APM Spring

User's guide

APM Spring

System for calculation and design of springs and torsion bars
Version 9.0

User's Guide

Introduction

APM Spring - what is this?

APM Spring this is the system for calculation and design of elastic machine element dimensions. System developed by the Research and Software Development Center APM Ltd.

With APM Spring You can calculate the following types of elastic elements:

- Compression Springs (round and rectangular cross section)
- Extension Springs (round and rectangular cross section)
- Torsion Springs (round and rectangular cross section)
- Disk Springs
- Flat Springs
- Torsion Bars

APM Spring allows to generate complete working drawing of the springs. Drawings are saved as AGR files or others CAD systems in DXF format.

Hardware and software requirements

APM Spring runs on the IBM PC family of computers (including all true IBM compatibles). **APM Spring** is intended to run under Microsoft Windows, 2000, XP.

What's in this manual

Introduction (this section) tells you what **APM Spring** is in general, what parameters and what types of springs could be calculated. In this section you can find the requirements to hardware and system software are listed.

Chapter 1, Problems, initial data and results: contains description of the problems solved with APM Spring. All the calculated parameters and initial data are listed.

Chapter 2, Quick example, answers to common questions contains answers to common questions that may arise when you work with **APM Spring**.

Chapter 3, Archive files, contains description of archive files at that user can save initial data and results of calculation. The file SPRING.INI is described as well.

Chapter 4, APM Spring environment, describes the main elements of **APM Spring** environment – information windows.

Chapter 5, Command reference, contains complete description of all commands of the main menu and popup menus.

Typefaces used in this book

To facilitate reading and avoid misunderstanding we use a set of typefaces. Their uses are as follows.

a:\setup	This typeface represents text as it appears or anything you must type (for example, `a:\setup` to start installation program).
SETUP.EXE	We use all capital letters for the names of files and keys.
Help	APM Spring command names are shown in boldface.
Results	Italics is used for the names of dialog boxes and controls

How to contact APM

To contact **APM** you can use one of the following ways:

Our fax number is +7(495) 585-06-11.

Call by phone +7(495) 585-06-11, 514-84-19(Moscow),.

Write a letter and send it to:

Research and Software Development Center APM Ltd.
Korolev-Center, box 58,
Moscow Region
141070 Russia
E-mail: com@apm.ru
Our site: http://www.apm.ru

Table of contents

Chapter 1
Problems, initial data and results

This chapter consists of two parts. In the first part types of spring that you can calculate are described. The second part contains the description of initial data.

Basic definitions and terminology

Elastic elements

Machine elements that have high *compliance* in conjunction with small dimensions are called *elastic elements*. We would remind you that compliance is defined as deformation caused by the load equal to 1 (in the considered system of units). Different types of elastic elements are manufactured, but the most widely used ones are the springs and torsion bars, so we will examine only these types.

Elastic elements are used as loading devices, as shock absorbers, dissipating energy of shocks, as devices for energy accumulation, etc. Henceforward we will assume the *linear* dependence between deformation and loading. Non-linear dependencies take place for non-cylindrical springs.

Depending on its functions springs can be classified into *compression springs, extension springs,* as well as *torsion* and *bending springs*. Below we will consider mostly the *coiled cylindrical springs* since they are most frequently used in mechanical engineering. Diameter of cylinder on which the wire is coiled is called *diameter of spring*.

Using APM Spring you can design and calculate the elastic elements of the seven most widely used types:

- Compression springs
- Extension springs
- Disk springs
- Torsion springs
- Flat springs
- Torsion bars
- Leaf springs

Usually, to produce spring the wire of round cross-section is used, but in some cases the wire of square or rectangular cross-section can be used. Round cross-section is characterised by its diameter, square one⎯by side of square. **Springs of rectangular cross-section are not calculated in APM Spring.**

The number of coils required to provide necessary deformation is called the number of *active coils*.
The distance between the next coils is called *Coil pitch*.
If the distance between the next coils is smaller then pitch, so coils is called *support(ing) coils*. These coils are placed at the ends of spring. By default the number of support coils is 0.
The number of active coils plus the number of support coils is called *number of total coils*
The finished (for example – grinding) support coils is called *finished or ending coils*. All finished coils are the support coils, but not all of the support coils are finished.
As a rule, 0.5 or 0.75 of coil circuit is finished. Consequently, the number of finished coils equals 0 (there is not finished coils), 1 (finished 0.5 of circuit from each side), 1.5 (finished 0.75 of circuit from each side).

By default, the number of finished coils is 0.

The number of finished coils is used for calculation of assembled length.

The number of support coils is used for calculation of number of total coils, and other parameters.

These parameters (number of support and finished coils) don't effect on spring drawing. User itself chooses the type of ends of a spring.

The angle of coiling is called the *helix angle*. Compression springs are coiled with clearance between the coils; its value is taken 15% of wire diameter in the conditions of complete compression. Extension springs and torsion springs are coiled without axial clearance.
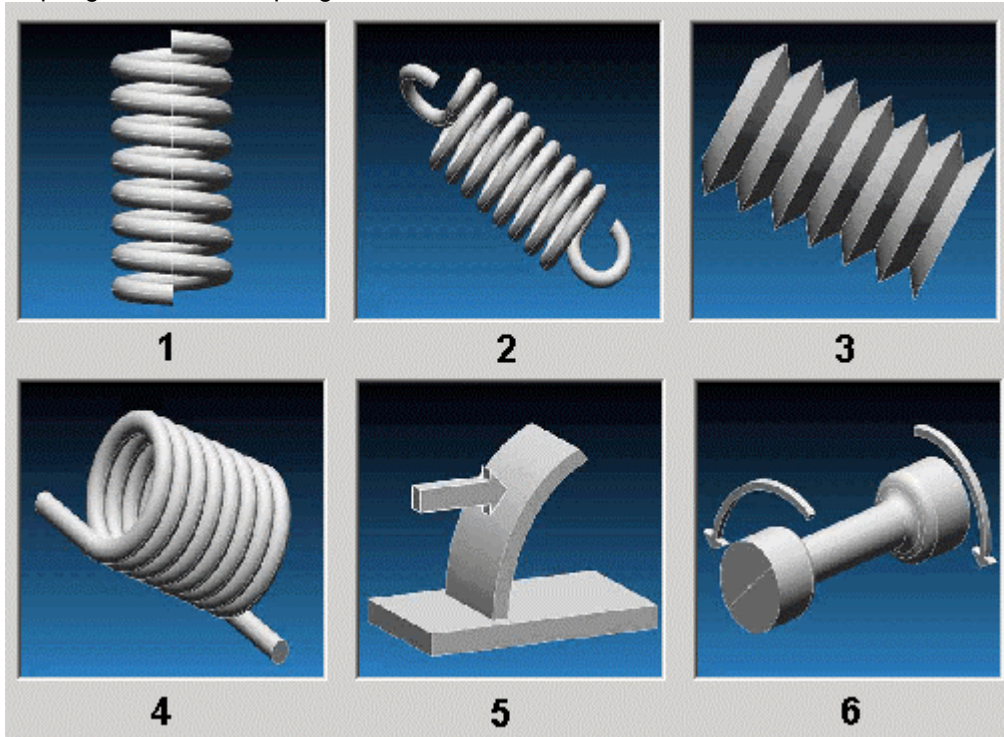
Fig.1.1 With APM Spring you can calculate elastic elements of the following types: 1.Compression spring, 2.Extension spring, 3.Disk spring, 4.Torsion spring, 5.Flat spring, 6.Torsion bar

Calculations – methods and results

APM Spring is the system for calculation and design of elastic elements, used in various machines and mechanisms. The system performs static analysis, fatigue analysis, buckling analysis.

Methods

Static analyses include strength and stiffness determination. Fatigue calculation is performed when variable external load is applied; it comes to determination of safety factor for fatigue strength.

Design calculation is intended to determine static strength and stiffness. It allows define dimensions of elastic elements that correspond to given safety factor, external loads and displacements.

Checking calculation imply that dimensions of elastic element are given. It allows define safety factor for static strength and fatigue strength (when variable load is applied).

Dimensions of springs and mechanical properties of materials can be taken from built-in database.

Static analyses imply stress determination. Calculated stresses are compared with allowable ones. Allowable stresses that are used in APM Spring are calculated from dependence of ultimate tensile strength on wire diameter for given material. This dependence in graph form can be created or

modified by user. Use *Material...* menu command or click *Material database* button in APM Spring main window to modify it.

If user has stress values considered to be more accurate, he can use *correction option*. **To correct allowable stresses you should select *More...* button in the *General Parameters* dialog box**.
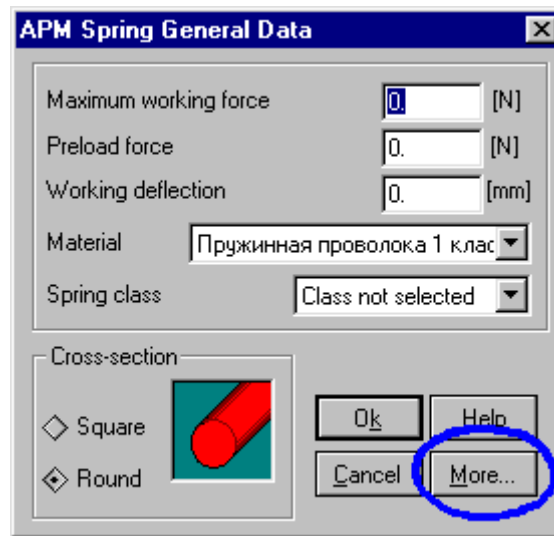
*Fig. 1.2 Dialog box for general data input. In the upper part of the dialog box general parameters are entered. **More…** button invokes on the screen dialog box for additional data input.*

Under *acting stresses* we imply:

♦ *shear stresses* for *compression springs, extension springs, torsion bars;*

♦ *normal bending stresses* for *torsion springs, bending springs, disk springs*.

Materials

In APM Spring you can add new materials and edit parameters of existing. Material parameter – this is ultimate tensile strength depending on wire diameter.
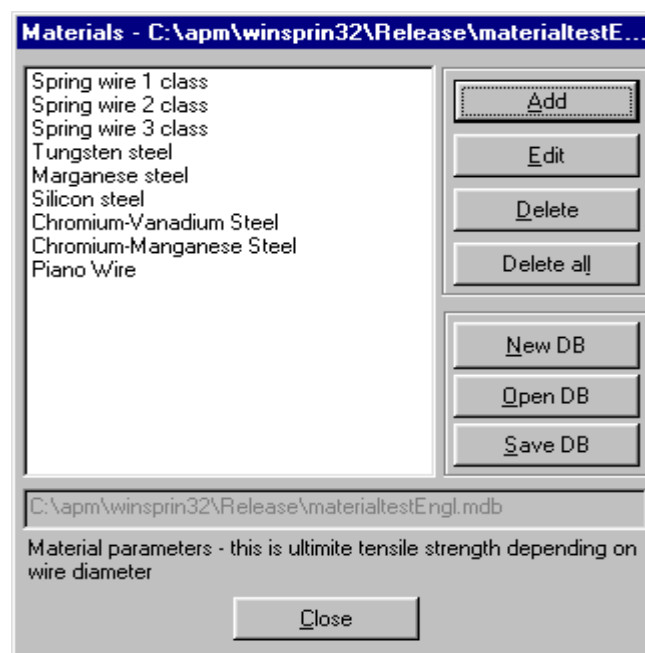
Fig.1.3. Dialog box for material edit

Fig. 1.4 General view of function editor.

Results

The following parameters are calculated:

- The number of coils for compression springs and extension springs; it is calculated on the base of required linear deformation;
- Spring index;
- The number of coils for torsion spring; it is calculated basing on the required angle of torsion;
- Length of torsion bar that is calculated using torsion angle;
- Free length of spring, assembled length of spring, min working length of spring;
- Distance between coils in free and working state (pitch of spring);
- Wire diameter, coil diameter (mean and outside);
- Critical speed and potential energy;
- Length of unfolded spring, length of blank of spring;
- Number of disk springs in the package that is calculated on the base of required axial deformation;
- Allowable stresses.

Disk springs data are stored in APM WinMachine general database of machine elements. Disk springs from the database are selected in design calculation. Database is expandable and editable, user can add new objects to it.

Helical springs are checked for buckling.

Initial data

Working force - working force applied to the spring. Measurement units - Newton(N).
Maximum force - maximum force applied to the spring. Measurement units - Newton(N).

Minimum force - minimum force applied to the spring. Measurement units - Newton(N). It is equal to 0 when loading is static.

Safety factor - safety factor for static strength of spring material.

Displacement - deflection either under maximum load (when dynamic loading is used), or under nominal load (in the case of static loading). Measurement units - millimetres (mm).

Working moment - working moment applied to the supporting coils of torsion spring or to the grips of torsion bar. Measurement units - Newton * meter (N * m).

Maximum moment - maximum moment applied to the supporting coils of torsion spring or to the grips of torsion bar. Measurement units - Newton * meter (N * m).

Minimum moment - minimum moment applied to the supporting coils of torsion spring or to the grips of torsion bar. Measurement units - Newton * meter (N * m). It is equal to 0 when loading is static.

Angle of torsion - the angle that corresponds either maximum load (when dynamic loading is used) or nominal load (under static loading). Measurement units - degrees.

Spring Geometry

Spring index is the ratio of spring diameter to wire diameter.

For springs with round cross-section the following values are used

Wire diameter W_d, mm	Spring index
$W_d < 2.5$	8
$2.5 < W_d < 5$	7
$W_d > 5$	6

For springs with square section the same values are used; in this case W_d is the square side.

When design calculations are performed it is possible to impose constraints on wire diameter and spring diameter. These constraints are entered in the *Additional Parameters* dialog box (Fig.1.3). The latter is invoked when you select *More…* button in the *General Parameters* dialog box (see above).

Spring diameter - for coiled springs diameter of cylinder used to coil spring; for disk spring - allowable external diameter. Measurement units - millimetres (mm).

Wire diameter - the diameter of wire with round cross-section used to manufacture spring. Measurement units - millimetres (mm).

Square side - the side of wire cross-section that has square shape. Measurement units - millimetres (mm).

When you perform design calculation you can specify only one parameter from the following ones: spring index, spring diameter, wire diameter.

Spring length - the length of spring in the absence of load. Measurement units - millimetres (mm).

Number of active coils - number of active coils of the springs. Number of supporting coils is set to 0 by default. Number of finished coils is 0 by default. You can select number of finished coils one of three: 0, 1, 1.5. 0 – spring has the plain ends.1 – from each side of spring grinded half of coil. 1.5 – from each side of spring grinded three fourth of coil.
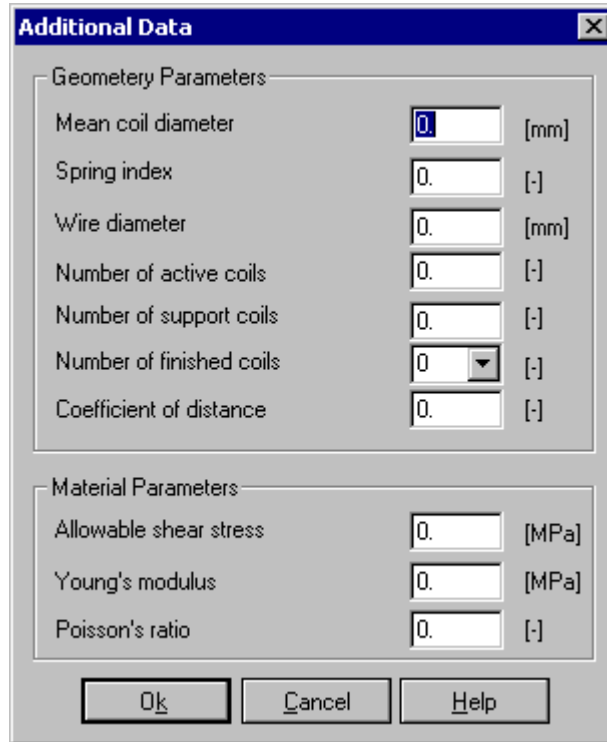
Fig. 1.3. Additional Data dialog box.

Material properties

Allowable shear stress (τ_a) – parameter of material equals to ultimate shear strength divided by static safety factor. For 1 class spring τ_a = $(0.25 \div 0.3)\,\sigma_b$, σ_b - ultimate tensile strength; for 2 class τ_a = $(0.45 \div 0.5)\,\sigma_b$; for 3 class spring τ_a = $0.6\,\sigma_b$.

Young's modulus (*E*) Young's modulus of spring material.

Poisson's ratio – Poisson's ratio of spring material. It is used for calculation of shear modulus

$$G = \frac{E}{2 \cdot (1 + \mu)}.$$

Working drawing generation.

APM Spring generates working drawing of spring and saves it in AGR file format (APM Graph).

To generate working drawing you should select *Drawing* button in *Results* dialog box. As a result dialog box will be displayed that allows to:

- Fill title block of drawing
- Enter additional parameters
- Specify technical requirements

APM Graph if installed will be run automatically after saving the drawing.

Chapter 2
Quick example, answers to common questions

In the first part of this chapter we give you an example of a sample session in order to demonstrate main operations required to calculate spring parameters. In the second section the answers to common questions that may arise when user works with **APM Spring** will be given.

APM Spring: quick example

To calculate elastic element with **APM Spring** you should perform the following actions:
- select spring type
- select calculation type
- enter initial data
- perform calculation
- look through the results

How to select spring type

First you should select type of spring to calculate. You can do this by three ways:
- select **Type | Spring** menu command
- double click with mouse left button in the spring type window
- press CTRL + R keys

Dialog box will be displayed where you can select a type of spring to be calculated.

How to select type of calculation

There are two general types of calculations in APM Spring—design and checking. The difference between these types is described in Chapter 1. To select type of calculation you should use commands of popup menu **Type | Calculations** or click left button on *Calculation type selection* button located in main window.
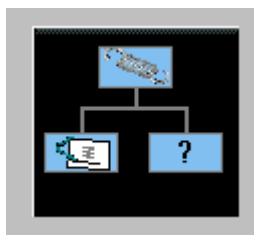
Fig. 2.1 Button Calculation type selection

You can also select type of calculation using following accelerators:
CTRL + D -- Design calculations
CTRL + C -- Checking calculations

How to enter initial data

To enter initial data select **Data...** command or click left button on General Parameter button in main window. Dialog box for data input correspond to selected spring type and type of calculation. It is necessary to enter all data listed in the window and press *Ok* for confirmation.

How to perform calculations

After you finish initial data entering you can start calculation. To do this there are two ways:
select **Calculate** command or

select ▦ button in the toolbar
Following message box is displayed at the end of calculation.
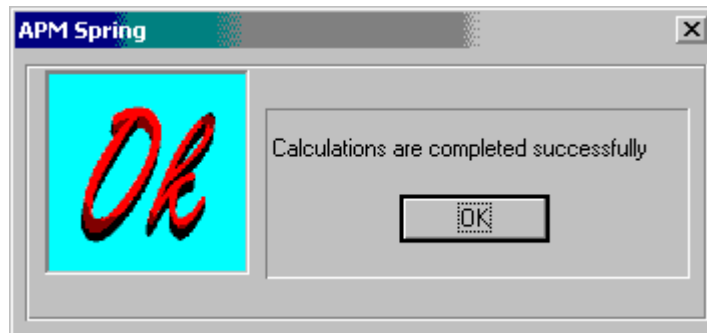
Fig. 2.2. Message box at the end of calculation.

How to look through the results

There are three ways to look through the results

- Select **Results...** command in main menu
- Press button ⬚ on toolbar.
- Press *Results* button in main window
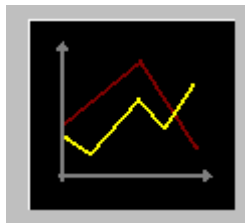
Fig. 2.2 Results button

Dialog box will be displayed with results summary. Selecting *Drawing* button you can initiate drawing generation.

APM Spring—answers to common questions

Question: What is APM Spring?
Answer: APM Spring is the program for elastic machine elements calculation and design developed in Research and Software Development Center APM Ltd (Moscow).

Q: How to select type of spring?
A: Use one of the following ways
select Type | Spring command

press CTRL + R keys
double click with mouse left button in the *Spring Type* window
In the dialog box that will be displayed select type of elastic element you want to calculate.

Q: How to select type of calculation?
A: Use Type | Calculations command or click left button on Calculation type selection button. Besides that you can use the following keys combinations
CTRL + D for design calculations
CTRL + C for checking calculations

Q: How to enter initial data?
A: The Data... command and left click on button General parameters or Add parameters invokes on the screen dialog box for initial data entering.

Q: How to perform calculations?
A: Use Calculate command.

Q: How to create working drawing?
A: Use command Results to open dialog box with calculation results. In this dialog box select *Drawing* button. New window with schematised picture of drawing is displayed. This picture contains three active zones accessible with mouse. The window has its own menu as well. Mouse double clicking in the first zone (or selecting Data | Construction command) allows enter drawing parameters that cannot be calculated and should be specified "manually". Second zone (Data | Technical Requirements) is responsible for technical requirements entering. Double clicking in the third zone (Data | Title Block command) invokes dialog box for title block filling. To move from one zone to another use TAB key. After you enter all parameters of the drawing, it is necessary to select Save... command. Dialog box will be displayed where you have to enter the name of the file for drawing and its type: agr. (Fig.2.3).
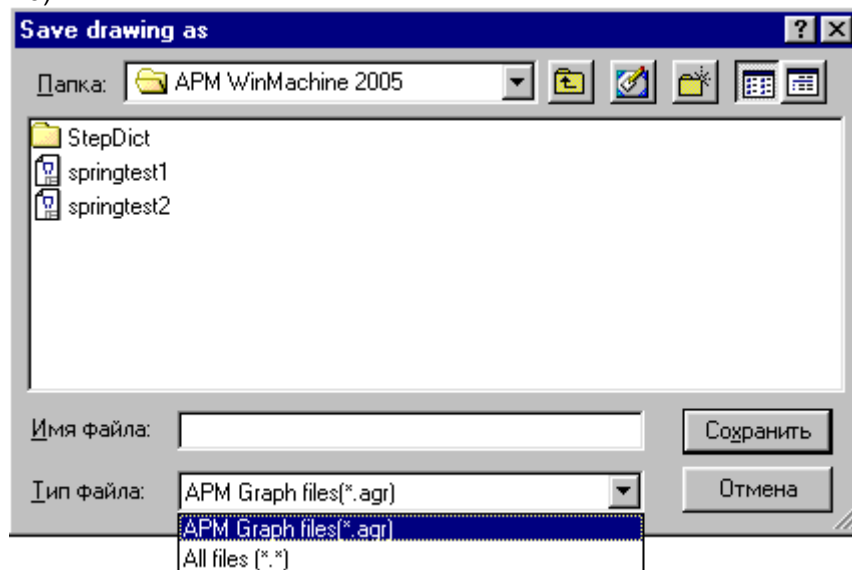
Fig. 2.3. Dialog box for entering the name of drawing file.

APM Graph if installed will run automatically after saving.
Q: How to look through the results?

A: Use Results... command or press [button] button in the toolbar or button *Results* in main window to call dialog box where results summary is shown.
Q: How to change wire cross-section type?
A: For coiled springs you can change wire cross-section type by selecting respective pictographic button in the dialog box for initial data entering.

Q: How to change material type?

A: You can change the material of spring in the *General Parameters* dialog box.

Q: How to contact APM?
A:
Our address:
APM Ltd. Research and Software Development Centre
Korolev - Center, box 58,
Moscow Region,
141070 Russia
Phone: +7 (495) 514-84-19
Fax/Phone: +7 (495) 585-06-11
E-mail: com@apm.ru;   our   site: http://www.apm.ru

Chapter 3
Archive files

When you work with **APM Spring** you can save initial data and calculation results as files on the hard disk or on the diskette in several file format. The saving is possible after you entered initial data

File format .spr

This is standard file format for system APM Spring. File content depends on the current position in problem solving. If you have already defined initial data, but perform not calculations, you can save only initial data. When calculations are finished you can save calculation results as well. When you load previously saved file, you will be just in the same position you were when the file was created. You can review data and results, modify data and repeat calculations, etc.

File format .rtf

Save data in the file with this format you can use it in MS WORD

File format .txt

Save data in the file with this format you can use it for creation spreadsheet in MS EXCEL or MS ACCESS.

How to create and load archive files see sections **Load Data command** and **Save Data command** in the Chapter 5.

Configuration file WINSPRIN.INI

Configuration file WINSPRIN.INI is used by **APM Spring** to store paths to some files used by the program and default values for some variables. The file is located in the WINDOWS directory (the directory containing WIN.COM file). Content of the WINSPRIN.INI is shown below.

[draw]
FILE=C1.AGR
DESIGN=White D. A.
CHECK=King N.I.
NCONTROL=Smith A. V.
TCONTROL=Stone V.V.
CONFIRM= Stone V.V.
LABEL=08766/8766
MATERIAL=40X13
STANDARD=1475-78
LITER=000
FIRM=APM center
DEPARTMENT=Design
HARDNESS=40
REQUIREMENTS=GOST 2.401-68
TWIST=RIGHT

[database]
STANDARD=GOST(Russia)

[**Database name**]
DB_Name=C:\Program Files\APM WinMachine 2005\MaterialDB.mdb

WINSPRIN.INI content is divided into several groups (sections). Each section has a header. Header is the string that starts with left bracket (**[**) and finished by the right bracket (**]**)**.** Each section contains information on logically related topics.

Here we give a brief description of all the sections:
- **[draw]** section

In this section APM Spring stores default values for drawing parameters.

1. FILE - name of drawing file, which user have entered in last session with **APM Spring.**
2. DESIGN - the name and surname of the man, who have worked with drawing.
3. CHECK - the name and surname of the man, who have check drawing.
4. NCONTROL - the name and surname of the controller
5. TCONTROL - the name and surname of the technical inspector.
6. CONFIRM - the name and surname of the man, who have confirm drawing.
7. LABEL - designation of drawing.
8. MATERIAL - mark of material.
9. STANDARD - standard for the material.
10. LITER - letter of drawing.
11. FIRM - name of the organisation, who have developed the drawing.
12. DEPARTMENT - name of subdivision of organisation, who have developed the drawing.
13. HARDNESS - hardness of working surfaces.
14. REQUIREMENTS - other technical requirements according to...
15. TWIST - direction of spring coiling. This section is written in Windows ANSI format, so to change it you should use the program, that supports this format.

- **[database] section**
1. STANDARD - current standard, used in the program.

- **[database_name] section**
1. DB_NAME –full path to current material database

Chapter 4
APM Spring environment

APM Spring is intended to run under Microsoft Windows 95 and a later. Standard dialog tools of Windows were used in the program. It follows standard conventions, recommended for a user interface of application programs, running under Microsoft Windows. So, those, who have any experience in Windows, will not encounter any problem with learning **APM Spring**. But if you haven't such experience, don't worry. Work with **APM Spring** is supposed to be easy both for specialist in mechanics and for amateur. User interface of **APM Spring** is fairly straightforward and intuitively clear. To learn how to perform calculations with **APM Spring** you will need no more than 1—2 sessions.

In this chapter we give you a brief description of the interface of **APM Spring**.
Systematic description of all menu commands and dialog box options is given in Chapter 5.

Information windows

Information windows are used to display initial data used for calculations. Six such windows are always present on the display. These are: *Type of Spring, General Parameters, Additional Parameters, Reference, Information About the Program* and window with buttons of quick choice.

Window "Type of Spring"

The *Type of Spring* window is situated in the top left part of the screen (Fig. 4.1.). It contains pictogram of currently selected type of spring.

Fig 4.1 Window "Type of Spring".

Double clicking in this window calls the dialog box for spring type selection. If type of spring is not selected, then text "Spring is not selected" is displayed in the centre of the window.

The General Parameters window

General Parameters window is used to show type of spring, type of calculation, standard and material (for disk spring - type) of spring (Fig. 4.2).
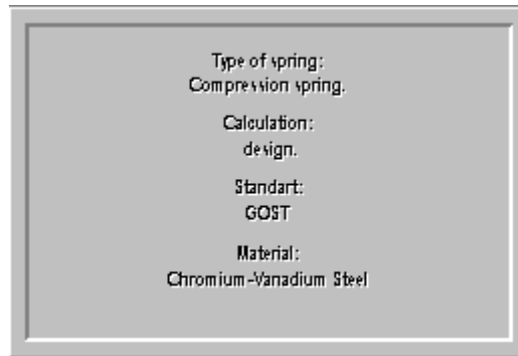
Fig. 4.2 Window "General Parameters"

Window "Numerical parameter"

The *Numerical Parameters* window is used to display initial data, that describe the spring parameter (Fig. 4.3). This window consists of two parts: the left part contains geometry parameters of spring, while characteristics of material are listed in the right part. Text "NOT AVAILABLE" is displayed in the centre of window if type of calculation and type of spring are not selected,.

General parameters:			Add parameters:		
Maximum working force	100.	[N]	Mean coil diameter	0.	[mm]
Preload force	10.	[N]	Spring index	0.	[-]
Spring class	1.	[-]	Wire diameter	0.	[mm]
Working deflection	30.	[mm]	Number of active coils	0.	[-]
			Number of supporting coils	0.	[-]
			Number of finished coils	0.	[-]
			Coefficient of relative distance	0.	[-]
			Allowable shear stress	0.	[MPa]
			Young's modulus	0.	[MPa]
			Poisson's ratio	0.	[-]

Fig. 4.3 "Numerical parameter" window

Window with buttons for quick selection

This window is situated in the top right part of the program window; it contains six buttons: calculation type, standard, material database, general parameters, additional parameters, results.

Fig. 4.4 Window with buttons for quick selection

These buttons are described in more details below.

Button for calculation type selection

This button is located in the left part of the window. When you press the button, menu for calculation type selection is displayed.
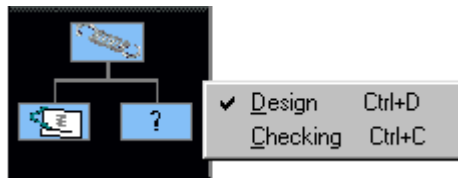

Fig. 4.5 Calculation type selection button

Changing the type of calculation showing in the General parameter window. If type of spring is not selected, this button is disabled.

Button for Standard selection

This button is located in the top centre part of the window. When you press this button, dialog box Standard is displayed.

Fig. 4.6 Standard selection button

Button "Material data base"

This button is located in the top right part of the window. When you press this button, dialog box *Materials...* is displayed.

Fig. 4.7 Button "Material data base"

Button "General parameters"

This button is located in bottom left part of the window. When you press this button, dialog box *General parameters* is displayed.
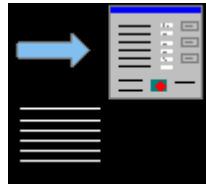

Fig. 4.8 Button "General parameters"

If type of spring and type of calculation are not selected, this button is disabled.

Button "Add parameter"

This button is located in bottom centre part of the window. When you press this button, dialog box *Add parameters* is displayed.

Fig. 4.9 Button "Add parameters"

If type of spring and type of calculation are not selected, this button is disabled.

Button "Results"

This button is located in bottom right part of the window. When you press this button, dialog box *Results* is displayed.
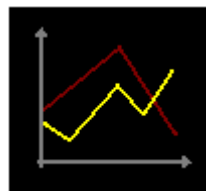

Fig. 4.10 Button "Results"

If the calculation of spring is not complete, this button is disabled.

Information About Program window

License information and version of APM Spring are shown in this window.

Fig.4.11 information About Program window

Chapter 5
Command Reference

In this section we give you a complete description of each menu command and dialog box option in the APM Spring environment. Fig. 5.1 shows the main menu of the APM Spring and all the popup menus called from the main menu.
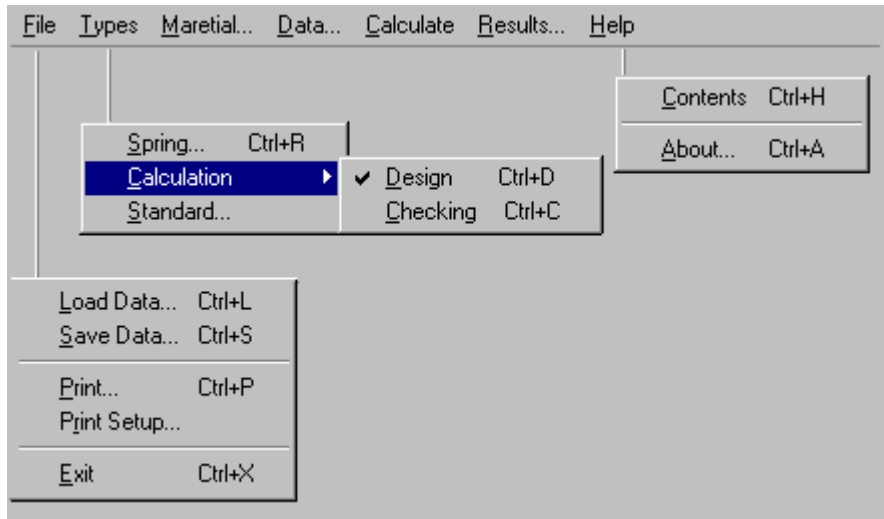

Fig. 5.1 APM Spring menu structure

File menu

The **File** menu includes commands to:

- load information from archive files
- save information to archive files
- print initial data and calculation results
- select printer and printing options
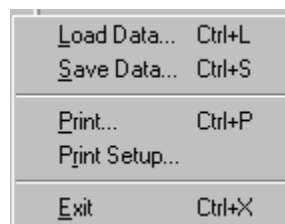- quit the program

Fig. 5.2 The File menu

Load Data command

The **File | Load Data** command opens the *Load Archive File* dialog box, shown below. By means of this dialog box you can select the archive file to be loaded (for description of archive files see Chapter 3).

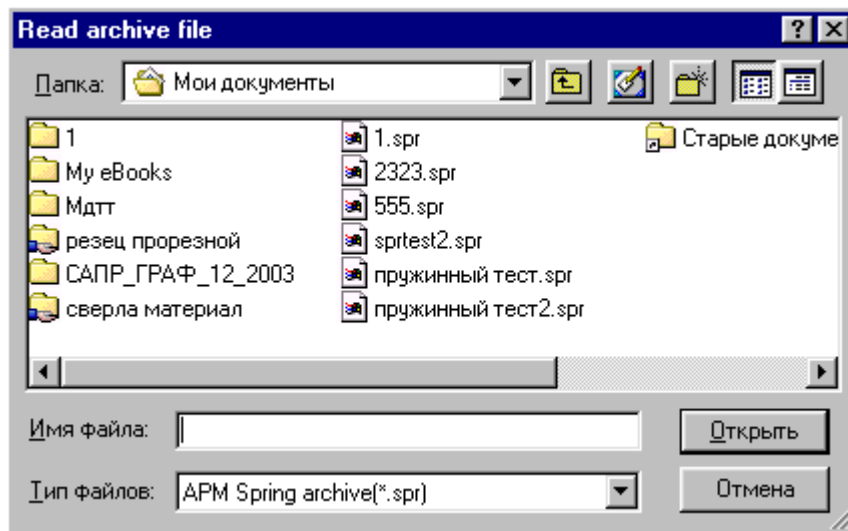**Shortcuts**

Toolbar
Keys: CTRL + L

Fig. 5.3. The Load Archive File dialog box

Save Data command

The **File | Save Data** command opens the *Save Archive File* dialog box, shown at Fig. 5.4. Using this dialog box you can specify the archive file in which initial data and calculation results will be saved.

Shortcuts

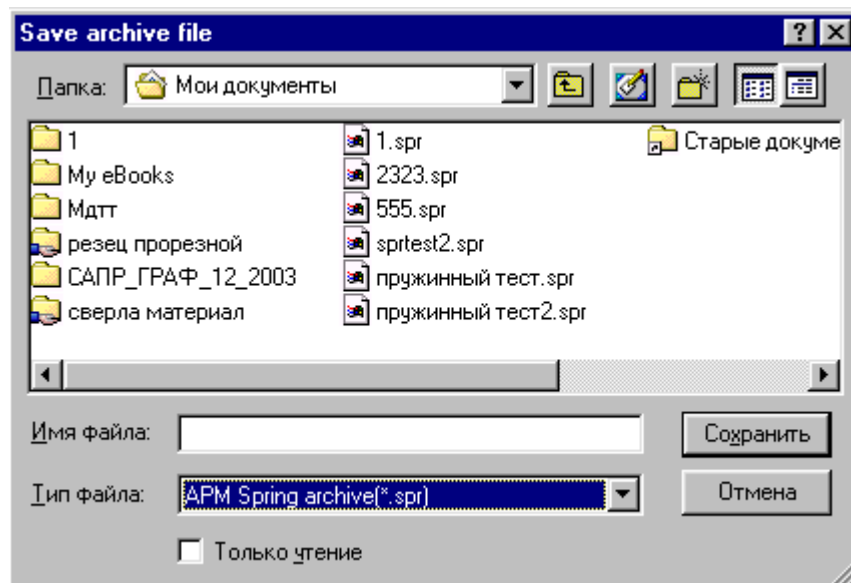Toolbar 💾

 Keys   CTRL + S

Fig 5.4 The Save Archive File dialog box

Print command

The **File | Print** command allows you to print out calculation results. When you select this command the standard dialog box is called on the screen.

Shortcuts

Toolbar 🖨

Keys   CTRL + P

Printer setup command

The **File | Printer setup** command invokes the standard Print Setup dialog box
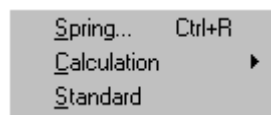
Exit command

Use **File | Exit** command to exit APM Spring.

Shortcuts

Keys   CTRL + X

Types menu

The **Types** command of the main menu invokes **Types** popup menu shown at Fig. 5.5.

Fig 5.5 Types popup menu

Below we give the description of the **Types** menu commands.

Spring command

The **Type | Spring** command displays the dialog box for choosing the type of spring. This dialog box is shown in Fig. 5.6.

The dialog box described includes 6 radio buttons. Every button designates one of the types of spring you can calculate in the APM Spring. All you have to do with this dialog box is to select a desired type of elastic element, either with a mouse or arrow keys and then press "Ok" button. As a result of your action in the *Spring Type* window (see Chapter 4) a pictogram of spring you've selected will be displayed. Simultaneously all the parameter values in the *Numerical Data* window and General parameters window will be set. The **Calculation** command in the **Type** popup menu, and calculation type selection button become enabled, so you can define type of calculation. The **Data, Calculate** and **Results** commands, General parameters, Add parameters and Result buttons become (or remain) disabled .
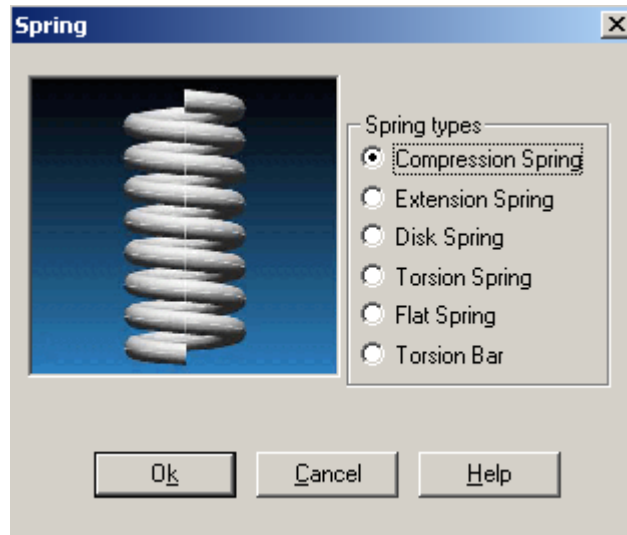
Fig. 5.5 Dialog box for spring type selection

Shortcuts
 Keys   CTRL + R

Calculation command

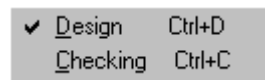The **Type | Calculation** command invokes **Calculation** popup menu shown at Fig. 5.6

*Fig. 5.6. **Calculation** popup menu*

The type of calculation that you have chosen is marked by the checkmark. Current type of calculation is shown in *General Parameter window*. After you select type of calculation **Data...** command in the main menu and General and Add parameter button become enabled.

Shortcuts   ---------
Button: Selection type calculation

Standard command

This command allows to select standard that will be used by the program to choose the disk spring. Selected standard will be saved in the WINSPRIN.INI file.

Shortcuts -------
Button: Standard

Material... menu command

Material... command displays the dialog box with the list of materials from current database.
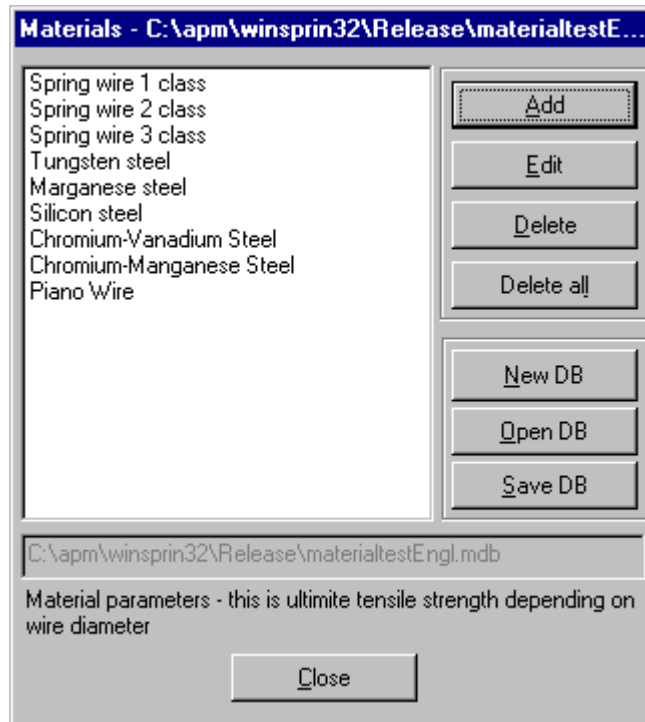

Fig 5.7 Materials dialog box

This window includes: name of the current database, list of materials from current database, and six buttons: Add, Edit, Delete, Delete all, New DB, Open DB, Save DB, Close. Below we describe each of them.

At the window caption and edit box you can see the full path to current materials database

At the list box you can see all materials form current database.

Add button let to add new material to database. Then you must enter the name of new materials (fig. 5.8), and after pressing *Ok* function editor window will be displayed.
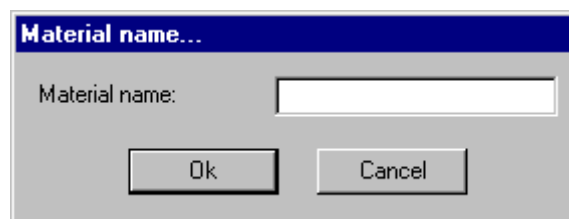
Fig. 5.8 Material name window

Edit button allows to change the name of existing materials and its parameter - ultimate tensile strength on wire diameter dependence in graph form.

Delete button let to delete the selected material.

Delete all button let to delete all materials form current database.

New DB button let to create new material database.

Open DB button let to open existing database.

S̲ave DB button let to save opened database with different name.

Close button closes dialog box.

Shortcuts -------
Button: Material database

Data... command

Data command displays the dialog box for initial data entering. The number of parameters to be entered depends on the type of spring to be calculated. As an example, in Fig. 5.9 the dialog box for entering initial data for compression spring is shown. In this window there are *Cross-Section* groupbox and *Material* list. Type of cross-section is shown as pictogram. The warning message window will be displayed in case of some input error (Fig.5.10).
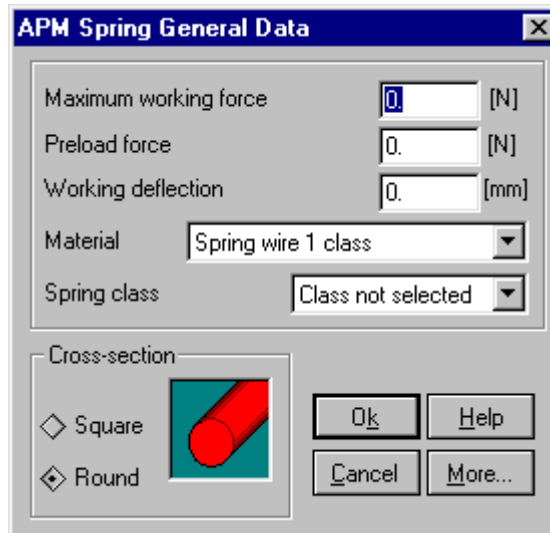

Fig. 5.9 The dialog box for Compression Spring data input.

Initial data are shown in the information windows *Numerical Parameters* and *General Parameter*.
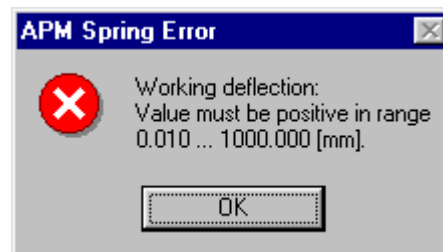

Fig. 5.10 The error message.

Calculate command

The **Calculate** command in the main menu starts calculations. When calculations will be completed, the message will be displayed (Fig.5.11)*.*

Shortcuts

Toolbar
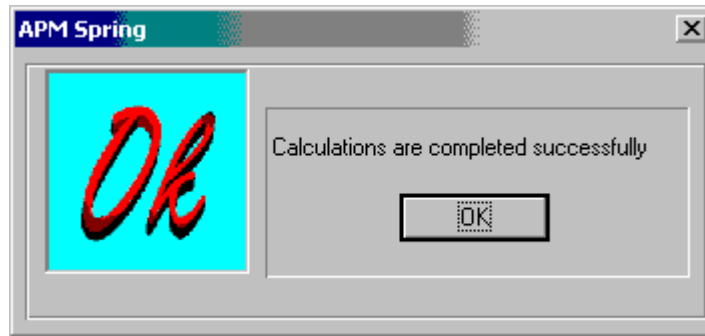
Fig. 5.11. "Calculations completed" message.

Results command

The **Results** command of main menu shows the dialog box *Results.* This window differs for the different types of spring and type of calculation. *Results* window for compression spring is shown below.

Fig. 5.12. Dialog box "Results" for compression spring

Select *Draw* button to invoke dialog box managing working drawing generation.
Displayed below dialog is used for additional selection for multi variant results.

Fig 5.13 Dialog boxes for choosing variant for drawing and printing

Draw dialog box has its own menu of common type and also custom menu that looks like a simplified drawing. Custom menu consists of three active zones; the first zone corresponds to **Data | Con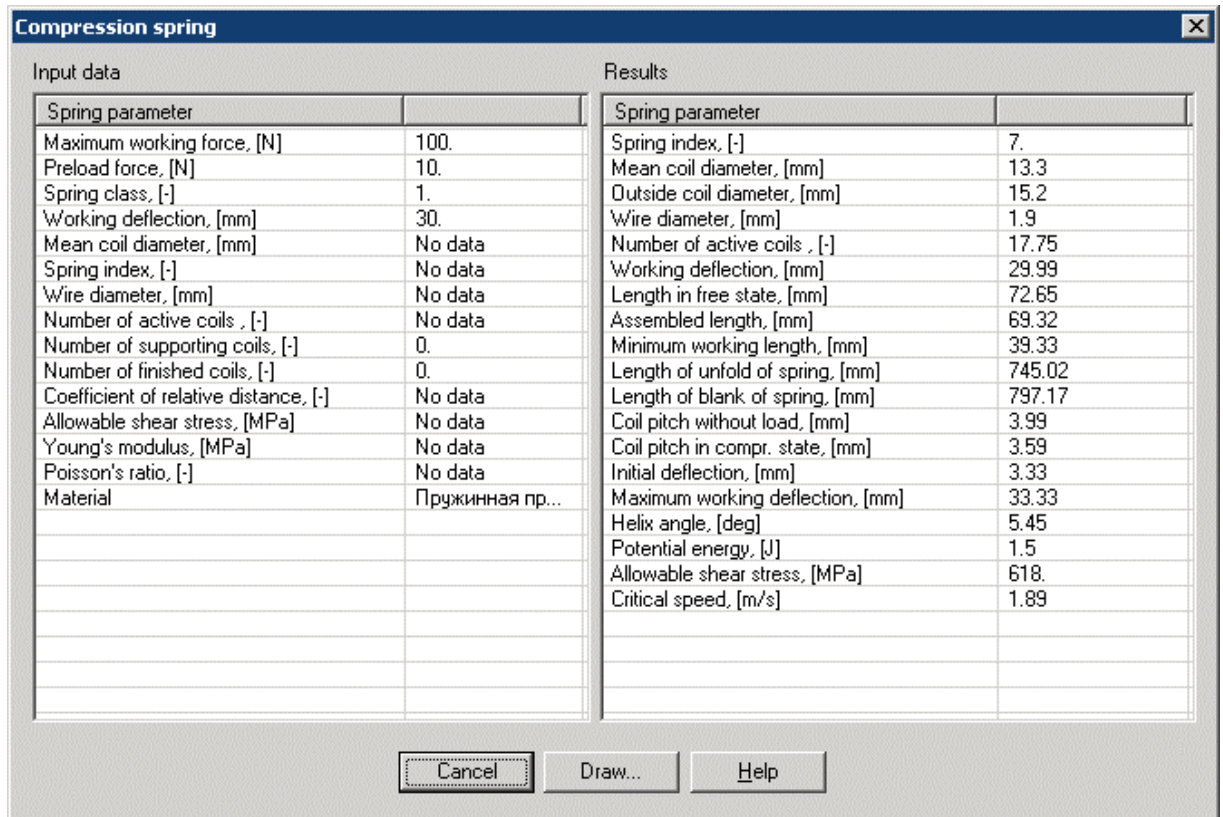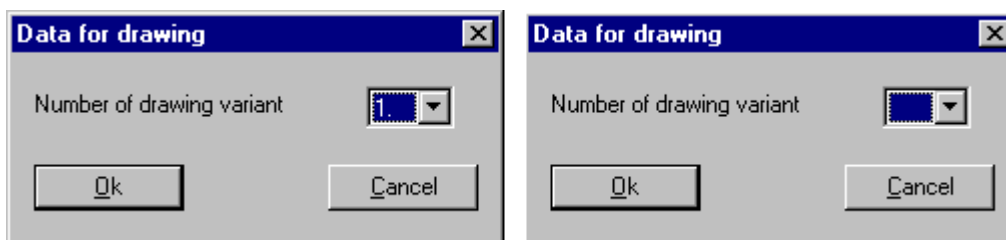struction...** command, the second⸺to **Data | Technical Requirements** command and the third⸺to **Data | Title Block** command. Double click in the each of active zone is equivalent to selecting of respective command. To move from one zone to another use TAB and SHIFT+TAB keys. Currently selected zone is surrounded by dotted frame. To execute the command associated with zone use SPACE and ENTER keys.

Let search for section "*Draw*". This button calls additional window, which have own menu and three sections: *Drawing* – section with image of drawing, *Technical requirements* – technical requirements for the drawing and section *Stamp*. Double click of mouse in each part of window call corresponding dialog window, where you can introduce suitable parameters. This result you can get using buttons *TAB* and *Space.* When you pressing *TAB* respective part of window encloses by the dotted line. By pressing the *Space* or *Enter* button you call the dialog box corresponding this section and type of spring. You can use menu as well(Fig. 5. 14).
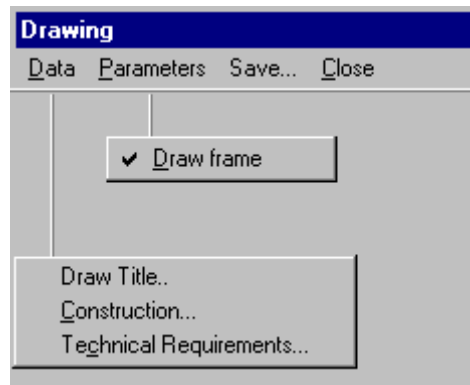

Fig. 5.14. Menu of Drawing window.

Draw Title... command

Data | Draw Title command calls the window that allows you to fill the title block of the drawing. With this window you can enter the name and surname of persons that develop and check the drawing, the name of the company, the standards used, document number, etc. Described window looks exactly like the title block of the drawing. To move from one field to another use either mouse or TAB/SHIFT+TAB keys. Use scroll bars to access invisible fields of title block.

Construction... command

Data | Construction... command invokes the dialog box for input additional data. These data are required for drawing development, but they cannot be calculated automatically. For compression, extension and torsion springs you can choose type of drawing of the spring. Fig. 5.15 shows such dialog box for compression spring.

If you do not enter data in this dialog box they will be calculated depending on the spring sizes.
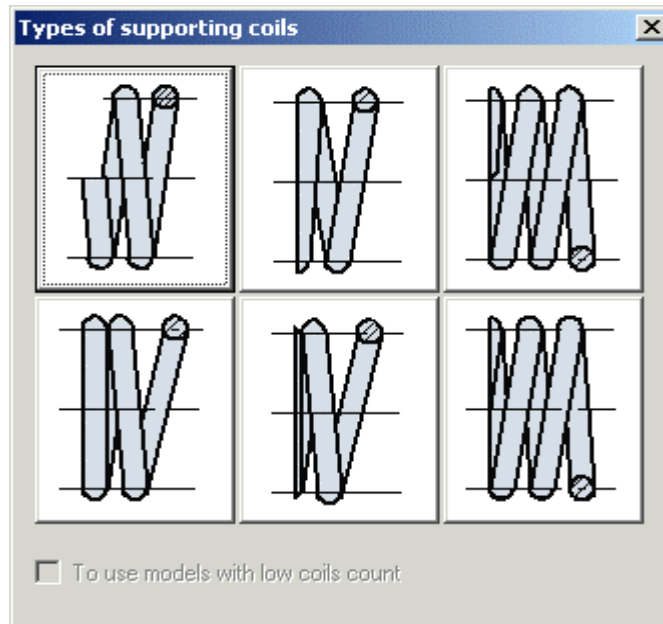
Fig. 5.15 Construction dialog box compression spring.

Technical Requirements... command

The **Data | Technical Requirements** command calls dialog box that let to enter technical requirements for current type of spring. This dialog box is shown in Fig. 5.16.

Fig. 5.16. Dialog box "Technical Requirements"

Parameters menu

This popup menu contains command – **Draw Frame**. Use this command, you can don't draw frame.

Save... Command

This command allows saving drawing in required format. If you save drawing as AGR file, APM Graph if installed will run automatically.

Close Command

This command closes *Draw* window.

Menu Help

Popup menu **Help** (Fig. 5.18) contains the commands that
- call the contents of **APM Spring** help system
- call "*About"* dialog box
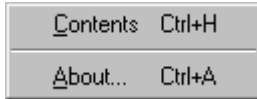
Fig. 5.18 Popup menu Help

Contents command

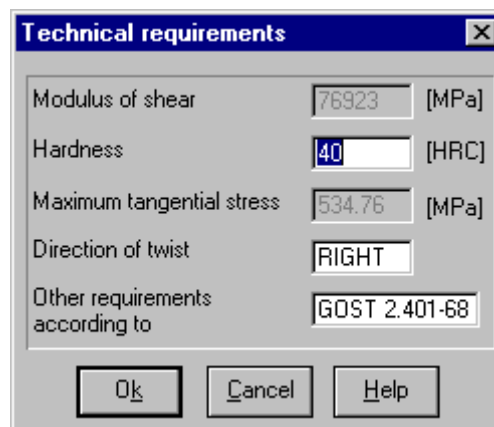**Help | Contents** command invokes window with **APM Spring** help contents. Select topic of your interest and click it with mouse or press ENTER key.

Shortcuts

toolbar

Keys   CTRL + H

About command

Help | About command calls *About* dialog box on the screen. It displays the program name and the version together with the license information.

Shortcuts
Keys   CTRL + A

System menu

The system menu let you interact with Windows. The commands of this menu are as follows:

Restore	Restores the previous size of application program window
Move	Let you move application program window with keyboard
Size	Let you change the size of application program window with keyboard
Minimize	Reduce application program window to icon state
Maximize	Restores application program window to its maximum size
Close	Terminates the program
Switch To	Let you switch to another program

To open the System menu use ALT+MINUS (-) keys or click the button in the left upper corner of the application program window.

Toolbar

Toolbar is the group of pictographic buttons located below the main menu (Fig.5.20.). The Toolbar is intended to speed up selection of some frequently used commands.

Fig 5.17 Toolbar of APM Spring

Buttons of the toolbar initiate the following commands (from left to right):
- **File | Load Data**
- **File | Save Data**
- **File | Print**
- **Calculate**
- **Results**
- **Help | Contents**

To execute command with toolbar you should click mouse left button on the appropriate button.

Accelerators

Accelerator is the combination of the keys used to speed up command selection. In the APM Spring the following accelerators are used.

Command	Accelerator
**File	Load Data**	CTRL+L
**File	Save Data**	CTRL+S
**File	Print**	CTRL+P
**File	Exit**	CTRL+X
**Types	Spring**	CTRL+R
**Types	Calculation	Design**	CTRL+D
**Types	Calculation	Checking**	CTRL+C
**Help	Contents**	CTRL+H
**Help	About**	CTRL+A

Chapter 6
Function Editor APM_FNED

Function editor APM_FNED is intended to enter and edit functions. The editor allows to use both graphics and analytical function specification. The editor includes parser for entering analytical expressions describing the functions.

To manage the editor use the toolbar buttons:

Fig. 6.1. The function editor toolbar.

OK button

Use this button to end function entering/editing, save changes and return to calling program.

Cancel button

Use this button to cancel function editor without saving changes.

Full Scale button

Use this button to set scale 1 : 1.

Zoom In Window button

Use this button to enlarge selected rectangle to the whole window. Press mouse left button and holding it, then select rectangle you want to enlarge. Use right mouse button to cancel operation.

Scale button

Use this button to enter specific scale. In response *Scale* dialog box is displayed.
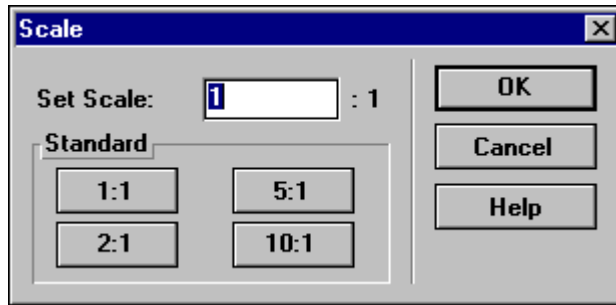
Fig. 6.2. The "Scale" dialog box

Use *Set Scale* edit box to enter vertical scale. The buttons of *Standard* group allows you to set one of four predefined scales. Note that you can change the vertical axis scale only.

Limits button

Use this button to enter graph limits. In response *Limits* dialog box is displayed.

Fig. 6.3. The "Limits" dialog box

Using this dialog box one can enter for the. One can also use *Auto* mode. In this case minimum and maximum values are used to determine limits.

Grid Parameters button

This button invokes *Grid Parameters* dialog box.

Cursor Step button

This button calls *Cursor Step* dialog box.

Palette button

This button invokes *Palette* dialog box.

New Function button

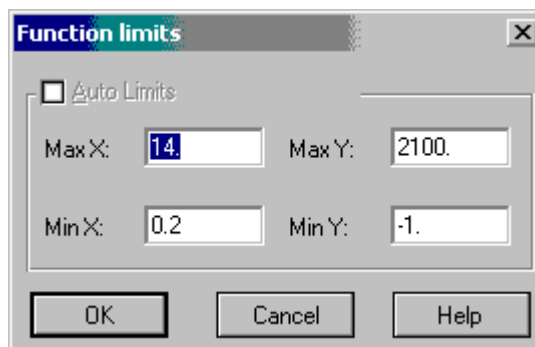This button deletes existing graph and starts new one.

Lengthen Function button

Using this button you can lengthen function up to the right limit. The lengthening is performed by addition of horizontal line to existing graph.

Analytical Function button

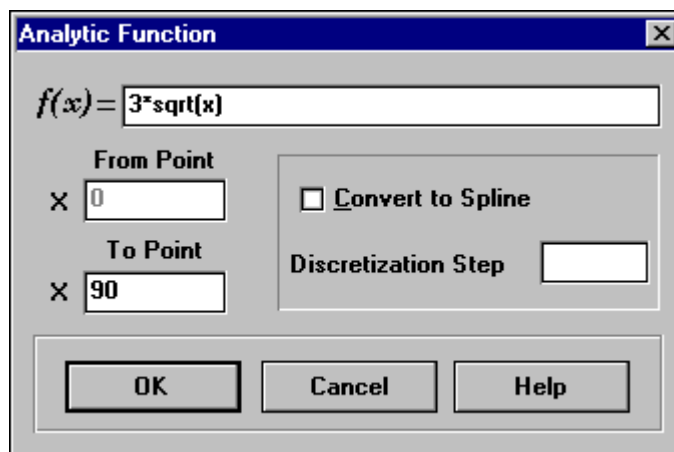
This button invokes *Analytic Function* dialog box.

Fig. 6.4. The "Analytical Function" dialog box.

In this dialog box you can enter parameters of analytical function. You can add analytical as graphics objects to the graph.

Use *Formula* edit box to enter expression describing analytical function.

Use *To Point* edit box to enter abscissa of starting point. Ordinate is determined using function expression.

Use *From point* edit box to enter abscissa of ending point. Ordinate is determined using function expression.

If the *Convert to Spline* checkbox is checked the analytical function will be converted to spline with given discretization step. In this case the restrictions acting in the case of analytical function will be removed, but the accuracy decreases.

Using *Discretization Step* edit box you can enter the step used to convert analytical function to spline. Since the restriction are imposed on the number of spline points, when using too small step you get the corresponding warning message.

Table button

This button displays dialog box *Specify Function by Table*. The possibility to describe function graphically remains.
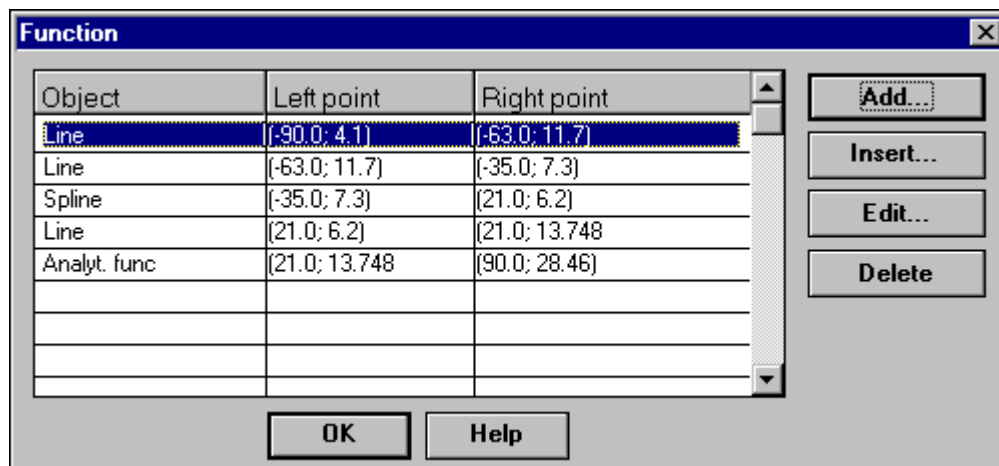

Object	Left point	Right point
Line	(-90.0; 4.1)	(-63.0; 11.7)
Line	(-63.0; 11.7)	(-35.0; 7.3)
Spline	(-35.0; 7.3)	(21.0; 6.2)
Line	(21.0; 6.2)	(21.0; 13.748
Analyt. func	(21.0; 13.748	(90.0; 28.46)

Fig. 6.5. Dialog window of function intervals.

In this dialog box the objects are listed including their boundary coordinates

Use *Add* button to select type of object to be added—line, spline, analytical function. Analytical function cannot be added to the graphs of the first and second derivatives.

Use *Insert* button to select type of object to be inserted—line, spline, analytical function. The object is inserted before current one (highlighted by selection bar). Analytical function cannot be inserted. The object cannot be inserted in the presence of analytical function.

Use *Edit* button to change the current object. In the presence of analytical function some restrictions are imposed to object editing.

Use *Delete* button to delete the current object. In the presence of analytical function some restrictions are imposed to object deletion.

If you select the object of 'line' type (when you add or insert the object), the *Line* dialog box is displayed.
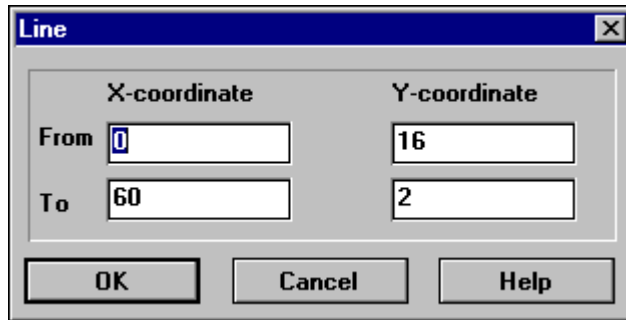
Fig. 6.6. The "Line" dialog box.

Using this dialog box you can enter line parameters.
In some modes (adding, insertion, editing) some of the edit boxes become unavailable.

If you select the object of 'spline' type (when you add or insert the object), the *Spline* dialog box is displayed.
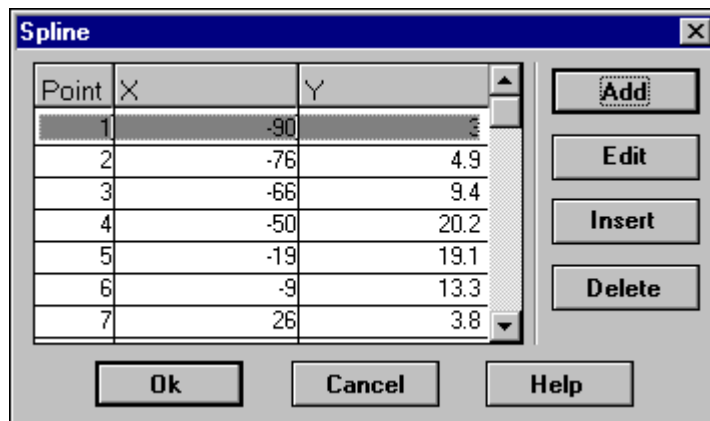

Fig. 6.7. The "Spline" dialog box.

In this dialog box the points used to construct spline are listed.

Use *Add* button to add new point to the spline.
Use *Edit* button to change current point of the spline.
Use *Insert* button to insert new point. The point is inserted before current one (highlighted by selection bar).
Use *Delete* button to delete current point of the spline.

Use *OK* button to confirm spline edit. The spline is checked for the presence of at least four points, as well as for agreement between spline end points and boundaries

If you select the object of type 'analytical function' the *Analytical Function* dialog box is displayed (see above).

Line button

Switch the program to line drawing.

Spline button

Switch the program to spline drawing.

Add Object button

This button switch the program to object adding mode.

Line drawing
To draw the line place cursor to one of its end points, press mouse left button and holding it move cursor to other end point, then release the button. When drawing, pressing of mouse right button cancels the drawing operation. If you continue the drawing, the first point will be the end point of the previous object. If the line you are drawing is the first object, the X coordinate is 0, the Y coordinate is determined by cursor position.

Spline drawing:
When you draw the spline its first point is set automatically: if you continue the drawing, the first point will be the end point of the previous object, if the spline you are drawing is the first object, the X coordinate is 0, the Y coordinate is determined by cursor position. To enter the second point press mouse left button and holding it move cursor to required point, then release button. As usually mouse right button pressing cancels the operation.

To enter following points of the spline use the same actions as for line drawing. To delete existing spline point move cursor to it and press mouse right button.

Use Ctrl + mouse right button combination to cancel spline drawing.

To draw spline one should enter at least four points. The set of points used to draw spline must not contain the points with coinciding coordinates, otherwise spline drawing is cancelled.

Press space bar to finish spline drawing.

Edit Function button

To edit the node, located between the objects, move cursor to it and press mouse left button. Holding left button you can move the node. If you press mouse right button at the moment, you cancel the editing. Releasing left button you set new position of the node. Now you can edit the objects, located to the left and to the right of the node. The editing performed just in the same way as the drawing does. Pressing of mouse right button (as well as combination of Ctrl + mouse right button for the spline) returns the object to initial state.

To edit spline, move cursor to it and press mouse left button. The program switches in edit mode. The combination Ctrl + mouse right button returns the object to initial state. Press space bar to finish editing.

To edit analytical function move mouse cursor to it and press mouse left button. The dialog box will be displayed; using it you can change parameters of analytical function.

Insert Object button

To insert new object, move the cursor to the node, that corresponds to objects you want to insert new object between. If you press mouse left button, the right object is displaced to distance that

is equal to distance between last point of object to right boundary of graph. Now you can enter new object just in the same way as you do it in the drawing mode. When you finish object insertion, the drawing is displaced to the left with leveling of Y coordinate. So editing of displaced object may be required. You can not insert analytical function. In presence of analytic function there exist some restrictions on object deletion..

Delete Object button

To delete object, move cursor either object or to node, the object located right of. Then press mouse left button to select object to be deleted. In this moment, pressing right button you will cancel deletion. Having release left button you delete the object. After deletion the object located to the right of deleted one moves to the left with Y coordinate levelling off. So editing of displaced object may be required. If analytic function is entered there exist some restrictions on object deletion.

Function button

This button switches the program to mode of function entering.

First Derivative button

This button switches the program to mode of first derivative entering.

Second Derivative button

This button switches the program to mode of second derivative entering.

Help button

This button displays help contents.

Status line

The status line is the bar in the lower part of the program window where various prompt information, current measurement units and cursor coordinates are displayed.