TMM-04 torsion test machine

Users manual

by
Dr. I. Groma

MRG Info BT

Budapest

http:\\www.mrginfo.hu

e-mail: groma@metal.elte.hu

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1 Introduction

TMM-04 is a general purpose free end torsion test machine. The system

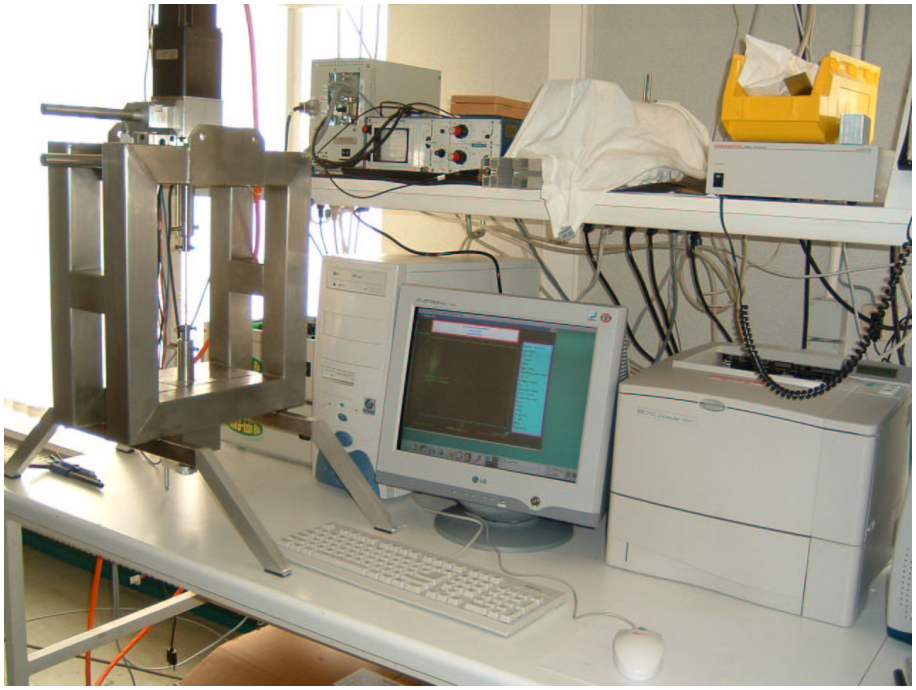

Figure 1: TMM-04 torsion test machine

is fully computer controlled. The rotation is driven by a precision 3 phase Berger Lahr stepping motor. The stepping pulses are provided by the computer. This results that the time variation of the rotation angle can be programmed by the user between wide range of limits. This allows to perform many different types of torsion testing. During testing the rotation angle, the torque required and the sample elongation are recorded with a hight performance 16 bit analog to digital converter. The torque is measured by a 200N load cell (HBM S2). The change of the sample length is detected by an inductive transducer (HBM WI).

Data are collected and plotted by the computer with 0.5KHz sampling rate. In order to achieve this sampling rate a Real Time Linux operation system is used (for details visit *http:\\www.rtlinux.org*), which is a modified version of a Mandrake 9.0 Linux system. By replacing the usual Linux system kernel with the Real Time kernel it can be guaranteed that a torsion machine controlling task is performed at each 100μs independently from the actual load of the computer.

The parameters of TMM-04 are the following:

Maximal rotation rate:	2 rad/s
Angle resolution:	0.36^0
Maximal torque range:	± 50 Nm
Torque resolution:	0.02 Nm
Elongation range:	± 5 mm
Elongation resolution:	0.1μm
Maximal sample length:	110 mm
Maximal sample diameter:	8 mm
Maximal data sampling rate:	500 s^{-1}

2 Starting the measuring software

Beside Real Time Linux (RTL) other operation systems are also installed on the controlling computer. Shortly after the computer is turned on a boot menu should appears on the screen. For performing torsion tests "rtlinux" has to be chosen. This is the default boot mode, so if another one is not selected RTL starts automatically within a few second.

For security reasons the TMM-04 controlling software can be run only by a dedicated user called "torsion". So after RTL booting when a login screen appears one has to login as "torsion" user. The password is provided by the system administrator. For starting the controlling software called "torsionmeasure" either run

torsionmeasure

from a xterm window or click on the "torsion" icon. (Unlike under Windows one has to click only once on the icon!) It is important to note that the controlling software cannot be started twice. If a second one is launched by mistake it is automatically killed by the system. So if "torsionmeasure" halts

after the appearance of an initializing icon it has to be checked if there is another running "torsionmeasure" task. The command

ps -aux

lists all the running processes. Since "torsionmeasure" can be run from a remote Linux system too, it can happen that one cannot directly see on the screen that "torsionmeasure" is already running. Nevertheless, it can happen that due to abnormal termination of "torsionmeasure" it cannot be restarted any more. In this case a lock file created at the startup of "torsionmeasure" needs to be deleted by the command

rm /var/lock/torsion/torsion.lock

(it is automatically deleted at the startup of the computer) but **one must not delete it if there is a running "torsionmeasure" task.**

We mention here that the TMM-04 controlling software is installed in the

/usr/local/torsion

directory. Care should be taken not to destroy it!

3 Using the Main menu

After starting "torsionmeasure" the window that can be seen on Fig.2 should appear. The description of the menu points are the following:

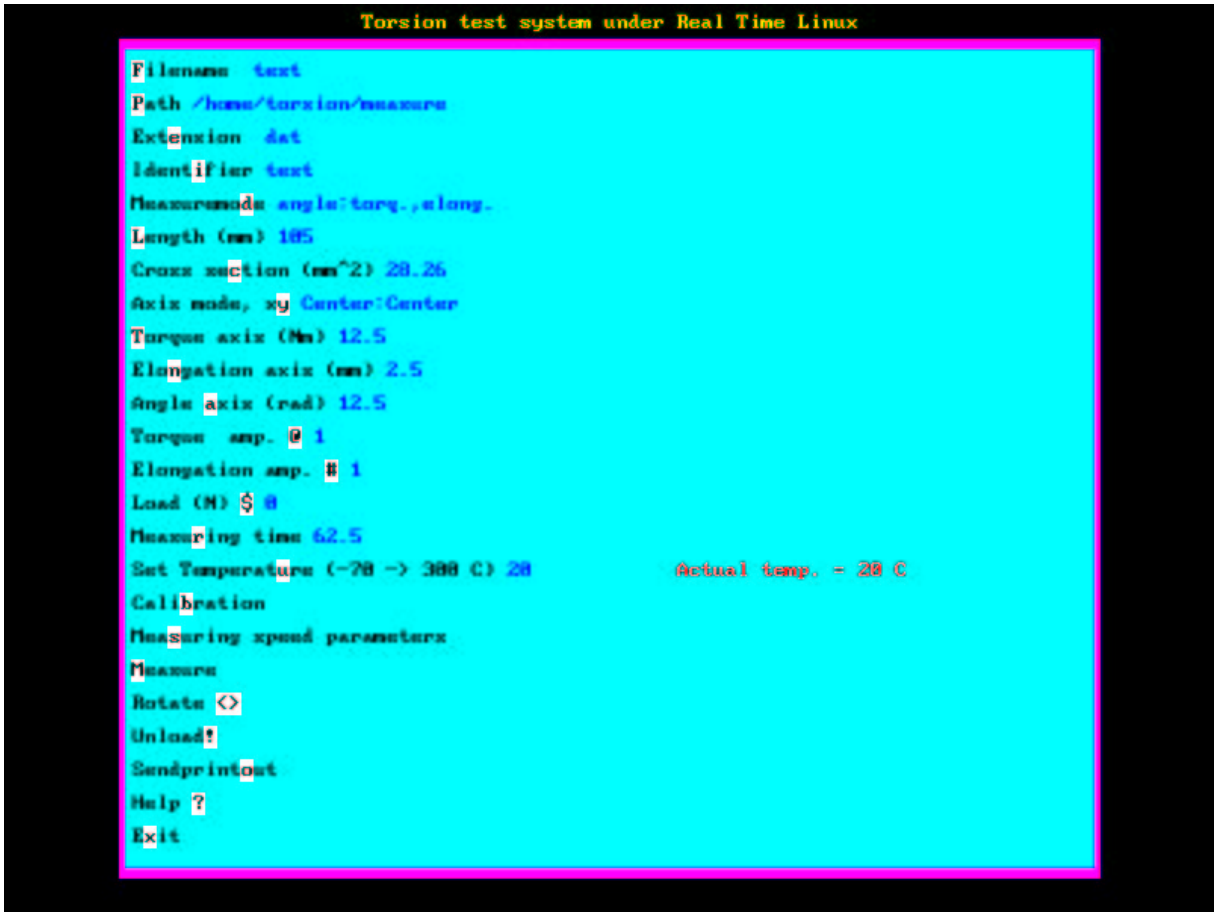

Figure 2: Main menu

Filename: The name of measuring data file can be set by this menu-point. In order to avoid overwriting existing file an internal number is added to the selected name. The number is automatically increased by the system after each measurement file saving. The full filename is combined from the *path*, the *filename* and the *extension* like (see Fig. 2)

/home/torsion/measure/{number}test.dat

Path: The directory where the measuring data file is saved can be set by this menu-point. After clicking on it a sub-menu appears (see Fig. 3) listing the existing directories within the directory selected before. The actual directory can be changed by clicking on the required directory name. If the required directory is reached press "Esc" to get back to the main menu.

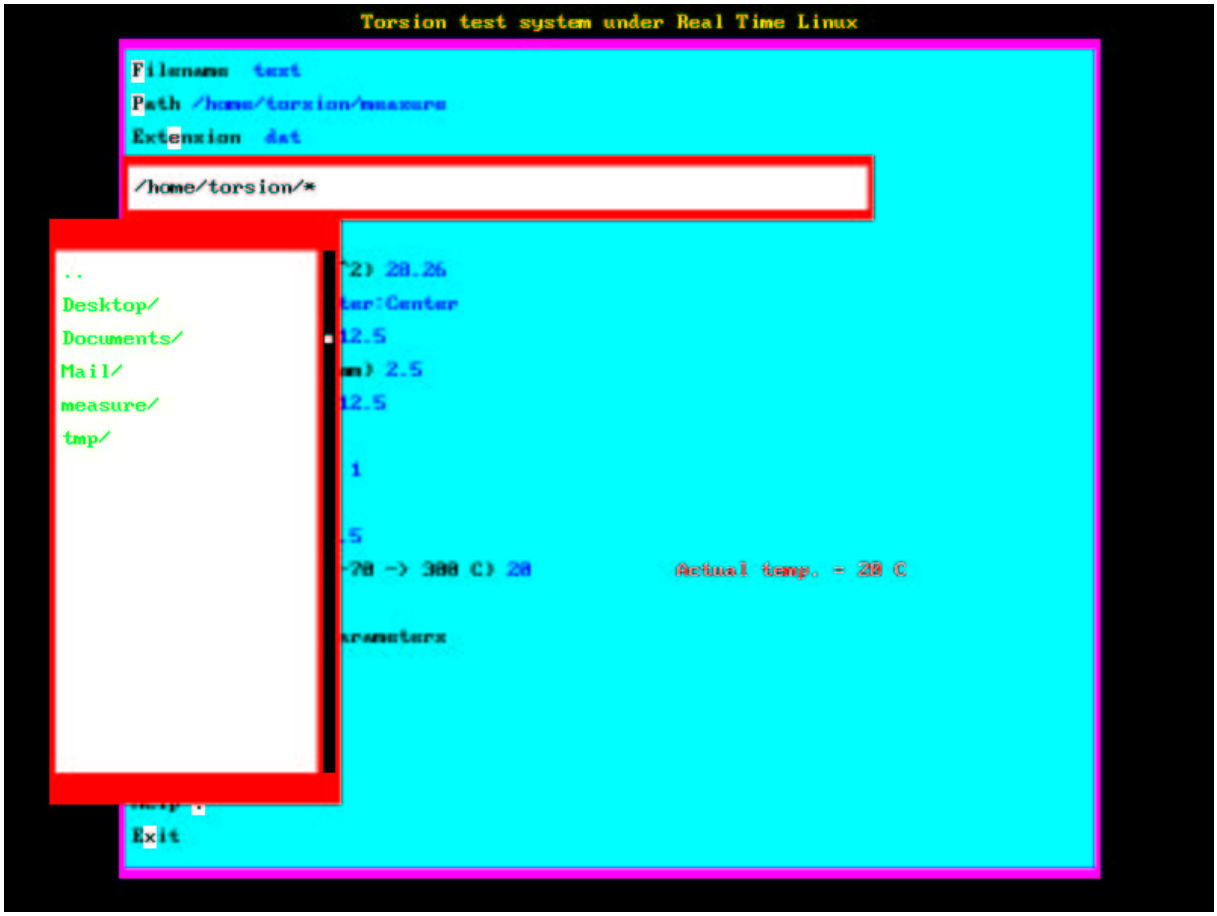

Figure 3: Main menu

Extension: The extension of the measuring data file can be selected by this menu-point.

Identifier: An arbitrary one line length text can be set by clicking on this menu-point. The date of the measurement is automatically added to the end. The identifier is saved at the top of the measuring data file.

Measuremode: With this menu-point one can select which of the measured date and how they are plotted during measurement. By clicking on the menu-point one can choose from the valid modes. The horizontal axis can be "time" or "angle". Depending on the mode selected the measured torque, elongation, angle and load (the measure of load is not implemented jet) can be plotted simultaneously as a function of time or rotation angle.

Length: The length of the sample should be given here in *mm*.

Cross section: The length of the sample should be given here. After clicking on it one is prompted for the diameter of the sample (in *mm*). The cross section is calculated.

Axis mode: The position of the (0,0) coordinate can be selected by this menu-point. By clicking on it one can select from the valid modes.

Torque axis: The scale of the torque axis should be defined here. It needs to have a nonzero starting value, but it can be changed during the measurement.

Elongation axis: The same as explained before for torque but for elongation.

Angle axis: The same as explained before for torque but for angle. Depending on the measuring mode the value given can correspond to either the horizontal or the vertical axis.

Torque amp: In order to increase the flexibility of the instrument a programmable internal amplifier is built in the controlling electronics. The signal coming from the load cell is amplified by the selected factor (2,5,10). So if during the test the required torque is considerably smaller than the maximal measurable torque (50Nm at the current setup) it can be useful to select an appropriate amplification.

Elongation amp: The same as explained before for torque but for elongation.

Measuring time: The scale of the time axis should be defined here. It needs to have a nonzero starting value, but it can be changed during the measurement.

Set temperature: The measuring temperature can be given by this menu-point. (Chamber has not installed jet.)

Calibration: The calibration sub-menu can be started by clicking on this menu-point. The details how to calibrate the instrument are explained in the section "Calibration".

Measuring speed parameters: The time variation of the rotation angle can be selected under this menu-point. The details are explained in section "Selecting measuring mode and deformation rate".

Measure: This menu-point starts the measuring windows. Details are explained in section "Running test"

Rotate: By clicking on this menu-point with the left or right button of the mouse the stepping motor turns plus or minus 1^0 respectively. This can be useful during sample assembling.

Unload: The sample can be unloaded with this menu-point. The stepping motor turns until the torque becomes zero. This can be useful for getting out an unbroken loaded sample.

Sendprintout: The printed figures (see under section "Running test") are not directly send to the printer. They are printed into ps files. The files are located in the */tmp/mprints* directory. They can be saved manually by copying them to a different place. In order to print them one has to click on this menu-point. After this the files are deleted. The unprinted figures are also deleted at the startup of "torsionmeasure"!

Help: One can read this manual by clicking on this menu-point.

Exit: "torsionmeasure" has to be terminated by clicking on this menu-point. Although under Linux there are many other way to terminate a task, in order to avoid uncompleted termination it is strongly recommended to use this. Always "Exit" before logging out or shutting down the computer. **Never turn the computer of before shutting Linux down. This can damage the file system!**

4 Calibration

During the torsion test the torque required at the given rotation angle is measured by a load cell positioned between two bars. One of the bars is fixed to the frame of the instrument, the other one to the stepping motor which can rotate freely (see Fig.4). The torque developed within the sample would rotate the whole stepping motor but it is balanced by the load cell.

In order to increase the flexibility of the instrument the distance between

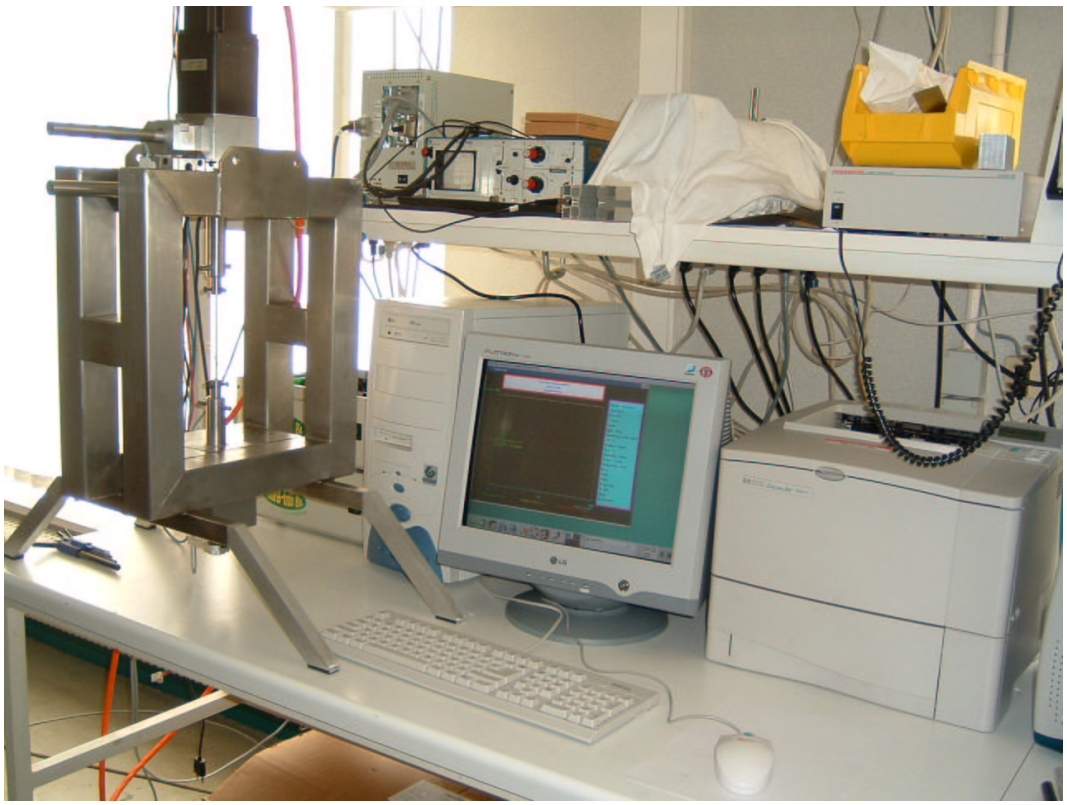

Figure 4: Method of torque measurement

the torsional axis and the load cell can be varied (see Fig.4). So for the calibration of the torque measurement the distance between the load cell and the rotation axis should be measured. Since this might not that easy to measure with the appropriate precision, one has to measure only the distance between the edge of the stepping motor an the marker on the load cell (see Fig.4). The rest is automatically added.

If it is necessary both the load cell used for torque measurement and the displacement transducer can be replaced by another one. HBM offers several

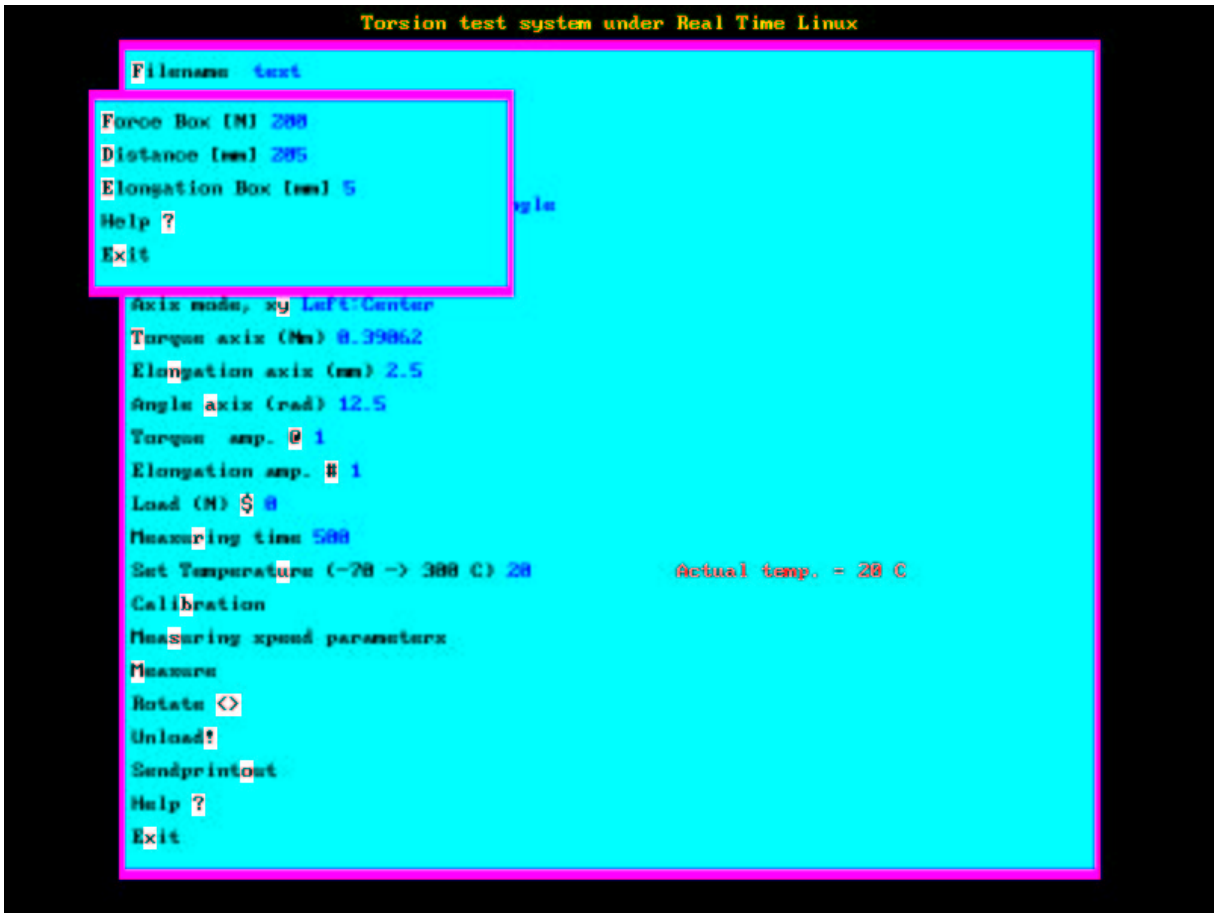

Figure 5: Calibration menu

different one. Their measuring limits (the force or displacement corresponding to 10V output signal) should be given. For the load cell shipped presently the limit is 200N, while for the displacement transducer it is 5mm.

The calibration parameter can be set in a sub-menu appearing after clicking on the "Calibration" menu-point in the main menu (see Fig.5).

5 Selecting measuring mode and deformation rate

The time variation of the rotation angle $\Theta(t)$ can be programmed by the user. Within certain rotation rate limits practically any $\Theta(t)$ function can be applied. The required $\Theta(t)$ function has to be composed from linear parts, referred to segments hereafter. What one has to give is the slope of the given segment and the angle up the that the function goes with this rate.

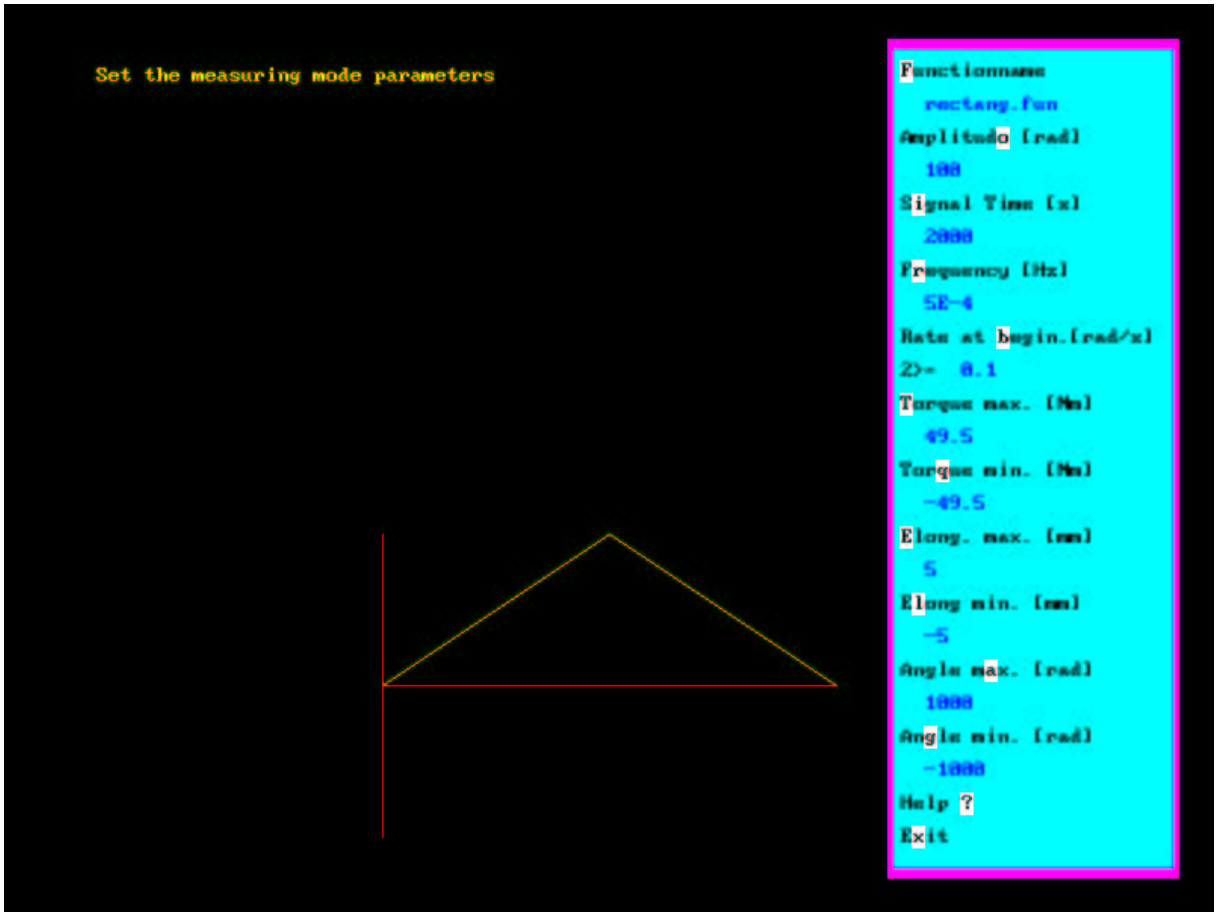

Figure 6: The $\Theta(t)$ function selection menu

The definition of a $\Theta(t)$ function is a sequence of statements like

1R
1A
1R

0A

where a statement with form $\{number\}G$ defines that *rate*=$\{number\}$ and $\{number\}A$ means that the function goes with the current rate up to *level*=$\{number\}$. The above example defines a triangle (see Fig.6) It is important to note that the rotation rate needs to have a nonzero positive value. The actual rotation direction is determined by the "current" and the "target" angles. So, if we are let say at *5 rad* and the next statement in the program sequence is *10A* the angle will increase, while if it is *-5A* the angle will decreases with the given rate. The example below defines a "triangular wave" like $\Theta(t)$ function.

1R
4A
1R
-4A
1R
0A

Since a statement *0R* would hold the stepping motor at the current angle forever, to hold the angle for a given time $\{time\}$ the statement $\{time\}T$ should be used.

The $\Theta(t)$ program files should be placed in the directory

/usr/local/torsion/functions

Several previously written function can be found in this directory.

The required function can be selected in the "Measuring speed parameters" menu (see Fig.6). After clicking on the **"Functionname"** menu-point a sub-windows listing all the available program-file should appear (see Fig.7). The first clicking on the required filename would draw the function curve. A second clicking on the same one would select it.

In order to increase flexibility the *rate* and *level* parameters given in a $\Theta(t)$ program are relative. The maximal value of the program function can be selected by the **"Amplitude"** menu-point. This does not effect *rate* values just the *levels*. It re-scales them to have the maximum of the function the required one.

The total signal time can be set the the required one by the **"Signal Time"** or **"Frequency"** menu-points. These do not affect *level*-s. but the *rate* and *time* values. They are re-scaled to have the required total signal time.

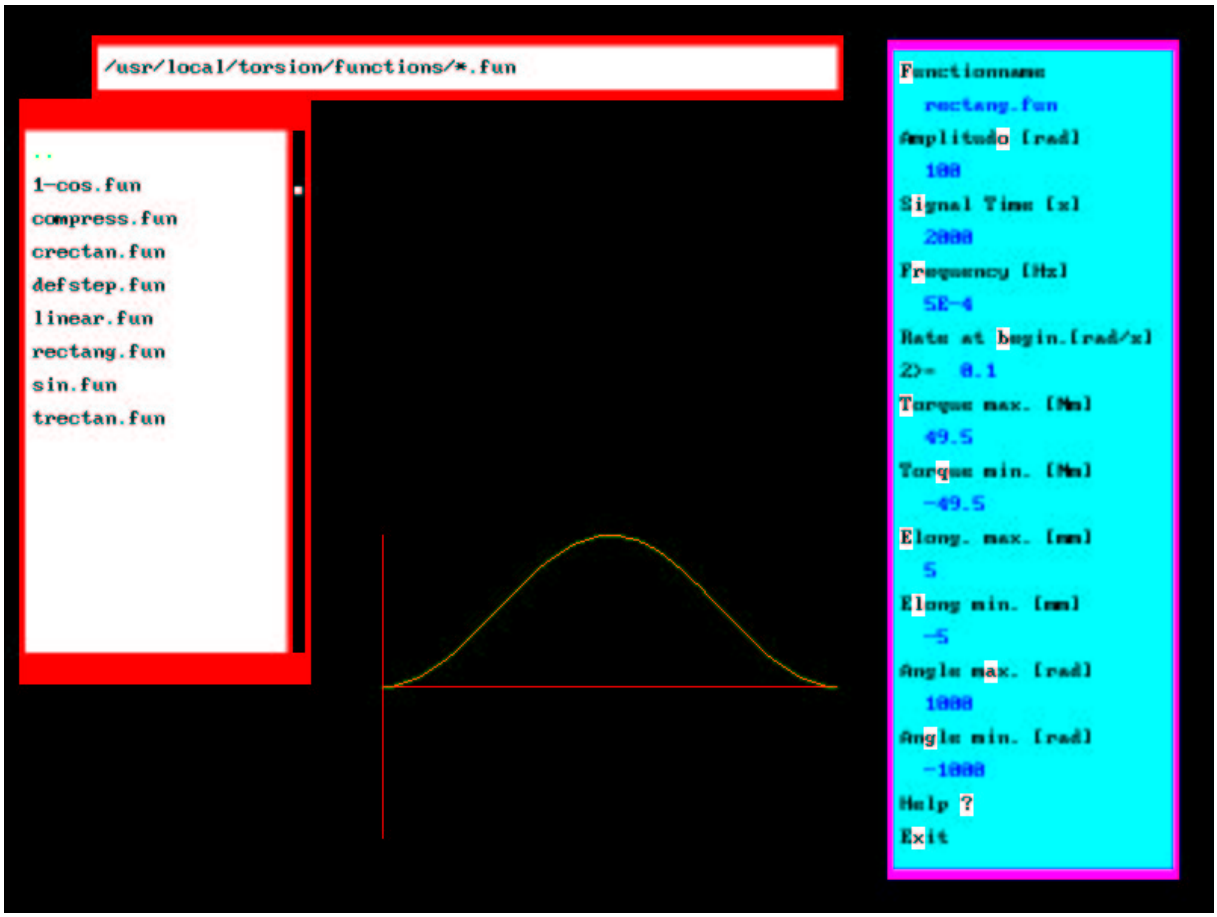

Figure 7: Selecting program file

It is often convenient to set the rate of the first program segment directly. This can be done by the **"Rate at the beginning"** menu-point. It sets the initial rotation rate the required one. The other *rate* parameters are re-scaled by the ratio of the given **"Rate at the beginning"** and the value of the first rate parameter in the program file. This does not effect the *level* values.

Emergency limits can also be set here. If during a test the torque, the elongation, or the rotation angle reach the limits set in the corresponding menu-point the test is stopped. This also happens if the torque reaches the maxima that the load cell can balance without damage.

6 Running test

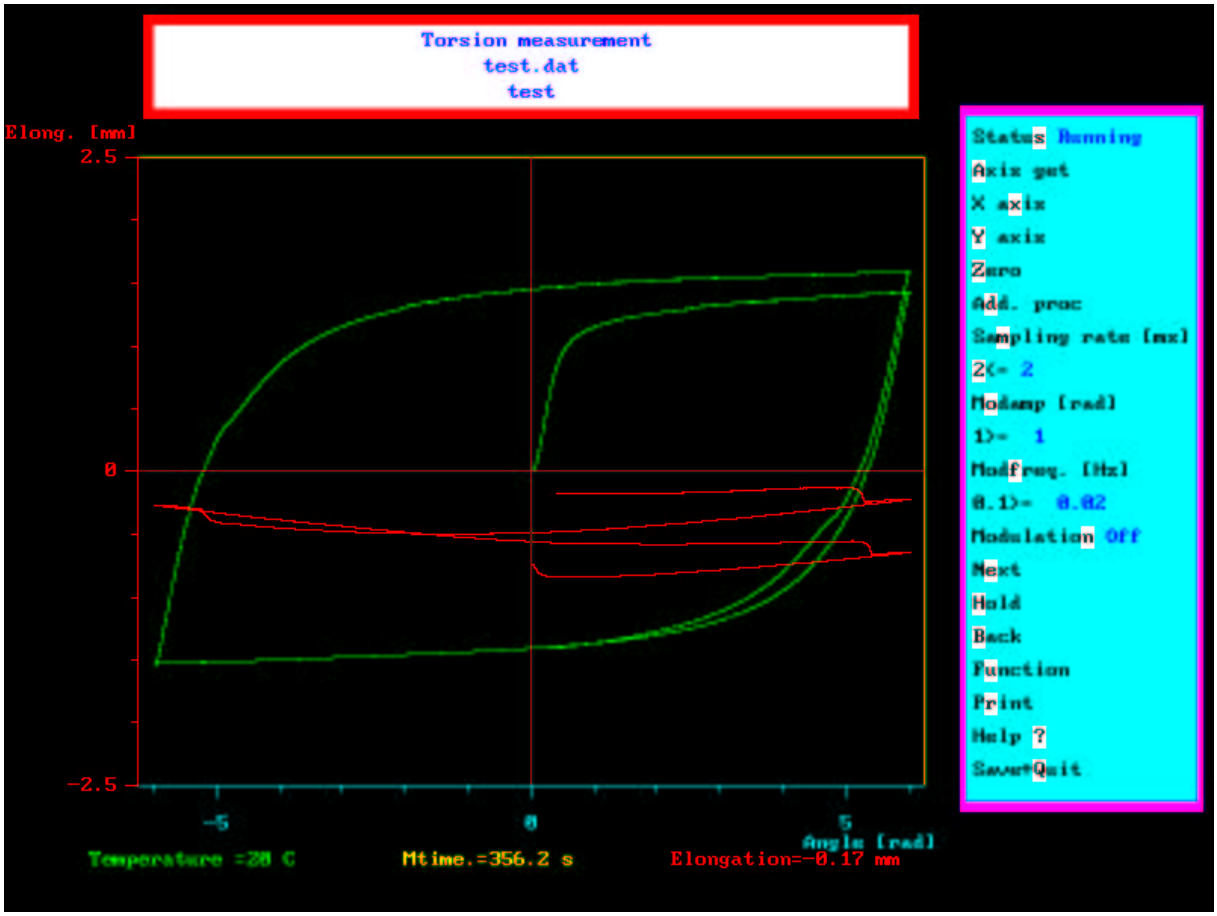

Figure 8: Test menu

After the sample was assembled in and the parameters of the $\Theta(t)$ function were selected the system is ready to perform the torsion test. For this the windows which can be seen on Fig.8 should appear. The test can be started/stopped by clicking on the menu-point **"Status"**.

The plotting and the performance of the test can be manipulated by the other menu-points as follows

Axis get: It selects the active vertical axis. The torque is plotted in green, the elongation is in red and the angle is in light blue.

X axis: The scale on the horizontal axis can be increased / decreased by a

factor of *2* by clicking the left / right mouse button respectively. The curves are automatically re-plotted.

Y axis: The same for the active vertical axis.

Zero: It sets the current torque and elongation to zero.

Add. proc: Two separate cursor can be placed by this menu-point.

Sampling rate: Data sampling interval can be set by this menu-point. The minimal time interval between two measured data is *2ms*. It can be modified during measurement too.

Modamp: The system allows to add a sinusoidal modulation to the programmed $\Theta(t)$ function. The amplitude of the modulation can be set by this menu-point. It cannot be larger than $1rad$.

ModFreq: The modulation frequency can be set by this menu-point.

Modulation: Modulation can be started / stopped by clicking on this menu-point. We have to say at this point that the modulated test is a new feature. There is only a very limited experience with this type of testing so far. Any suggestion for improving it is warmly welcome.

Next: The performance of the test can be influenced by this menu-point. By clicking on it would force the system to stop the current $\Theta(t)$ programming segment. The system continues with the next one.

Hold: By clicking on it the stepping motor should stop. By another clicking the $\Theta(t)$ program should continue with the next programming segment.

Back: It turns the motor back to zero angle.

Function: By clicking on it one can get back the "Measuring speed parameters" menu. The parameters can be changed.

Print: This menu-point prints the measuring plot that can actually be seen on the screen. The printing creates a postscript file. In order to send it to the printer press **"Sendpintout"** in the main menu. The *ps* file can be converted to *jpg* format by the command

convert {*filename*}.*ps* {*filename*}.*jpg*

Help: A help windows explaining the usage of the measuring menu can be get by this menu-point.

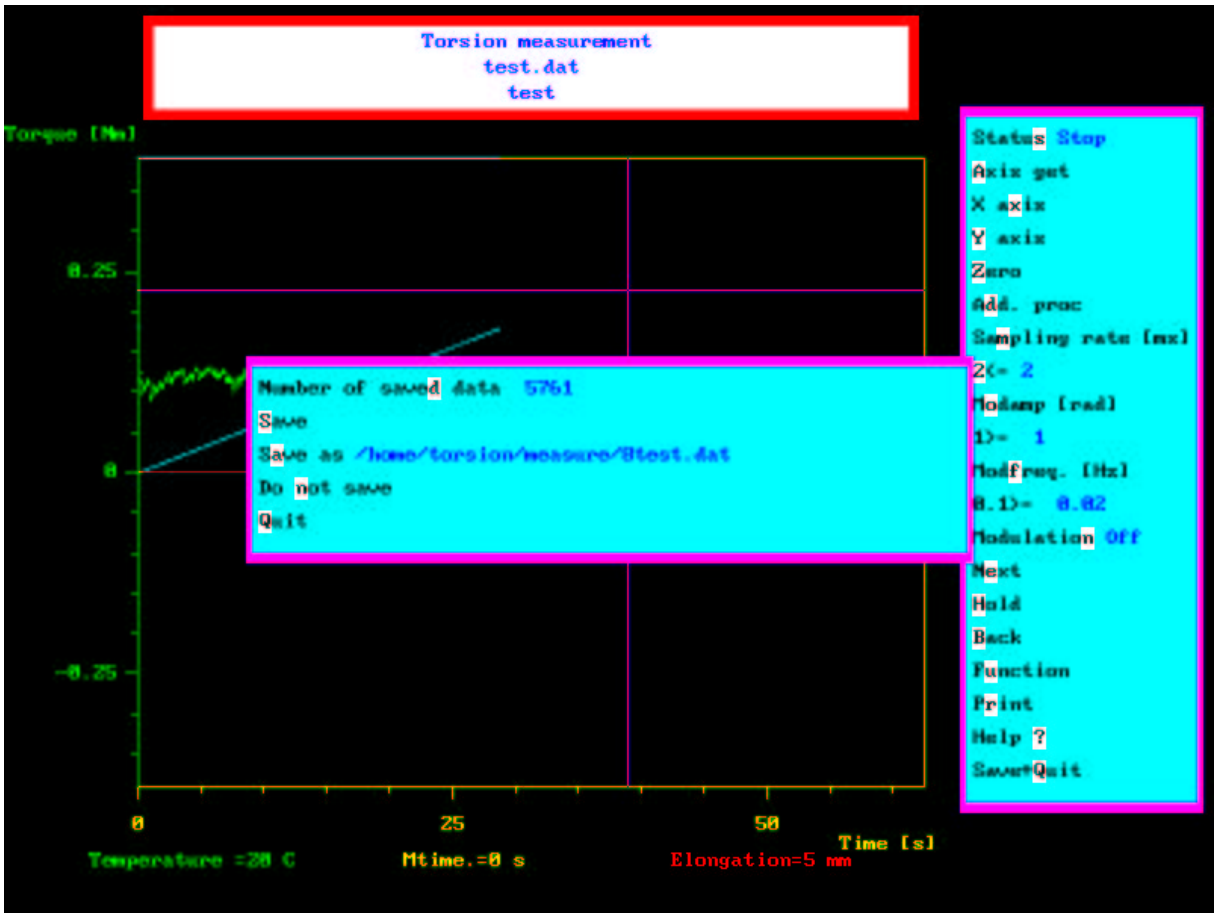

Figure 9: Save menu

Save+Quit: If the test is finished the measured data can be saved under this menu-point. By clicking on it the sub-menu that can be seen on Fig. 9 should appear. In the first line the total number of collected data points is given. By changing it to any smaller number would cause to reduce the number of saved data points to the given number. Data are selected homogeneously from the total data set collected.

The usage of the other sub-menu points are obvious.

If the controlling electronics in not on or for some reason the stepping motor is overheated a message **"The motor is not ready!"** should appear on the screen. In this case check the system.

Enjoy your work!