive is the system that prepares initial data for these design and calculation modules. It is necessary to install all above-mentioned modules for running APM Drive.

Hardware and Software requirements

Hardware minimum: CPU 600 MHz, RAM 64 Mb. Software MS Windows 2000, XP.

Typefaces used in this book

To facilitate reading and avoid misunderstanding we use a set of typefaces.

Help Boldface is used for command names of APM Drive

Results Italics is used for the names of dialog boxes and its controls

Chapter 1

APM Drive Calculations

APM Drive allows to perform following calculations

- Kinematic scheme design calculation;
- Torque checking calculation of kinematic scheme;
- Longevity checking calculation of kinematic scheme;



Design calculation

Geometry dimensions of kinematic scheme elements (gears, shaft, bearings) are calculated based on working conditions by design calculation. Output torque, output rotational frequency, input/output ratio and longevity are considered as initial data. Besides you can specify additional parameters for each scheme element such as material, thermal treatment, etc. Based on these data **APM Drive** calculates basic dimensions of gear to satisfy contact and bending fatigue strength, performs preliminary selection of shaft geometry based on fatigue strength and selects required bearings.

Shaft geometry can be exactly defined after first calculation namely specified shaft segments diameters, place grooves, keys, splines, fillets, etc. You can set required bearings manually as well. Design calculation can be done with different constraints. See section «Design with constraints ».

Torque checking calculation

Load capacity of both whole scheme and each scheme element is calculated by torque checking calculation. Initial data for this calculation are geometry parameters of scheme elements (gears, bearings, shafts), given materials, thermal treatment of gears, output rotational frequency, longevity. Safety factors for fatigue and static strength as well as maximum power and other parameters are calculated as a result.

As mentioned above it is necessary to enter geometry parameters of gears, shafts and bearings to perform checking calculation. Use **View | Parameters**  command of main menu or **Parameters** command of popup menu. Popup menu is available by right mouse click on selected scheme element in «Select»  mode.

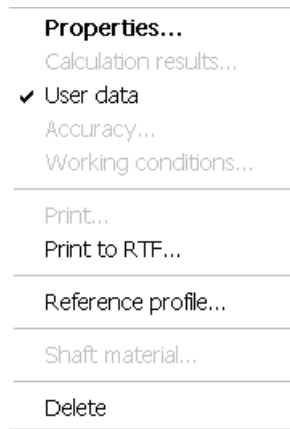




Fig. 1.1 Popup menu.

If bearings are not specified before the calculation they will be selected in calculation process.

Longevity checking calculation

Longevity of kinematic scheme elements is calculated by longevity checking calculation. Initial data for this calculation are geometry parameters of scheme elements (gears, bearings, shafts), given materials, thermal treatment of gears, output rotational frequency, torque, etc.

Use **View | Parameters**  command of main menu or **"Parameters"** command of popup menu to specify geometry parameters of scheme elements. Popup menu is available by right mouse click on selected scheme element in «Select»  mode.

If bearings are not specified before the calculation they will be selected in calculation process.

Design with constraints

It is possible to place additional constraints on designed gears parameters in **APM Drive**. Such need arises for example by gear design with standard center distance or required helix angle, etc. Enter **additional data** to define constraints. Use *Additional data* dialog that is invoked by "More..." button from main geometry data (**Parameters** command of main or popup menu). Indication of set constraint is nonzero value in corresponding edit box. This is valid for all additional parameters except addendum modification that can be zero.

It is necessary to enter main data to perform calculation. Enter additional data to set constraints only.

Chapter 2

Kinematics scheme editor

In this editor you can enter all necessary information for design and calculation of drive unit (Fig.1.1). You can create a kinematic scheme using the primitive elements.

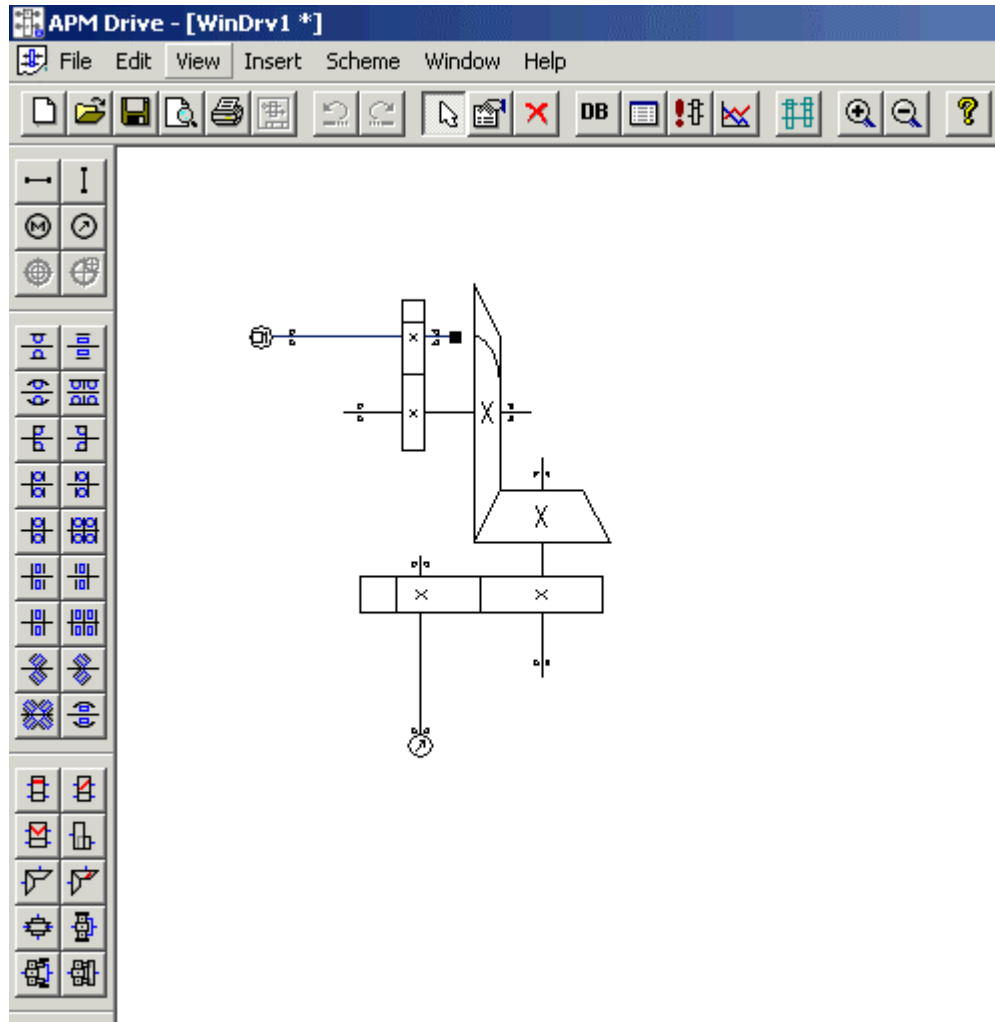


Fig. 1.1 Kinematic scheme editor.

You can manage visibility of the control bars by means of menu item **View | Controls bars**. There are 4 control bars: Toolbar, Shafts, Bearings, Transmissions.

Toolbar



Fig.1.2 *Toolbar*.

By means of this control bar you can create new scheme, save, print it, edit primitive parameters, etc. (see Chapter 2).

Control bar *Shafts*



Fig. 1.3 Control bar *Shafts*

By means of this control bar you can add vertical and horizontal shafts to the scheme, set input and output shafts.

Control bar *Bearings*

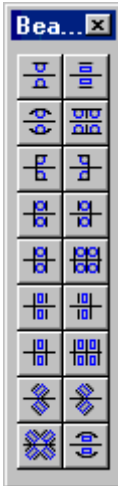


Fig.1.4 Control Bar *Bearings*

By means of this control bar you can add various bearings to the scheme.

Control bar *Transmissions*

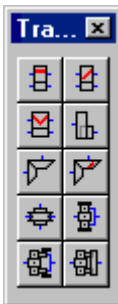


Fig.1.5 Control Bar *Transmissions*

By means of this control bar you can add various transmissions to the scheme.

Status line

Help for current command shows here.

Mouse scrolling

If you have mouse with roll of scrolling, you can use it for scaling of working area. Down scrolling is zoom in, up scrolling – zoom out.

Right mouse button



If any scheme element is selected you can call contextual menu with commands list for this elements by right mouse button click.

Fig 1.6 Contextual menu

Chapter 2

APM Drive Commands

File menu

This menu includes commands for creating new scheme, working with files, printing and exporting of the scheme.

New – creates new kinematics scheme.

Button: .

Open – opens created file. After selecting this command, the standard dialog box *Open file* will be shown on the screen.

Button: .

Close – closes current kinematics scheme.

Save – saves current scheme in file with extension .awd. Standard dialog box *Save file as* will be shown if document was not previously saved.

Button: .

Save as – saves current scheme in a file. Standard dialog box *Save as* will be displayed after selecting this command.

Print – prints current scheme. Standard *Print* dialog box will be displayed after this command selection.

Button: .

Print Preview – shows preview of printing document.

Button: .

Print setup – allows to select printer and to change its settings. Standard dialog box *Print setup* will be displayed after this command selecting.

Print to RTF – saves scheme in RTF file.

Export – creates the drawing of drive unit in APM Graph. Dialog box *File export* will be displayed as a result.

Button: .

Exit – closes all opened schemes and exit program.

Edit menu

This menu includes commands for working with scheme elements (selecting, deleting, etc).

Select – allows selecting scheme elements.

Button: .

Select all – selects all scheme elements.

Unselect – unselects of all scheme elements.

Delete – deletes selected elements.

Button: .

View menu

The commands of this menu allow scaling scheme, show/hide the control bars, call dialog boxes for entering the parameters of elements.

Zoom in– extends the sizes of the working area.

Button: .

Zoom out – decreases the sizes of the working area.

Button: .

Control bars – Using this submenu you can on/off required control bars.




Fig. 2.1 Control bars submenu.

Properties – allows viewing and editing properties of scheme elements. In case of shaft selected, APM Shaft has running with pictured shaft. In case of transmissions selected, the dialog box APM Trans for current transmissions will be shown. In case of bearing selected, the dialog box APM Bear will be shown.


Button: .

Insert menu

Shaft – in this submenu you can select the necessary type of shaft and then add it to the scheme.

Horizontal shaft – .

Vertical shaft – .

Input shaft – 


Output shaft – 

Bearing – Using this submenu you can set bearing of required type addition mode.


Ball – 

Roller – 


Self aligning – 


Ball radial thrust (Left) – 


Ball radial thrust (Right) – 


Ball radial thrust (two sided) – 

Ball thrust (Left) – 


Ball thrust (Right) – 

Ball thrust (single) – 


Ball thrust (double) – 

Roller radial thrust (Left) – 

Roller radial thrust (Right) – 

Roller radial thrust (double) – 

Roller spherical – 

Roller thrust (Left) – 

Roller thrust (Right) –



Roller thrust (single) –



Roller thrust (double) –



Transmission – using this submenu you can set gear of required type addition mode.

External spur gear –



Internal spur gear –



External helical gear –



Herringbone gear –



Straight bevel gear –



Spiral bevel gear –



Worm –



Planetary 1 –



Planetary 2 –



Planetary 3 –



Scheme menu

Standards – allows selecting the standard from the database.

Button: .

Initial data - allows entering the initial data for the scheme– fig. 2.2

Button: .

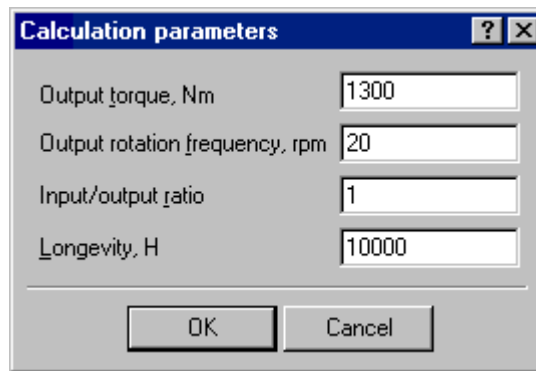



Fig 2.2. Dialog box *Calculation parameters*


Calc – runs calculation of the scheme.

Button: 

Calculation results – shows the windows with the results of calculation for selected element (from programs APM Trans, APM Bear APM Shaft).

Button: 

Handle laying out – allows entering and editing parameters for laying out of the scheme. Fig. 2.3.

Button: 

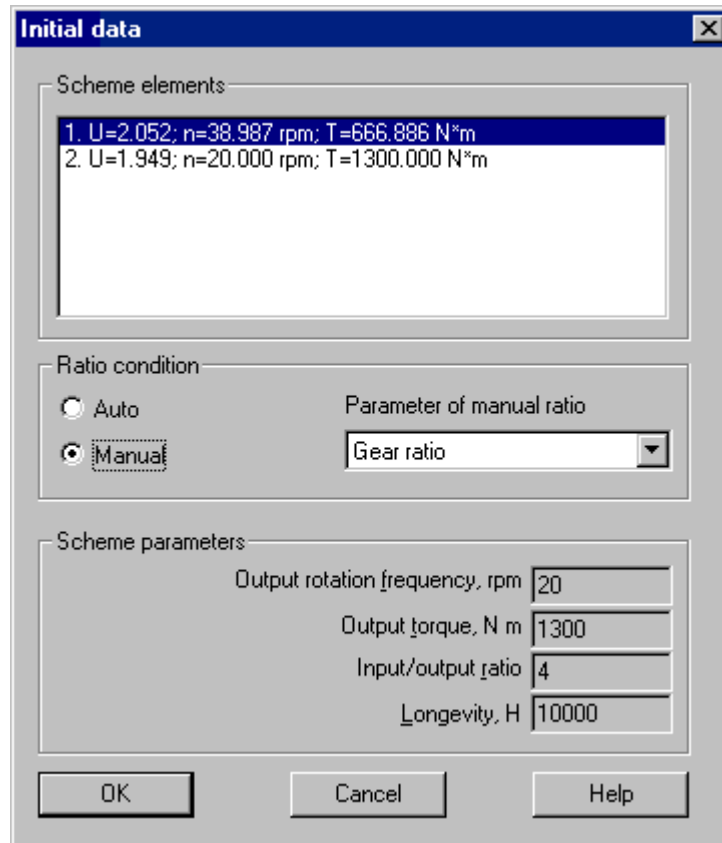


Fig. 2.3 Dialog for stage input/output ratio edit.

Select bearings – this command bans utilization user data for bearings.

Set operating regime – allows to set operating regime. This command invokes dialog box for predefined regime selection. Select *User type* regime to enter arbitrary load regime. Dialog box *Regime of loading* will be displayed on the screen as a result - fig. 2.4.

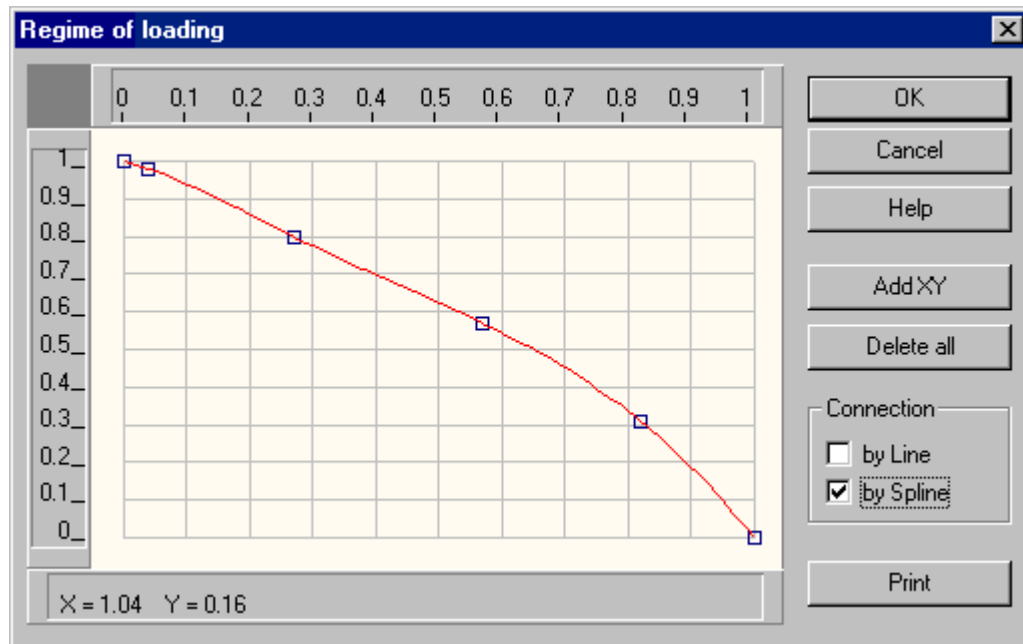


Fig.2.4 The dialog box *Regime of loading*.

Use in calculation – this command permits utilization users regime of loading for calculation.

Set shaft material – allows setting shaft material or using materials from database. After selecting this command dialog box *Shaft material* will be shown.

Side view – command switches editor to drive side view creation that can be used to arrange shafts offsets in 3D space. Click left mouse button at the left or right end of scheme to create a new view. See chapter 4.

Calculation type menu

This menu commands set current calculation type.

Results menu

General results – command calls dialog with resume results.

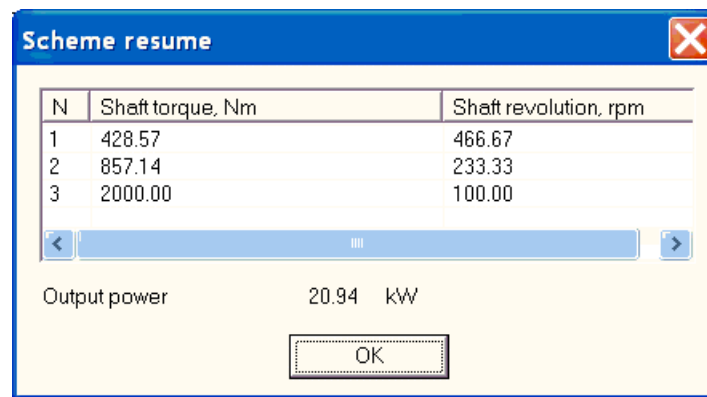


Fig.3.5 General results dialog.

Window menu

New – allows opening the current scheme in new window.

Cascade – allows arranging opened window one by one.

Tile – allows to arrange opened window so, that all windows have equal squares on the screen.

Help menu

Contents – calls APM Drive help.

About APM Drive – calls *About* dialog box.

Button: .

Chapter 3





Procedure and features of calculation

APM Drive uses for calculation and design following systems: APM Trans, APM Shaft, APM Bear, APM Data, и APM Graph. We can divide the procedure of the settlement and design into 6 steps. Main steps (1,2,5,6) are necessary for design and calculation; auxiliary steps (3,4) allow demonstrating all possibilities of APM Drive.

Set required calculation type before calculation using **Calculation type** menu. Design calculation steps are described below. Features of checking calculations will be pointed out later.

Step 1 – main

The design process begins with composition of the kinematic scheme. Using the control bars *Shaft*, *Bearing*, *Transmission*, or corresponding menu commands you can create required drive unit. Smallest operable scheme (Fig.3.1) should include following elements:

- Two shafts ( - horizontal or  - vertical);
- One transmissions;
- Two bearings on each shaft;
- An input  and output  shaft.

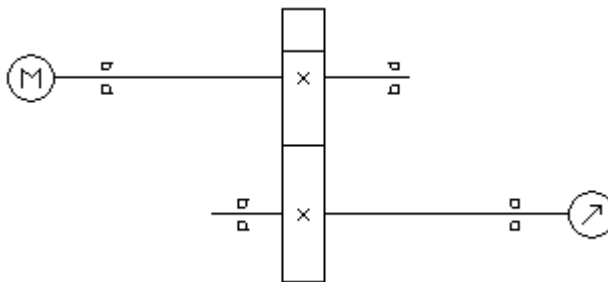




Fig. 3.1 The smallest operable scheme.

Step 2 – main

Then you should enter initial data for calculation using command **Initial data**. Call this command pressing button  or selecting corresponding menu item. In the dialog box (Fig. 2.2) you should enter following parameters:

- Output torque [N*m];
- Output rotation frequency [r/min];
- Input/output ratio [-];
- Longevity [h].

Step 3 – auxiliary

After entering the initial data you can control or edit input/output ratio for multistage drive unit using **Handle laying out** command .

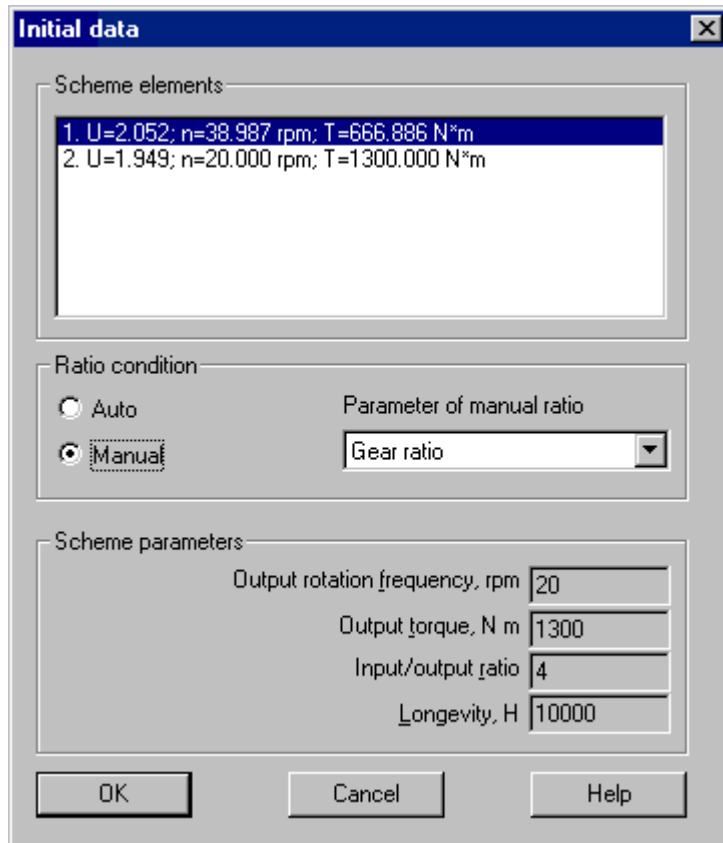


Fig. 3.2 *Initial data* dialog.

In this dialog box (Fig. 3.2) you can see current values of transmission ratio, rotation frequency, and torque for every stage of scheme. Make following sequence of operations to change these parameters:

- Set radio button **Manual**. **Scheme elements** list box will be enable.
- Select an item to be changed in the combo box **Parameter of manual ratio**.
- Double click on required item of **Scheme elements** list box to edit. Dialog box **Parameters of gear № N** (Fig. 3.3) where N – number of stage from **Scheme elements** list box will be displayed as a result.

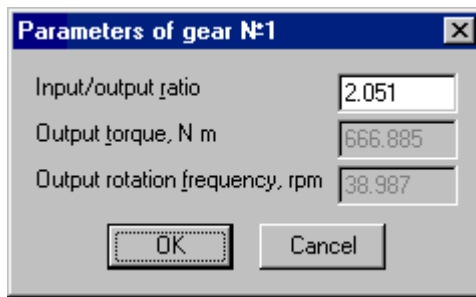



Fig. 3.3 *Parameters of gear №1* dialog

You can change only transmission ratio for the last stage of scheme.

Step 4 – auxiliary

You can enter parameters any bearing, shaft or gear manually. Use **Parameters**  command of main menu or contextual menu item (click right mouse button). Dialog box from APM Bear, APM Shaft or APM Trans depending on selected scheme element will be displayed. To get more information about these modules see corresponding module documentation or help.

Besides main parameters you also can change all other elements properties by using corresponding dialogs:

- You can select from database or set manually material properties of shafts. To set material for all shafts of the scheme use menu command **Scheme | Set shaft material**, to set material for each shaft - corresponding item of contextual menu (right mouse button click).
- You can set the accuracy and the working conditions for bearings using contextual menu. You can also calculate scheme with specified bearings in design calculation if menu item **Scheme | Select bearings** is unchecked.
- You can select the reference profile for each transmission using contextual menu (right mouse button click).
- You can set operating regime for scheme using **Scheme | Set operating regime** menu item.

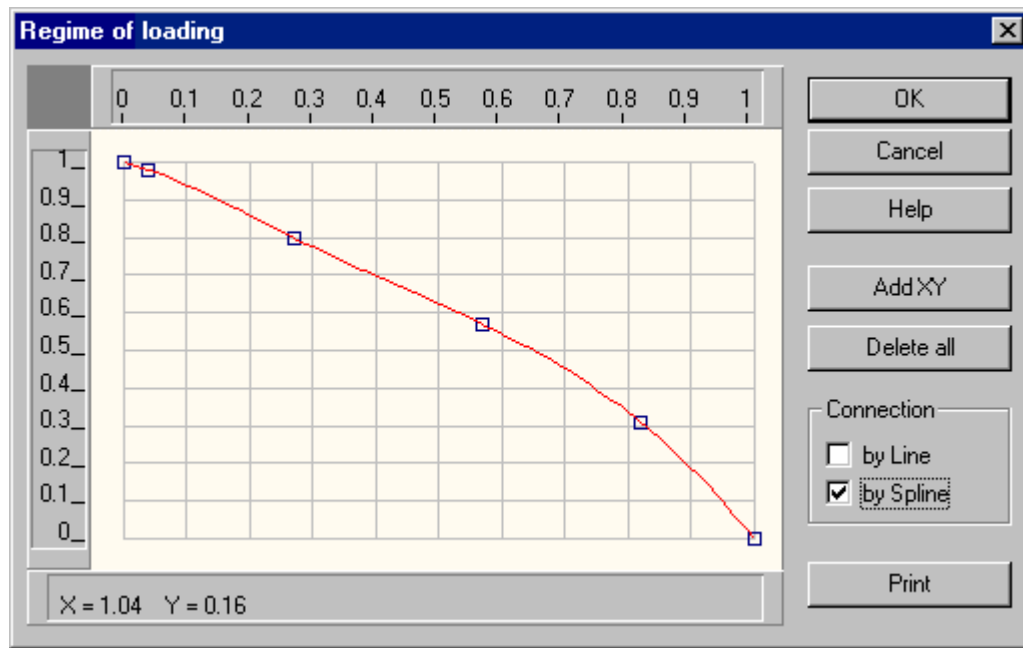






Fig.3.4 *Regime of loading* dialog.

Use *Regime of loading* editor to enter arbitrary operating regime as a time - torque dependence. Horizontal axis – relative operating time (relation of operation time at given torque to total working time), vertical axis – relative torque (relation of current torque to maximum torque). Check **Scheme | Use in calculation** menu item to take into account regime of loading by calculation.

Step 5 - main

Calculate the scheme using **Scheme | Calculation**  command. The calculation order is gears – shafts – bearings. Important feature of design calculation relates with this order: to modify elements of recently calculated scheme first change gear properties then – shafts and finally – bearings otherwise your modification will be canceled if **Scheme | Select Bearings** and **Scheme | Shaft Design** flags are switched on.


Step 6 – main

General results and each scheme element results are available after performed calculation. Select required scheme item (**Edit | Select** command ) and use **Results | Scheme element calculation results**  or **Scheme | Properties**  to get selected element results or modify initial data. APM Drive calls corresponding engineering systems APM Trans, APM Shaft or APM Bear to display results of required element.


In process of design calculation APM Drive performs gear design, shaft design, selects required bearings from database. Any drive unit element may be modified at any stage and scheme recalculated.

It is possible that a shaft diameter at bearing position is nonstandard or there is no bearing with required internal diameter in database. You should manually correct shaft segment diameters in that case and recalculate the scheme.

After calculation end you can create drawings of scheme elements. You can draw calculated bearings using mechanical database. Drawings are saved in file with extension .agr (APM Graph files). Using 2D graphic editor APM Graph you can work with all your drawings. APM Graph allows work with drawings created from all modules.

Finally initial data and results can be saved in RTF file and assembly drawing of drive unit can be generated using APM Graph. The automatic generation of drive units is performed by **Export** command (button ).

Procedure and features of checking calculation

Checking calculation procedure is similar to design one except for need of gear geometry specifying before calculation. Use **Properties** command  to enter gear geometry parameters. An example of gear geometry specifying is displayed on fig. 4.5

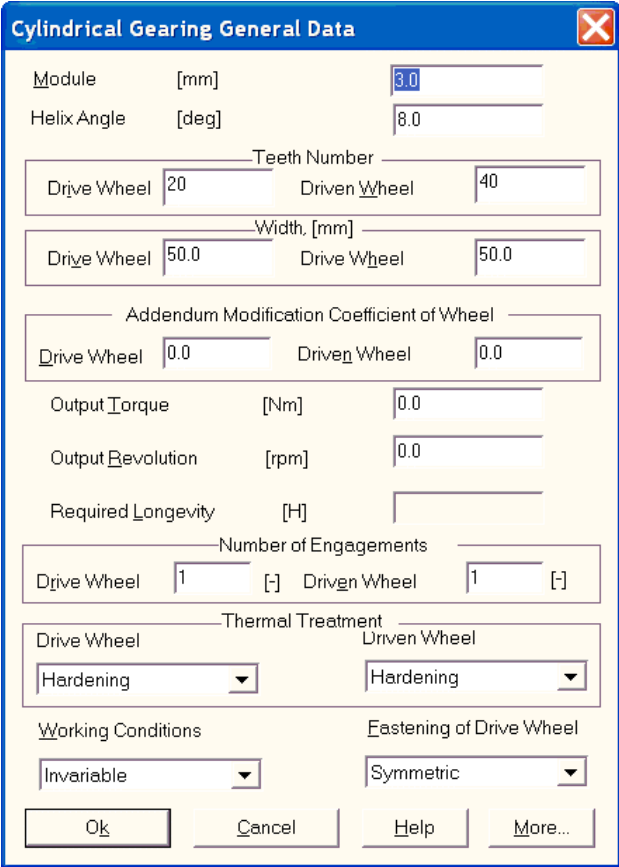


Fig.4.5 Gear geometry dialog for checking calculation

Use the same command to set required bearing and shaft geometry.

Handle laying out command is not available for checking calculation.

Extra option of checking calculation is availability to set shafts offsets in 3D space.

Shaft location in 3D space¹

All shafts are in the same plane by default. Shaft arrangement in 3D space is available in checking calculation. Scheme side view is used to make this arrangement. Select **Scheme | Side View** command to switch editor in side view create mode. Move cursor to the left or right side of the scheme and click left mouse button. New side view will be created as a result. Scheme example with a left view is shown below. All shaft are in the same plane as by default.

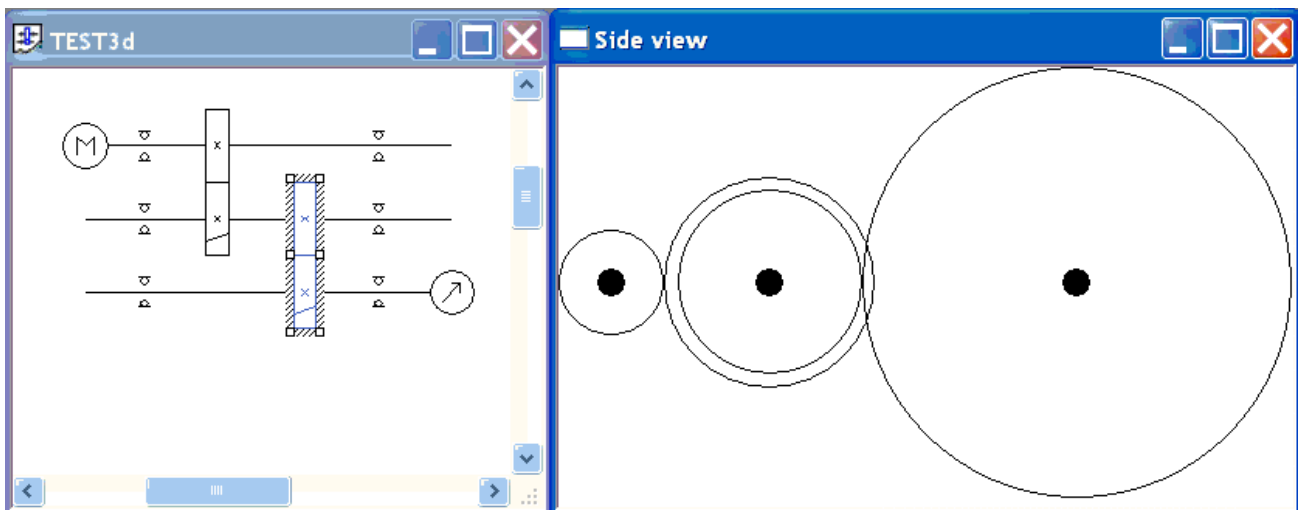


Fig.4.6 Scheme left view

To set shaft offset click left mouse button on required shaft in a side view. Dialog box for relative shaft position in 3D space will be displayed as a result.

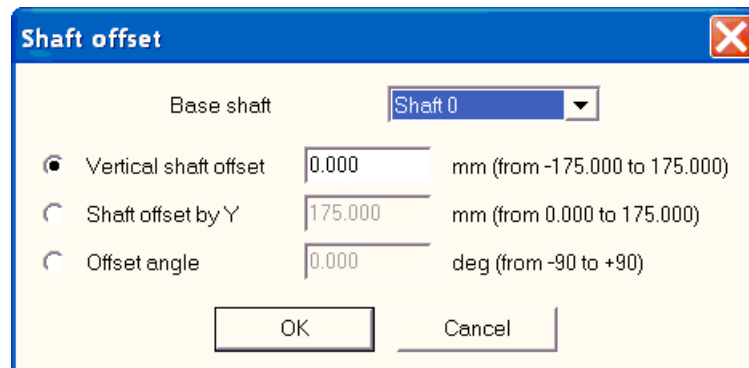


Fig.4.7 *Shaft offset* dialog

Both selected shaft and base shaft for offset counting are marked with a corresponding color. It should be noted that offset value is limited by gear center distance. An example of shaft offset specifying is shown in a figure below.

¹ Available in version 9.2

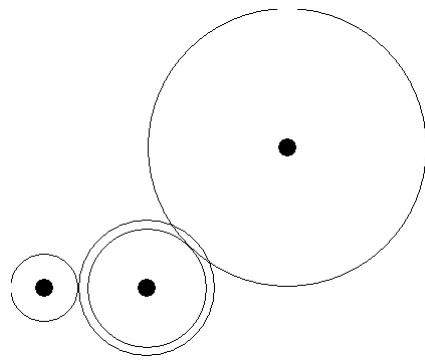


Fig.4.8 Example of shafts 3D location.