MADYN 2000 Version 3.4

The main new features in MADYN 2000 version 3.4 are:

1. Introduction of ALP3T version 4.3 for linear analysis besides ALP3Tversion 3.2. Version 4.3 until now has only been used for the analysis of the nonlinear characteristics of fluid film bearings. The new version allows using the 2-phase flow in the cavitation zones also for linear characteristics. Moreover the analysis is generally more robust.
2. Nonlinear non-dimensional bearing characteristics can now be imported from text files for “user defined” and “standard” bearings.
3. Shafts can be output in a text file with flexible format defined by SIF (**S**haft **I**nterface **F**ile). These files are normally used to define the format for the import of a shaft from a text file.
4. The sensitivity of magnetic bearings according to the ISO standard 14839-3 can be calculated. This analysis is a special type of harmonic response analysis called **M**agnetic **B**earing **S**ensitivity (MBS).
5. Licence borrowing: This feature allows borrowing a licence from one computer or server to another computer, typically to a laptop.

In the following these features are described more in detail.

Beside these main features bugs have been corrected, further input checks have been introduced and the following improvements of result and load plots are implemented:

- The number of modes in a figure for compact mode shape plots can be specified.
- The load plot for transient analyses also contains the denotation of the excitation functions in case “Load Values as List” is selected in the plot MADYN menu.

1. ALP3T Version 4.3

1.1 Selection of the Version

The version, which is used to calculate the linear fluid film bearing characteristics (Alp3t vers. 3.2 or vers. 4) can be selected under “Preferences” in the “Extras” menu (see figure below).

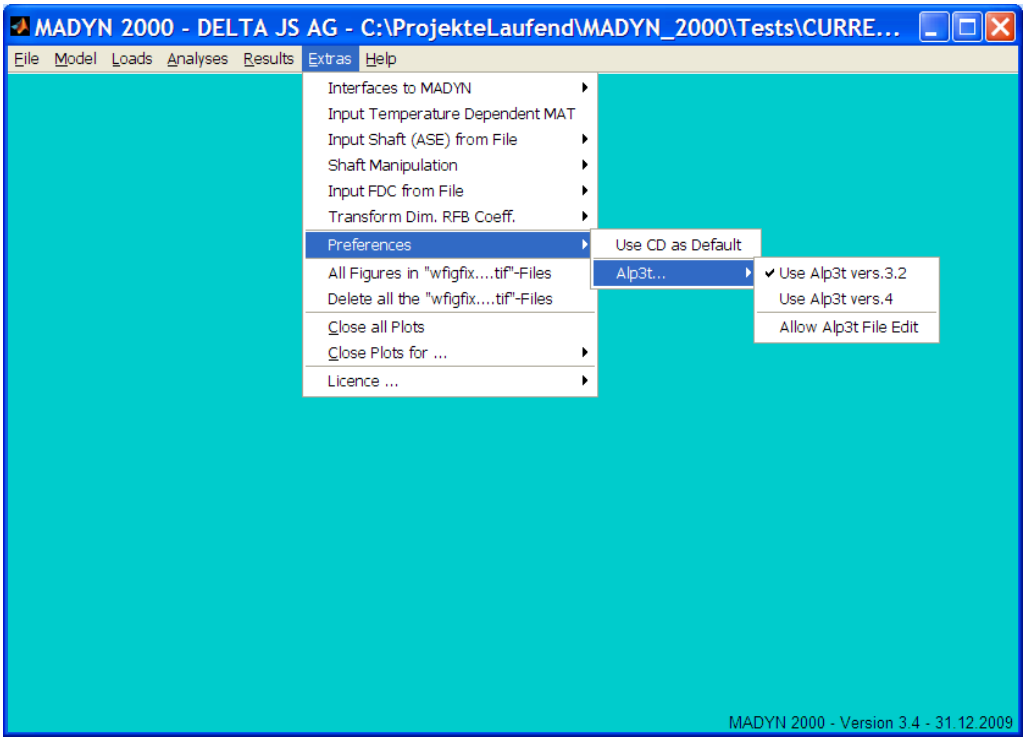


Figure 1.1.1: Selection of the ALP3T version

1.2 Two Phase Flow for Linear Characteristics

In case version 4.3 of ALP3T is used a 2-phase flow model can be considered in the cavitation zones for “variable adiabatic” and “constant adiabatic” fluid film bearing analyses by activating a check box in the RFB GUI (see figure 1.2.1).

The model in the cavitation zones has some influence on the rotor dynamic bearing coefficients. The extent of the influence depends on the size of the cavitation zones. In the following a comparison is shown for results of a heavily loaded cylindrical bearing with two pads. The specific bearing load is 24.4bar. The geometry of the bearing can be seen in figure 1.2.2, the coefficients calculated by a “variable adiabatic” analysis in figure 1.2.3.

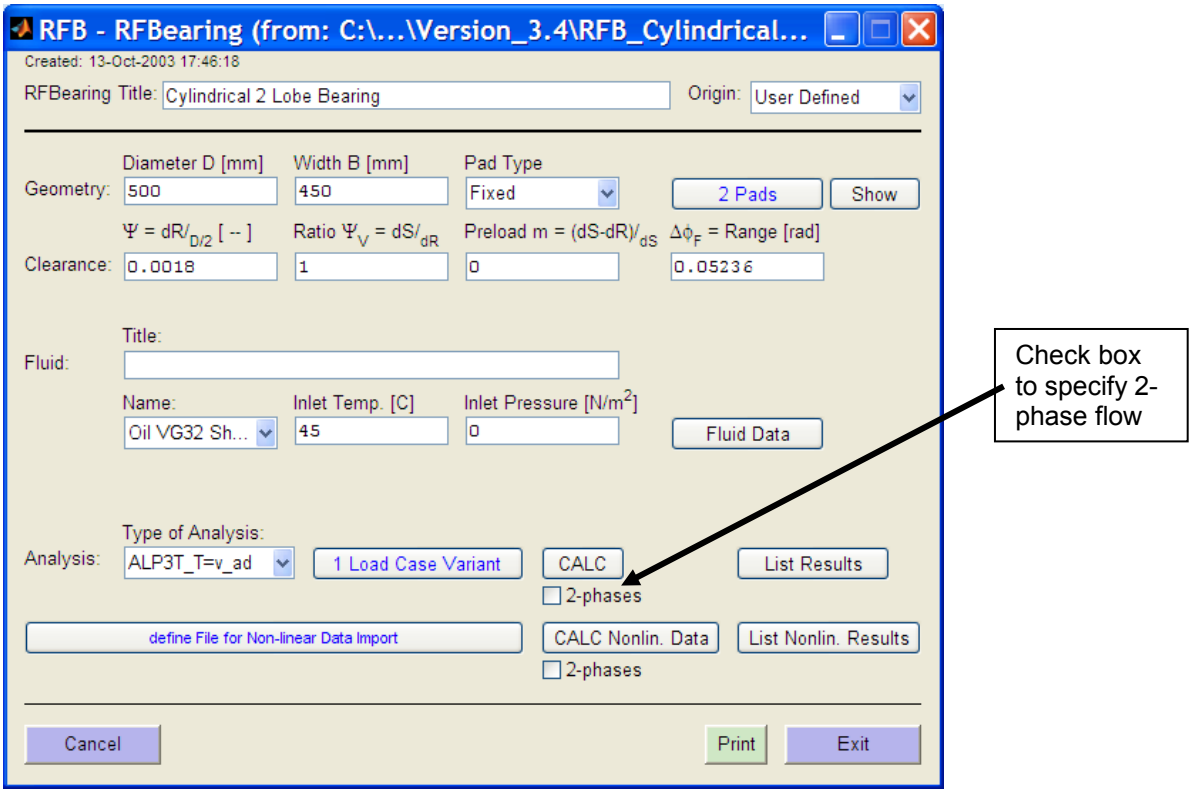


Figure 1.2.1: RFB GUI

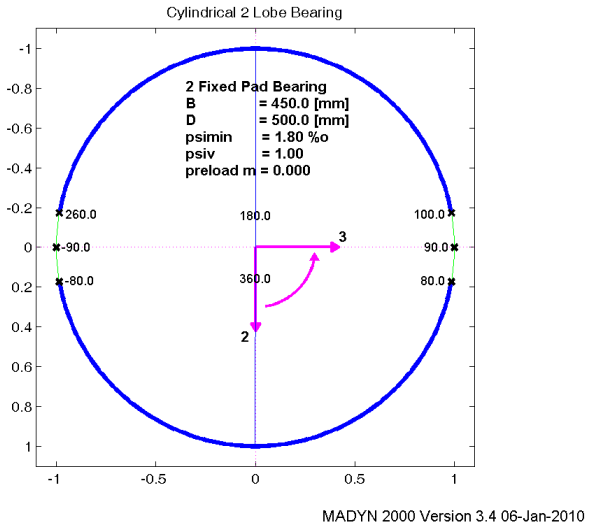


Figure 1.2.2: Bearing geometry of the examples

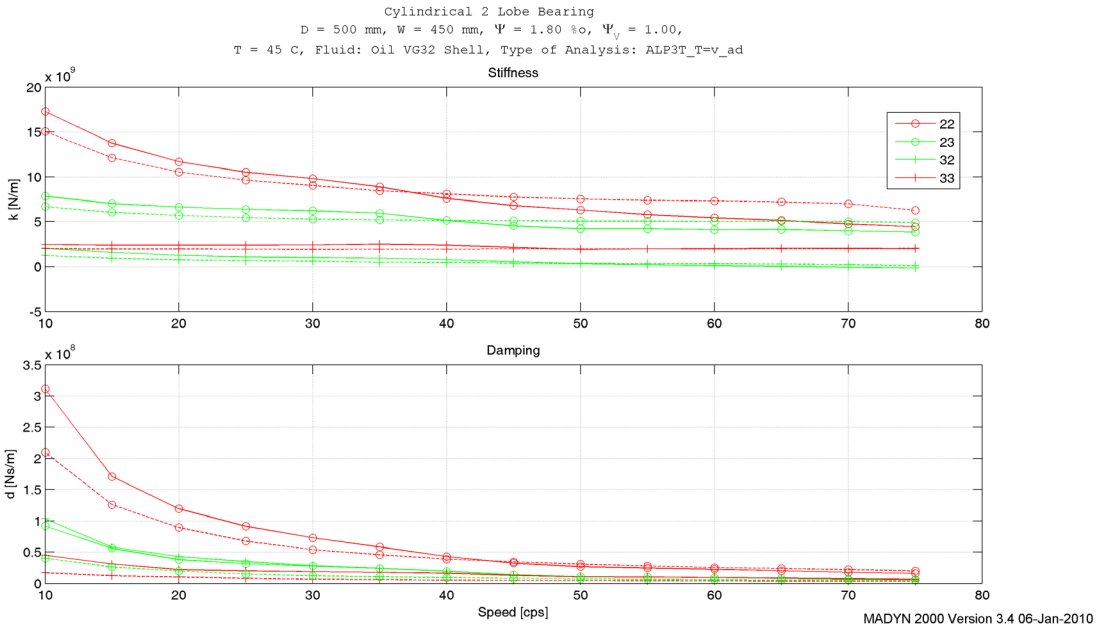


Figure 1.2.3: Rotor dynamic bearing coefficients with two phase flow (solid lines) and single phase flow (dashed lines)

The two phase flow model has been introduced for the analysis of the nonlinear bearing characteristics in version 3.1. This model yields much smoother fields for the non-linear force and thus causes fewer problems in the time integration for the non-linear equations of the rotor bearing system. This was the main reason for its introduction. Now it is possible to calculate consistent linear coefficients to the non-linear characteristics. Concerning the physical validity of the results please refer to /1/.

2. Import of Nonlinear Bearing Characteristics

For user defined and standard bearings nonlinear characteristics can be imported. The respective buttons in the RFB GUIs (see the figure below) start a dialogue to select a text file.

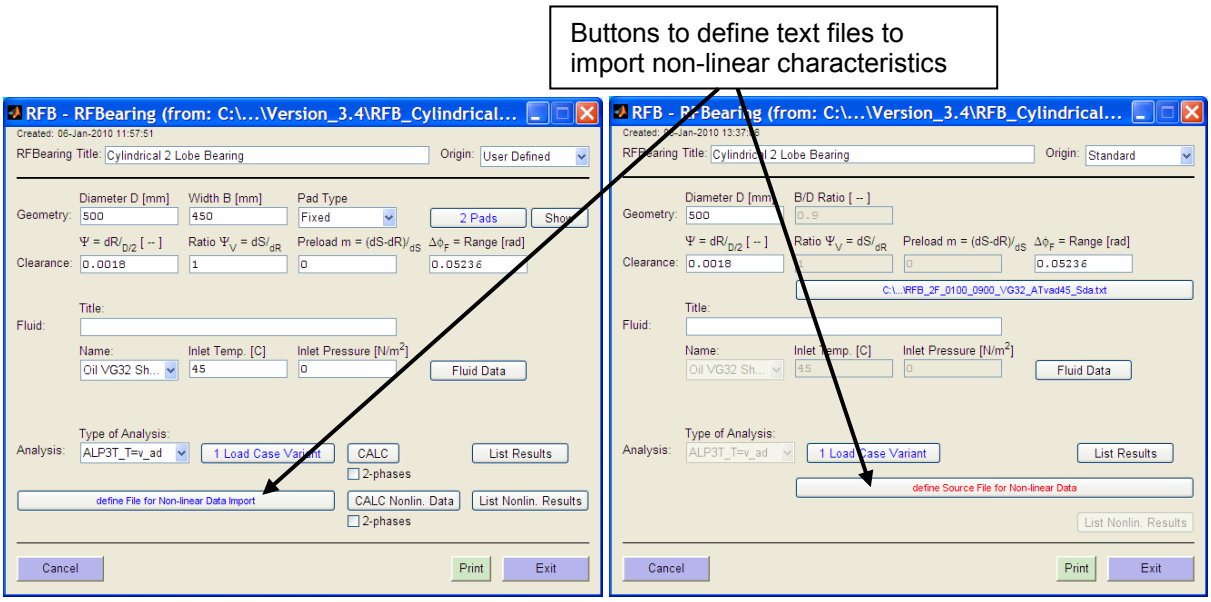
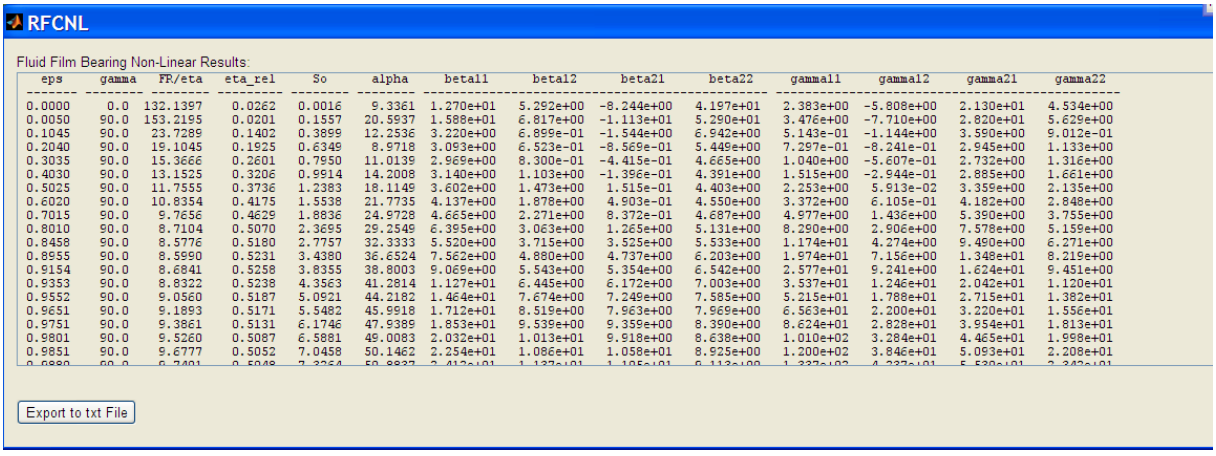


Figure 2.1: RFB GUIs for user defined and standard bearings

The text file must contain a list with the same columns as the list created by ALP3T (see figure 2.2).



eps	gamma	FR/eta	eta_rel	So	alpha	beta11	beta12	beta21	beta22	gamma11	gamma12	gamma21	gamma22
0.0000	0.0	132.1397	0.0262	0.0016	9.3361	1.270e+01	5.292e+00	-8.244e+00	4.197e+01	2.383e+00	-5.808e+00	2.130e+01	4.534e+00
0.0050	90.0	153.2195	0.0201	0.1557	20.5937	1.588e+01	6.817e+00	-1.113e+01	5.290e+01	3.476e+00	-7.710e+00	2.820e+01	5.629e+00
0.1045	90.0	23.7289	0.1402	0.3899	12.2536	3.220e+00	6.899e-01	-1.544e+00	6.942e+00	5.143e-01	-1.144e+00	3.590e+00	9.012e-01
0.2040	90.0	19.1045	0.1925	0.6349	8.9718	3.093e+00	6.523e-01	-8.569e-01	5.449e+00	7.297e-01	-8.241e-01	2.945e+00	1.133e+00
0.3035	90.0	15.3666	0.2601	0.7950	11.0139	2.969e+00	8.300e-01	-4.415e-01	4.665e+00	1.040e+00	-5.607e-01	2.732e+00	1.316e+00
0.4030	90.0	13.1525	0.3206	0.9914	14.2008	3.140e+00	1.103e+00	-1.396e-01	4.391e+00	1.515e+00	-2.944e-01	2.885e+00	1.661e+00
0.5025	90.0	11.7555	0.3736	1.2383	18.1149	3.602e+00	1.473e+00	1.515e-01	4.403e+00	2.253e+00	5.913e-02	3.359e+00	2.135e+00
0.6020	90.0	10.8354	0.4175	1.5538	21.7735	4.137e+00	1.878e+00	4.903e-01	4.550e+00	3.372e+00	6.105e-01	4.182e+00	2.848e+00
0.7015	90.0	9.7656	0.4629	1.8836	24.9728	4.665e+00	2.271e+00	8.372e-01	4.687e+00	4.977e+00	1.436e+00	5.390e+00	3.755e+00
0.8010	90.0	8.7104	0.5070	2.3695	29.2549	6.395e+00	3.063e+00	1.265e+00	5.131e+00	8.290e+00	2.906e+00	7.578e+00	5.159e+00
0.8458	90.0	8.5776	0.5180	2.7757	32.3333	5.520e+00	3.715e+00	3.525e+00	5.533e+00	1.174e+01	4.274e+00	9.490e+00	6.271e+00
0.8955	90.0	8.5990	0.5231	3.4380	36.6524	7.562e+00	4.880e+00	4.737e+00	6.203e+00	1.974e+01	7.156e+00	1.348e+01	8.219e+00
0.9154	90.0	8.6841	0.5258	3.8355	38.8003	9.069e+00	5.543e+00	5.354e+00	6.542e+00	2.577e+01	9.241e+00	1.624e+01	9.451e+00
0.9353	90.0	8.8322	0.5238	4.3563	41.2814	1.127e+01	6.445e+00	6.172e+00	7.003e+00	3.537e+01	1.246e+01	2.042e+01	1.120e+01
0.9552	90.0	9.0560	0.5187	5.0921	44.2182	1.464e+01	7.674e+00	7.249e+00	7.585e+00	5.215e+01	1.788e+01	2.715e+01	1.382e+01
0.9651	90.0	9.1893	0.5171	5.5482	45.9918	1.712e+01	8.519e+00	7.963e+00	7.969e+00	6.563e+01	2.200e+01	3.220e+01	1.556e+01
0.9751	90.0	9.3861	0.5131	6.1746	47.9389	1.853e+01	9.539e+00	9.359e+00	8.390e+00	8.624e+01	2.828e+01	3.954e+01	1.813e+01
0.9801	90.0	9.5260	0.5087	6.5881	49.0083	2.032e+01	1.013e+01	9.918e+00	8.638e+00	1.010e+02	3.284e+01	4.465e+01	1.998e+01
0.9851	90.0	9.6777	0.5052	7.0458	50.1462	2.254e+01	1.086e+01	1.058e+01	8.925e+00	1.200e+02	3.846e+01	5.093e+01	2.208e+01

Figure 2.2: Non-linear bearing characteristic

3. Shaft Output via SIF

A flexible format for importing shafts can be defined in a so called SIF file. SIF stands for **S**haft **I**nterface **F**ile. The same interface file can now be used to export a shaft to a text file. The context menu of the shaft GUI, which is opened by a right mouse click, now has the additional items “Export with SIF” and “Export with default SIF” (see figure 3.1). The first item asks for a SIF file, in case of the second item the default SIF file stored in the preferences folder is used. The SIF MATLAB mat files must be created beforehand from a SIF text file (same procedure as for the import).

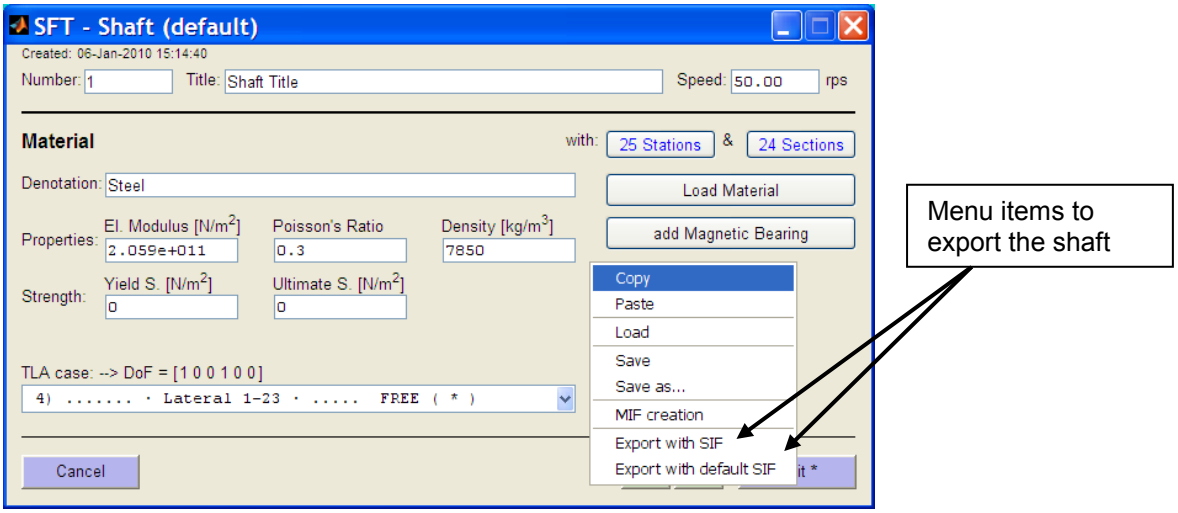


Figure 3.1: Shaft GUI with the context menu and two new items for the export via SIF

The SIF text file and exported shaft text file of the demonstration example on the MADYN 2000 CD in the folder “Shaft_Input_w_EXCEL” are shown on the following page.

SIF text file from which a SIF mat file must be created:

```
Shaft

Conical Length  IDsb    IDmb    IDst    ODsb    ODmb    ODst    M       Thetap  Thetae  Centre  addmass addinertiap     addinertiab     Temperature  Denotation

-       MM      MM      MM      MM      MM      MM      MM      KG      KG_M^2  KG_M^2  MM      KG/M    KG_M^2/M        KG_M^2/M        C               -

1       1       1       1       1       1       1       1       1       1       1       1       1               1               1               1

SFT
```

Exported text file of the shaft model:

```
Shaft Title
* #   Conical  Length  IDsb  IDmb  IDst   ODsb   ODmb   ODst     M    Thetap    Thetae  Centre  addmass  addinertiap  addinertiab  Temperature Denotation
*          [-]    [mm]  [mm]  [mm]  [mm]   [mm]   [mm]   [mm]  [kg]  [kg m^2]  [kg m^2]    [mm]    [kg/m]  [kg m^2/m]  [kg m^2/m]          [C] [-]
    1        0   166.7     0     0     0    130    130    130     0         0         0       0       0            0            0          40 ''
    2        0    23.3     0     0     0    130    130    130     0         0         0       0       0            0            0          40 ''
    3        0      60     0     0     0    130    130    130     0         0         0       0       0            0            0          40 'Coupling connection'
    4        0   200.5     0     0     0    140    140    140     0         0         0       0       0            0            0          40 ''
    5        0      15     0     0     0    156    156    156     0         0         0       0       0            0            0          40 ''
    6        0      45     0     0     0  172.5  172.5  172.5     0         0         0       0       0            0            0          40 ''
    7        0    44.5     0     0     0  172.5  172.5  172.5     0         0         0       0       0            0            0          40 'DE bearing'
    8        0      73     0     0     0    200    200    200     0         0         0       0       0            0            0          40 ''
    9        0   226.4     0     0     0  247.4  247.4  247.4    50         3       1.5    -100    1500          150           75          40 'End windings'
   10        0   205.1     0     0     0  247.4  247.4  247.4     0         0         0       0    1500          150           75          40 ''
   11        0   205.1     0     0     0  247.4  247.4  247.4     0         0         0       0    1500          150           75          40 ''
   12        0   205.1     0     0     0  247.4  247.4  247.4     0         0         0       0    1500          150           75          40 'Centre of lamination'
   13        0   205.1     0     0     0  247.4  247.4  247.4     0         0         0       0    1500          150           75          40 ''
   14        0   226.4     0     0     0  247.4  247.4  247.4     0         0         0       0    1500          150           75          40 ''
   15        0     147    30    30    30    200    200    200    50         3       1.5     100       0            0            0          40 'End windings'
   16        0      50    30    30    30  172.5  172.5  172.5     0         0         0       0       0            0            0          40 ''
   17        0      82    30    30    30    149    149    149     0         0         0       0       0            0            0          40 ''
   18        0   136.5    30    30    30    149    149    149     0         0         0       0       0            0            0          40 ''
   19        0      60    30    30    30    149    149    149     0         0         0       0       0            0            0          40 ''
   20        0      32    30    30    30    149    149    149     0         0         0       0       0            0            0          40 ''
   21        0      44    30    30    30    131    131    131     0         0         0       0       0            0            0          40 ''
   22        0      44    30    30    30    131    131    131     0         0         0       0       0            0            0          40 'NDE bearing'
   23        1     140    30    30    30    131    131    131     0         0         0       0       0            0            0          40 ''
   23        1       0    30    30    30    120    120    120     0         0         0       0       0            0            0          40 ''
   24        0      84    30    30    30     90     90     90     0         0         0       0       0            0            0          40 ''
```

4. Magnetic Bearing Sensitivity MBS

This type of harmonic response analysis allows checking the magnetic bearing sensitivity according to ISO 14839-3. The analysis is defined by a new type of load called “Magnetic Bearing Sensitivity”. Figure 4.1 shows how to open the load GUI from the system explorer. The load GUI itself is shown in figure 4.2. The MBS load GUI contains a list of all actuators of the system and their directions for selection to calculate the sensitivity.

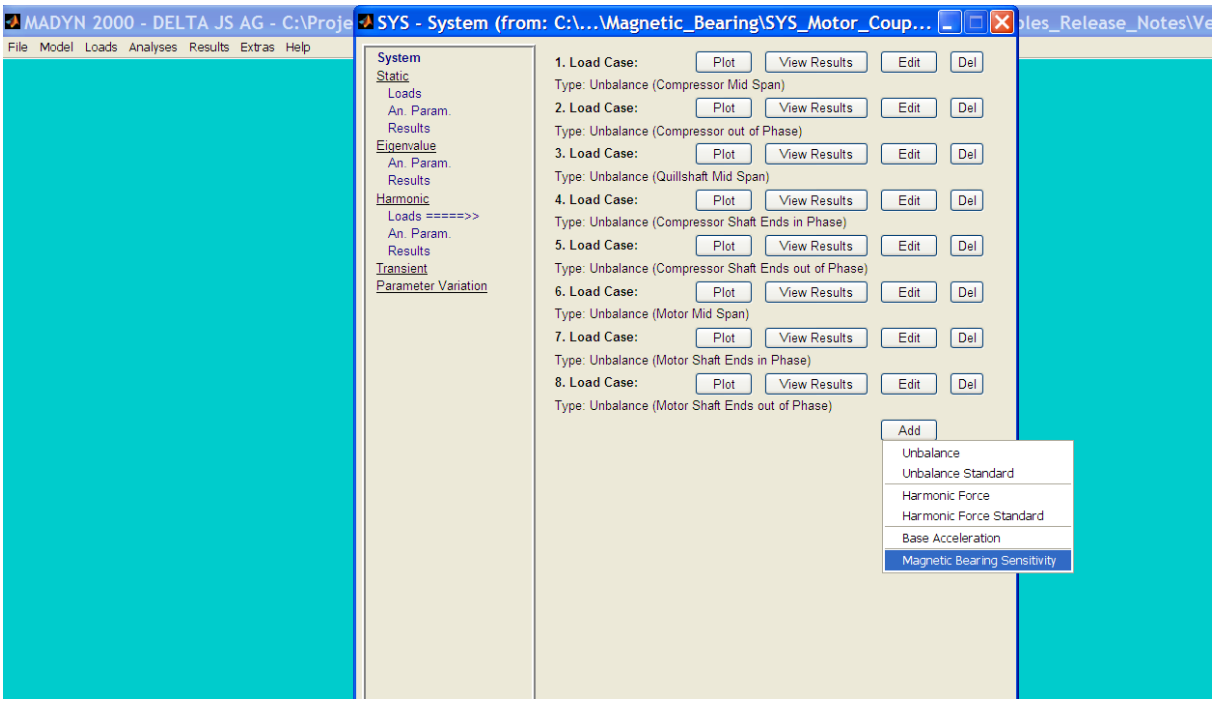


Figure 4.1: Opening the load GUI for MBS

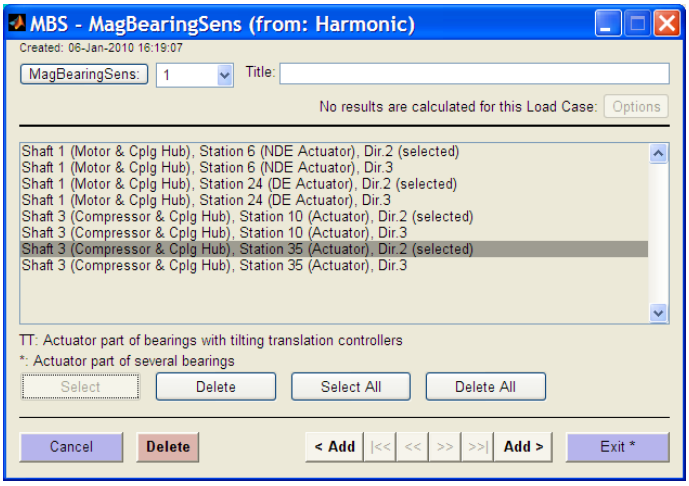


Figure 4.2: MBS load GUI

The analysis GUI is shown in figure 4.3. It now contains a check box for the new analysis type “Magnetic Bearing Sensitivity”. Other parameters are similar to the harmonic force response analysis HAF.

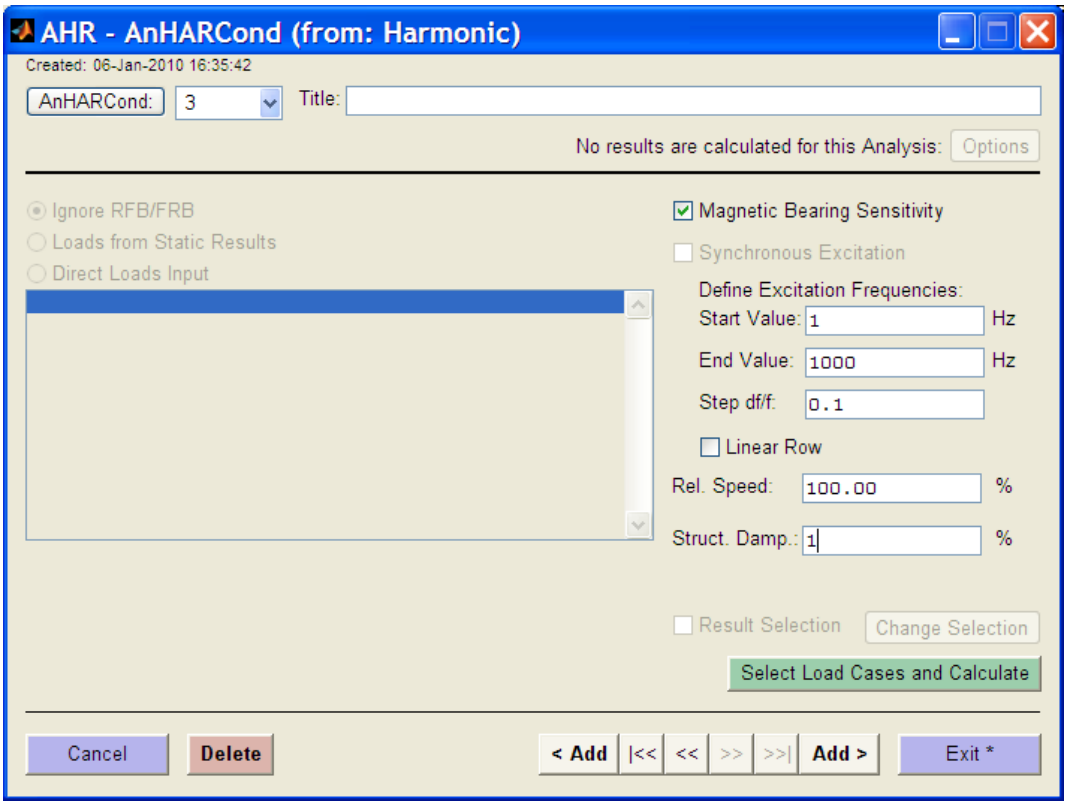


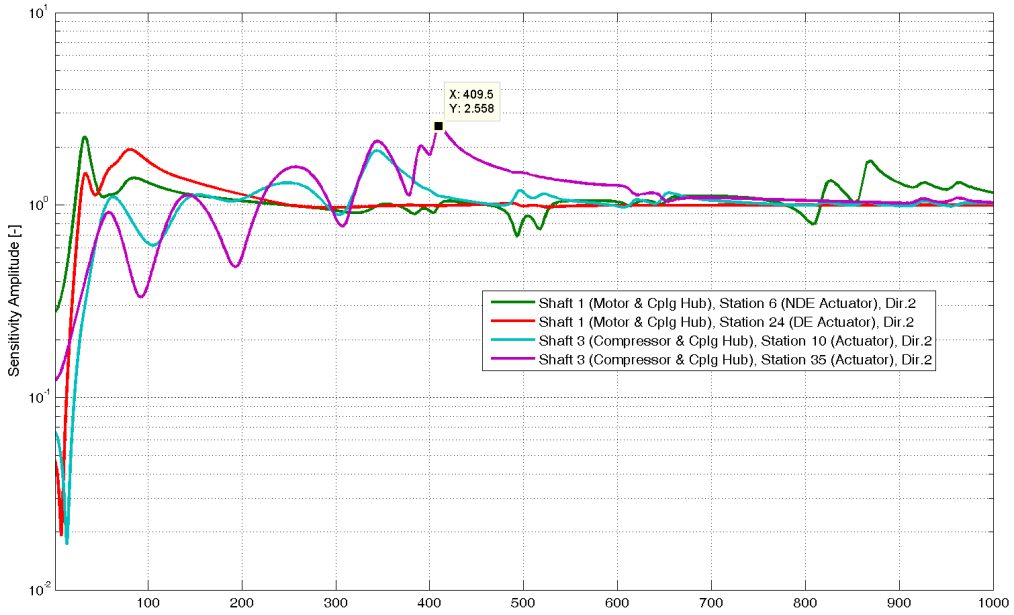
Figure 4.3:Harmonic response analysis GUI

The result of the magnetic bearing sensitivity analysis is a transfer function. The sensitivities of all actuators of the magnetic bearing demonstration example are shown in figure 4.4. According to ISO 14839-3 the allowable level for newly commissioned machines is less than 3, which is fulfilled in the current case. For more details see the latest MADYN 2000 documentation and the ISO standard /2/.

Motor Coupling Compressor

Harmonic Response Analysis
Load case: MagBearingSens
Analysis: 06-Jan-2010 16:43:06 - 1387 exc.freq(s)
Result Type: Magnetic Bearing Sensitivity

Struct. Damping: 1 %
Relative Speed: 1.000



MADYN 2000 Version 3.4 06-Jan-2010

Figure 4.4: Magnetic bearing sensitivities

5. Licence Borrowing

Licences can be borrowed to another computer. For the borrowing computer the following requirements must be fulfilled:

- MADYN 2000 must be installed.
- The computer must have a licence for zero users. This licence must be requested from DELTA JS.

To borrow a licence a special program must be started from the WINDOWS start menu (see the following figure) on the lending computer.

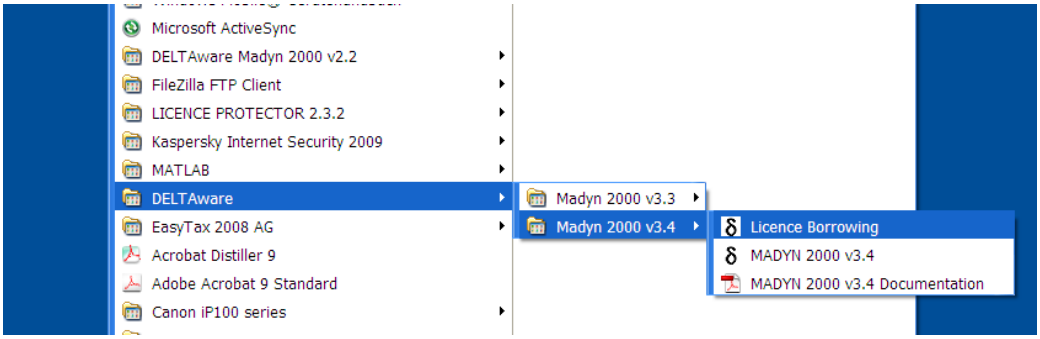


Figure 5.1: Starting the licence borrowing program

The lending computer must have a normal single PC licence or a concurrent licence. Moreover it must have all access rights to the licence file on the borrowing computer. The window of the licence borrowing program with two panes for the lending and borrowing computer is shown in figure 5.2. When transferring a licence, the number of licences on the lending computer is reduced by one. When transferring the licence back it is added again. Please refer to the latest MADYN 2000 documentation for more details.

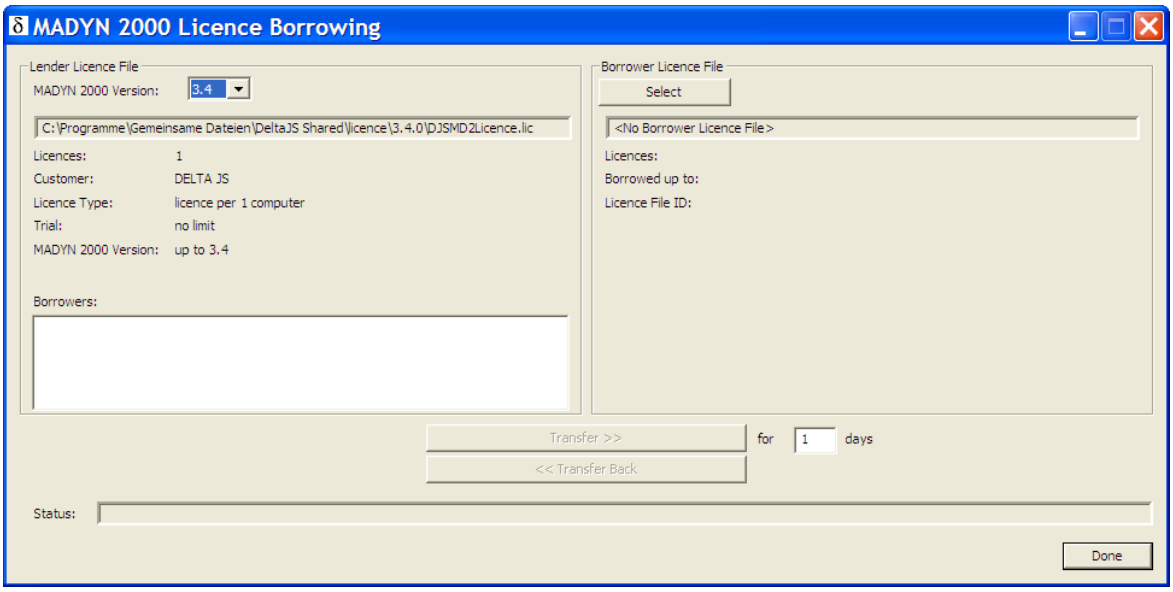


Figure 5.2: Window of the licence borrowing program

6. References

/1/ Andreas Fuchs: Schnelllaufende Radialgleitlagerungen im instationären Betrieb, Dissertation TU Braunschweig und FVV Bericht Frankfurt, 2002.

/2/ ISO Standard 14839-3: Mechanical vibration – Vibration of rotating machinery equipped with active magnetic bearings – Part 3: Evaluation of stability margin