

WinMachine

APM Screw

Version 9.0

User's Guide

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Introduction

What is APM Screw?

APM Screw is a system for designing and calculation of non-ideal screw gears.

With **APM Screw** you can calculate the following parameters of screw gears:

- screw gear geometry
- forces acting in the gear
- longevity
- maximum load capacity

The system can calculate and design three types of screw gears:



- gliding screw gears
- ball screw gears (with or without preload)
- planet screw gears

Hardware and software requirements

APM Screw is designed for IBM PC and compatible computers with Pentium III and compatible processor or higher. **APM Screw** works under Microsoft Windows 2000 and XP.

Conventions used in this manual

We have used the following font and symbol conventions in this manual:

a:\setup	This designates the text which user has to type with the keyboard
SETUP.EXE	Capital letters are used for file names and key names
Help	Bold letters represent APM Screw commands
<i>Results</i>	Italic is used for names of dialogs and dialog items
KEY1+KEY2	Plus (+) between key names means that you need to press first key and, while depressing it, press the second key.
KEY1,KEY2	Comma (,) between key names means that you need to press and release keys in a sequence
	This sign is followed by method with which you can carry out some command with the keyboard
	This sign is followed by method with which you can carry out some command with the mouse

Guide contents

This guide is arranged as follows:

Introduction (this section) describes general features of **APM Screw**, hardware and software requirements and conventions used in this document

Chapter 1, Problems, initial data and results describes problems solved with **APM Screw** and contains the list of parameters required for calculations

Chapter 2, How to work with APM Screw leads you through a sample session with **APM Screw**

Chapter 3, APM Screw command reference gives a complete description of all commands, menus and keyboard shortcuts used in the system

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Chapter 1

Problems, initial data and results

APM Screw can calculate screw gears. Screw gears are designed for transformation of rotation into transitional movement. Such gears consist of screw and nut. In some cases between screw and nut there are other components (balls or rolls) which act as satellites.

There are three types of screw gears:

- gliding screw gears
- ball screw gears
- planetary screw gears

Gliding screw gears have limited area of usage. They consist of a surface hardened screw and bronze nut. The gear can be easily manufactured but has low efficiency. The main criterion selecting such gears is wear resistance which limits the nominal specific pressure on the nut-screw contact surface. **APM Screw** can calculate gliding gears with trapezoidal and triangular thread profiles.

APM Screw can perform design and checking calculations. Design calculation determines the geometry of gear by known loading and materials, while checking calculation obtains gear's output parameters by known geometry of the gear.

In ball screw gear, there are balls between screw and nut. They decrease friction and increase efficiency of a gear. Gears of this type include return channel for rolling bodies. Depending on its usage, ball screw gear can be mounted with or without axial preload. In the former case screw gear is assembled of two half-nuts. The preload allows to increase stiffness and control this parameter.

In the planetary screw gear there are rollers used as transitional elements. By analogy with common planetary gear, such rollers are called satellites. There are no return channels in such gears, so they considered more reliable comparing ball screw ones. Moreover, planetary screw gear can carry higher load than ball screw gear of the same size. Its shortcoming lies in the complexity of manufacturing and therefore higher cost. When necessary planetary screw gear can be mounted with axial preload.

The features of screw gear design

Screw gear design scheme in **APM Screw** substantially differs from conventional methods. The gear is considered having manufacturing errors. Henceforth we will call such gear non-ideal. Non-ideal model allows to get substantial improvement of calculation accuracy. The methods used are completely original and have no world analogies.

The base of screw gear design is contact stiffness determination. Other parameters are more or less dependent on the stiffness including

- moment of friction
- loss of power
- axial, radial and angular runout

- heat release
- longevity
- maximum contact stress, etc.

Non-ideal model allows to determine dispersion of parameters in addition to mean values.

To calculate longevity the same methods, used for rolling contact bearings are employed. The only difference is that the equivalent load is calculated based on the actual distribution of forces, acting on the rolling bodies (with manufacturing errors considered).

The static strength calculation consist in contact stress determination. It should be remembered, that stresses must not exceed 3500 Mpa, since plastic deformation can arise.

Initial data

For calculation of screw gears, **APM Screw** requires the following initial data:

Table 1 Initial data for gliding screw gear calculations

Geometry			
Outer screw diameter	d_e	mm	$5 \div 2000$
Inner screw diameter	d_i	mm	$5 \div 0.7 d_e$
Screw pitch	p	mm	$2 \div 100$
Nut height	h	mm	$2p \div 50p$
Accuracy			
Screw diameter accuracy		mm	$0.0002 \div 20$
Nut diameter accuracy		mm	$0.0002 \div 20$
Screw pitch accuracy		mm	$0.0002 \div 20$
Nut pitch accuracy		mm	$0.0002 \div 20$
Screw surface roughness		mkm	$0.1 \div 40$
Nut surface roughness		mkm	$0.1 \div 40$
Working conditions			
Axial force	F_a	N	$0 \div 10^6$
Rotation frequency	ω	rpm	$0.2 \div 3000$
Yield point		N/mm/mm	$100 \div 20000$
Screw material			steel/cast-iron/brass
Nut material			high-carbon steel, low-carbon steel
Thread type			triangle, trapezoidal

Table 2 Initial data for ball screw gear calculations

Geometry			
Mean screw radius	r_m	mm	$6 \div 2000$
Rolling body radius	r_b	mm	$1 \div 300$
Track radius	r_t	mm	$1 \div 300$
Number of rolling bodies in a track	n_b		$3 \div 100$
Number of tracks	n_t		$1 \div 20$
Accuracy			
Screw track radius accuracy		mm	$0.0002 \div 20$
Nut track radius accuracy		mm	$0.0002 \div 20$
Screw pitch accuracy		mm	$0.0002 \div 20$
Nut pitch accuracy		mm	$0.0002 \div 20$
Pitch error		mm	$0.0002 \div 20$
Working conditions			
Axial force	F_a	N	$0 \div 10^6$
Radial force	F_r	N	$0 \div 10^5$
Overturning moment		N·m	$0 \div 9 \cdot 10^5$

Rotation frequency	ω	rpm	0.2÷3000
Dynamic factor	k		1÷10
Preload force *	F_p	N	0÷10 ⁴
Preload displacement *	D_p	mm	0÷2

* Only one of these parameters can be specified

Table 3 Initial data for planet screw gear calculations

Geometry			
Mean screw diameter	d_s	mm	6÷2000
Mean nut diameter	d_n	mm	6÷2000
Screw pitch	p	mm	1÷200
Satellite profile radius	r_g		10÷2000
Number of satellites	n_g		3÷100
Number of working turns	n_t		1÷50
Accuracy			
Screw diameter accuracy		mm	0.0002÷20
Nut diameter accuracy		mm	0.0002÷20
Satellite diameter accuracy		mm	0.0002÷20
Screw pitch accuracy		mm	0.0002÷20
Nut pitch accuracy		mm	0.0002÷20
Satellite pitch accuracy		mm	0.0002÷20
Pitch error		mm	0.0002÷20
Working conditions			
Axial force	F_a	N	0÷10 ⁶
Radial force	F_r	N	0÷10 ⁵
Overturning moment		N·m	0÷9·10 ⁵
Rotation frequency	ω	rpm	0.2÷3000
Dynamic factor	k		1÷10
Preload force *	F_p	N	0÷10 ⁴
Preload displacement *	D_p	mm	0÷2

* Only one of these parameters can be specified

Results

APM Screw can calculate the following parameters of screw gears:

- Moment of idling, N·m
- Power of idling, W
- Power at working load, KW
- Longevity, h
- Maximum contact stress, N/m²
- Heat release, J/h
- Loss of power, KW
- Moment of friction, N·m
- Efficiency
- Axial displacements, mkm
- Radial displacement, mkm
- Angular displacement, °

For comparison, longevity and load carrying capacity are calculated by classical methods. For ball screw gears, **APM Screw** calculates and shows radial forces acting on rolling bodies.

Chapter 2

How to work with APM Screw

As most Windows program, **APM Screw** offers to users convenient and intuitively clear graphic interface. This manual assumes a certain degree of understanding of Microsoft Windows. Refer to your Windows manual for instructions on working in Microsoft Windows environment.

The typical sequence of actions while working with **APM Screw** is as follows:

1. Install **APM Screw** on your computer
2. Run the program
3. Select screw gear type
4. Supply initial data
5. Perform calculations
6. Look through the results

Running APM Screw

To start **APM Screw**, open **APM WinMachine** file group and double-click on **APM Screw** icon.

APM Screw window

APM Screw's main window and its fields are shown on Fig.1

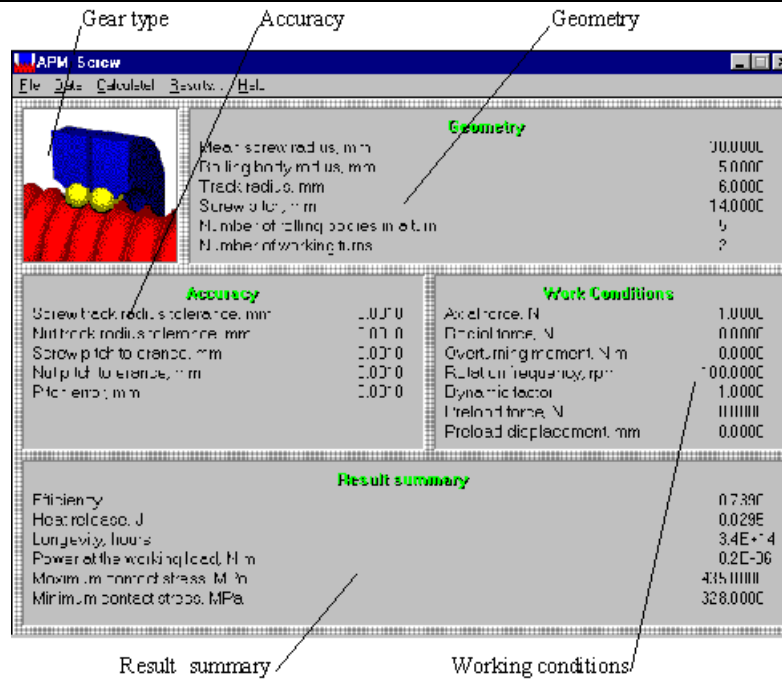


Fig.1. The main window of APM Screw

Gear type selection

To select the type of gear you want to calculate use command **Data | Gear Type**. As a result you will see the dialog box which is shown on Fig. 2 Select gear the necessary gear type and press **OK**.

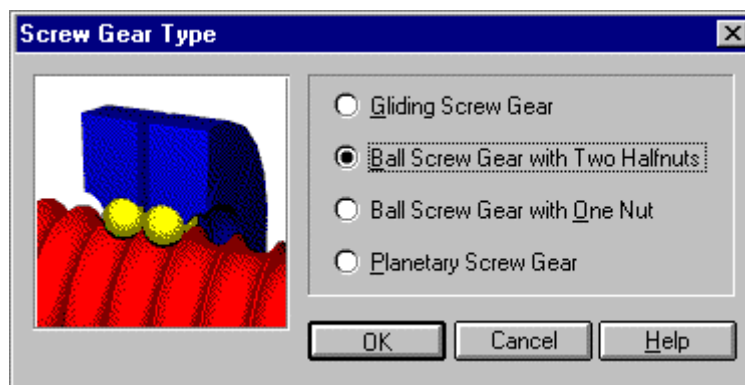


Fig.2 Gear type selection dialog

Entering the initial data

Before you can perform calculations you have to supply three groups of initial data which describe gear's geometry, accuracy and working conditions. Each group is shown in its region of the main window (see Fig.1).

To enter the initial data use commands **Data | Geometry...**, **Data | Accuracy...** and **Data | Working conditions...** for each group respectively. You will see dialogs such as shown on Fig.3. Fill in each field of the dialog and press **OK**.

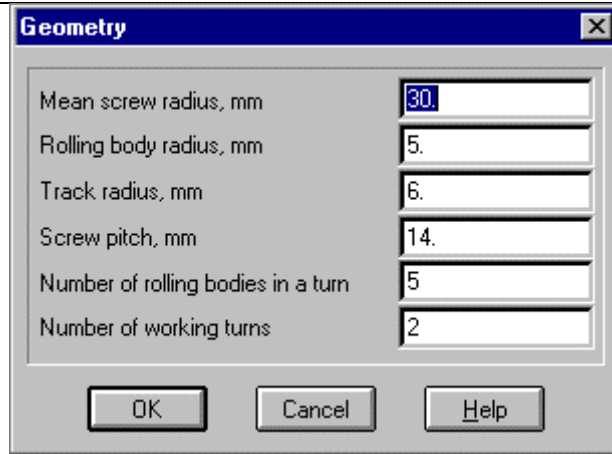


Fig.3 Geometry dialog box

The system checks the initial parameters and signals if there were errors or discrepancies. (Fig.4) In that case you should correct the value of parameter.



Fig.4 Error message

Loading data from files

If you earlier saved data with command **File | Save...**, you can load them with command **File | Load...**

Performing calculations

When all initial data are correctly specified (this is indicated by highlighted region titles) you can perform calculations. Use command **Calculate!** from the main menu.

Some calculations can take a lot of time to complete (especially if there is no math co-processor). You can watch the progress of calculations by progress indicator. (Fig.5)

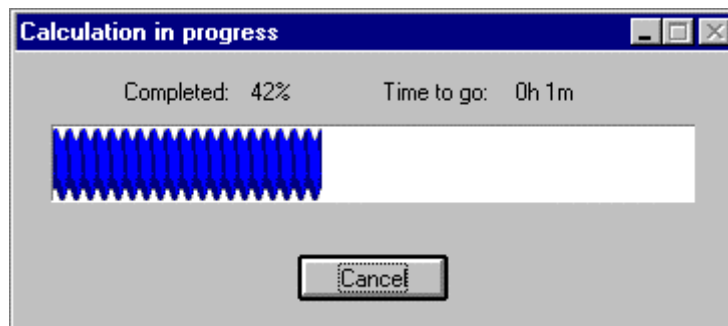


Fig.5 Progress indicator

Looking through calculation results

When the calculation is over, the summary of results is shown in *Results Summary* region of the main window. To look through all the results use command **Results...** from the main menu.

This command calls out the dialog box shown on Fig.6. It has a number of buttons which you can use to look through results in different forms.

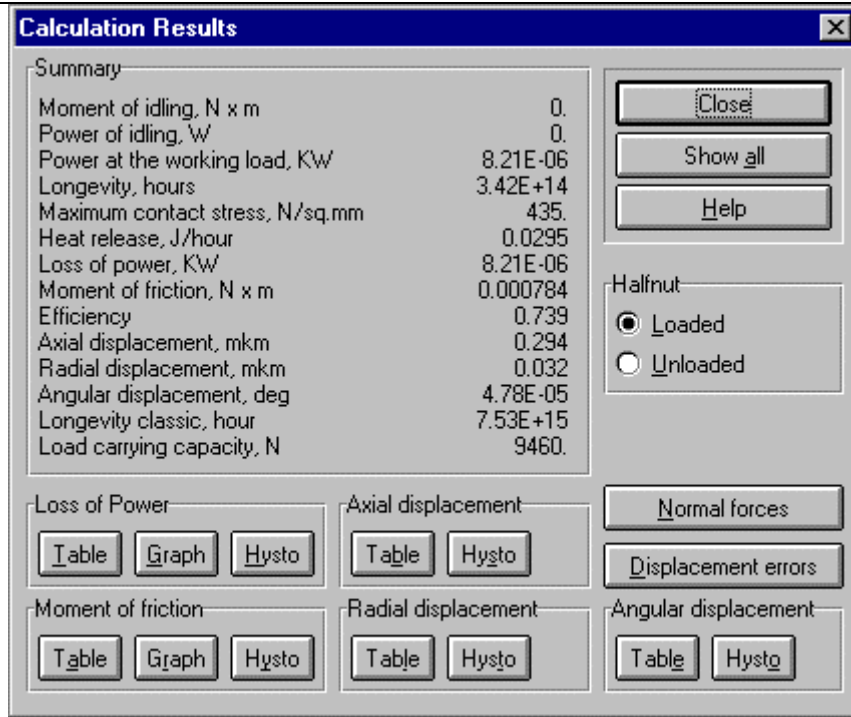


Fig.6 Result selection dialog box

Saving initial data and results

You can save initial data and/or calculation results for subsequent retrieval. For this purpose uses command **File | Save**.

Printing

To receive a hardcopy of **APM Screw** data, use command **File | Print**. This command calls out a dialog box (Fig.7) with which you can select items to print. Check necessary items and press *Print* button.

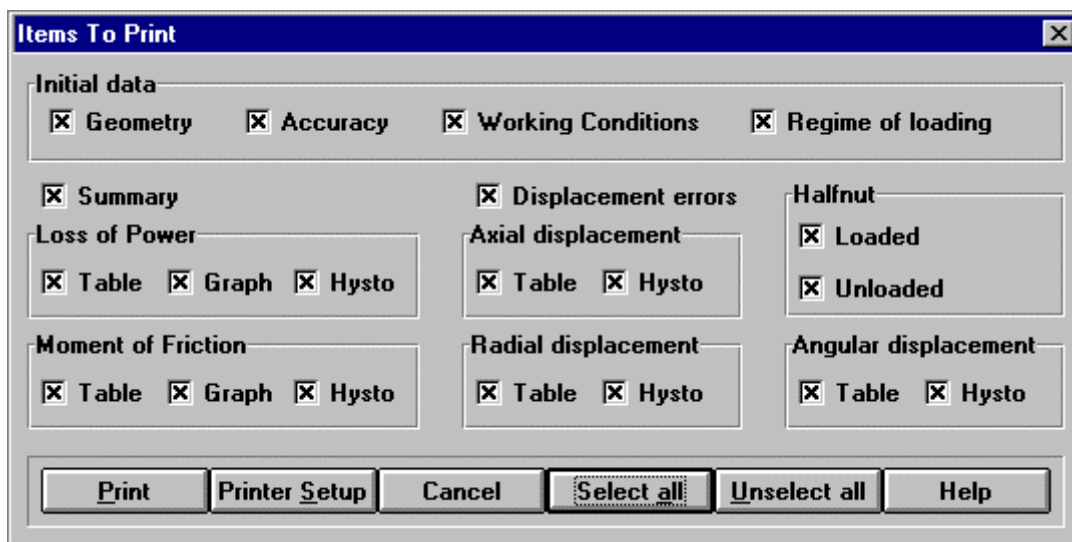


Fig.7 Printing selection dialog

Chapter 3

APM Screw command reference

This chapter contains complete description of menu command and dialog box options used in **APM Screw**. Fig.8 shows the main menu of **APM Screw** along with its submenus.

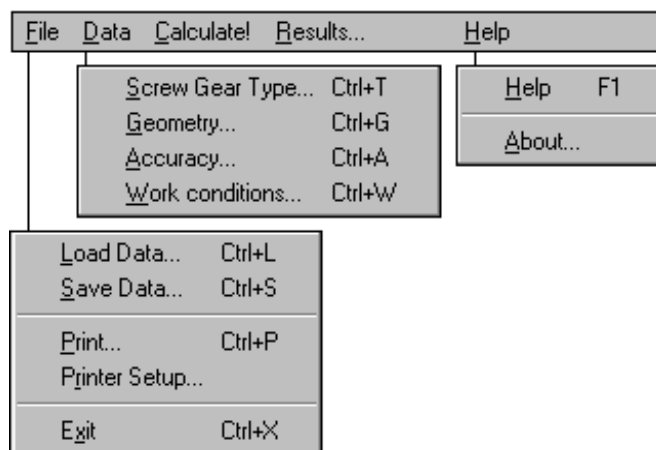


Fig.8 APM Screw menu structure

File Menu

The **File** menu contains commands for the following actions:

- loading data form files
- saving data into files
- printing
- setting up printer
- quitting the program

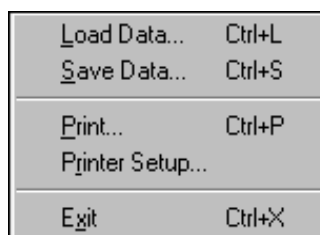


Fig.9 File Menu

Load... Command

File | Load command allows you to restore previously saved data.

 CTRL+L

Save... Command

With **File | Save** command you can save initial data and calculations results into a file.

 CTRL+S

Print... Command

File | Print command allows you put initial data and calculation results on paper. When you select this command you will see the dialog box (Fig.10) with which you can select data you want to print out. To print all items, press *Select All* button. To clear all marks, press *Unselect all* button. With *Printer Setup* button you can choose printer to print on, and set printing options.

 CTRL+P

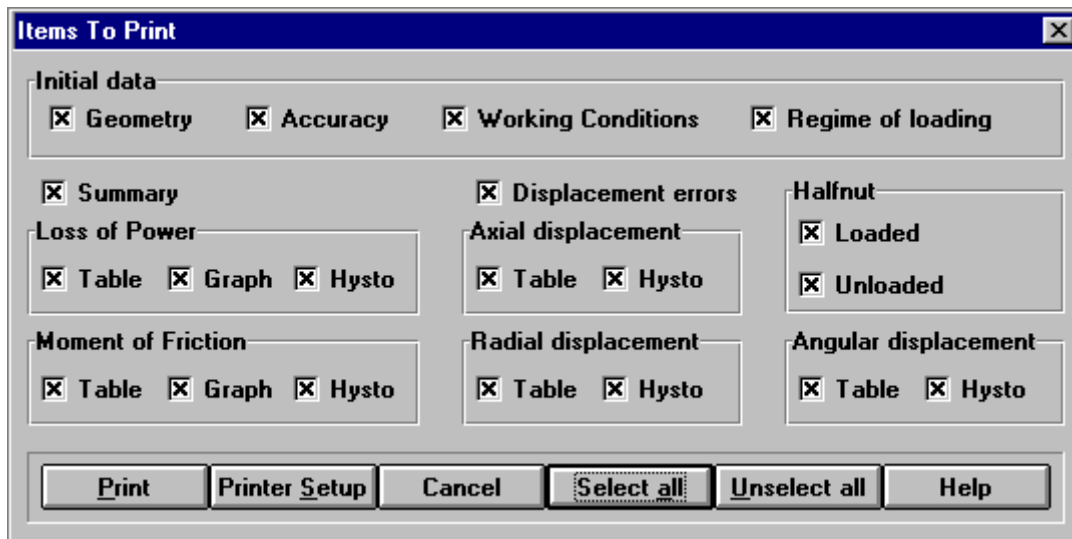


Fig.10 Dialog box for selecting items to print

Printer Setup... Command

With **File | Printer Setup** command you can choose printer to print on and set printing options.

Exit Command

File | Exit command terminates APM Screw session.

 CTRL+X

Data Menu

Data menu contains commands for entering the initial data. First, you have to select gear type with **Data | Screw gear type...**, and then supply the rest of the data.

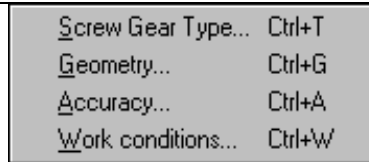


Fig.11 Data Menu

Screw gear type Command

Data | Screw gear type command shows you the dialog box in which you have to select type of the gear you want to calculate (Fig.12). When you select gear type, you will see the picture of the gear in the *Gear type* window of the main window.

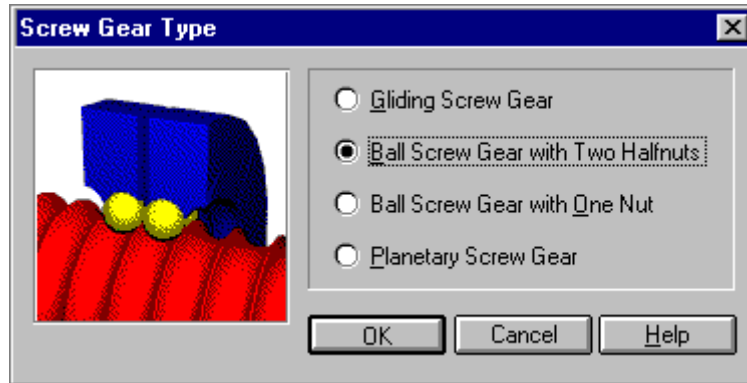




Fig.12 Gear type selection dialog

-  CTRL+T
-  Double click on *Gear type* windows

Geometry... Command

Data | Geometry... command allows you to specify geometrical parameters of the screw gear. The dialog boxes for entering geometry data (depending on type of the gear) are shown on Fig.13-15.

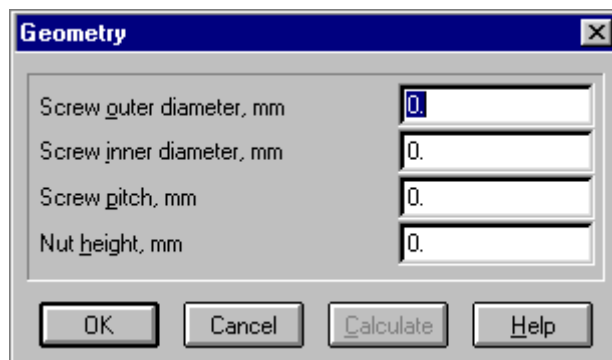


Fig.13 Dialog box for entering geometrical parameters of a gliding screw gear

For gliding screw gears, you can calculate geometrical parameters considering gear's working conditions. To do that, you have to specify the working conditions of the gear with **Working conditions** command and then press *Calculate* button in *Geometry* dialog box. You will get recommended geometrical parameters of the gear for specified working conditions.

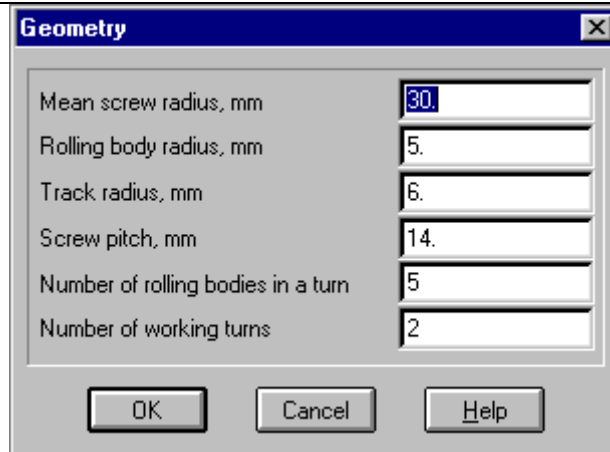


Fig.14 Dialog box for entering geometrical parameters of a ball-screw gear

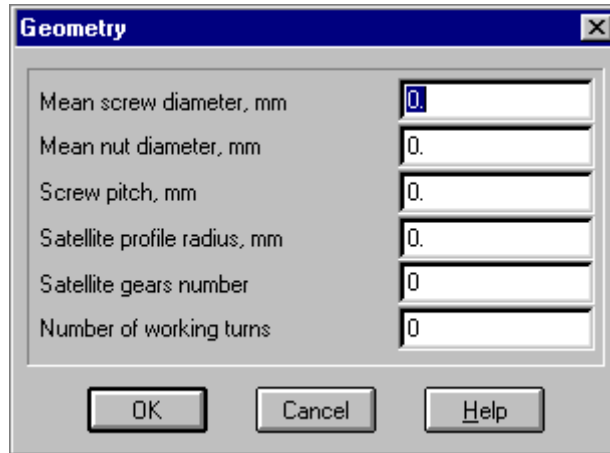




Fig.15 Dialog box for entering geometrical parameters of a planetary screw gear

-  CTRL+G
-  Double click on *Geometry* window

Accuracy Command

APM Screw calculates non-ideal gears, so you have to specify accuracy of manufacturing of the screw gear. You do it with **Data | Accuracy...** command. Dialog boxes for entering accuracy data are shown on Fig.16-18

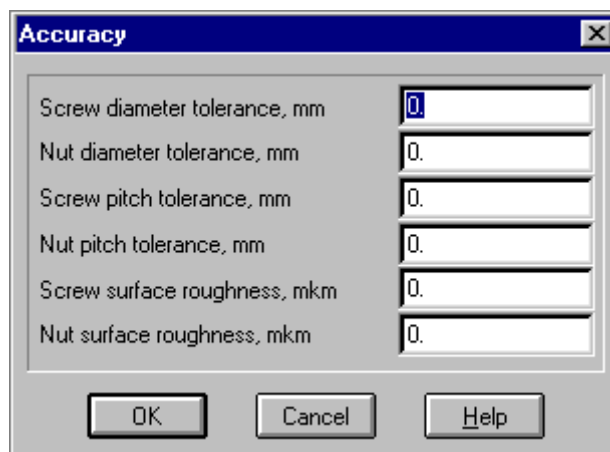


Fig.16 Dialog box for entering accuracy parameters of gliding screw gears

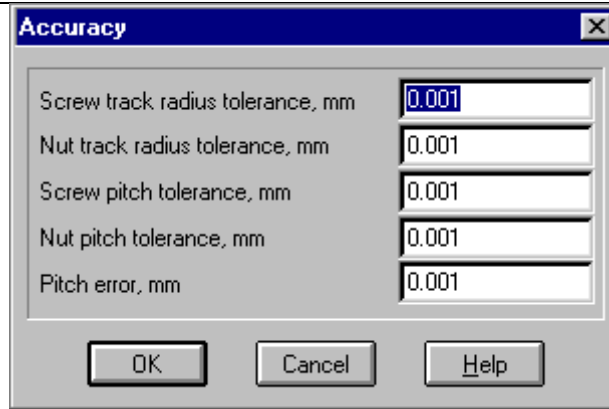


Fig.17 Dialog box for entering accuracy parameters of ball screw gears

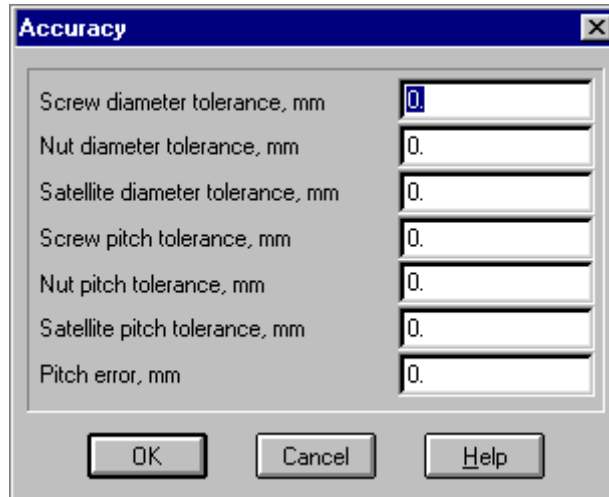




Fig.18 Dialog box for entering accuracy parameters of planetary gears

-  CTRL+A
-  Double click on *Accuracy* window

Working conditions Command

Use **Data | Working conditions...** command for specifying the working conditions of the gear. Corresponding dialog boxes are shown on Fig.19, 20

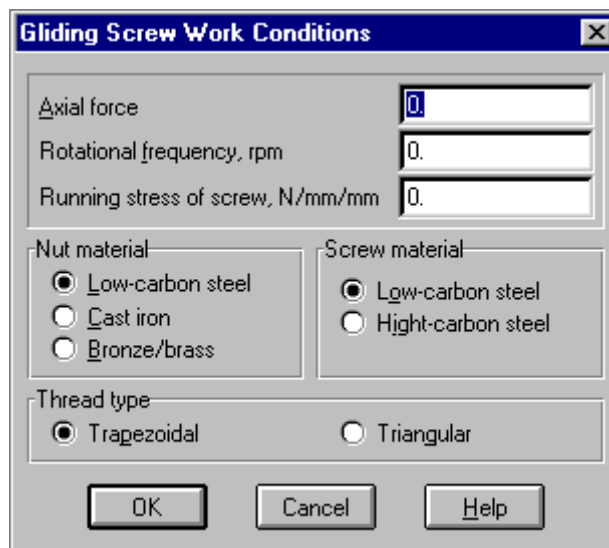


Fig.19 Dialog box for specifying the working conditions of gliding screw gears

For gliding screw gears you can get recommended geometrical parameters by known working conditions. When you have specified the working conditions of the gear, press *Calculate* button in *Geometry* dialog. (Fig.13)

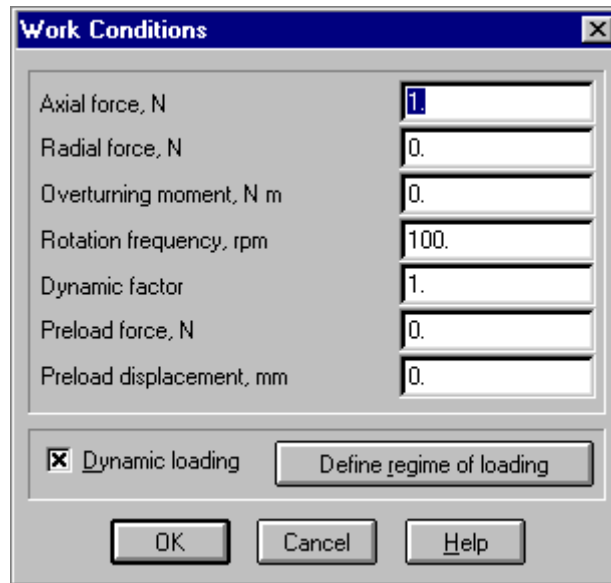


Fig.20 Dialog box for specifying the working conditions of ball screw and planetary gears

For ball screw and planetary gears you can specify the regime of loading. In the Accuracy dialog check *Dynamic loading* check-box and press *Define regime of loading* button. As a result, you will see dialog box shown on Fig.21. With mouse or Add XY button add several points in descending order and select connection style. You must specify at least 4 points.

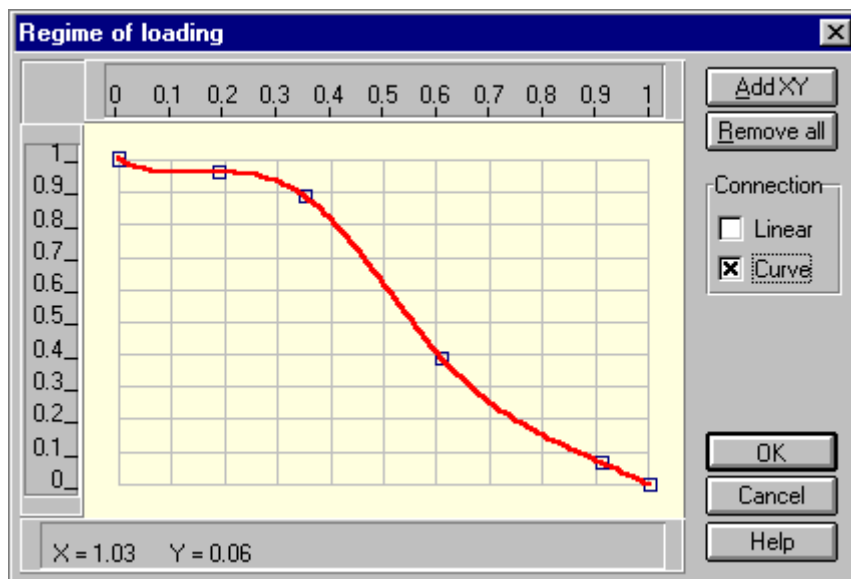



Fig.21 Dialog box for defining regime of loading for ball screw and planetary gears

-  CTRL+W
-  Double click on *Working conditions* window

Calculate! Command

When you have correctly entered all necessary data, you can perform calculations with **Calculate!** command. You can watch progress of calculations on progress indicator.

-  CTRL+C

Results... Command

When calculation is over, the main results are shown in the summary window and Results... command became available. With this command you can look through the calculation results. You do that selecting items in the dialog box shown on Fig.22. Results are available in different forms: table, graphics, histogram.

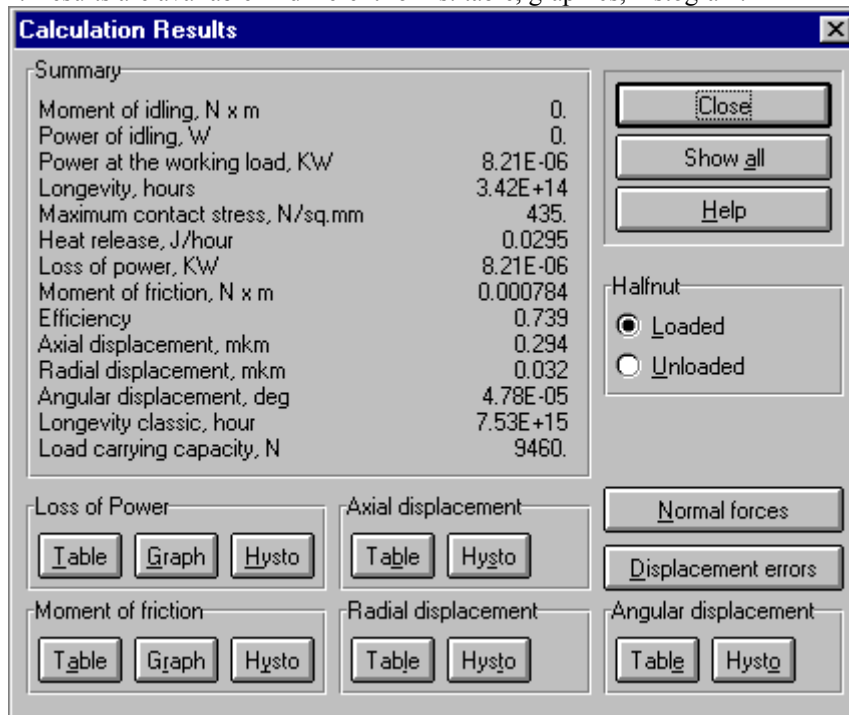


Fig.22 Results browsing dialog

Help Menu

Help menu (Fig.23) contains commands for the following actions:

- displaying help system of **APM Screw**
- showing information about the program

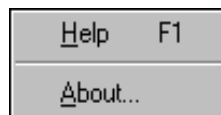


Fig.23 Help Menu

Help Command

Help | Help calls out APM Screw help system.

 F1

About... Command

Help | About... command shows dialog box that contains information about the APM Screw and license information.

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