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<<DyRoBeS - RotorBal>> Help Index

Influence coefficient method is used in the balancing calculation. The theory is based on two papers:

1. Tessarzik, J. M., Badgley, R. H., and Anderson, W. J., 1972, Flexible Rotor Balancing by the Exact Point-Speed Influence Coefficient Method, ASME Journal of Engineering for Industry, Feb., 1972, pp 148-158.
2. Lund, J. W. and Tonnesen, J., 1972, Analysis and Experiments on Multi-Plane Balancing of a Flexible Rotor, ASME Journal of Engineering for Industry, Feb., 1972, pp 233-242.

Since the least square method is used to solve the simultaneous equations, the Number of Measured Probes times the Number of Speed Points must be greater than or equal to the Number of Balancing Planes. (NsXNm >= Nb).

To use the influence coefficient method, no prior knowledge in rotor mode is required. However, trial weights are required to obtain the influence coefficients.

All the inputs are self-explanatory. They are briefly described below:

1. Number of Balancing Planes: Nb

The balancing planes are the planes along the rotor where the trial weights and balancing corrections are applied. Note that the trial weight can be **left-in** or **removed** after the trial run.

2. Number of Measured Probes: Nm

The measurement probes are where the vibrations are taken and recorded. The purpose of the balancing is to find the optimal balancing corrections at the balancing planes such that the vibrations at the measurement probes are minimized.

3. Number of Speeds/Cases: Ns

The number of speeds or cases allows for different speeds or cases, such as idle speed, full speed, full load, unloads, etc…

4. Runout Compensation

Runout can be included or excluded in this balancing calculation.

5. Comments

Up to 3 comment lines can be used to describe the system under study.

6. Graphic Data

The following graphic data are used for the graphic purposes which do not affect the calculation results. These data can be changed in the postprocessor if necessary.

6.1. Shaft Rotation: CCW or CW

6.2. Phase: Lag or Lead

Phase Lag indicates that the phase angle increases against the shaft rotation direction, and Phase Lead indicates that the phase angle increases with the shaft rotation direction.

6.3. 0 degree: Up or Right.

0 degree position defines the reference mark where all the angles (phases) are measured from.

6.4. Number of Balancing Holes

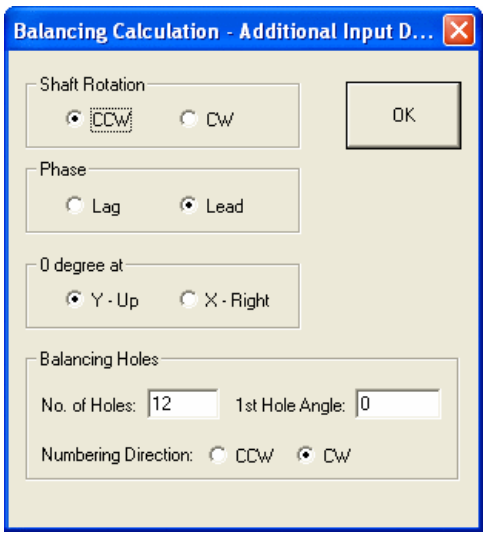
To be used if the balance weight is to be divided into two holes.

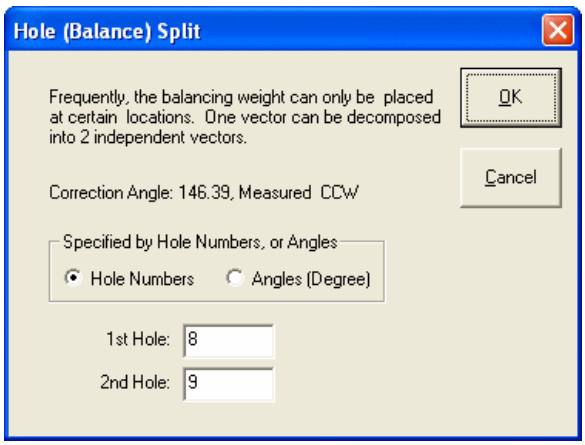
6.5 1st Hole Angle

Phase angle of the first hole from the zero degree position. Measured according to Phase Lag or Phase Lead in 6.2.

6.6 Number Direction

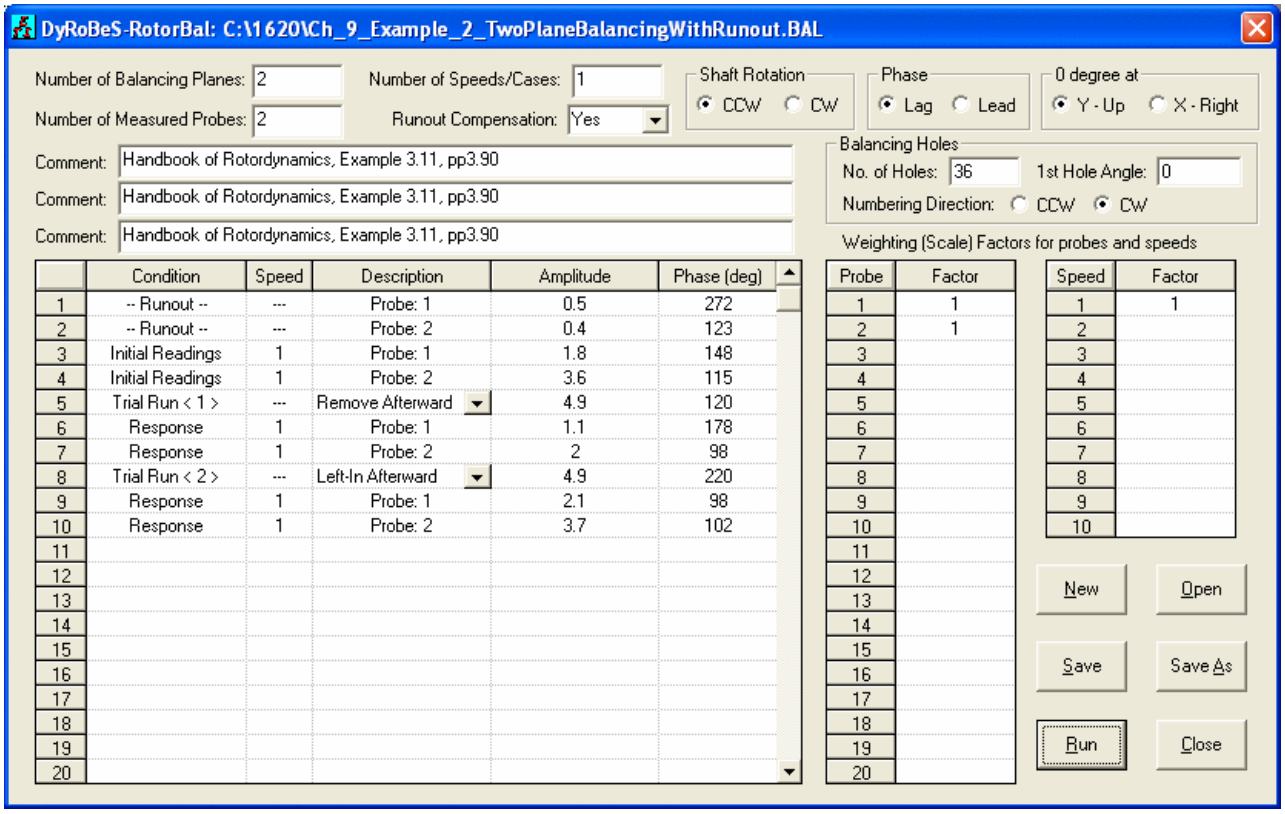
The hole numbering direction can be either CCW or CW.

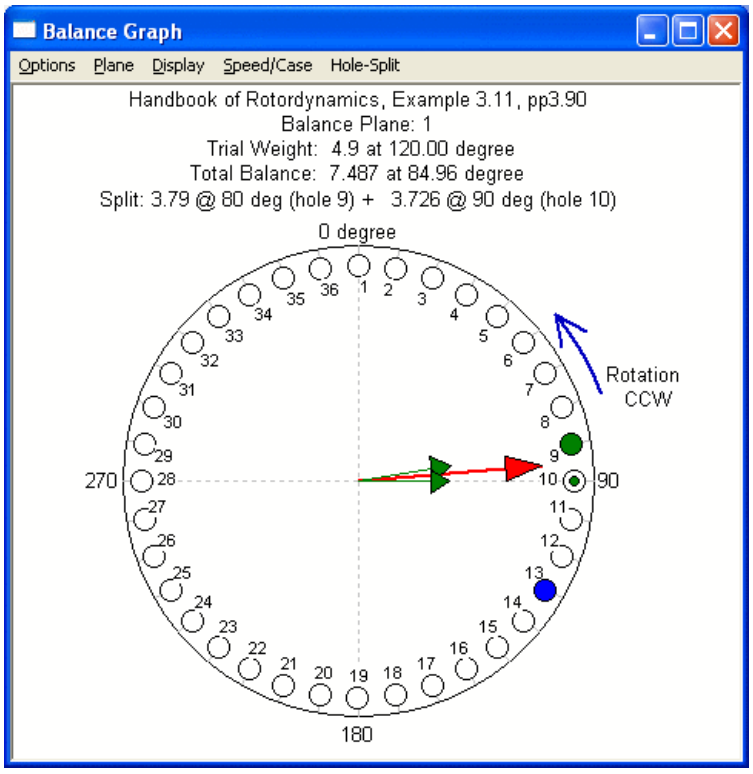


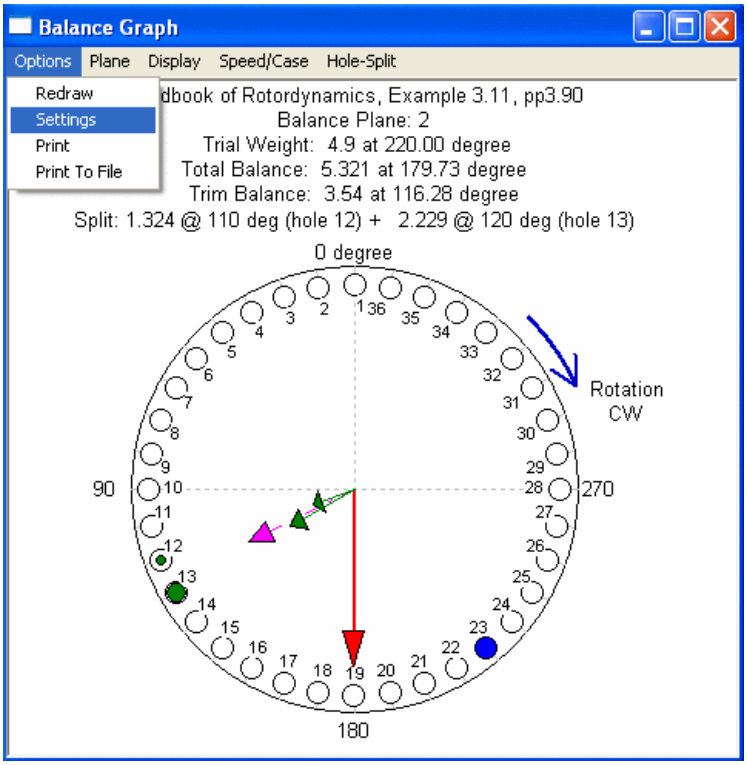


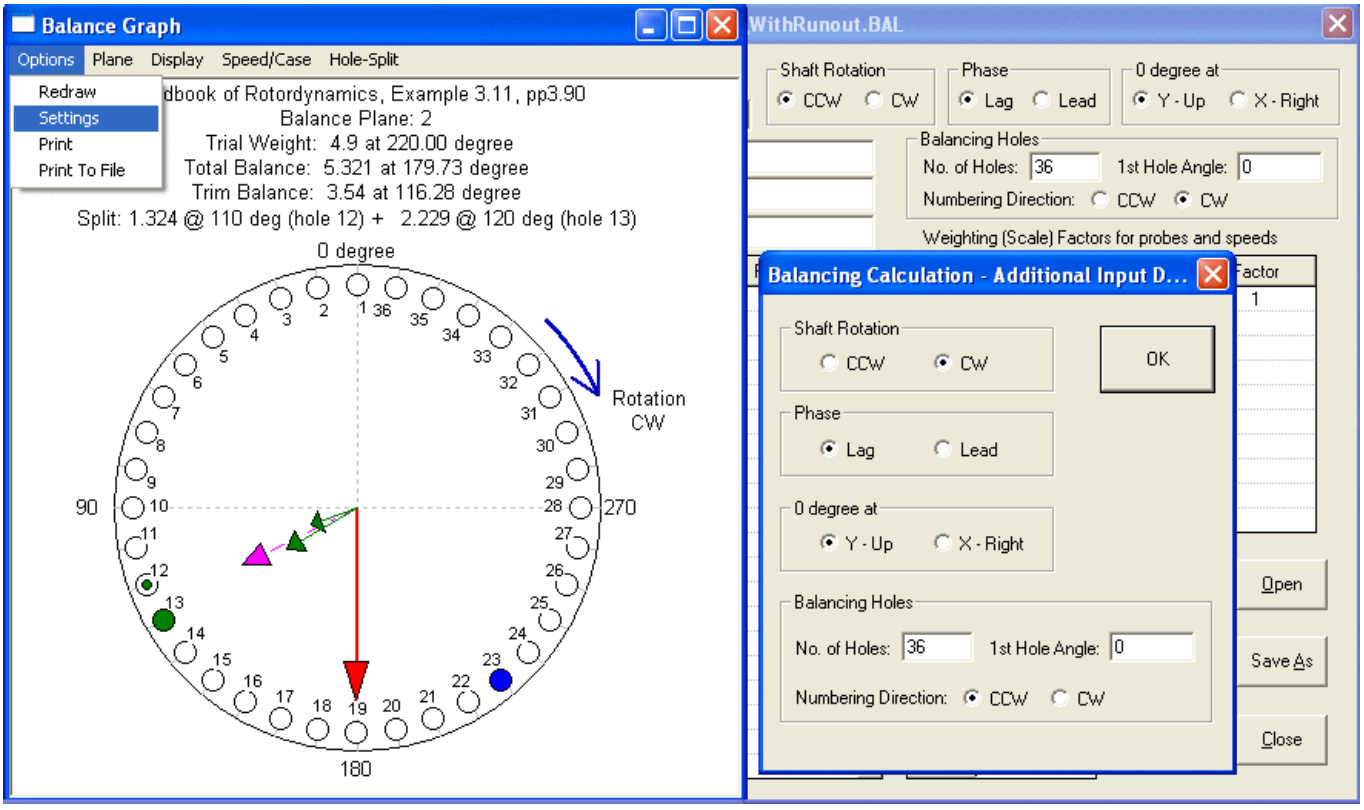
7. Weighting Factors

Weighting factor allows one to strengthen or weaken the data from the measurement probes or speeds. For example, one may use higher weighting factors for the probes where the critical components are located and/or speeds where the rotor will be operated most of the time. Weighting factor zero indicates that the specific probe data will not be included in the calculation.


DyRoBeS-RotorBal: C:\1620\Ch_9_Example_2_TwoPlaneBalancingWithRunout.BAL
Number of Balancing Planes: 2
Number of Speeds/Cases: 1
Number of Measured Probes: 2
Runout Compensation: Yes
Shaft Rotation CCW CW
Phase Lag Lead
0 degree at Y - Up X - Right
Comment: Handbook of Rotordynamics, Example 3.11, pp3.90
Comment: Handbook of Rotordynamics, Example 3.11, pp3.90
Comment: Handbook of Rotordynamics, Example 3.11, pp3.90
Balancing Holes
No. of Holes: 36
1st Hole Angle: 0
Numbering Direction: CCW CW
Weighting (Scale) Factors for probes and speeds
Condition Speed Description Amplitude Phase (deg)
1 -- Runout -- --- Probe: 1 0.5 272
2 -- Runout -- --- Probe: 2 0.4 123
3 Initial Readings 1 Probe: 1 1.8 148
4 Initial Readings 1 Probe: 2 3.6 115
5 Trial Run < 1 > --- Remove Afterward 4.9 120
6 Response 1 Probe: 1 1.1 178
7 Response 1 Probe: 2 2 98
8 Trial Run < 2 > --- Left-In Afterward 4.9 220
9 Response 1 Probe: 1 2.1 98
10 Response 1 Probe: 2 3.7 102
Probe Factor
1 1
2 1
Speed Factor
1 1
New
Open
Save
Save As
Run
Close


Balance Graph
Options Plane Display Speed/Case Hole-Split
Handbook of Rotordynamics, Example 3.11, pp3.90
Balance Plane: 1
Trial Weight: 4.9 at 120.00 degree
Total Balance: 7.487 at 84.96 degree
Split: 3.79 @ 80 deg (hole 9) + 3.726 @ 90 deg (hole 10)
0 degree
Rotation CCW
90
180
270





8. PostProcessor Graphic Data

The following graphic data are used for the graphic purposes which do not affect the calculation results. These data can be changed in the postprocessor if necessary.

8.1. Shaft Rotation: CCW or CW

8.2. Phase: Lag or Lead

Phase Lag indicates that the phase angle increases against the shaft rotation direction, and Phase Lead indicates that the phase angle increases with the shaft rotation direction.

8.3. 0 degree: Up or Right.

0 degree position defines the reference mark where all the angles (phases) are measured from.

8.4. Number of Balancing Holes

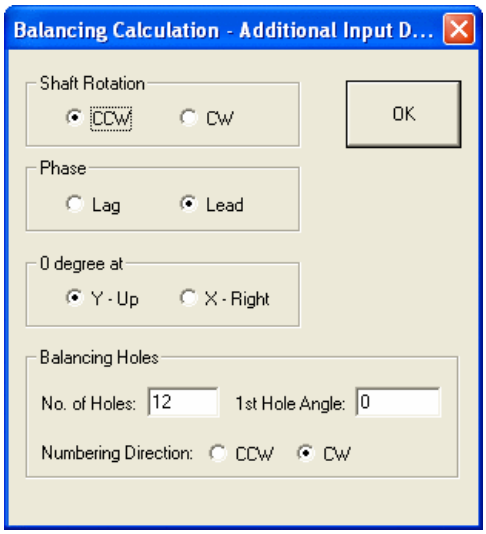
To be used if the balance weight is to be divided into two holes. Any vector can be decomposed into two independent vectors.

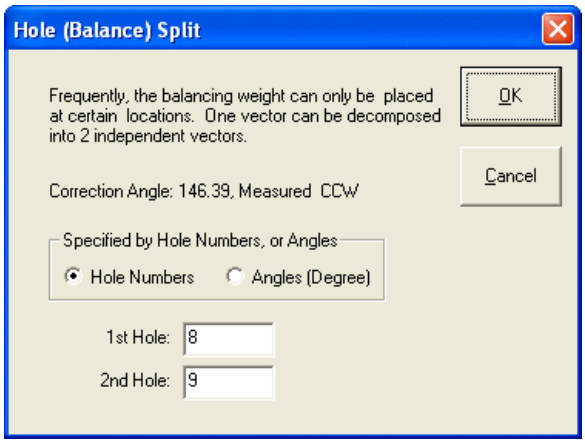
8.5 1st Hole Angle

Phase angle of the first hole from the zero degree position. Measured according to Phase Lag or Phase Lead in 6.2.

8.6 Number Direction

The hole numbering direction can be either CCW or CW.





Example 1:

DyRoBeS_RotorBal - Input Data

Number of Balancing Planes: 2 Number of Speeds/Cases: 1

Number of Measured Probes: 2 Runout Compensation: Yes

Shaft Rotation: (•) CCW ( ) CW

Phase: (•) Lag ( ) Lead

Comment: Handbook of Rotordynamics, Example 3.11, pp3.90

Comment: Runout compensation is included

Comment: The first trial weight is removed afterward, 2nd trial weight is left-in

0 degree at: (•) Y - Up ( ) X - Right

	Condition	Speed	Description	Amplitude	Phase (deg)
1	-- Runout --	---	Probe: 1	0.5	272
2	-- Runout --	---	Probe: 2	0.4	123
3	Initial Readings	1	Probe: 1	1.8	148
4	Initial Readings	1	Probe: 2	3.6	115
5	Trial Run < 1 >	---	Remove Afterward	4.9	120
6	Response	1	Probe: 1	1.1	178
7	Response	1	Probe: 2	2	98
8	Trial Run < 2 >	---	Left-In Afterward	4.9	220
9	Response	1	Probe: 1	2.1	98
10	Response	1	Probe: 2	3.7	102
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Weighting (Scale) Factors for probes and speeds

Probe	Factor
1	1
2	1
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

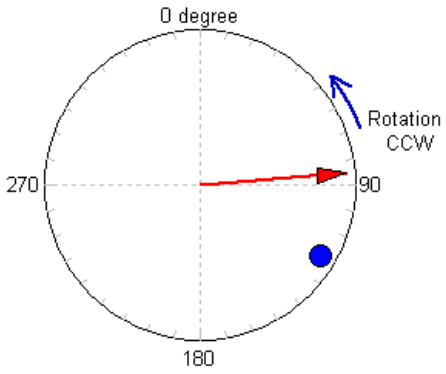
Speed	Factor
1	1
2	1
3	1
4	1
5	1
6	1
7	
8	
9	
10	

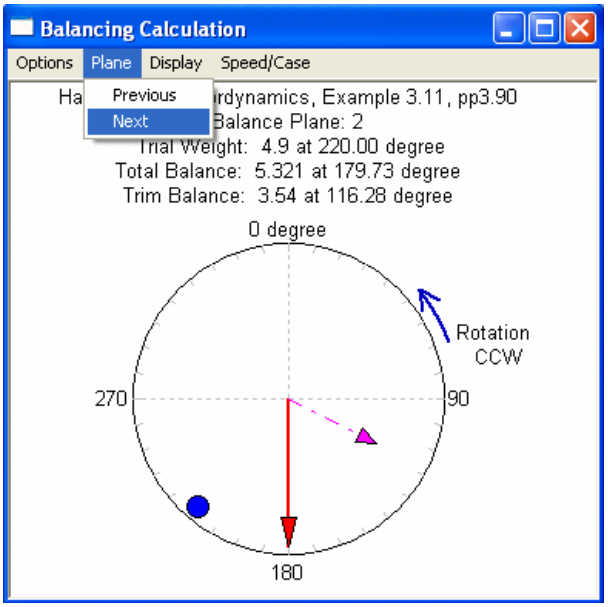
New Open Save Save As Run Close

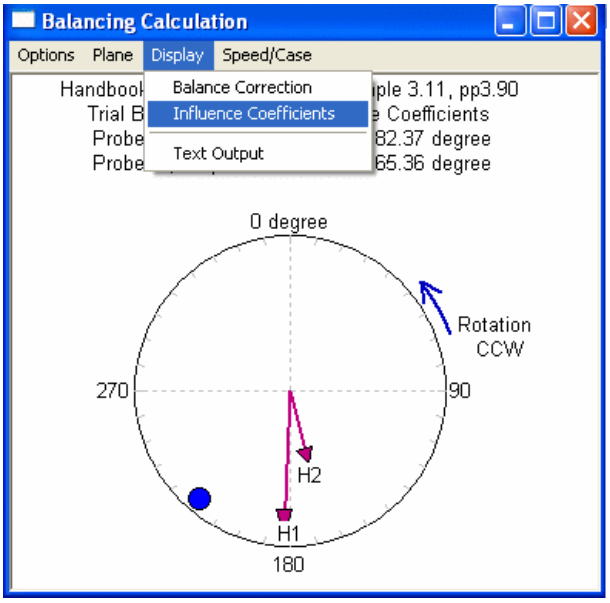
Balancing Calculation

Options Plane Display Speed/Case

Handbook of Rotordynamics, Example 3.11, pp3.90
Balance Plane: 1
Trial Weight: 4.9 at 120.00 degree
Total Balance: 7.487 at 84.96 degree



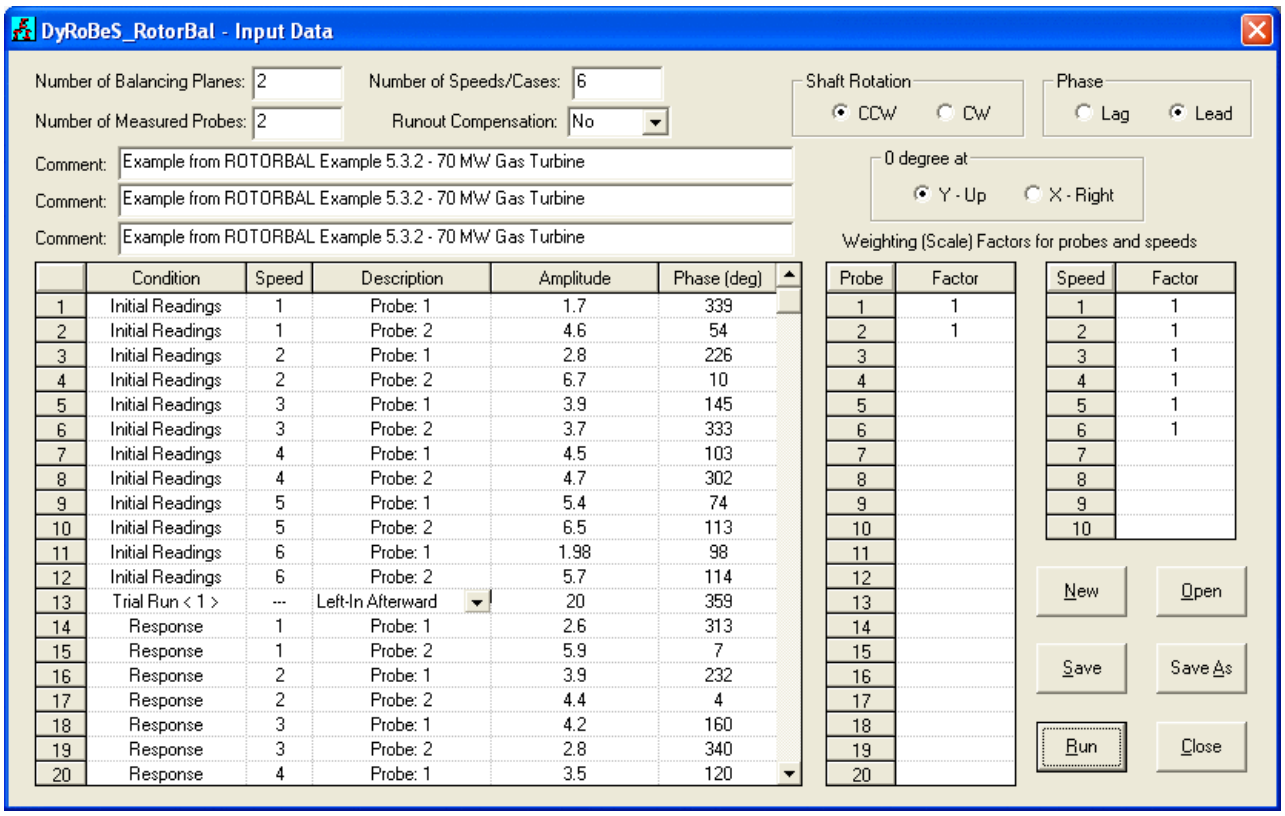


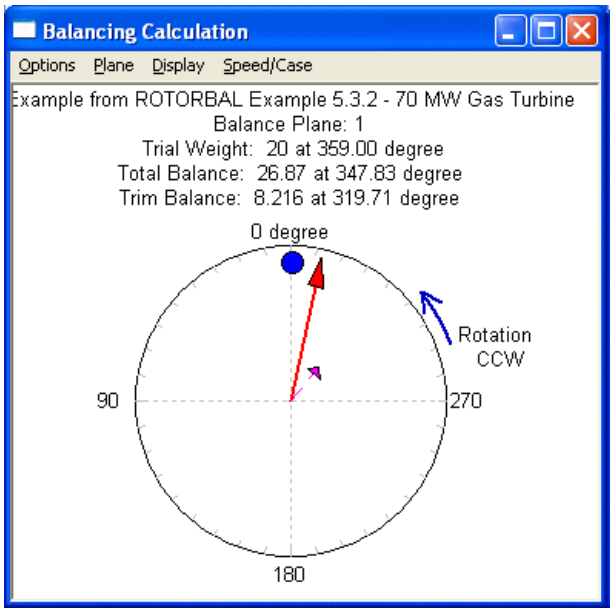


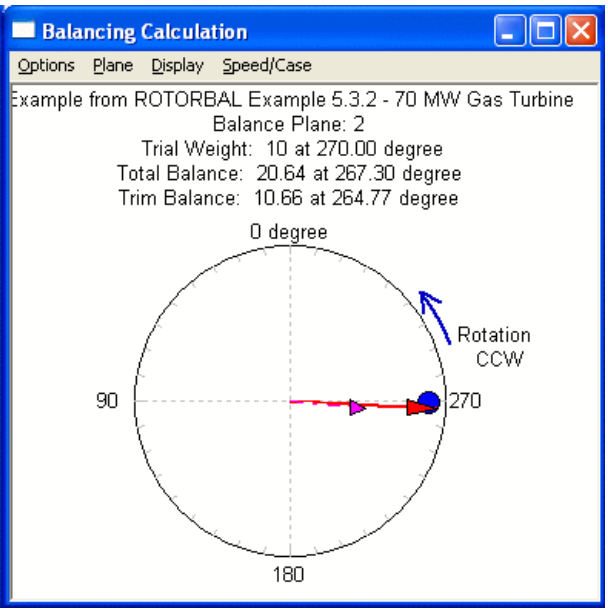

```
Handbook of Rotordynamics Example 3.11, pp 3.90
Runout Compensation is included
The first trial weight is removed afterward, 2nd trial weight is left-in

   *****  Number of Speeds or Cases   :   1
   *****  Number of Balancing Planes  :   2
   *****  Number of Measurement Probes:   2

   *****  Runout (slow-roll vectors)  *****
      Probe      Amplitude     Phase Angle
        1         0.50000         272.00
        2         0.40000         123.00

   ======  Initial Response (Without Trails)  ======
      Speed    Probe      Amplitude     Phase Angle
        1        1          1.8000         148.00
        1        2          3.6000         115.00

   **************  Trial Unbalance Run: 1  **************
      Plane      Amplitude     Phase Angle   Afterward
        1          4.9000         120.00      Remove

   ---------  Response to Trial Unbalance  ---------
      Speed    Probe      Amplitude     Phase Angle
        1        1          1.1000         178.00
        1        2          2.0000         98.000
```

```
**************  Trial Unbalance Run: 2  **************
   Plane      Amplitude     Phase Angle   Afterward
     2          4.9000         220.00      Left-In

---------  Response to Trial Unbalance  ---------
   Speed   Probe      Amplitude     Phase Angle
     1       1          2.1000         98.000
     1       2          3.7000         102.00

***  Weighting Factors for probes and speeds ***
     Probe     Weighting Factor
       1            1.0000
       2            1.0000

     Speed     Weighting Factor
       1            1.0000

================================================
<<<<<<<<  Total Balance Correction  >>>>>>>>
  Correction Required to Balance the Rotor
   Plane No.    Amplitude     Phase Angle
      1          7.4873         84.957
      2          5.3209         179.73


<<<<<<<<<<  Trim Balance Correction  >>>>>>>>>>
  Correction Required if Trial Weight Left-in
  Trim Balance = Total Balance - Trial Weight
   Plane No.    Amplitude     Phase Angle
      2          3.5402         116.28
================================================
________________________________________________

**********  The Influence Coefficients  ***********
                              Influence Coef.
  Trial-Run  Speed  Probe   Amplitude    Phase
      1        1      1      0.20617      175.
      1        1      2      0.36446      194.
      2        1      1      0.34092      182.
      2        1      2      0.16986      165.
________________________________________________

====================  Predicted Residual Response ========================
                    ----- WithOUT Runout -----    ------ With Runout ------
 Speed   Probe      Amplitude      Phase Angle    Amplitude     Phase Angle
   1       1          0.0000         0.0000        0.50000        272.00
   1       2          0.0000         0.0000        0.40000        123.00
=========================================================================
```

Example 2:








```
Example from ROTORBAL Example 5.3.2 - 70 MW Gas Turbine
2 probes at 6 speeds
No runout

   *****  Number of Speeds or Cases   :   6
   *****  Number of Balancing Planes  :   2
   *****  Number of Measurement Probes:   2

   *****  NO Runout Compensation

   ======  Initial Response (Without Trails)  ======
      Speed    Probe      Amplitude      Phase Angle
        1        1          1.7000         339.00
        1        2          4.6000         54.000
        2        1          2.8000         226.00
        2        2          6.7000         10.000
        3        1          3.9000         145.00
```

```
     3       2          3.7000         333.00
     4       1          4.5000         103.00
     4       2          4.7000         302.00
     5       1          5.4000         74.000
     5       2          6.5000         113.00
     6       1          1.9800         98.000
     6       2          5.7000         114.00

**************  Trial Unbalance Run: 1  **************
   Plane      Amplitude     Phase Angle   Afterward
     1          20.000         359.00      Left-In

---------  Response to Trial Unbalance  ---------
   Speed   Probe      Amplitude     Phase Angle
     1       1          2.6000         313.00
     1       2          5.9000         7.0000
     2       1          3.9000         232.00
     2       2          4.4000         4.0000
     3       1          4.2000         160.00
     3       2          2.8000         340.00
     4       1          3.5000         120.00
     4       2          5.4000         325.00
     5       1          4.1000         73.000
     5       2          3.7000         97.000
     6       1          1.5000         141.00
     6       2          3.1000         99.000

**************  Trial Unbalance Run: 2  **************
   Plane      Amplitude     Phase Angle   Afterward
     2          10.000         270.00      Left-In

---------  Response to Trial Unbalance  ---------
   Speed   Probe      Amplitude     Phase Angle
     1       1          1.8000         319.00
     1       2          4.3000         15.000
     2       1          3.1000         244.00
     2       2          3.4000         9.0000
     3       1          3.2000         107.00
     3       2          1.9000         329.00
     4       1          2.4000         122.00
     4       2          4.4000         330.00
     5       1          2.4000         61.000
     5       2          3.5000         101.00
     6       1          1.0200         170.00
     6       2          3.1100         104.00

***  Weighting Factors for probes and speeds ***
     Probe     Weighting Factor
       1            1.0000
       2            1.0000

     Speed     Weighting Factor
       1            1.0000
       2            1.0000
       3            1.0000
       4            1.0000
       5            1.0000
       6            1.0000

================================================
<<<<<<<<  Total Balance Correction  >>>>>>>>
  Correction Required to Balance the Rotor
   Plane No.    Amplitude     Phase Angle
      1          26.867         347.83
      2          20.639         267.30


<<<<<<<<<<  Trim Balance Correction  >>>>>>>>>>
  Correction Required if Trial Weight Left-in
  Trim Balance = Total Balance - Trial Weight
   Plane No.    Amplitude     Phase Angle
      1          8.2159         319.71
      2          10.660         264.77
================================================
```

********** The Influence Coefficients **********

Trial-Run	Speed	Probe	Influence Coef. Amplitude	Phase
1	1	1	0.65281E-01	279.
1	1	2	0.21766	317.
1	2	1	0.57655E-01	248.
1	2	2	0.11846	202.
1	3	1	0.54915E-01	228.
1	3	2	0.49103E-01	134.
1	4	1	0.77078E-01	242.
1	4	2	0.10636	26.
1	5	1	0.65130E-01	258.
1	5	2	0.15575	313.
1	6	1	0.67568E-01	230.
1	6	2	0.14110	312.
2	1	1	0.83143E-01	210.
2	1	2	0.17475	257.
2	2	1	0.10809	105.
2	2	2	0.10554	258.
2	3	1	0.34210	118.
2	3	2	0.10027	271.
2	4	1	0.11046	26.
2	4	2	0.10867	214.
2	5	1	0.18221	359.
2	5	2	0.32108E-01	318.
2	6	1	0.78362E-01	12.
2	6	2	0.27106E-01	279.

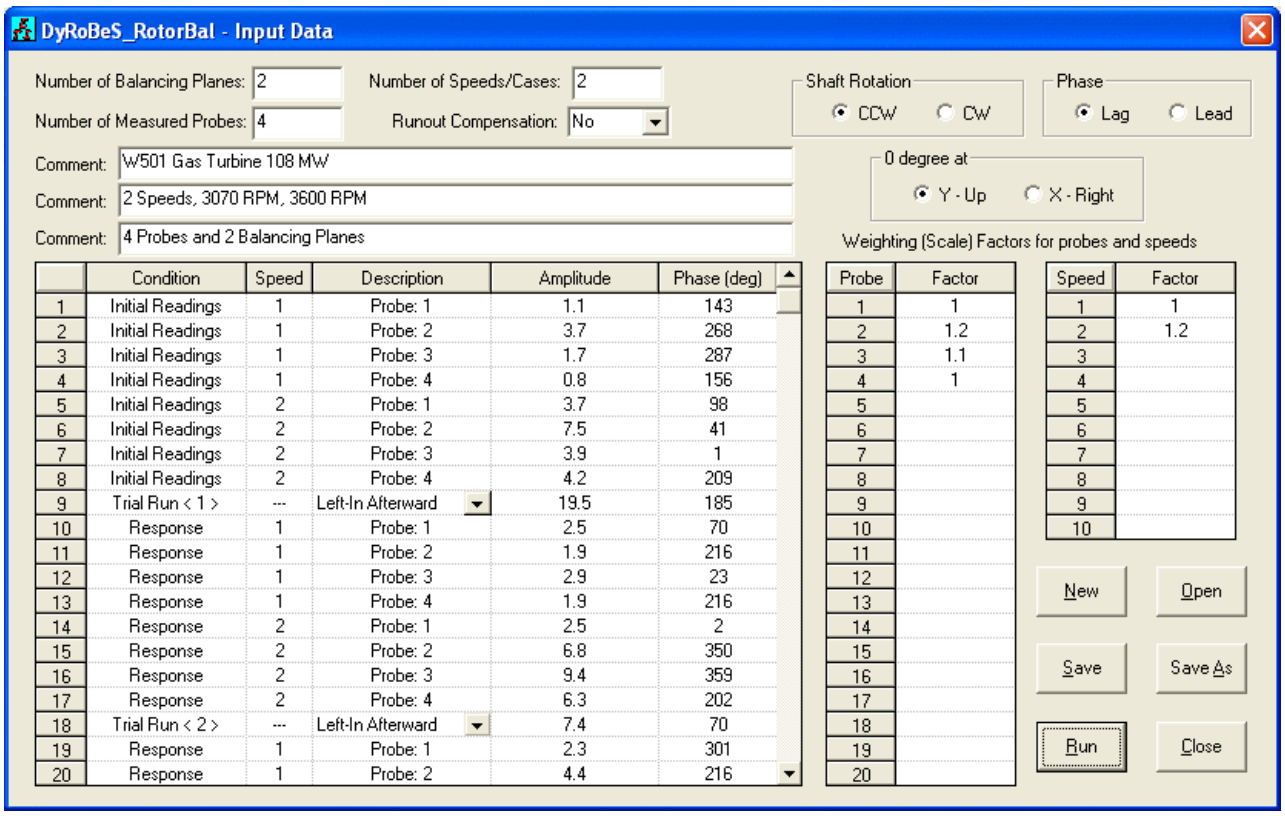
========== Predicted Residual Response ==========

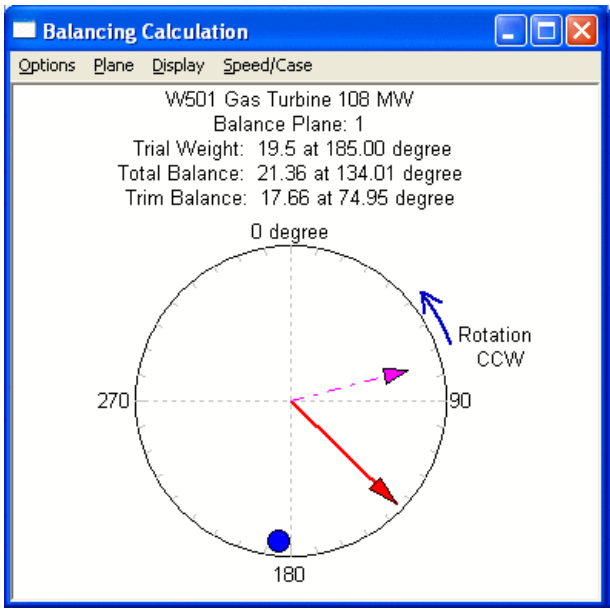
Speed	Probe	----- WithOUT Runout ----- Amplitude	Phase Angle	------ With Runout ------ Amplitude	Phase Angle
1	1	1.0968	310.43	1.0968	310.43
1	2	2.6067	358.29	2.6067	358.29
2	1	2.8744	257.03	2.8744	257.03
2	2	1.7963	40.778	1.7963	40.778
3	1	4.8509	66.019	4.8509	66.019
3	2	0.73525	317.09	0.73525	317.09
4	1	1.6051	154.41	1.6051	154.41
4	2	4.3282	341.01	4.3282	341.01
5	1	0.55031	343.11	0.55031	343.11
5	2	2.1098	114.00	2.1098	114.00
6	1	1.6347	207.09	1.6347	207.09
6	2	2.0997	118.93	2.0997	118.93

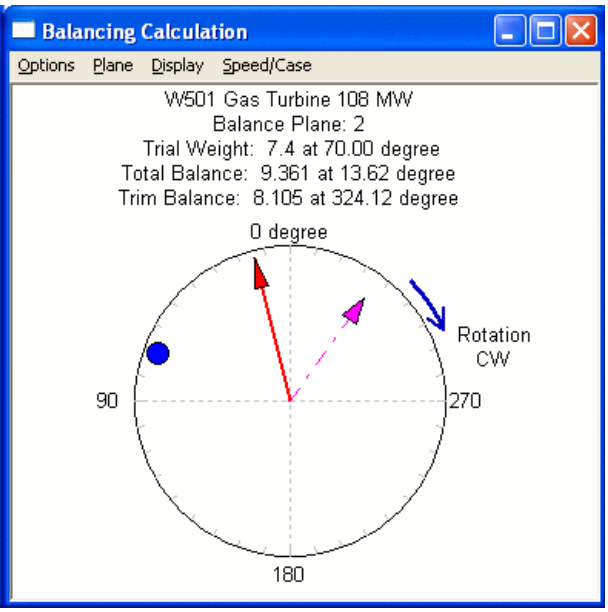
==========

==========

Example 3:








```
W501 Gas Turbine 108 MW
2 Speeds, 3070 RPM, 3600 RPM
4 Probes and 2 Balancing Planes

*****  Number of Speeds or Cases   :   2
*****  Number of Balancing Planes  :   2
*****  Number of Measurement Probes:   4

*****  NO Runout Compensation

======  Initial Response (Without Trails)  ======
   Speed    Probe      Amplitude     Phase Angle
     1        1          1.1000         143.00
     1        2          3.7000         268.00
     1        3          1.7000         287.00
     1        4         0.80000         156.00
     2        1          3.7000         98.000
```

```
     2       2          7.5000         41.000
     2       3          3.9000         1.0000
     2       4          4.2000         209.00

**************  Trial Unbalance Run: 1  **************
   Plane      Amplitude     Phase Angle   Afterward
     1          19.500         185.00      Left-In

---------  Response to Trial Unbalance  ---------
   Speed   Probe      Amplitude     Phase Angle
     1       1          2.5000         70.000
     1       2          1.9000         216.00
     1       3          2.9000         23.000
     1       4          1.9000         216.00
     2       1          2.5000         2.0000
     2       2          6.8000         350.00
     2       3          9.4000         359.00
     2       4          6.3000         202.00

**************  Trial Unbalance Run: 2  **************
   Plane      Amplitude     Phase Angle   Afterward
     2          7.4000         70.000      Left-In

---------  Response to Trial Unbalance  ---------
   Speed   Probe      Amplitude     Phase Angle
     1       1          2.3000         301.00
     1       2          4.4000         216.00
     1       3          2.5000         294.00
     1       4         0.80000         139.00
     2       1          1.7000         12.000
     2       2          5.6000         355.00
     2       3          5.3000         344.00
     2       4          3.8000         181.00

***  Weighting Factors for probes and speeds ***
     Probe     Weighting Factor
       1            1.0000
       2            1.2000
       3            1.1000
       4            1.0000

     Speed     Weighting Factor
       1            1.0000
       2            1.2000

================================================
<<<<<<<<  Total Balance Correction  >>>>>>>>
  Correction Required to Balance the Rotor
   Plane No.    Amplitude     Phase Angle
      1          21.356         134.01
      2          9.3609         13.616


<<<<<<<<<  Trim Balance Correction  >>>>>>>>>>
  Correction Required if Trial Weight Left-in
  Trim Balance = Total Balance - Trial Weight
   Plane No.    Amplitude     Phase Angle
      1          17.665         74.947
      2          8.1048         324.12
================================================

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**********  The Influence Coefficients  ***********
  -- Before application of Weighting Factors --
                              Influence Coef.
  Trial-Run  Speed  Probe   Amplitude    Phase
      1        1      1      0.12406      219.
      1        1      2      0.15077      294.
      1        1      3      0.18008      227.
      1        1      4      0.84732E-01   56.
      1        2      1      0.23984      125.
      1        2      2      0.31737       95.
      1        2      3      0.28226      173.
      1        2      4      0.11241        3.
      2        1      1      0.58558      204.
      2        1      2      0.33784      146.
```

2	1	3	0.51293	174.
2	1	4	0.25519	350.
2	2	1	0.11851	92.
2	2	2	0.17773	78.
2	2	3	0.60743	127.
2	2	4	0.41498	338.

Predicted Residual Response

		----- WithOUT Runout -----		------ With Runout ------	
Speed	Probe	Amplitude	Phase Angle	Amplitude	Phase Angle
1	1	3.9669	49.648	3.9669	49.648
1	2	1.9065	348.46	1.9065	348.46
1	3	2.2628	79.442	2.2628	79.442
1	4	0.22558	305.47	0.22558	305.47
2	1	1.8109	9.5156	1.8109	9.5156
2	2	1.8740	232.93	1.8740	232.93
2	3	3.3169	159.79	3.3169	159.79
2	4	1.8632	30.989	1.8632	30.989