APM Trans

User's Guide

APM Trans

The system for mechanical transmission calculation

Version 9.1

User's Guide

Research and software development center APM Ltd., Korolev-Center, box 58, Moscow region, Russia 141070.

Printed in Russia.

Introduction

APM Trans-what is it ?

APM Trans is the system for calculation and design of mechanical transmission developed by the Research and Software Development Center **APM Ltd**.

Using **APM Trans** you can calculate the following:

- General geometry parameters
- Forces, acting in the meshing
- Longevity
- Maximum allowable load
- Control parameters

The system allows to calculate eight the most widely used types of transmission:

- external and internal spur gearing with involute teeth
- helical gearings
- herring bone gearings
- bevel gearing with standard involute teeth and circular teeth
- worm gearings
- flat belt transmissions
- V-belt transmission
- chain transmission

With **APM Trans** you can generate the working drawings of the transmission in the DXF format and APM Graph file format.

Hardware and software requirements

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

What's in this manual

Introduction (this section) tells you what **APM Trans** is in general, what parameters and what types of transmission could be calculated. You will know the requirements to hardware and system software.

Chapter 1, Problems and results contains description of the problems solved with APM Trans. All the calculated parameters and initial data are listed. The standards used for transmission calculation are described.

Chapter 2, How to work with APM Trans leads you through a sample session in order to demonstrate main operations -- how to install and start the program, enter initial data, perform calculations, browse the results, specify working drawing.

Chapter 3, APM Trans in answers and questions contains answers to common questions that may arise when you work with **APM Trans**.

Chapter 4, Data base and archive files summarizes the local data base features -- structure, using, updating. File of system initialization is described as well.

Chapter 5, APM Trans environment describes the main elements of **APM Trans** environment -- menus, dialog boxes and controls, information window's.

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 **Trans** 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:

Phone +7(495) 585-06-11 (fax), 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@apmwm.com
www.apmwm.com

Chapter 1

Problems and results

APM Trans is intended for mechanical transmission calculation and design. It allows:
- to specify transmission design
- to perform all the calculations required
- to obtain working drawings of transmission

Transmission types

APM Trans allows calculating transmissions of the following types:

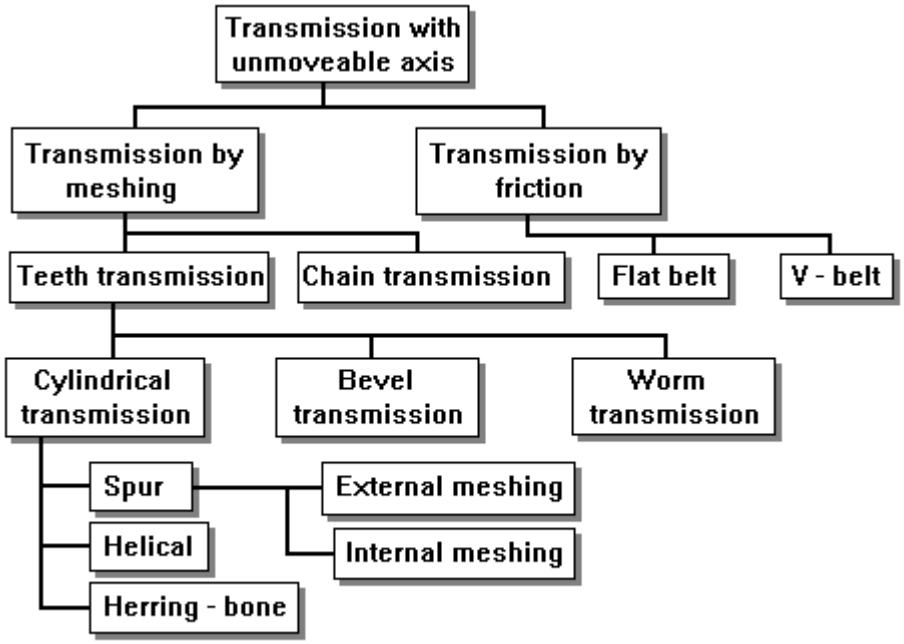


Fig 1.1 Types of transmission calculated with APM Trans.

Calculation types

Using **APM Trans** you can perform the following types of calculations:

- transmission design
- load capacity calculation
- design with constraints

Transmission design

With this type of calculation you define gear dimensions based on required power. Basic initial data for design calculation are torque transmited by transmission, revolution of driven shaft, type of loading, required longevity. **APM Trans** calculates geometry of transmission based on criteria of bending and pitting endurance.

You can impose the constraints on the dimensions of the transmission, for example you can design the transmission with given centre distance, etc.

Load capacity calculation

With this type of calculation you can determine the load capacity of the given transmission (with known dimensions, material, thermal treatment, etc.). Two subtypes of calculation are realized in the system:

- Maximum transmitted torque checking
- Longevity of transmission with given loads checking

Extra option is available for cylindrical gears namely **required summary addendum modification calculation** by given center distance.

Design with constraints

It is possible to place additional constraints on designed gear. For example gear with standard center distance or required helix angle, module, etc. can be designed. Enter ***additional data*** to define constraints. Use *Additional data* dialog that is invoked by *"More…"* button from main geometry data dialog.

Initial data

All initial data in **APM *Trans*** are divided into two groups: *General data* and *Additional data*. *General data* are the minimum data required to perform calculations of given type. *Additional data* are used to impose constraints to designed transmission and are optional.

Both general and additional data for each transmission type are listed below.

Cylindrical gearings. Design calculation.

General data for design calculation

1. Torque at the output shaft
2. Rotational speed of the output shaft
3. Gear ratio
4. Required lifetime
5. Number of meshing of each wheel per one revolution of drive wheel
6. Location of the wheel at the shaft (symmetrical, non-symmetrical, cantilever)
7. Thermal treatment for each wheel (martempering, hardening, carburizing, carbonitriding, nitriding)
8. Operation mode (constant, heavy, mean, mean-probable, light, very light)

Additional data for design calculation

1. Centre distance

2. Wheel facewidth ratio (relative to the centre distance)
3. Module
4. Helix angle
5. Addendum modification coefficient for each wheel
6. Average hardness of teeth surface. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
7. Average hardness of teeth core. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
8. Teeth number of each wheel
9. Reversible or nonreversible transmission. Nonreversible transmission assumed by default.
10. Standard center distance flag. If it is switched on center distance is selected from R40 row.
11. Pinion material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.
12. Wheel material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.

Cylindrical gearings. Checking calculation.

General data for checking calculation

1. Module.
2. Helix angle (for herringbone and helical gearing only).
3. Teeth number of each wheel.
4. Width of each wheel.
5. Addendum modification coefficient of each wheel.
6. Output torque (for longevity checking calculation) [Nm].
7. Output revolution [rpm].
8. Required longevity (for torque checking calculation) [H].
9. Number of engagements of each wheel.
10. Thermal treatment of each wheel.
11. Working condition (operation mode – invariable, heavy, mean equiprobable, mean normal, etc.).
12. Fastening of drive wheel.

Additional data for checking calculation

1. Gear manufacturing accuracy.
2. Average surface hardness. Average hardness is defined by thermal treatment by default.
3. Average hardness of teeth core. Average hardness is defined by thermal treatment by default.
4. Pinion material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.
5. Wheel material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.
6. Reversible or nonreversible transmission. Nonreversible transmission assumed by default.
7. Roll diameter. It is used in roller test.
8. Teeth number for common normal length test
9. Center distance. It is used for summary addendum modification calculation to get specified center distance.

Bevel gearings. Design calculation.

General data for design calculation

1. Torque at the output shaft
2. Rotational speed of the output shaft
3. Gear ratio
4. Required lifetime
5. Thermal treatment for each wheel (see cylindrical gearings)
6. Operation mode (see cylindrical gearings)

Additional data for design calculation

1. Helix angle.
2. Facewidth of wheel
3. External module at outer tooth end
4. Average hardness of teeth surface. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
5. Average hardness of teeth core. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
6. Type of drive shaft supporting (roll bearings or ball bearings)
7. Reversible or nonreversible transmission. Nonreversible transmission assumed by default.
8. Tooth shape (for spiral bevel gear).
9. Addendum modification coefficient of pinion.
10. Coefficient of pinion teeth thickness change
11. Gear-shaping cutter head diameter. If not defined it is selected from APM Mechanical database. See *Gear-shaping cutter head* below.
12. Point width of gear-shaping cutter. If not defined it is selected from APM Mechanical database. See *Gear-shaping cutter head* below.
13. Pinion material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.
14. Wheel material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.

Bevel gearings. Checking calculation.

General data for checking calculation

1. Helix Angle.
2. Teeth number of each wheel.
3. Average facewidth of wheel.
4. Outer Module.
5. Addendum Modification Coefficient of each wheel.
6. Output torque (for longevity checking calculation) [Nm].
7. Output Revolution
8. Required longevity
9. Thermal treatment for each wheel
10. Operation mode

Additional data for checking calculation

1. Average hardness of teeth surface. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
2. Average hardness of teeth core. If not defined by user **APM Trans** assumes average hardness specified by given type of thermal treatment.
3. Type of drive shaft supporting (roll bearings or ball bearings).
4. Tooth shape.
5. Reversal or not reversal transmission. Not reversal transmission assumed by default.

6. Gear accuracy.
7. Coefficient of pinion teeth thickness change
8. Gear-shaping cutter head diameter. If not defined it is selected from APM Mechanical database. See *Gear-shaping cutter head* below.
9. Point width of gear-shaping cutter. If not defined it is selected from APM Mechanical database. See *Gear-shaping cutter head* below.
10. Pinion material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.
11. Wheel material. It is selected from gear material database. If it is not specified allowable stresses are calculated according to selected thermal treatment and hardness.

Worm gearings. Design calculation.

General data for design calculation

1. Torque at the output shaft
2. Rotational speed of the output shaft
3. Gear ratio
4. Required lifetime
5. Material of the worm wheel rim (tin bronze, tinless bronze, cast iron)
6. Operation mode (see cylindrical gearings)

Additional data for design calculation

1. Module
2. Diameter coefficient. Worm diameter coefficient is numerically equal to ratio of worm reference diameter to module.
3. Center distance
4. Wheel facewidth coefficient
5. Number of worm threads
6. Coefficient of worm coil effective thickness.
7. Select worm from database flag. Worm is selected from APM Mechanical database according to current selected standard if this flag is switched on. Database path for worm table: *Standards – Parts – Transmissions – Transmission types – Worms.*

Worm gearings. Checking calculation.

General data for checking calculation

1. Module
2. Coefficient of worm diameter
3. Addendum modification coefficient
4. Number of worm threads
5. Number of wheel teeth
6. Output torque
7. Output revolution
8. Required longevity
9. Aluminium in alloy presence
10. Operation mode (see cylindrical gearings)

Additional data checking calculation

1. Heat-Transfer Factor
2. Bending Safety Factor
3. Yield point of Wheel Material
4. Breaking Point of Wheel Material

5. Coefficient of worm coil effective thickness.
6. Fan ability flag

Chain transmission. Design calculation.

General data for design calculation

1. Torque at the output shaft
2. Rotational speed of the output shaft
3. Gear ratio
4. Required lifetime
5. Sprocket profile (convexo-concave, rectilinear)
6. Transmission loading type (smooth, quiet, with light shocks, with medium shocks, with heavy shocks, vibrational)
7. The type of the chain used in transmission
8. Lubrication type (without lubrication, periodical, non-periodical, intra-hinge, oil bath lubrication, spraying, circulating, drop-feed lubrication)

Additional data for design calculation

1. Teeth number of each wheel
2. Centre distance

Chain transmission. Checking calculation.

General data for checking calculation

1. Input revolution [rpm].
2. Required longevity.
3. Center distance.
4. Sprocket teeth number of each star**.**
5. Sprocket profile type (convexo-concave and rectilinear).
6. Lubrication type (without lubrication, periodical, nonperiodical, intrahinge, by oil bath, by spraying, circulational, drop-feed).
7. The type of transmission loading (smooth, quiet, with light shocks, with medium shocks, with heavy shocks, vibrations).

Belt transmission. Design calculation.

General data for design calculation

1. Transmitted power
2. Rotational speed of input shaft
3. Gear ratio
4. Dynamics factor
5. Type of mechanism for belt tension control (for flat belt transmissions only)

Additional data for design calculation

1. Center distance (in the range of standard belt lengths).
2. The slope of the transmission axis to the horizon (for flat belt transmission only)
3. Maximum number of the belts in the transmission (for V-belt transmissions only). Should not exceed 8.

Belt transmission. Checking calculation.

General data for checking calculation

- Rotational speed of the output shaft [rpm]
- Driving Pulley Diameter [mm]
- Driven Pulley Diameter [mm]
- Belt length [mm]
- Belt thickness [mm] (only for flat belt transmission)
- Belt tape width [mm] (only for flat belt transmission)
- Angle between center distance line and horizontal [deg] (only for flat belt transmission)
- Safety factor
- Belts number (only for V – belt transmission)
- Belt cross section (only for V – belt transmission)
- Type of transmission adjustment (only for flat belt transmission)

Materials and Thermal treatment

Mechanical properties of gear materials are defined basically by their thermal treatment. Thermal treatment is used to increase load-carrying capacity of the wheels. Four common types of thermal treatment are considered in ***APM Trans.*** Averaged allowable stresses depend on gear hardness according to selected calculation standard.

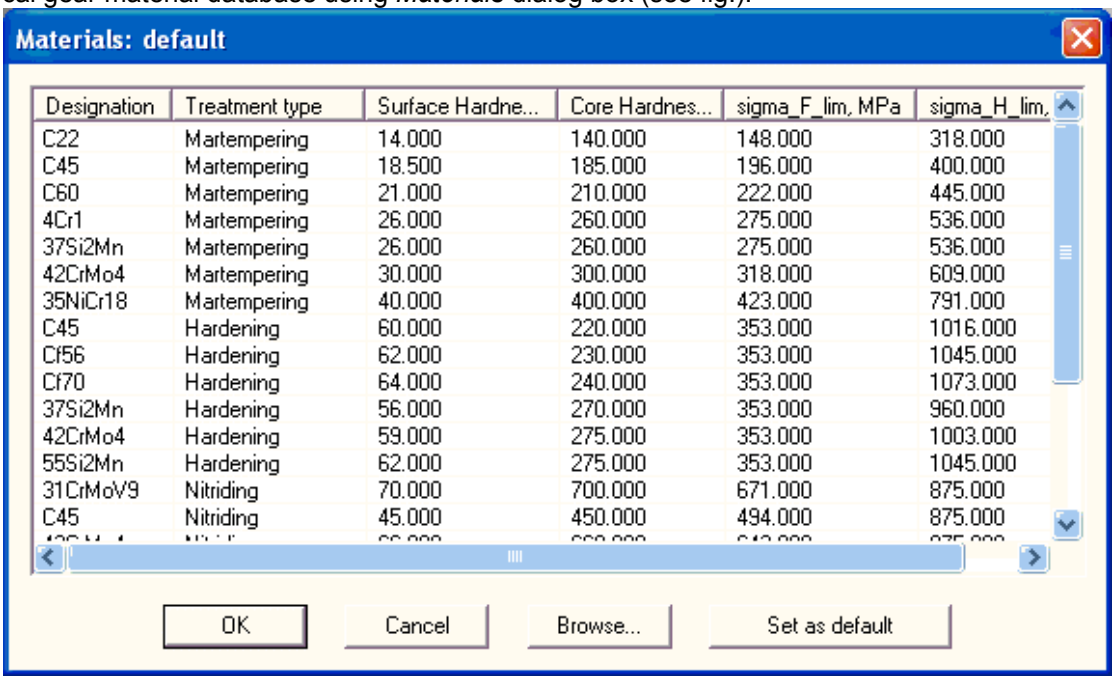
This dependence for GOST is represented below as an example.

Type	**Hardness**	σ_{h0}	σ_{f0}	$\sigma_{h\,max}$	$\sigma_{f\,max}$
1 – Martempering	27.0	20*HRC+70	18*HRC	48.4*HRC	27.4*HRC
2 – Hardening	50.0	17*HRC+200	600	40*HRC	1320
3 - Caburizing	59.0	23*HRC	820	40*HRC	1300
4 - Nitriding	60.0	1050	684	35*HRC	1000

Gear wheel materials (GOST):

Steel quality	*Thermal treatment*	*Teeth surface hardness*	*Teeth core hardness*
40,45 40X, 40HN, 45HC, 35HM, 40HFA,40XN2MA, 18H2N4BA etc.	*Normalization, refining*	*180…360HB*	*180…360HB*
45, 40H, 40HN, 35HM, 38HC, 40HN4MA etc.	*Volumatrical hardening*	*45…55HRC*	*45…55HRC*
40, 45, 50, 50G, 40H, 40HN, 38HC, 40HN2MA, 50PP, U6 etc.	*Surface hardening*	*45…55HRC*	*27…35HRC*
15H, 20H, 12HN3A, 15HF, 12HN2, 12HN4A, 20HN3A, 20H2N4A, 20HN, 18H2N4BA, 25HGM, 18HGT, 30HGT, 15HGN2TA, 20HGR, 20HGNR, 20HGNTR, 20HGSA etc.	*Carburizing*	*56…62 HRC*	*32…45HRC*
38H2MUA, 38H2U, 40H, 40HFA, 40H2HMA etc.	*Nitriding*	*550…750HV*	*32…42HRC*

Following data can be define to set get gear material mechanical properties more precisely: surface hardness, core hardness, gear material directly. Gear material is selected fron local gear material database using *Materials* dialog box (see fig.).



Designation	Treatment type	Surface Hardne...	Core Hardnes...	sigma_F_lim, MPa	sigma_H_lim,
C22	Martempering	14.000	140.000	148.000	318.000
C45	Martempering	18.500	185.000	196.000	400.000
C60	Martempering	21.000	210.000	222.000	445.000
4Cr1	Martempering	26.000	260.000	275.000	536.000
37Si2Mn	Martempering	26.000	260.000	275.000	536.000
42CrMo4	Martempering	30.000	300.000	318.000	609.000
35NiCr18	Martempering	40.000	400.000	423.000	791.000
C45	Hardening	60.000	220.000	353.000	1016.000
Cf56	Hardening	62.000	230.000	353.000	1045.000
Cf70	Hardening	64.000	240.000	353.000	1073.000
37Si2Mn	Hardening	56.000	270.000	353.000	960.000
42CrMo4	Hardening	59.000	275.000	353.000	1003.000
55Si2Mn	Hardening	62.000	275.000	353.000	1045.000
31CrMoV9	Nitriding	70.000	700.000	671.000	875.000
C45	Nitriding	45.000	450.000	494.000	875.000

Fig 1.2 Gear material selection from a database

Material selection with required thermal treatment is performed from databases of gear materials (fig. above). Allowable stress limit for pitting resistance and bending are represented taking into account safety factors. A database for gear materials is a separate file of MS Access format installed in APM WinMachine installation directory. These files have *"gearmat*.mdb"* name by default and are available for customization.

Gear shaping cuttur head parameters for bevel gears

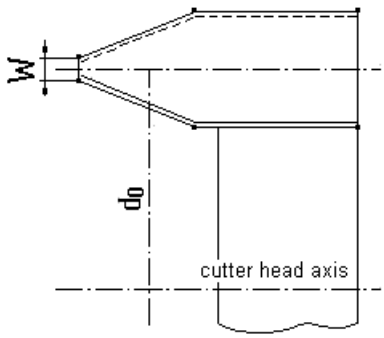


Fig.1.3 Point width of Gear-shaping cutter head

Point width of Gear-shaping cutter head is selected from APM Mechanical Database according to tooth shape if not defined by user.

Database path is: *Standard — Tools — Point width of gear-shaping cutter head*.

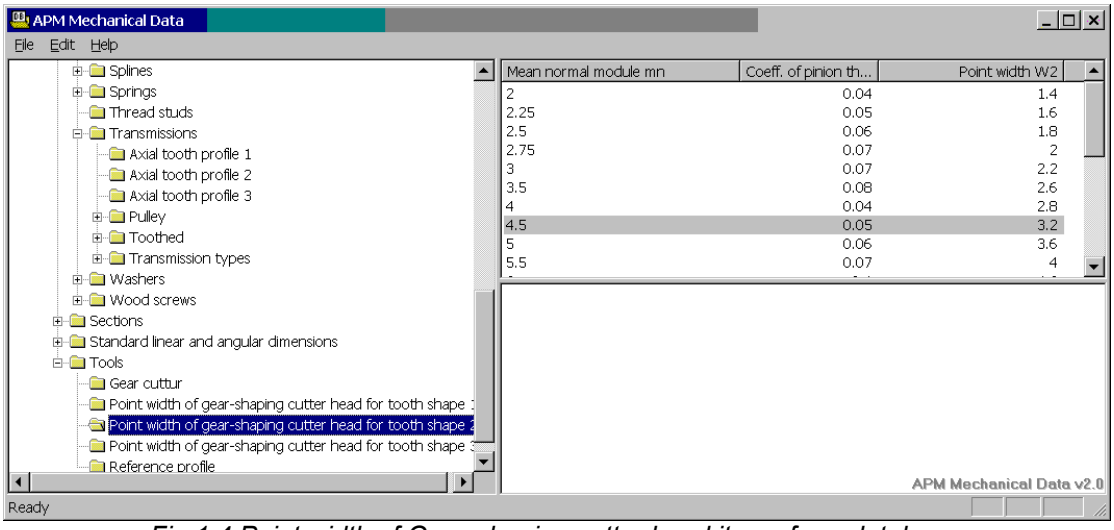


Fig.1.4 Point width of Gear-shaping cutter head items from database.

Results

APM Trans allows to calculate the following parameters:

Cylindrical gearings:

- General geometry parameters:

Parameter name	Designation
Centre distance	A_w
Module	**M**
Number of teeth	***Z***
Helix angle	β
Addendum modification coefficient	***x***
Reference diameter	***D***
Pitch diameter	d_w
Base diameter	d_b
Tip diameter	d_a
Root diameter	d_f
Tooth height	***h***
Facewidth of wheel	***Bw***

- The forces acting in the transmission

Parameter name	Designation
Axial force	F_a
Radial force	F_r
Tangential force	F_t
Arm of the resultant force	***R***
The distance between wheel side and force point	***L***

- Used material parameters

Parameter name	Designation
Allowable bending stresses	$[\sigma_f]$
Allowable contact stresses	$[\sigma_h]$

Note: Two parameters are used in the **APM Trans** to describe used materials (steels): the hardness of tooth working surface and the type of thermal treatment. Experience shows that these two parameters are sufficient to characterize material properties, since having the same thermal treatment and hardness, the steel has approximately equal strength parameters.

- Face profile parameters

Parameter name	Designation
Tooth profile slope at the point on the addendum circle	α_a
Profile's curvature radius at the point on the tip circle	ρ_a
Curvature radius of the active profile at the lower point	ρ_p

- Constant chord parameters

Parameter name	Designation
Constant chord of the tooth	S_c
Constant chord height	h_c
Base helix angle	β_b
Curvature radius of tooth profiles in the points that define the constant chord location	ρ_s

- Common normal parameters

Parameter name	Designation
Estimated number of teeth along the common normal length	z_{nr}
Common normal length	W
Curvature radius of profiles in the points of intersection with common normal	ρ_w
Angle of profile in the points of intersection with common normal	ρ_w

- Tooth parameters along the chord

Parameter name	Designation
Estimated diameter	$d_y = d$
Helix angle at the estimated diameter	β_y
Profile angle at the estimated diameter	α_y
Circumferential width of the teeth at the estimated diameter	S_{ty}
Half of angular thickness of equivalent cylindrical wheel	ψ_{yv}

Width along the tooth chord	S_y
Height up to tooth chord	h_y

- Roller test parameters

Parameter name	Designation
Roller diameter	D
Angle of tooth profile in the point, laying on the circle, passing through the roller center	α_D
Diameter of the circle, passing through the roller center	d_D
Dimension by rollers tips	M
Curvature radius of gear profiles in the points with roller	ρ_m

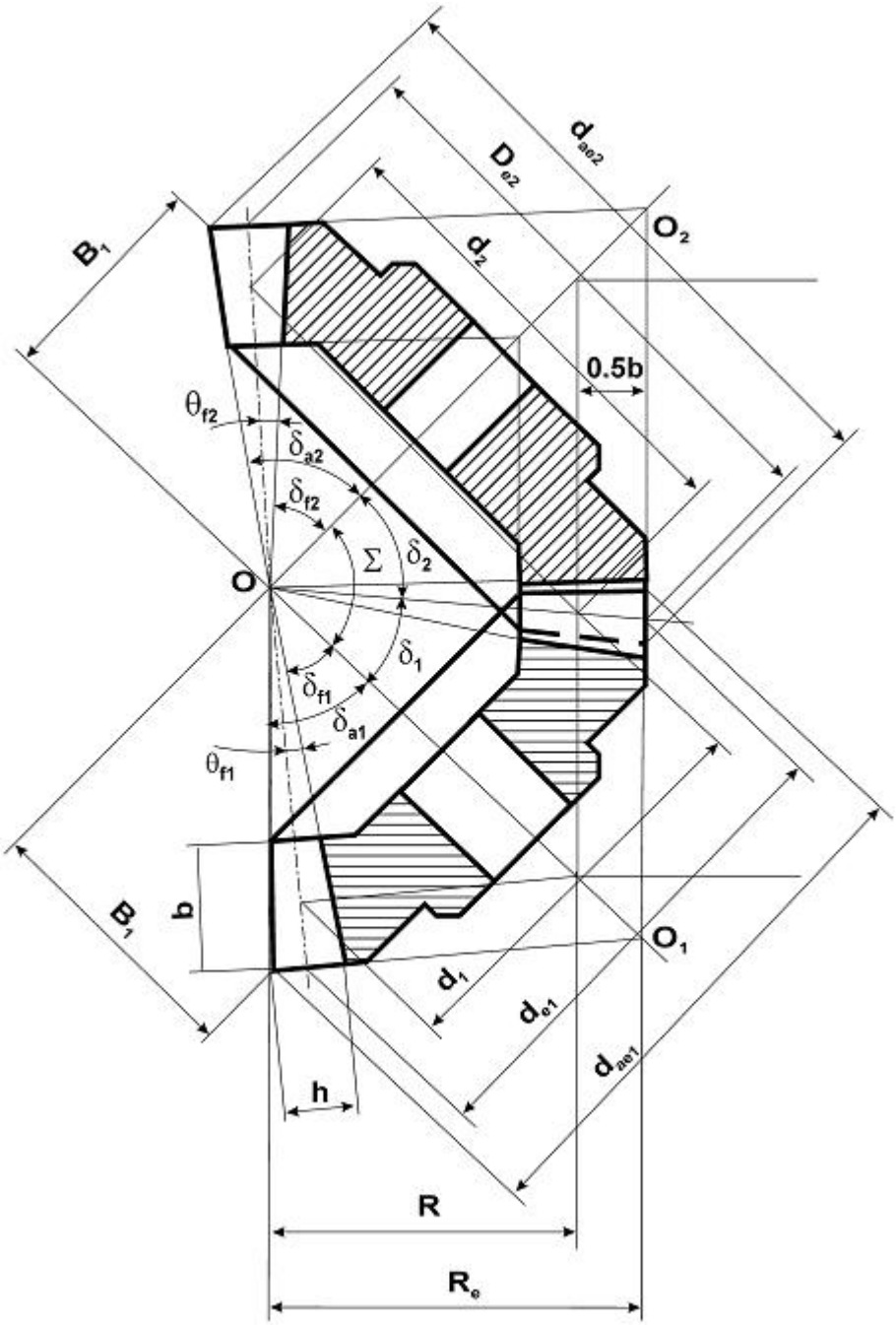
- Parameters of the mutual location of the coinciding teeth profiles

Parameter name	Designation
Meshing pitch	p_α
Axial pitch	p_x
Trace of the teeth	p_z

- Meshing quality parameters

Parameter name	Designation
Axial contact ratio	ε_β
Transverse contact ratio	ε_α
Total contact ratio	ε_γ
Normal width of the teeth on the tip diameter	S_{na}
Minimum number of pinion teeth under given modification coefficient without undercutting	$Z_{\min}$
Pressure angle	α_{tw}
Radial backlash	c

Bevel gearings:



•General geometry parameters

Parameter name	Designation
Helix angle at mid-facewidth	β
Outer circular module	m_e
Outer normal module	m_{ne}
Normal module at mid-facewidth	m_n
Outer cone distance	$\boldsymbol{R_e}$
Middle cone distance	R
Outer pitch diameter	$\boldsymbol{D_e}$
Pitch diameter at mid-facewidth	D
Addendum modification coefficient	$\boldsymbol{x}$

Pitch cone angle	δ_w
Teeth number	Z
Facewidth	b

- Forces acting in the transmission (see parameters of cylindrical transmissions).
- Used material parameters (see parameters of cylindrical transmissions).
- Additional geometry parameters

Parameter name	Designation
External addendum diameter	D_{ae}
External teeth addendum	h_{ae}
External teeth dedendum	h_{fe}
External teeth height	h_e
Normal tooth width at mid-facewidth	S_n
Addendum angle	θ_a
Dedendum angle	θ_f
Addendum cone angle	δ_a
Dedendum cone angle	δ_f
Distance between cone apex and addendum plane	B

- checking parameters by the chord

For straight bevel gears

Parameter name	Designation
External chordal thickness	S_{ce}
Height to external chord	h_{ce}
Half of outer angular thickness of the tooth	ψ_{ae}
External pitch thickness of the tooth along the chord	S_{e0}
Height to external pitch chord	h_{ae0}

For spiral bevel gears

Parameter name	Designation
Chordal thickness at mid-facewidth	S_c
Height to chord at mid-facewidth	h_c
Half of angular tooth thickness at mid-facewidth normal section	ψ_n
Pitch chordal thickness at mid-facewidth	S_0
Height to pitch chord at mid-facewidth	h_{a0}

- Checking parameters of the meshing quality

Parameter name	Designation
Axial contact ratio	ε_β

Contact ratio	ε_α
Total contact ratio	ε_γ

Worm gearings:

- General geometry parameters

Parameter name	Designation
Centre distance	a_w
Module	m
Diameter ratio	q
Addendum modification coefficient	x
Pitch lead angle	γ
Working lead angle	γ_w
Worm working pitch diameter	D_{w1}
External diameter of the worm wheel	$D_{am\,2}$
Worm turn height	H_1
Worm turn addendum	H_{a1}
Root fillet radius of worm	$\rho_{f\,1}$
The radius of depression on the tip surface of worm wheel	R
Pitch diameter	D
Tip diameter	D_a
Root diameter	D_f
Facewidth of the rim	B
Number of worm thread starts	Z_1
Teeth number of the worm wheel	Z_2

- Forces acting in the transmission (see parameters of cylindrical transmissions).
- Operating parameters of the transmission

Parameter name	Designation
Transmission power	P
Efficiency of the transmission	η

- Parameters for checking on mutual location of side surfaces of the worm turns

Parameter name	Designation
Step of worm	p
Travel of the turn	p_z
Pitch thickness along the worm turn chord	S_a
Height up to chord of the turn	H_a
Roller diameter	D_r
Worm dimension by the rollers	T_r

Chain transmissions:

- Centre distance of the transmission

•Parameters of the face profile of the sprockets. Depending on the profile type these parameters are divided into two groups:

1.For rectangular profile

Parameter name	Designation
Teeth number of the sprocket	Z
Sprocket pitch	t_z
Half of the angular pitch	τ
Diameter of the circle, inscribed into pitch polygon	d_c
Tooth height measured from the pitch line	h_t
Pitch circle diameter	D_d
Addendum circle diameter	D_e
Dedendum circle diameter	D_i
The displacement of the space arch centers	e
Space radius	r
Tooth head radius	r_2
Half of the space angle	β_v
Half of the tooth angle	γ_m
Rectilinear part of the profile	h_r
Maximum chord	L_x

2.For convexo-concave profile

Parameter name	Designation
Teeth number of the sprocket	Z
Sprocket pitch	t_z
Half of the angular pitch	τ
Diameter of the circle, inscribed into pitch polygon	d_c
Tooth height measured from the pitch line	h_t
Pitch circle diameter	D_d
Addendum diameter	D_e
Dedendum diameter	D_i
The displacement of the space arch centers	e
Space radius	r
Fillet radius	r_1
Tooth head angle	r_2
Half of the space angle	α
Fillet angle	β
Half of the tooth angle	ϕ
Rectilinear part of the profile	FG
Distance between root and tip arc centers	O_1O_2

Coordinated of the root arch center	O_{1x}
	O_{1y}
Coordinates of the tooth addendum arch center	O_{2x}
	O_{2y}
Maximum chord	L_x

•Parameters of the sprocket cross-section

Parameter name	Designation
Shoulder circle diameter	D_c
Maximum tooth width	b_2
Face ring diameter	B
Teeth's thickness at tip diameter *	b_3
Chamfering radius of the shoulder	R
Radius of chamfering of the tooth side surface	R_3

* - this parameter is calculated for rectilinear profile only.

Belt transmissions:
•Centre distance of the transmission
•Geometry parameters

Parameter name	Designation
Pulley diameter	D
Pulley width	B
Half of opening angle of the transmission branch*	ψ

* - this parameter is calculated for flat-belt transmission only.

•Loading parameters

Parameter name	Designation
Pressure on the shaft	Q
Preload force	F

Methods and standards

Cylindrical transmission standards

•**ISO CD 9085-1 (Calculation of load capacity of spur and helical gearings) , AGMA** and GOST (Russian) standards are available for gear strength calculation.

• Different type of basic rack can be used in calculation. Default basic rack depends on set standard.

Basic rack (Fig. 1.5) is characterized by the main profile angle α, tooth addendum coefficient h_a^*, radial clearance coefficient in the pair of initial contours c^*, tooth dedendum coefficient $h_f^* = h_a^* + c^*$, boundary height coefficient $h_l^* = 2h_a^*$, root fillet coefficient ρ_f^*.

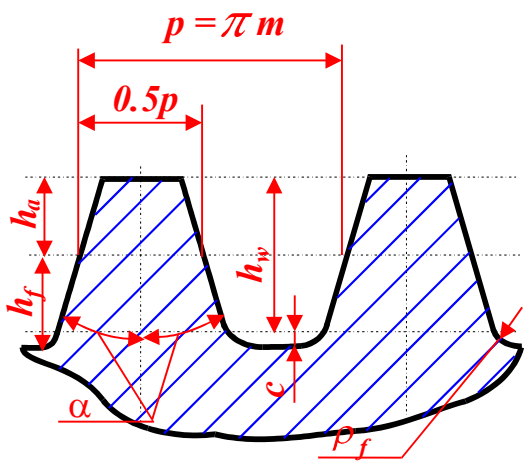


Fig 1.5 Parameters of basic rack for cylindrical transmission.

Tooth addendum h_a, radial clearance **c**, tooth dedendum h_f, tooth limit depth h_l, root fillet radius ρ are defined by multiplying of corresponding coefficients on module. Parameters of default basic rack for GOST are shown in the table 1.1.

Table 1.1 **Default basic rack parameters for GOST 308-76**

Parameter	Designation	Value
Main profile angle	α	20°
Tooth addendum coefficient	h_a^*	1.0
Radial clearance coefficient in the pair of initial contours	c^*	0.25
Tooth dedendum coefficient	h_f^*	1.25
Limit depth coefficient	h_l^*	2.0
Root fillet radius	ρ_f^*	0.38

- ***GOST 2475-62 and GOST 3722-60:*** These standards are used for default roller selection to calculation test parameters by roller. Roller diameter can be selected manually.

Bevel gearing standards

Bevel gearings are calculated in the APM Trans under the following assumptions:

- Helix angle at reference cone at mid-facewidth is equal to **35** deg.
- Mid-facewidth is taken as section for calculation.
- Facewidth coefficient is assumed **0.285.**
- Modulus of addendum modification coefficients of pinion and wheel assumed equal for gear design and can be different for load capacity calculation
- APM Mechanical Data is used for gear shaping cutter parameters selection.

The following standards are used:

- **ISO/DIS 10 300 (Calculation of load capacity of bevel gearings), AGMA** and GOST (Russian) standards are available for gear strength calculation.
- Different type of basic rack can be used in calculation. Default basic rack depends on set standard. Parameters of default basic rack for GOST are in the table 1.2

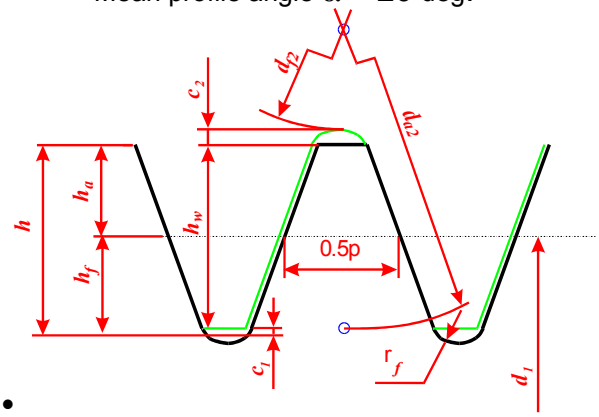
Table 1.2 **Basic rack parameters by GOST 13754-81**

Parameter	Designation	Value
Main profile angle	α	20°

Teeth addendum coefficient	h_a^*	1.0
Radial clearance coefficient in the pair of initial contours	c^*	0.25
Root fillet coefficient	ρ_f^*	0.2

Worm gearing standards

- Different type of basic rack can be used in calculation. Default basic rack depends on set standard.
- Mean profile angle α = 20 deg.



Worm teeth parameters such as teeth addendum h_a, radial clearance ***c,*** teeth dedendum h_f, tooth depth h_l, root fillet ρ are defined by multiplying of corresponding coefficients on module. Value of basic rack parameters for worm gears by GOST are showed in the table 1.3.

.

Fig. 1.6 Parameters of initial contour for worm gearings

Table 1.3 **Basic rack parameters by GOST *266-76***

Parameter	Designation	Value
Teeth addendum coefficient	h_a^*	1.0
Radial clearance coefficient in the pair of initial contours	c^*	0.2
Teeth dedendum coefficient	h_f^*	1.2
Tooth depth coefficient	h_l^*	2.2
Root fillet coefficient	ρ_f^*	0.3

Working drawing generation

APM Trans allows to generate working drawings of the designed transmission elements (gear wheels, pulleys, sprockets) using APM Graph editor. These drawings can be saved in APM Graph files. You can see example of the working drawing generated by **APM Trans** in fig 1.4.

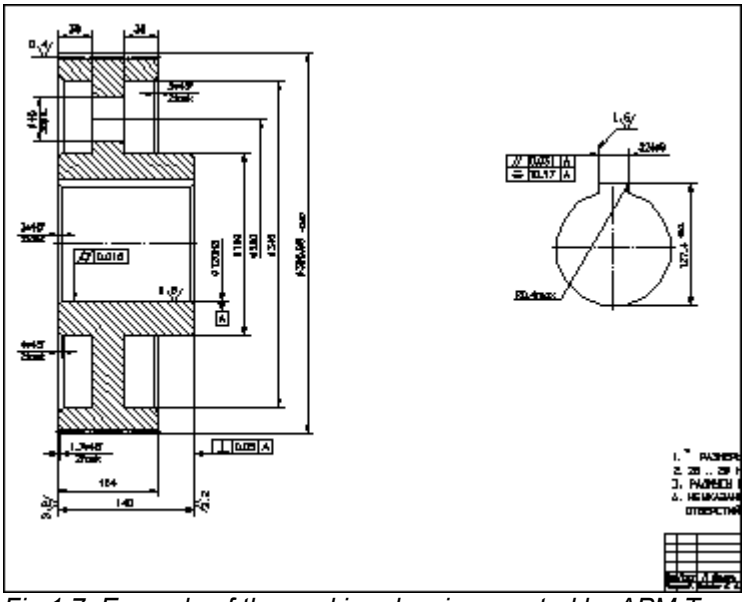


Fig 1.7. Example of the working drawing created by APM Trans.

User interface of drawing facility is simple and clear. It allows to get the working drawings with minimum efforts.

To generate the drawing the following parameters are required:

Construction features of the designed transmission element.

1.The type of wheel hub
2.Type of wheel-shaft joint
3.Parameters of the spline joints
4.Dimensions:
- Diameter of the hole in the hub
- Number of the holes in the wheel plate
- Length of the hub
- Displacement of the left face of hub relative to pulley (sprocket) (for chain and belt transmission only).

5.For bevel transmissions - type of wheel construction.
6.For chain transmissions - type of sprocket plate and tooth side surface construction.
7.For the flat-belt transmissions - type of the working surface of the pulley.

Chapter 2
How to work with APM Trans

As any other Windows application program **APM Trans** provides handy and intuitively clear user interface, based on the CUA (Common User Access) and GUI (Graphical User Interface) standards.

Typical sequence of actions when you work with **APM Trans** includes the following operations:

1. Selection of the transmission type
2. Selection of the calculation type
3. Standard selection
4. Initial data entering
5. Calculation
6. Result items selection
7. Results looking through
8. Specifying the working drawing

Type of transmission selection

To select type of transmission to be calculated use **Types | Transmission…** command**.** In the dialog box that will be displayed (see Fig. 5.9) choose type of transmission you want to design.

Type of calculation selection

Two types of calculation are implemented in the **APM Trans** -- transmission design and load capacity calculation (see Chapter 1). To select type of calculation use **Type | Calculation | Type of Calculation** command. Type of calculation can be one of the following:

- Transmission design
- Calculation of maximum load for given lifetime
- Calculation of lifetime for given maximum load

Standard selection

Standard should be selected before calculation. Standard dependend data will be selected from the database for calculation. Select **Data Base | Set Standard…** command to set required standard. The list of available standards is also selected from APM MechanicalDataBase.

Initial data input

To enter initial data use **Data** command. In response to this command dialog box for data input will be displayed. Contents of this dialog box depend on the transmission type and type of calculation (see Fig. 5.11).

All initial data can be divided into two groups - "general", without which it is impossible to calculate the transmission and "additional", used to impose some constraints on the transmission. Usually in the dialog box that invoked in response to **Data** command general data are entered. This dialog box contains "**More...**" button, that calls dialog box for additional data input. You may not specify all additional data. The system treats any non-zero value in the edit box for additional parameter as indication that users have entered this parameter. So if you do not want specify additional parameter, you should leave zero in the respective edit

box. This true for all additional parameters except for addendum modification coefficient (which can have zero value).

After pressing *"Ok"* button all the data entered by user are checked. If any of parameters is out of allowable range, warning message will be displayed (see Fig.2.4).

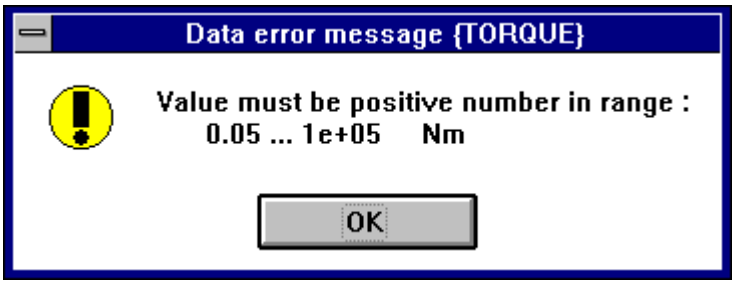


Fig. 2.1 Data error warning message

After you press "*Ok*" button, the system moves input focus to the edit box with wrong value. Type right value and press "*Ok*" again.

Loading data from the archive files

If you want to repeat calculation of transmission earlier stored with **File** | **Save** command use **File** | **Load** command. After this command you will be just in the same position you was when archive file was created.

Calculations

After entering initial data you can perform calculation. To do this select **Calculate!** command in the main menu.

If the calculations are successfully finished affirmative message is displayed (see Fig. 2.2).

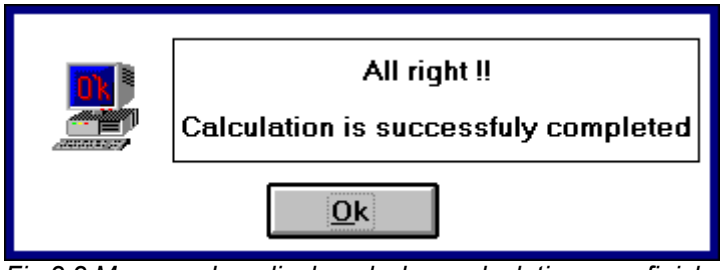


Fig 2.2 Message box displayed when calculations are finished

If APM **Trans** cannot calculate transmission with parameters you have specified, error message will be displayed (see Fig.2.3). The list of error messages is given in Appendix 1. Change parameter values and try again.

Fig 2.3 Calculations error message

In some cases when calculations are finished warning message showed at Fig. 2.4 is displayed. It means that system has ignored some of the additional parameters. This could happen either on construction consideration (for instance, very thin wheel), or if you entered too many additional parameters (for example, calculating cylindrical transmission you specified centre distance, module and addendum modification coefficient simultaneously).

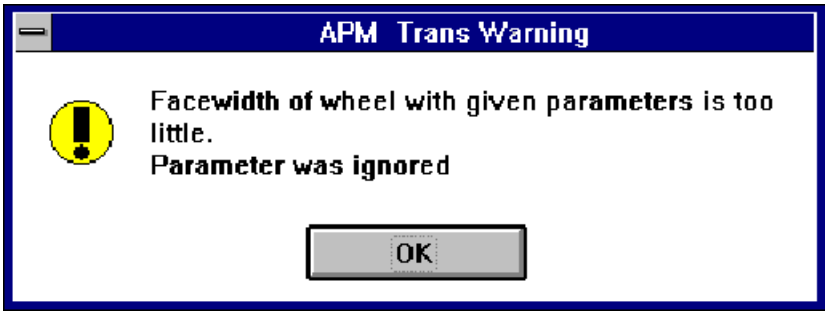


Fig. 2.4 Calculation warning message

If load capacity calculation was executed, immediately after it window with calculation result is showed (maximum allowable torque or lifetime, see Fig.2.5). If you calculate worm gearing this window will contain the requirements to the cooling system.

Fig. 2.5 Window with load capacity calculation results

Looking through the results

After calculations finished you can look through the results using **Results** command. Dialog box is displayed that contains a series of checkboxes. Each of these checkboxes is responsible for demonstration of the separate group of result items. Dialog box contents depend on the transmission type. In Fig.5.13 you can see dialog box for demonstration cylindrical transmission calculation results. To facilitate selection, dialog box contains two buttons - "Select All" and "Unselect All". When you have selected all items you want to see, press "*Ok*" button. Doing this you find yourself in a chain of result groups demonstration. When you want go to another result group you should press "*Next*" button. At any time you can interrupt demonstration by selection "*Interrupt*" button. This scheme works for transmission of all types, except for belt transmissions. For the latter one the table is displays that contain calculation results for all belt types, stored in data base.

Archive file creation

In the **APM Trans** you can save initial data and calculation results as archive files. To create archive file use **File** | **Save** command. Dialog box is displayed that allows you to specify archive file name and path to it. (see Fig. 5.3).

There is one constraint for using this command - you can save information only if you have entered initial data. Till this moment **Save** command is disabled.

Printing

To print out initial data and calculation results use **File | Print** command. On this command dialog box is displayed for selection result items to be printed. By appearance and functions it is similar to the dialog box for results looking through (see above). The main

difference is that confirmation button labeled "*Print*". Following window for printing setup will be shown. After you select all options required and select "*Ok*" button **APM Trans** begin printing. Information box is displayed that showing printing job status (Fig. 2.6). At any moment you can cancel printing by pressing "*Cancel*" button.

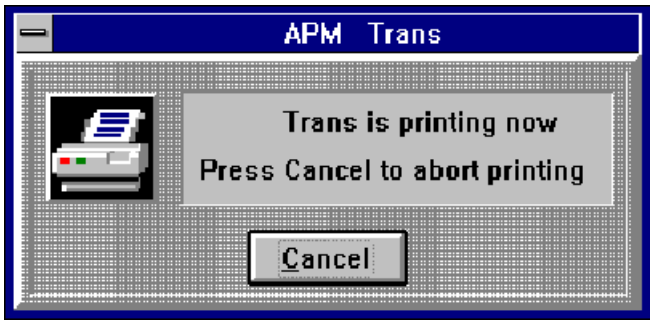


Fig. 2.6 Window displaying printing status

Working drawing generation

APM Trans allows you generate working drawings of the calculated transmissions elements. Drawing generating with **Trans** is simple and handy. To create drawing you should perform the following:

- Select *Drawing* checkbox in the dialog box for results looking through (Fig.5.13).
- In the *Drawing* window enter parameters characterizing drawing and transmission element construction.
- Using **Save…** command select target file name and type (APM Graph file or DXF files) to make final revisions and get a hardcopy of the drawing**.**

Entering the data describing the drawing

Drawing window is divided into several zones. Each zone is responsible for its own group of parameters (see Fig.2.7).

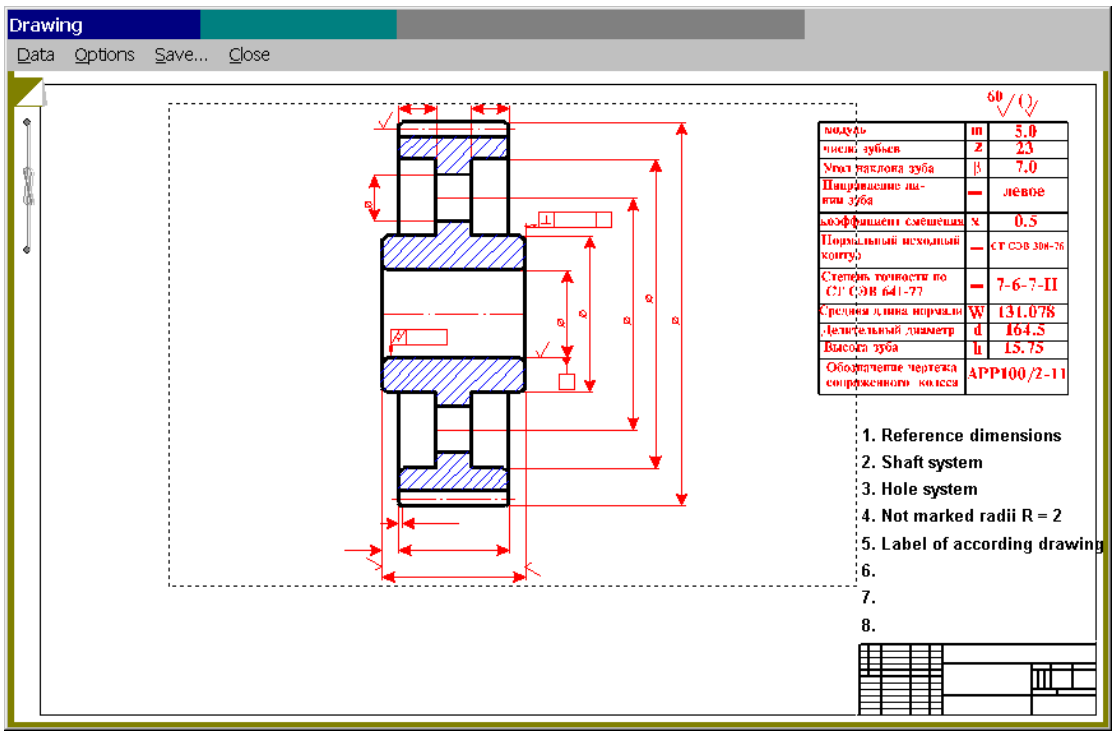


Fig. 2.7 Drawing Window

Zone 1 - Title block
Zone 2 - Features of transmission element construction
Zone 3 - Meshing table parameters.
Zone 4 - Specifications.

Construction features entering

To enter these data select Zone 2 of *Main Drawing Window*. To do it just double-click in this zone with mouse. This way you initiate the chain of dialog for data input. Each next window will be displayed only if you select "*Ok*" button in previous window. The scheme of data entering chain is showed in Fig. 2.11. Variants of transmission elements construction are illustrated with explanatory pictures and drawings, so user will have no problems with selection. An example is shown in Fig.5.38.

Depending on transmission type in drawing data chain new subchains can be added:

- Branch A - executed for bevel gearings.
- Branch B - executed for flat-belt transmission.
- Branch C - executed for worm gearing.
- Branch D - executed if you select spline joint for fastening the wheel on the shaft..
- Branch E - executed for chain transmission.

In the last turn those wheel geometry parameters are entered which cannot be strictly determined by the system. When designing pulleys and sprockets you can select non-symmetrical hub. Moreover if earlier you have selected one-sided hub, you can press in the hub end in the direction of plate. If you selected double-sided hub, you can determine the displacement of the hub's left end relative to pulley or sprocket end.

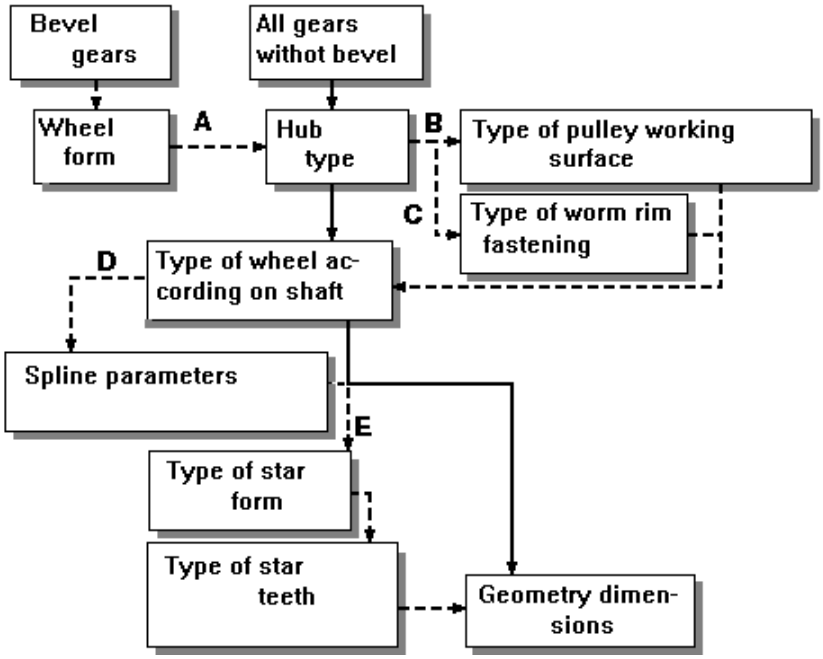


Fig. 2.8 Structure of drawing data entering chain

Title block specifying

To specify title block select *Zone 1* in the *Drawing* window. Dialog box for title block filling will be displayed (see Fig. 5.37). It looks just like standard title block. Use mouse, TAB key and scroll bars to move from one field to another.

Meshing table parameters entering

To fill meshing table you should double click in Zone 3 of the *Drawing* window. It should be noted that this zone is inaccessible if the drawing must not have the meshing table or if the table does not contain non-calculated parameters. Dialog box for meshing table parameters

input is displayed (see Fig. 5.39). In this dialog box you should enter parameters that could not be calculated - tooth line direction, designation of conjugate element drawing, etc.

Specifications entering

If you want to set up specifications, choose Zone 4 of the *Drawing* window. The dialog box for specifications input will be displayed (see Fig.5.40). Parameters that you should enter in this window are described in chapter 1.

Grawing generation

To generate drawing use **Save…** command of the *Drawing* window. When you select this command, standard Save file dialog box is displayed.

Quitting APM Trans

To quit *APM Trans* use **File | Exit** command.

Chapter 3

APM Trans—answers & questions

Question: APM Trans—what is it?

Answer: APM Trans is the program for mechanical transmission calculation and design developed in the Research and Software Development Center APM Ltd., Moscow, Russia.

Q: What types of transmission could be calculated with APM Trans?

A: APM Trans allows to calculate the following types of transmission:

- external and internal spur gearing with involute teeth
- helical gearings
- herring bone gearings
- bevel gearing with standard involute teeth and circular teeth
- worm gearings
- flat belt transmissions
- V-belt transmission
- chain transmission

See section *Types of transmission* in Chapter 1.

A: What parameters could be calculated Trans?

Q: Using **APM Trans** you can calculate the following parameters:

- Geometry parameters
- Forces, acting in the transmission
- Longevity
- Maximum allowable load
- Checking parameters

For detail see section *Results* in Chapter 1.

A: How to contact APM?

Q: : Phone : **+7(495) 585-06-11(fax), 514-84-19.**
Send the letter to :
Research and Software
Development Center APM Ltd.,
Korolev-Center, box 58,
Moscow Region,
Russia, 141070
e-mail: com@apmwm.com

CHAPTER 4

The APM Trans environment

In this chapter we give you a brief description of the most frequently used APM Trans environment components.

Systematic description of all menu commands and dialog box options is given in Chapter 5.

The environment components

Menus

Menu is a displayed list of commands (actions) available when you are working with a program. We shall speak about four kinds of menu—system, program, main and popup.

System menu (see Fig. 5.42, Chapter 5) is your "window to Windows." It allows you to interact with Windows. Using the system menu you can exit the program, interrupt the program execution for a some time and switch to another program, resize and move your program window and so on. For the list of System menu commands see section *System Menu* in Chapter 5.

The program menu contains commands of the application program. The program menu usually has hierarchical structure with the main menu at the top. The main menu is always on the screen. Each item of the main menu is either a command (which performs an immediate action), or a name of the next level menu—so called popup menu. (The word "popup" reflects a style of menu—it is used for menus, primarily invisible and called to screen ("popup") only when necessary.) Items of popup menu are, in their turn, either commands, or popup menus of the next level in menu hierarchy. Fig. 5.1 (Chapter 5) demonstrates the main menu of the APM Trans together with all its popup menus.

Dialog boxes

Dialog boxes are windows that are used for data input, options selection, for displaying additional and explanatory information, warning messages—in other words, these are windows used to keep up the dialog with a user. You can easily see where you will meet a dialog box—command (in the menu and on the buttons) invoking a dialog box is followed by ellipsis.

Information windows

Information windows are used to display the state of the currently solving problem.

Transmission Type window

Transmission Type window is located in the left hand upper part of the screen (see Fig. 4.1). In this window picture of current transmission and its name are present.

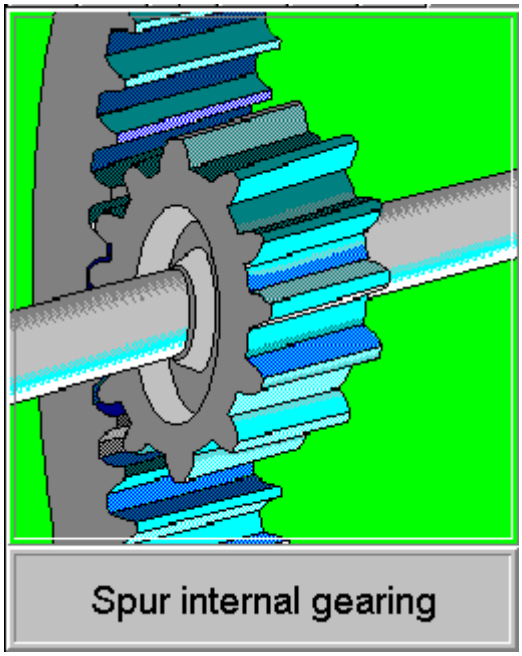


Fig 4.1 Transmission Type window.

Options window

This window shows current transmission options as pictograms (Fig 4.2).

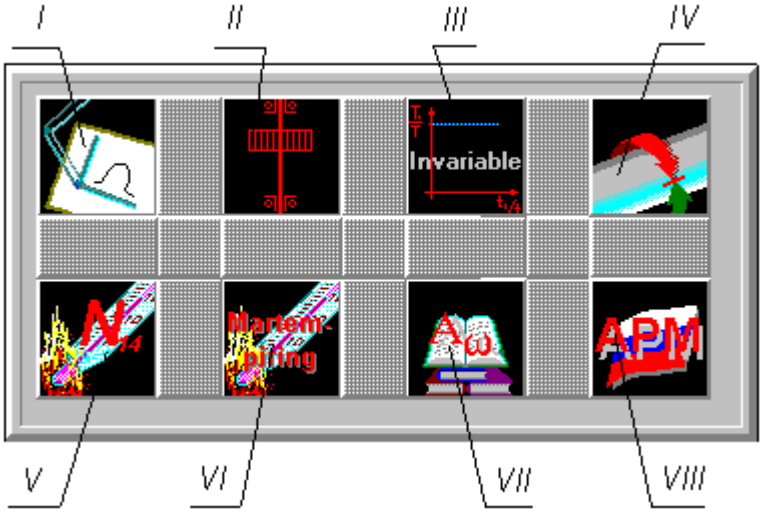


Fig 4.2 Options window.

Contents of this window depend on current transmission. Each group of pictograms describes its own group of options. Description of the each pictogram is given below:

Pictograms independent on transmission type

Group *I* - Type of calculation:

Calculation type is not selected

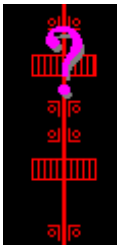
Design calculation

Longevity checking calculation

Torque checking calculation

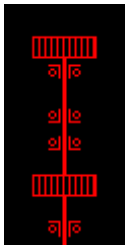
Pictograms that depend of transmission type

Group *II* -
Cylindrical transmission - Type of drive wheel location:



Location type is not selected

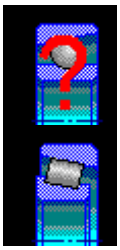
Asymmetric location



Cantilever location

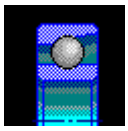
Symmetric location

Bevel transmission - Type of input shaft bearings:



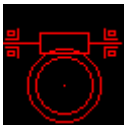
Supports type is not selected

Roller bearings



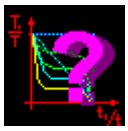
Ball bearings

Worm transmission - Type of worm location assumed in the APM Trans by default:



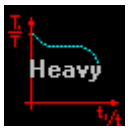
V-Belt, Flat Belt, Chain transmission - not used.

Group *III* -
Cylindrical, bevel and worm transmission - Mode of operation

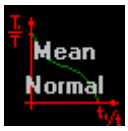


Mode of operation is not selected

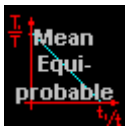
Constant regime



Heavy regime



Mean- normal regime



Mean - equiprobable regime

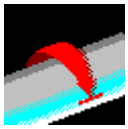
Light regime

Extra light regime

V-Belt, Flat Belt, Chain transmission - not used.

Group IV -
Cylindrical and bevel transmission - Reversibility of transmission

Reversible transmission



Non-reversible transmission

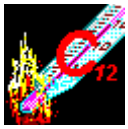
Worm, V-Belt, Flat Belt, Chain transmission - not used.

Group *V*-
Cylindrical and bevel transmission - Thermal treatment of drive wheel

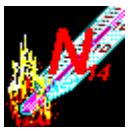
Thermal treatment is not selected

Martempering

Hardening



Carburazing and Nitrocarburazing



Nitriding

Worm transmission - materials of wheel rim.

Material is not selected

Tin bronze

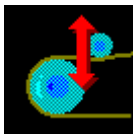
Tinless bronze

Cast iron

Belt transmission - type of belt adjustment mechanism.

Type is not selected

Adjustment by shaft displacement

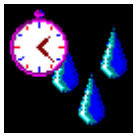


Adjustment by roller

Chain transmission - type of chain lubrication.

Lubrication type is not selected

Transmission is not lubricated



Periodical lubrication

Aperodical lubrication

Oil bath lubrication

Drop feed lubrication

Intra-hinge lubrication

Lubrication by spraying

Circular lubrication

Group VI-

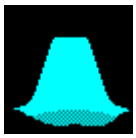
Cylindrical and bevel transmission - type of thermal treatment of driven wheel (see group VI above)

Worm transmission - material of worm assumed in the APM Trans by default (Steel).

Belt transmission - not used.

Chain transmission - type of sprocket profile.

Profile not selected



Rectilinear profile

Convexo-concave profile

Group VII -

Cylindrical transmission - show numerical set to which center distance will be rounded to.

Non-standard distance (Ra40 set)

Standard interaxis distance

Bevel transmission - Show interaxis angle assumed in the APM Trans by default (90 deg).

Worm, belt and chain transmission - not used..

Group VIII-
Not used for all types of transmission.

Initial Data window

This window shows initial data for current transmission. "N\def" is used when parameter value is not entered yet. "N\usd" is displayed for parameters that are not used for transmission of current type.. Example of the *Initial Data* window you can see in Fig. 4.3.

Output Torque	200.00	[Nm]	Relative Width	N\Used
Output Revolution	275.00	[rpm]	Module	N\Used
Gear Ratio	4.00	[-]	Helix Angle	N\Used
Longevity	20000.0	[H]	Coefficient X1	N\Used
Centre Distance	N\Used		Coefficient X2	N\Used

Fig 4.3 Initial Data window

On-line Help window

This window provides you with on-line help on currently selected menu command (see Fig. 4.4).

Fig 4.4 On-line Help window fragment

Chapter 5

Command reference

In this section we give you a complete description of each menu command and dialog box option in the APM Trans environment. Fig. 5.1 shows the main menu of the APM Trans and all the pulldown menus called from the main menu. Local menu of *Drawing Window* is shown in Fig. 5.35.

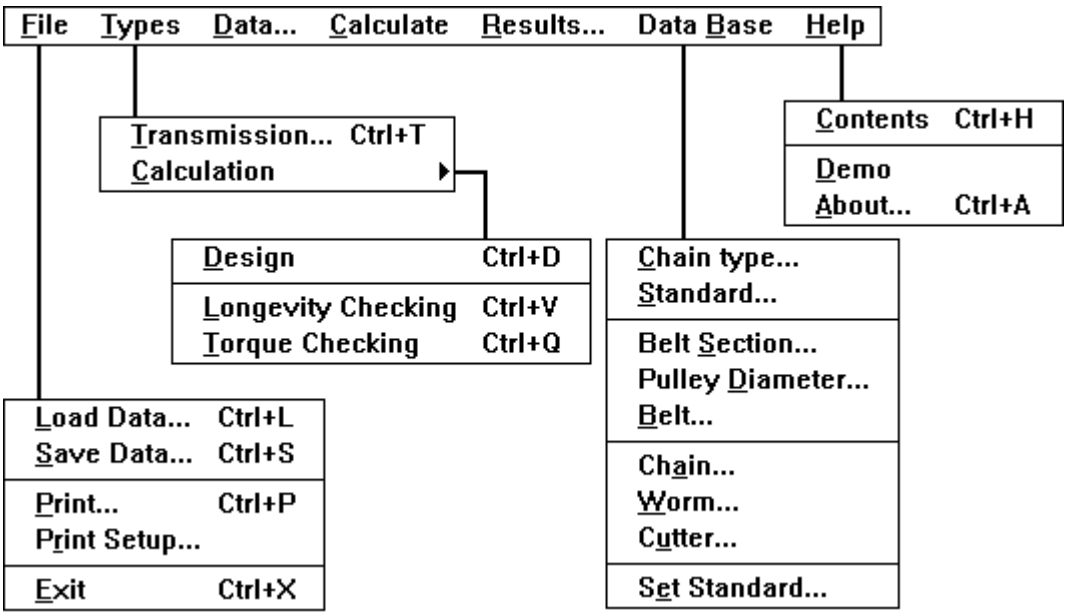


Fig 5.1 APM Trans menu structure

File menu

The **File** menu includes commands for

- loading information from archive files

- saving information to archive files
- printing initial data and calculation results
- choosing printer and printing options
- quitting the program

Load data...	Ctrl+L
Save data...	Ctrl+S
Print...	Ctrl+P
Printer setup...	
Exit	Ctrl+X

Fig 5.2 The File menu

Load command

The **File | Load** 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 4).

Shortcuts

Speedbar 
Keys CTRL + L

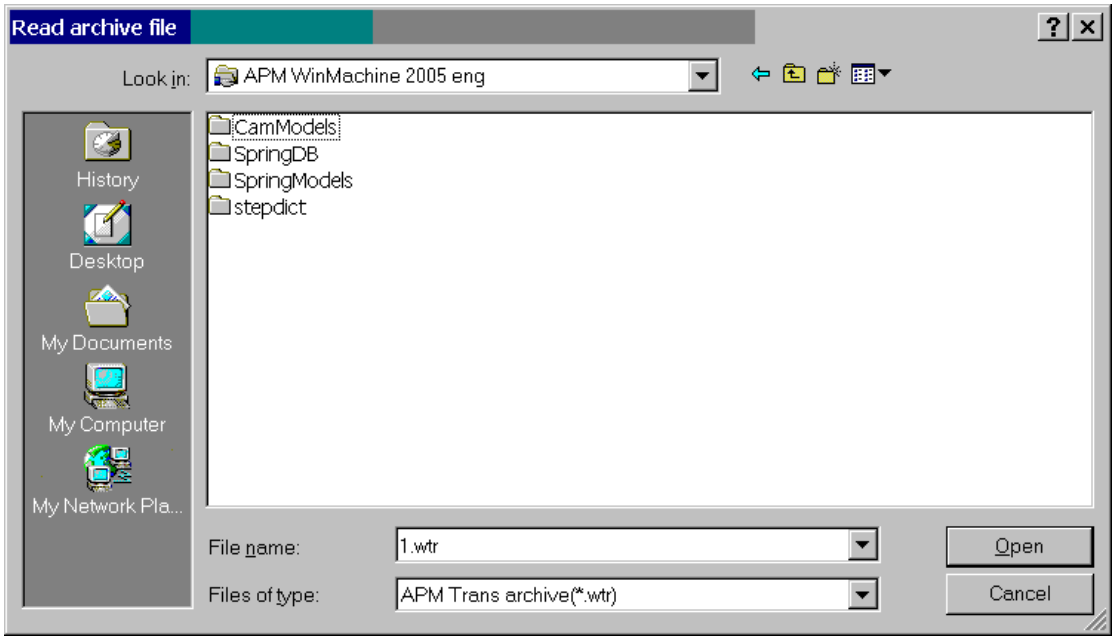


Fig 5.3 The Load Archive File dialog box

The dialog box consists of five major elements. These are *File Name* edit control and list box, *Directories*, *List Files of Type* and *Drives* list boxes.

Functions of these elements are as follows:

•*File Name* edit control allows you to enter explicit file name or filter for the selection of files in the current directory;
• *File Name* list box shows you all the files in the current directory matching with the current filter;
•*Directories* list box allows you to move around the directories at the current drive;
•*Drives* list box allows you to change a current drive;
•*List Files of Type* provides you with a set of predefined filters for file groups selection.

By means of these controls you can navigate around the drives and directories, select groups of files of your interest and finally find the file you need.

Save command

The **File | Save** 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

Speedbar 
Keys CTRL + S

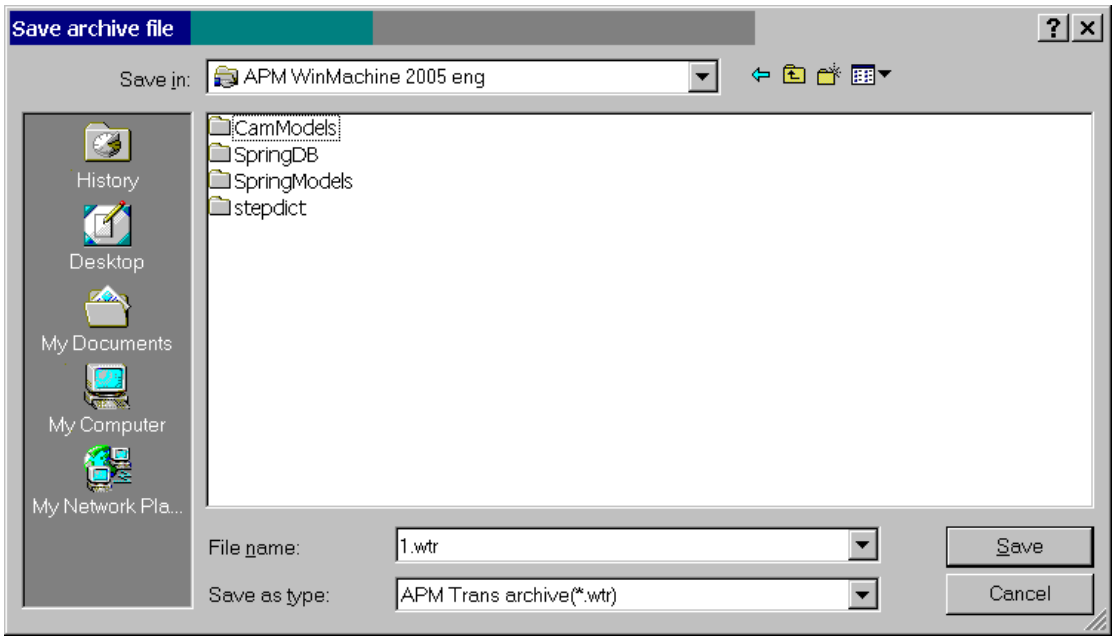


Fig 5.4 The Save Archive File dialog box

The *Save Archive File* dialog box consists of the same elements as the *Load Archive File* dialog box, described above.

Print command

The **File | Print** command allows you to print out calculation results. When you select this command the dialog box shown in Fig. 5.5 is called on the screen.

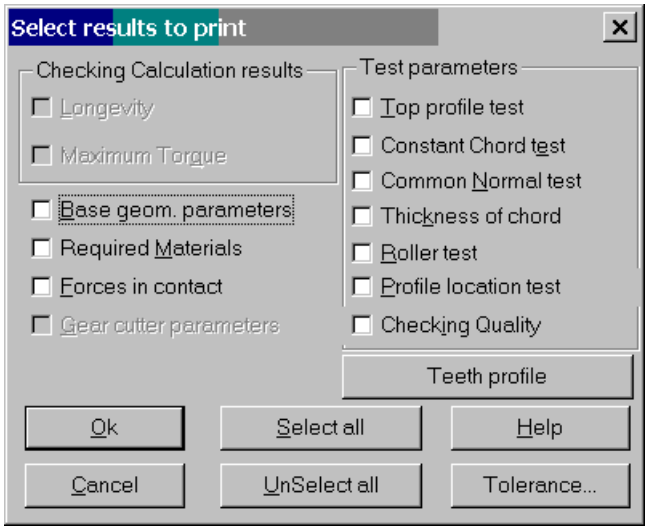


Fig 5.5 The Select Results for Printing dialog box

For each parameter you can print out there is separate check box in this dialog box. Mark items you want to be printed and select *Print* button. Use *Select All* button if you want to print out all the results. Use *Unselect All* button if you want to clear all check boxes. After you choose items to be printed and have selected *Print* button, another dialog box will be displayed (see Fig. 5.6).

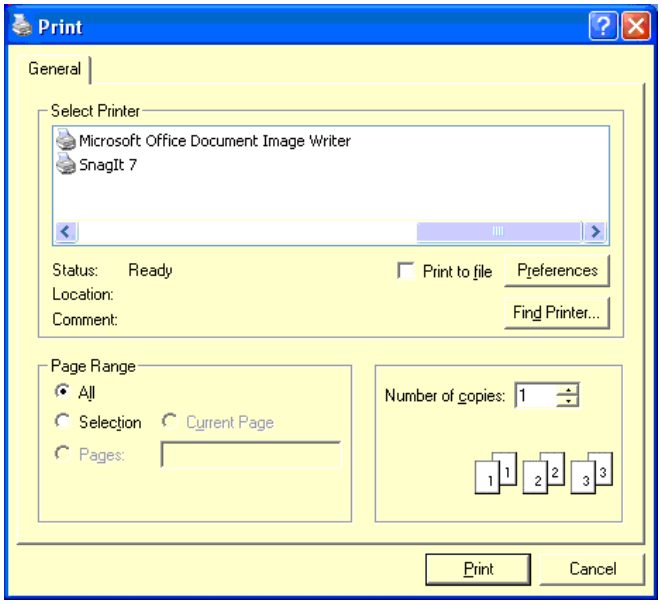


Fig 5.6 The Print dialog box.

Using this dialog box you can specify some options of printing. In the left upper part of dialog box currently selected type of printer is indicated. To change it use Control Panel application of Microsoft Windows. For details see you Microsoft Windows User's Guide. *Print Range* group box let you choose what part of results will be printed. We do not recommend you use controls of this group box. The matter of fact is that described dialog box is part of Microsoft Windows not APM Trans. In APM Trans items to be printed are determined in another way (see above). *Print Quality* list box let you select printing resolution (in dots per inch) from a number of allowed ones (for printer of currently selected type). *Setup* button invokes dialog box for detailed specification of printing option. This dialog box is different for each type of printer. In *Copies* edit control you can indicate number of copies you want to get. If you mark *Print to File* check box, printing will be directed in the file instead of printer. You can print out this file later.

Shortcuts

Speedbar 
Keys CTRL + P

Printer setup command

The **File | Printer setup** command invokes the Print Setup dialog box shown at Fig. 5.7.

With this dialog box you can specify printer settings. Using controls of *Printer* group box you can select type of printer (from a number of already installed in Microsoft Windows. To install new printer use *Printers* utility of *Control Panel* application, described in your Microsoft Windows User's Guide). With *Orientation* group box controls you can select how the printing will be oriented relatively to paper sheet—parallel to short side *(Portrait)* or to long side *(Landscape).* Controls of *Paper* group box let you choose paper sheet size (*Size* list box) and the type of paper advance (*Source* group box). And finally, *Options* button invokes printer-specific dialog box for more detailed tuning of printing.

Exit command

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

Shortcuts
Keys CTRL + X

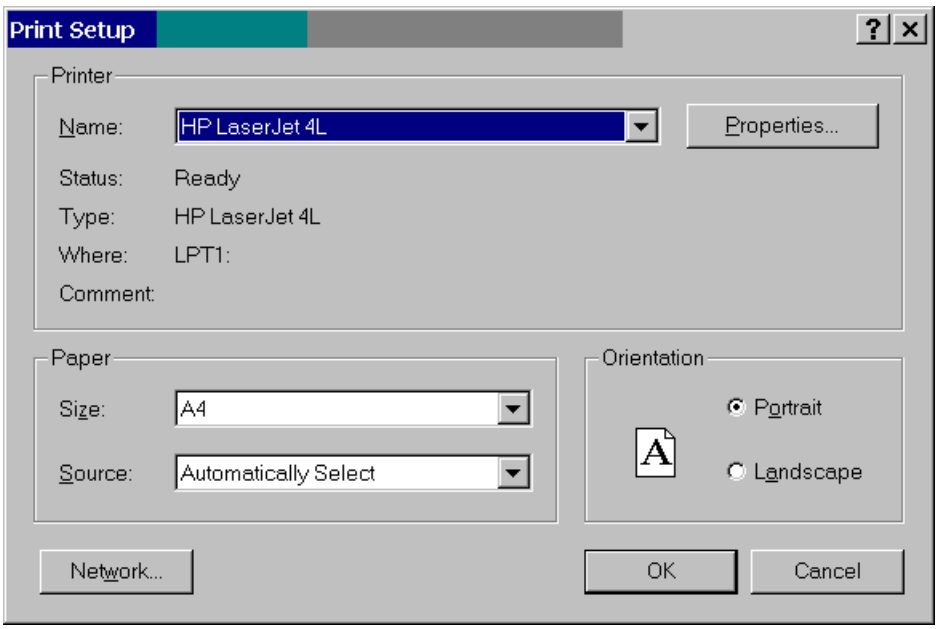


Fig 5.7 The Print Setup dialog box

Types menu

The **Types** command of the main menu invokes **Types** popup menu shown at Fig. 5.8.

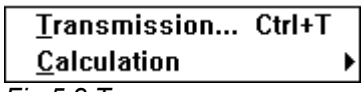


Fig 5.8 Types popup menu

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

Transmission command

The **Types | Transmission** command displays the dialog box for choosing the type of transmission. This dialog box is shown in Fig. 5.9.

The dialog box described includes 10 radio buttons. Each button designates one of the types of transmission you can calculate in the APM Trans. All you have to do with this dialog box is to select a desired type of transmission, either with a mouse or arrow keys or underlined letters in transmission type names and then "press" Ok button. As a result of your action in the *Transmission Type* window (see Chapter 4) a pictogram of transmission you've selected will be displayed. Simultaneously all the parameter values in the *Initial Data* window will be set to "not defined." The **Calculation** command in the **Data** popup menu become enabled, so you can define type of calculation. The **Data, Calculate** and **Results** commands become (or remain) disabled (grayed).

Shortcuts
Keys CTRL + T

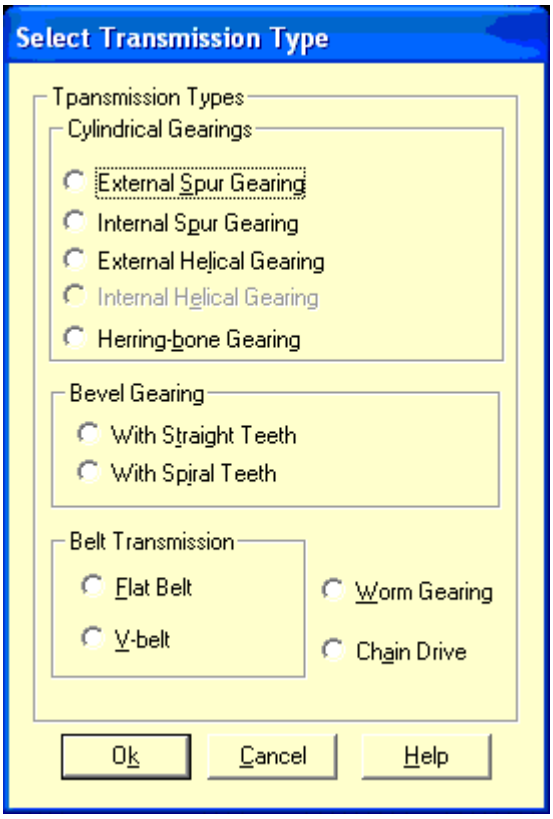


Fig. 5.9 Dialog box for transmission type selection.

Calculation command

The **Types | Calculation** command invokes **Calculation** popup menu shown at Fig. 5.8

Design	Ctrl+D
Longevity Checking	Ctrl+V
Torque Checking	Ctrl+Q

Fig 5.10 Calculation popup menu.

Here we give the description of the **Calculation** menu commands.

Design command

Design command select *transmission design* as current type of calculation (see Chapter 1).

Shortcuts
Keys CTRL + D

Longevity Checking command

This command selects *longevity checking* as current type of calculation (see Chapter 1).

Shortcuts
Keys CTRL + V

Torque Checking command

This command selects *maximum torque checking* as current type of calculation (see Chapter 1).

Shortcuts
Keys CTRL + Q

Data command

The **Data** command displays the dialog box for initial data input. This dialog box includes edit controls and list boxes for each parameter. The numbers of parameters to be entered depend on the type of transmission to be calculated. As an example in Fig. 5.11 the dialog box for initial data input of the spur transmission is shown.

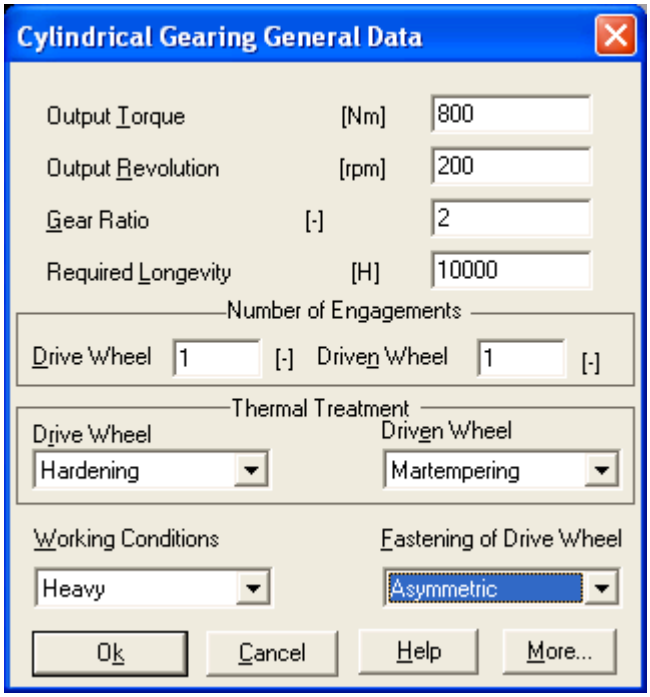


Fig. 5.11 The dialog box for the spur transmission initial data input

When you finish input of all the parameters, presented in the dialog box, select *Ok* button to inform a program that you confirm values you have entered. Immediately after this, the values you have entered will be displayed in the *Initial Data* window. Simultaneously in the *Options* window will be displayed all the options selected. Of course, at any moment you can select a *Cancel* button to cancel a dialog box. You must remember, however, that you cannot perform calculation until you define all the parameters.

To avoid errors during the data input, checking for allowable values is implemented. The width of allowable intervals is sufficiently big to include all cases of practical interest. These intervals for initial data are depend to current transmission type.

If you have entered the value that is out of allowable interval for respective parameter, the warning message will be displayed after you select *Ok* button.

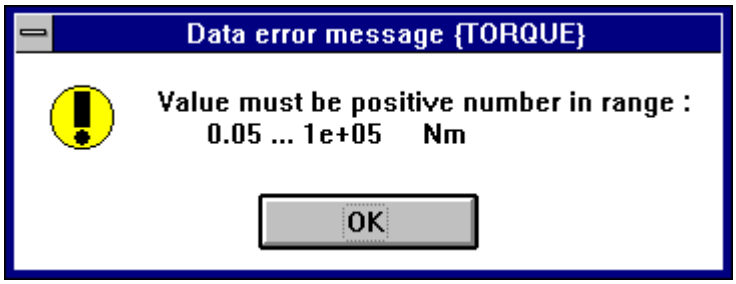


Fig. 5.12 An example of warning message displayed when data are out of allowable limits.

After you select *Ok* button you will be brought back just to that item of *Initial Data* dialog where you entered erroneous value. Besides checking for allowable values there are some other kinds of initial data control.

Description of the initial data is given in the Chapter 1.

Calculate command

The **Calculate** command of the main menu starts calculation.

Shortcuts

Speedbar 

Results command

The **Results** command of the main menu invokes the *Results* dialog box. Using this dialog box user can select and look through any of the calculation results. Contents of this dialog box depend on transmission type. In Fig.5.13 you can see an example of the *Results* dialog box for cylindrical transmission.

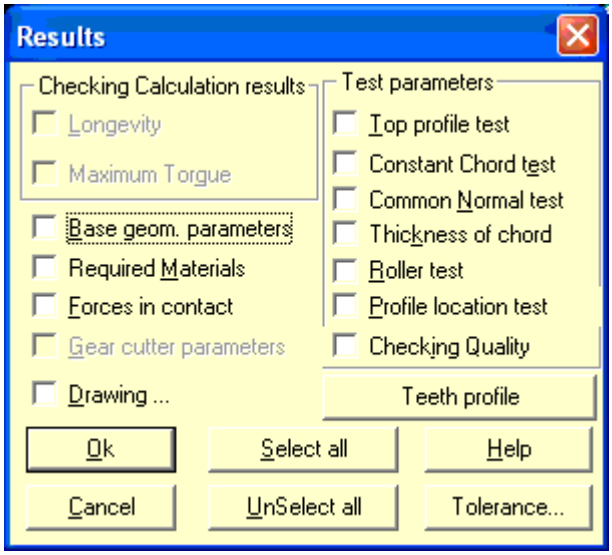


Fig 5.13 Dialog box for results selection.

For each parameter you can see through there is separate check box in this dialog box. Mark items you want to look and select *Ok* button. Use *Select All* button if you want to look all the results. Use *Unselect All* button if you want to clear all check boxes.

Shortcuts

Speedbar 

Help menu

Help popup menu (Fig. 5.14) contains commands that
•call **APM Trans** help system
•switch program to the demonstration mode
•display *About* dialog box

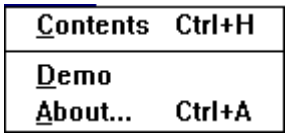


Fig 5.14 The Help popup menu

Contents command

Help | Contents command invokes window with **APM Trans** help contents. Select topic of your interest and click it with mouse or press ENTER key. In fact, when you call help in application program that runs under Microsoft Windows, the special program in Windows starts (WINHELP.EXE). This is a sophisticated hypertext system, that provides you with versatile tool for reference information retrieving. For detailed information about Windows help system please refer to your Microsoft Windows User's Guide. To get on-line information use **Help | How to Use Help** command in the menu of help system.

Shortcuts

Speedbar 
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

Drawing subsystem commands

Fig. 5.15 shows the local menu of **APM Trans** drawing subsystem. It is the part of *Drawing* dialog box that manage drawing generation process. This dialog box is displayed when you select *Drawing* checkbox in the *Results* dialog (see above).

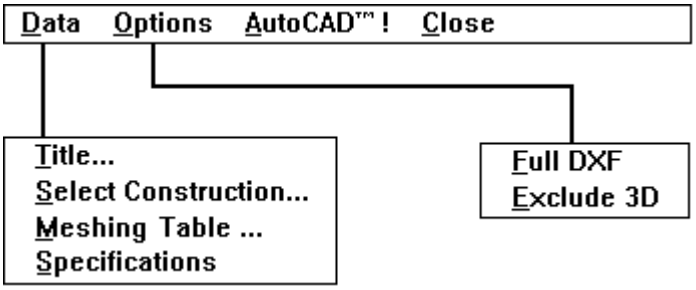


Fig 5.15 Drawing subsystem menu.

Data menu

Data menu is used to access to different groups of drawing parameters. Here we give the list of these groups:

- Title block parameters.
- Parameters characterizing construction of transmission elements.
- Meshing parameters table.
- Specifications.

Fig 5.16 The Data menu.

Title command

Use the **Title** command to fill the title block of the drawing. Dialog box used for this purpose you can see in Fig 5.37.

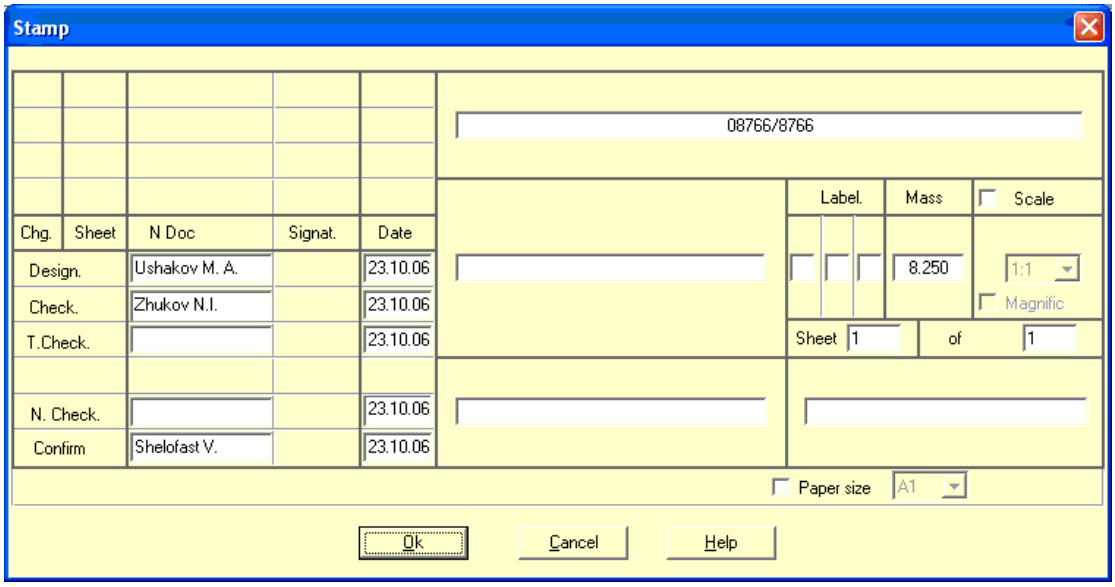


Fig 5.17 Dialog box for title block filling

Use TAB and SHIFT+TAB keys to move around the edit controls. To access invisible controls use scroll bar at the bottom of the window. *Ok* button is used to close dialog box and confirm entered data.

Select construction command

Select construction command is used to specify features of transmission construction. By this command you start the chain of data input steps. Each member of this chain is the dialog box with pictographic radio-buttons. These buttons represent the possible variants of transmission construction. Select appropriate buttons to specify desired transmission construction. As an example in Fig.5.18 you can see the dialog box used to select the type of wheel-shaft joint. The second pictographic button is selected ("pressed in"), indicating that user have choose the keyed type of wheel-shaft joint.

Length of data input chain and its contents depend on transmission type (see Chapter 2).

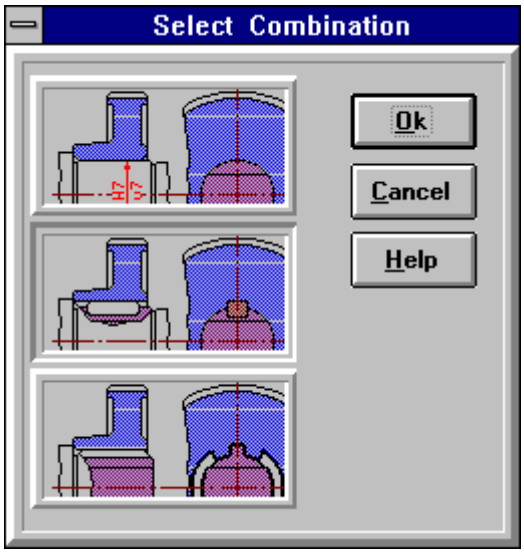


Fig 5.18 Dialog box used to select the type of wheel - shaft joint.

Meshing table command

Use **Meshing table** command to enter those of meshing parameters that are not calculated with APM Trans. Example of this dialog box you can see on Fig 5.19.

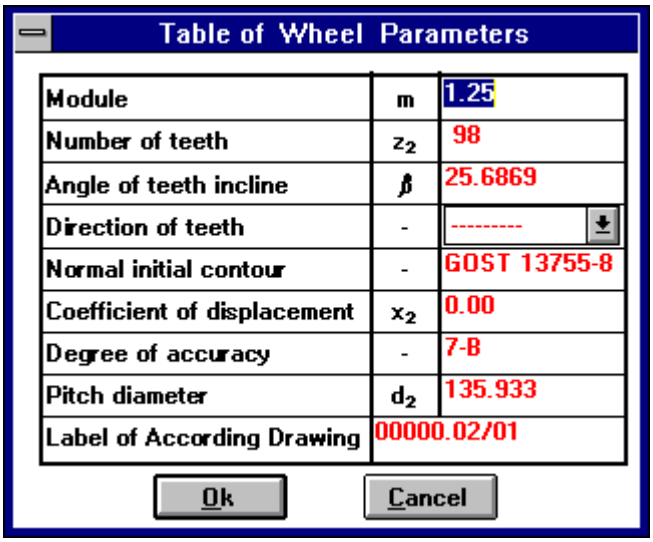


Fig 5.19 Dialog box for meshing table parameters input.

Specifications command

Specifications command invokes the dialog box shown in Fig.5.20.

In this window user could enter the following data:
- The chamfering radii non-specified on the drawing
- Non-specified maximum deviations of dimensions in the shaft system.
- Non-specified maximum deviations of dimensions in the opening system.
- Non-specified maximum deviations of other dimensions.

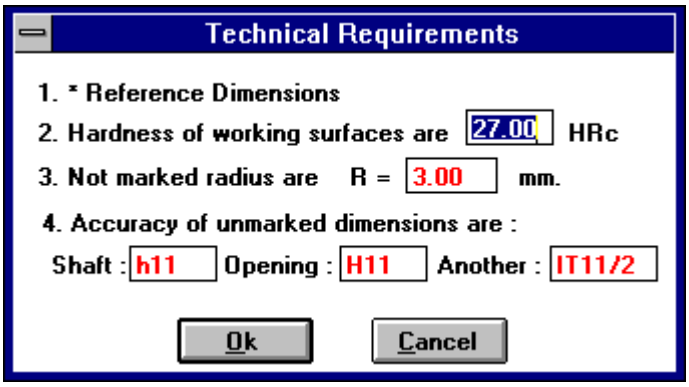


Fig 5.20 Dialog box for specifications input.

Close command

Use **Close** command to close *Drawing* window and quit drawing subsystem.

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 iconized state
Maximize	Restores application program window to its maximum size
Close	Terminates the program
Switch To	Let you switch to another program

Fig 5.21 The System Menu of the APM Trans

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

Speedbar

Speedbar is the group of pictographic buttons located below the main menu (Fig. 5.23). The speedbar is intended to speed up selection of some frequently used commands.

Fig 5.22 The speedbar of the APM Trans

Buttons of the speedbar initiate the following commands (from left to right):

- **File | Load**
- **File | Save**
- **File | Print**
- **Types | Transmission**
- **Data**
- **Calculation | Calculate**
- **Results**
- **Help | Contents**

To execute command with speedbar simply click the appropriate button with mouse.

Accelerators

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

Command	Accelerator
File | Load	CTRL+L
File | Save	CTRL+S
File | Print	CTRL+P
File | Exit	CTRL+X
Types | Transmission	CTRL+T
Types | Calculation | Design	CTRL+D
Types | Calculation | Longevity Checking	CTRL+V
Types | Calculation | Torque Checking	CTRL+Q
Help | Contents	CTRL+H

Contents

Index