



Model created in COMSOL Multiphysics 6.4

Comparison of Different Hydrodynamic Bearings

Introduction

This example compares the load-carrying abilities of several hydrodynamic journal bearings types. The simulation is performed using the Hydrodynamic Bearing interface, which solves the Reynolds equation to compute the pressure distribution in a thin fluid film. This example includes a cylindrical, elliptical, split halves, and various multilobe bearings.

Model Definition

In total, eight different bearings are compared. The journals rotate inside the bearings at a constant velocity of 2000 rpm, and their static equilibrium positions are determined under external loads in the range $W \in [10^2, 10^5]$ N.

The bearing types include *cylindrical*, *elliptical*, *split halves*, as well as various *multilobe* bearings. These are all categorized as *fixed-profile* bearings.

The bearing configurations analyzed in this model are shown in [Figure 1](#).

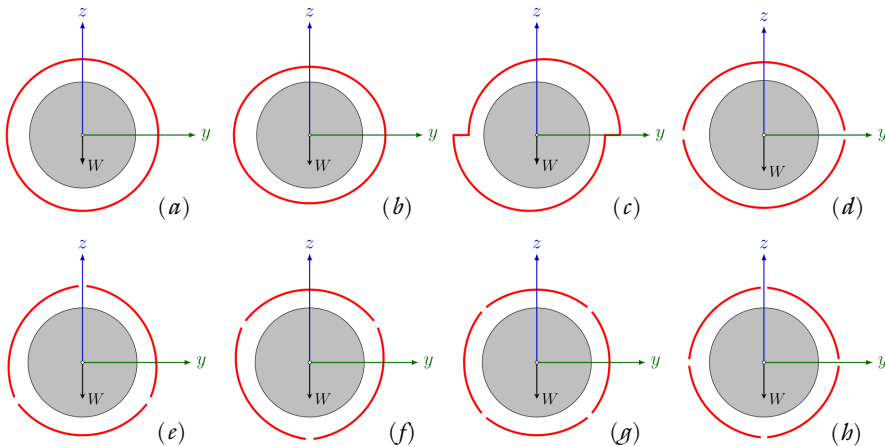


Figure 1: Modeled bearing configurations, (a) Cylindrical, (b) Elliptical, (c) Split halves, (d) 2-lobe, (e) 3-lobe (LOP), (f) 3-lobe (LBP), (g) 4-lobe (LOP), (h) 4-lobe (LBP).

The *cylindrical* bearing, also known as a *plain* bearing, is the most simple type of hydrodynamic journal bearing. It is characterized by its uniform initial film thickness, meaning the film thickness remains constant if the journal is concentric with the bearing.

The *elliptical* bearing has, as its name suggests, an elliptically shaped profile. This non-uniform profile preloads the bearing, which allows to generate a hydrodynamic pressure even when the journal is concentric with the bearing.

Another type of bearing that possesses this ability is the *split halves* bearing. This bearing type has a profile discontinuity caused by an offset between its upper and lower parts. The offset implies that the bearing is unidirectional.

The *multilobe* bearing comes in many distinct configurations. Commonly, these are assembled by a number of non-concentric *lobes* (sometimes referred to as *pads*). This example focuses on the two, three and four lobe configurations. Two distinct variations of the three and four lobe bearings will be considered, namely, the *load-on-pad* (LOP) and the *load-between-pad* (LBP) configuration. These configurations differ only in their orientation relative to the applied load direction.

FLUID PROPERTIES

The parameters needed for the computation are the dynamic viscosity, the density at cavitation pressure, and the compressibility. The fluid parameters used in this model are summarized in [Table 1](#). These resemble the fluid properties of a generic oil.

TABLE 1: FLUID PROPERTIES.

Property	value
Dynamic viscosity	72 mPa·s
Density	860 kg/m ³
Compressibility	2·10 ⁻⁸ Pa ⁻¹

BEARING DATA

All bearings, except for the cylindrical bearing, are preloaded so that their minimum and maximum initial film thickness are identical. This can be achieved by defining

$$C_{\min} = C_0 - d_0, \quad C_{\max} = C_0 + d_0, \quad d = \frac{C_0}{10} \quad (1)$$

where the clearance C_0 is selected as 200 μm .

Cylindrical

The initial film thickness in a cylindrical bearing is given by

$$h_b = C$$

where C is the constant clearance. The clearance is selected as $C = C_0$.

Elliptical

The initial film thickness in an elliptical bearing can be expressed as

$$h_b = C_{\min} + (C_{\max} - C_{\min}) \cos \theta$$

where C_{\min} and C_{\max} are minimum and maximum manufactured clearance, and θ is the circumferential coordinate relative to the local y direction. The minimum and maximum clearances are selected in accordance with [Equation 1](#).

Split Halves

The initial film thickness in a split halves bearing is given by

$$h_b = C + d \cos \theta \cdot \text{sign}(\sin \theta)$$

where C is the clearance in the non-preloaded configuration, and d is the preload. The preload is often expressed relative to the clearance. Here the non-preloaded clearance and the preload are selected as $C = C_0$ and $d = d_0$, respectively.

Multilobe

The initial clearance in a multilobe bearing is expressed as

$$h_b = C - d \cos(\theta - \alpha_m), \quad \alpha_m = \frac{\pi}{N} (1 + 2i)$$

where C is the clearance in the non-preloaded configuration, d is the preload, α_m is the mid-pad angle of the i th lobe, and N is the number of lobes. For this bearing type, the clearance and preload are selected as:

$$C = C_0 + d_0 \left(\frac{1 + \cos\left(\frac{\pi}{N}\right)}{1 - \cos\left(\frac{\pi}{N}\right)} \right), \quad d = \frac{2d_0}{1 - \cos\left(\frac{\pi}{N}\right)}$$

These expressions can be simplified for the two, three and four-lobe bearings. These are summarized in [table 2](#).

TABLE 2: CLEARANCE AND PRELOAD FOR MULTILOBE BEARINGS.

Number of lobes, N	Clearance, C	Preload, d
2	$C_0 + d_0$	$2d_0$

bearing center as the applied load decreases to zero. However, the locus curves are unique for each individual bearing.

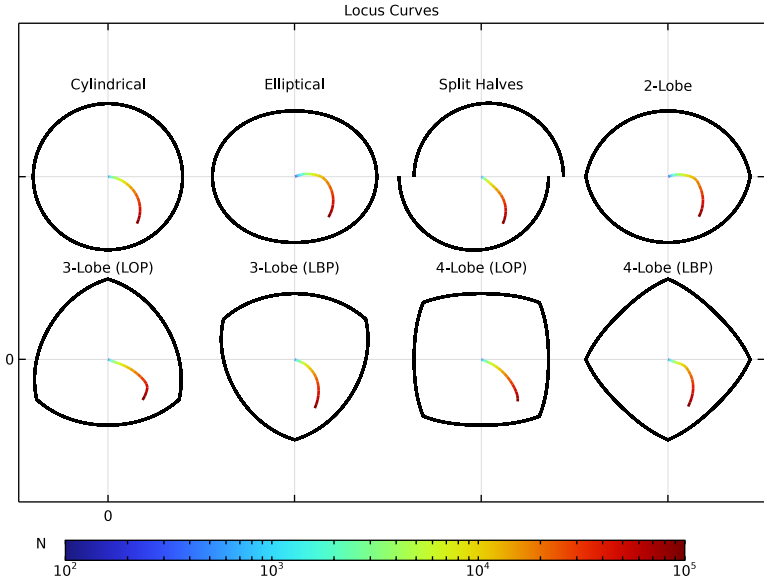


Figure 3: Locus curves.

Figure 4 shows the relative eccentricity of the different bearing types as function of the external load. The journals approach the bearing centers as the external load decreases. At

the maximum load, the cylindrical and 4-lobe (LOP) bearings show the highest eccentricities, whereas the 2-lobe bearing has the smallest eccentricity.

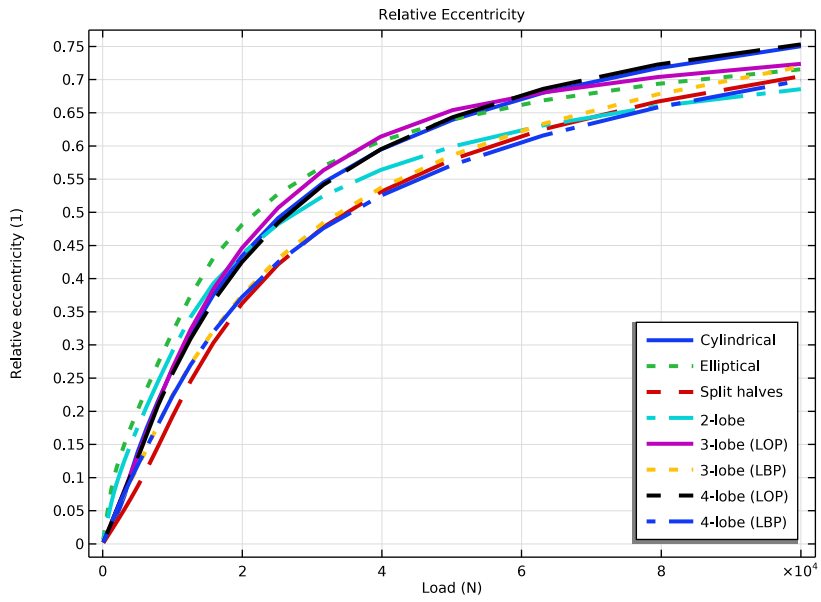


Figure 4: Relative eccentricity as function of external load.

Figure 5 shows the film thickness profiles when the journals are concentric with the bearings. The geometric parameters of bearings are selected such that the minimum and maximum clearances are the same among all bearings, except for the cylindrical bearing.

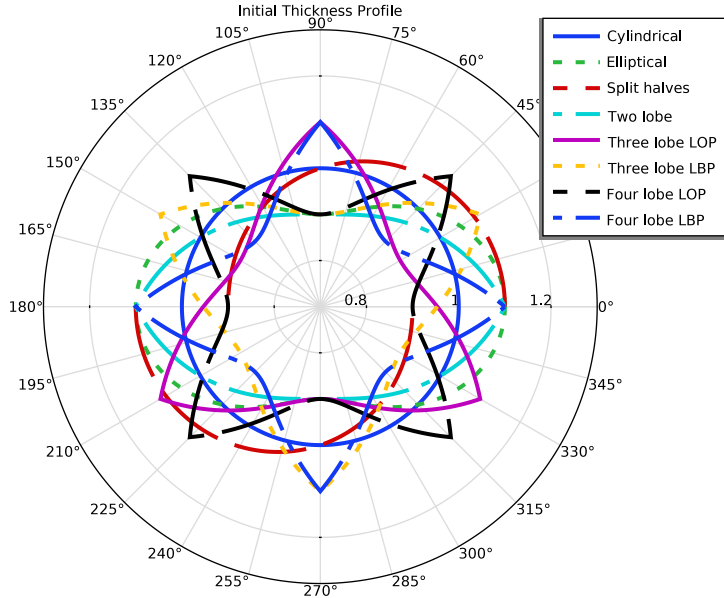


Figure 5: Initial thickness profile.

Figure 6 shows the film thickness when the journals are located at their associated static equilibrium due to an external load of approximately 2500 N.

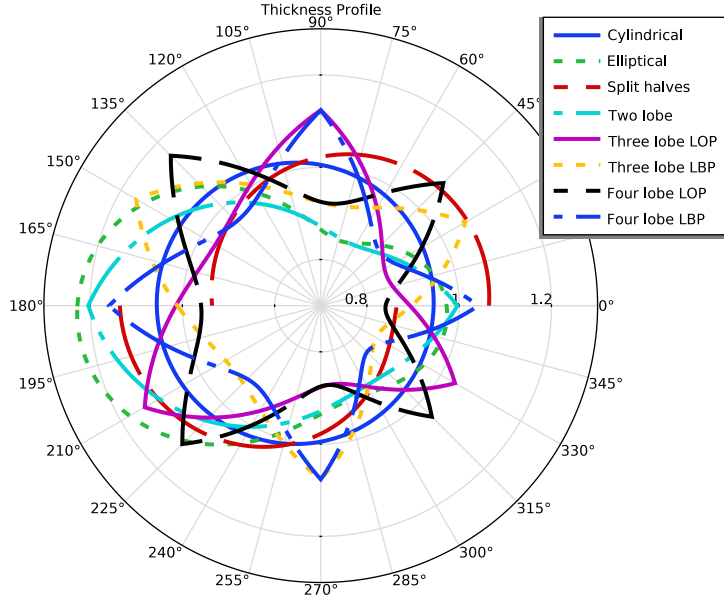


Figure 6: Current thickness profile.

Figure 7 and Figure 8 illustrate the fluid pressure and velocity on an unwrapped surface due to an external load of 10 kN.

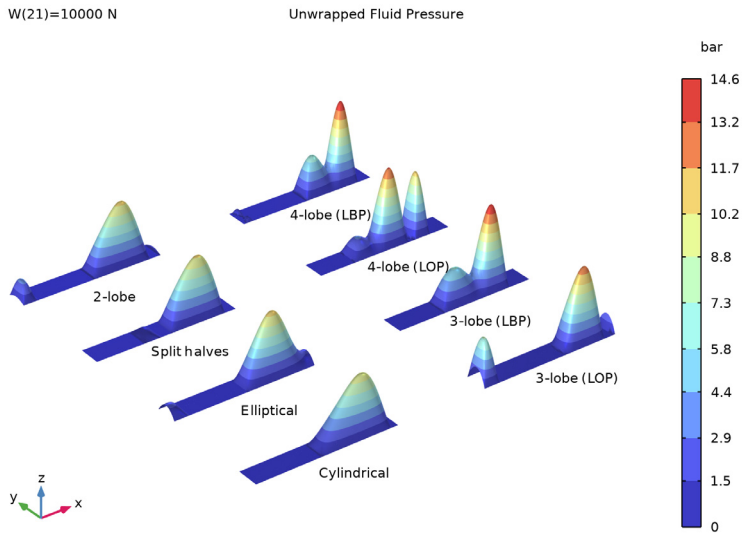


Figure 7: Unwrapped fluid-film pressure profile.

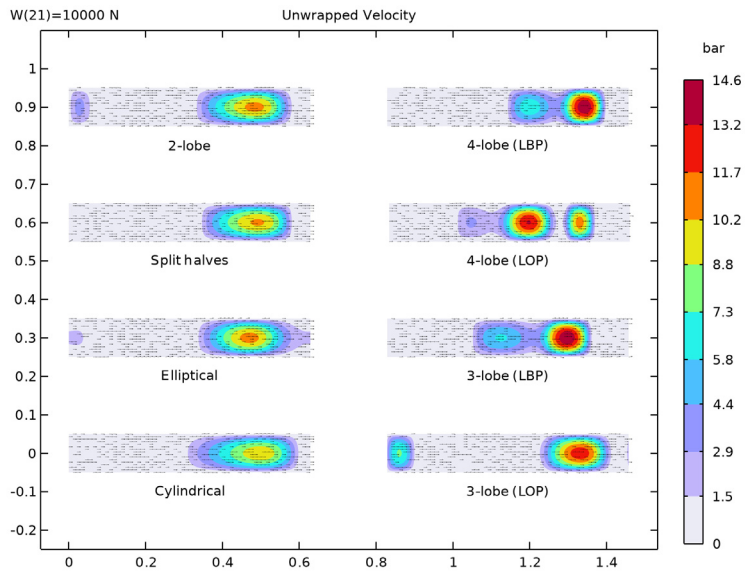



Figure 8: Unwrapped fluid-film pressure and velocity field.

Application Library path: Rotordynamics_Module/Tutorials/
hydrodynamic_bearings_comparison




Modeling Instructions

From the **File** menu, choose **New**.

NEW


In the **New** window, click  **Model Wizard**.

MODEL WIZARD

- 1 In the **Model Wizard** window, click  **3D**.
- 2 In the **Select Physics** tree, select **Structural Mechanics > Rotordynamics > Hydrodynamic Bearing (hdb)**.
- 3 Click **Add**.
- 4 Click  **Study**.
- 5 In the **Select Study** tree, select **General Studies > Stationary**.
- 6 Click  **Done**.


GLOBAL DEFINITIONS


Parameters I

- 1 In the **Model Builder** window, under **Global Definitions** click **Parameters I**.
- 2 In the **Settings** window for **Parameters**, locate the **Parameters** section.
- 3 Click  **Load from File**.
- 4 Browse to the model's Application Libraries folder and double-click the file `hydrodynamic_bearings_comparison_parameters.txt`.

GEOMETRY I


Cylinder I (cyl1)

- 1 In the **Geometry** toolbar, click  **Cylinder**.
- 2 In the **Settings** window for **Cylinder**, locate the **Size and Shape** section.
- 3 In the **Radius** text field, type Rj.
- 4 In the **Height** text field, type H.



- 5 Locate the **Axis** section. From the **Axis type** list, choose **x-axis**.
- 6 Locate the **Object Type** section. From the **Type** list, choose **Surface**.
- 7 Click  **Build Selected**.

Array 1 (arr1)

Replicate 7 more cylinders along the x direction by executing the following commands.


- 1 In the **Geometry** toolbar, click  **Transforms** and choose **Array**.
- 2 Select the object **cyll** only.
- 3 In the **Settings** window for **Array**, locate the **Size** section.
- 4 In the **x size** text field, type 8.
- 5 Locate the **Displacement** section. In the **x** text field, type $2 \cdot H$.

Form Union (fin)


- 1 In the **Geometry** toolbar, click  **Build All**.
- 2 Click the  **Zoom Extents** button in the **Graphics** toolbar.

DEFINITIONS

Cylindrical bearing

- 1 In the **Definitions** toolbar, click  **Explicit**.
- 2 In the **Settings** window for **Explicit**, type **Cylindrical bearing** in the **Label** text field.
- 3 Locate the **Input Entities** section. From the **Geometric entity level** list, choose **Boundary**.
- 4 Select **Boundary 1** only.
- 5 Select the **Group by continuous tangent** checkbox.
Selecting this checkbox allows automatic selection of multiple surfaces across which the tangent is continuous.

Elliptical bearing

- 1 Right-click **Cylindrical bearing** and choose **Duplicate**.
- 2 In the **Settings** window for **Explicit**, type **Elliptical bearing** in the **Label** text field.
- 3 Locate the **Input Entities** section. Click  **Clear Selection**.
- 4 Select **Boundaries 5–8** only.

Explicit Selections

1 Repeat above sequence of commands to add more **Explicit** selections using the information given in the following table:

Name	Selection
Split halves bearing	9, 10, 11, 12
Two lobe bearing	13, 14, 15, 16
Three Lobe bearing (LOP)	17, 18, 19, 20
Three lobe bearing (LBP)	21, 22, 23, 24
Four lobe bearing (LOP)	25, 26, 27, 28
Four lobe bearing (LBP)	29, 30, 31, 32

The table above displays the entire selection for each bearing. But to create for example the **Hydrodynamic Journal Bearing (Split halves)** selection, selecting surface 9 is enough. This is so because you duplicate the existing selection to create the new ones and the **Group by continuous tangent** checkbox is already selected within the old.

2 In the **Model Builder** window, collapse the **Definitions** node.

HYDRODYNAMIC BEARING (HDB)

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Hydrodynamic Bearing (hdb)**.

2 In the **Settings** window for **Hydrodynamic Bearing**, locate the **Physical Model** section.

3 From the **Fluid type** list, choose **Liquid with cavitation**.

Hydrodynamic Journal Bearing (Cylindrical)

1 In the **Model Builder** window, under **Component 1 (comp1)** > **Hydrodynamic Bearing (hdb)** click **Hydrodynamic Journal Bearing 1**.

2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (Cylindrical) in the **Label** text field.

3 Locate the **Bearing Properties** section. In the **C** text field, type C0.

4 Locate the **Journal Properties** section. From the **Specify** list, choose **Load**.

5 Specify the **W_j** vector as

0	x
0	y
-W	z

6 Specify the \mathbf{u}_{j0} vector as

0	x
0	y
-0.1*C0	z

7 From the **Velocity of the journal** list, choose **Revolutions per time**.

8 In the f_j text field, type Omega.

9 Locate the **Fluid Properties** section. From the μ list, choose **User defined**. In the associated text field, type mu.

10 In the ρ_c text field, type rhoc.

11 In the β text field, type beta.

12 Locate the **Bearing Properties** section. From the \mathbf{X}_c list, choose **From geometry**.

Hydrodynamic Journal Bearing (Elliptical)

1 Right-click **Hydrodynamic Journal Bearing (Cylindrical)** and choose **Duplicate**.

2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (Elliptical) in the **Label** text field.

3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Elliptical bearing**.

4 Locate the **Bearing Properties** section. From the **Bearing type** list, choose **Elliptical**.

5 In the C_{\min} text field, type Cmin.

6 In the C_{\max} text field, type Cmax.

Hydrodynamic Journal Bearing (Split halves)

1 Right-click **Hydrodynamic Journal Bearing (Elliptical)** and choose **Duplicate**.

2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (Split halves) in the **Label** text field.

3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Split halves bearing**.

4 Locate the **Bearing Properties** section. From the **Bearing type** list, choose **Split halves**.

5 In the C text field, type C0.

6 From the **Preload factor** list, choose **Compute from offset**.

7 In the d text field, type d0.

Hydrodynamic Journal Bearing (2-lobe)

1 Right-click **Hydrodynamic Journal Bearing (Split halves)** and choose **Duplicate**.

- 2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (2-lobe) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Two lobe bearing**.
- 4 Locate the **Bearing Properties** section. From the **Bearing type** list, choose **Multilobe**.
- 5 In the C text field, type C_{21} .
- 6 From the **Preload factor** list, choose **Compute from offset**.
- 7 In the d text field, type d_{21} .

Hydrodynamic Journal Bearing (3-lobe LOP)

- 1 Right-click **Hydrodynamic Journal Bearing (2-lobe)** and choose **Duplicate**.
- 2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (3-lobe LOP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Three Lobe bearing (LOP)**.
- 4 Locate the **Bearing Properties** section. In the C text field, type C_{31} .
- 5 In the d text field, type d_{31} .
- 6 In the N text field, type 3.

Hydrodynamic Journal Bearing (3-lobe LBP)

- 1 Right-click **Hydrodynamic Journal Bearing (3-lobe LOP)** and choose **Duplicate**.
- 2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (3-lobe LBP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Three lobe bearing (LBP)**.

Hydrodynamic Journal Bearing (4-lobe LOP)


- 1 Right-click **Hydrodynamic Journal Bearing (3-lobe LBP)** and choose **Duplicate**.
- 2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (4-lobe LOP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Four lobe bearing (LOP)**.
- 4 Locate the **Bearing Properties** section. In the C text field, type C_{41} .
- 5 In the d text field, type d_{41} .
- 6 In the N text field, type 4.

Hydrodynamic Journal Bearing (4-lobe LBP)

- 1 Right-click **Hydrodynamic Journal Bearing (4-lobe LOP)** and choose **Duplicate**.
- 2 In the **Settings** window for **Hydrodynamic Journal Bearing**, type Hydrodynamic Journal Bearing (4-lobe LBP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Four lobe bearing (LBP)**.

Next set the orientation of the bearings using the following instructions.

Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LOP)

- 1 In the **Physics** toolbar, click  **Boundaries** and choose **Bearing Orientation**.
- 2 In the **Settings** window for **Bearing Orientation**, type Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LOP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Three Lobe bearing (LOP)**.
- 4 Locate the **Bearing Orientation** section. In the ϕ text field, type $-\pi/6$.

Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LBP)


- 1 Right-click **Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LOP)** and choose **Duplicate**.
- 2 In the **Settings** window for **Bearing Orientation**, type Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LBP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Three lobe bearing (LBP)**.
- 4 Locate the **Bearing Orientation** section. In the ϕ text field, type $\pi/6$.

Bearing Orientation Hydrodynamic Journal Bearing (4-lobe LOP)

- 1 Right-click **Bearing Orientation Hydrodynamic Journal Bearing (3-lobe LBP)** and choose **Duplicate**.
- 2 In the **Settings** window for **Bearing Orientation**, type Bearing Orientation Hydrodynamic Journal Bearing (4-lobe LOP) in the **Label** text field.
- 3 Locate the **Boundary Selection** section. From the **Selection** list, choose **Four lobe bearing (LOP)**.
- 4 Locate the **Bearing Orientation** section. In the ϕ text field, type $\pi/4$.

MESH I

Mapped I


- 1 In the **Mesh** toolbar, click  **More Generators** and choose **Mapped**.
- 2 In the **Settings** window for **Mapped**, locate the **Boundary Selection** section.
- 3 From the **Selection** list, choose **All boundaries**.

Distribution I

- 1 Right-click **Mapped I** and choose **Distribution**.
- 2 In the **Settings** window for **Distribution**, locate the **Edge Selection** section.
- 3 From the **Selection** list, choose **All edges**.
- 4 Locate the **Distribution** section. In the **Number of elements** text field, type 15.
- 5 In the **Model Builder** window, right-click **Mesh I** and choose **Build All**.

STUDY I

Step 1: Stationary

- 1 In the **Model Builder** window, under **Study I** click **Step 1: Stationary**.
- 2 In the **Settings** window for **Stationary**, click to expand the **Study Extensions** section.
Use following instructions to add an **Auxiliary sweep** on load W .
- 3 Select the **Auxiliary sweep** checkbox.
- 4 Click  **Add**.
- 5 In the table, enter the following settings:



Parameter name	Parameter value list	Parameter unit
W (Load on bearing, z-component)	$10^{\wedge}range(2, 0.1, 5)$	N

- 6 In the **Study** toolbar, click  **Compute**.

Set preferred units for the pressure by following the instructions below.

RESULTS

Preferred Units I

- 1 In the **Results** toolbar, click  **Configurations** and choose **Preferred Units**.
- 2 In the **Settings** window for **Preferred Units**, locate the **Units** section.
- 3 Click  **Add Physical Quantity**.

- 4 In the **Physical Quantity** dialog, type `pres` in the text field.
- 5 In the tree, select **General > Pressure (Pa)**.
- 6 Click **OK**.
- 7 In the **Settings** window for **Preferred Units**, locate the **Units** section.
- 8 In the table, enter the following settings:

Quantity	Unit	Preferred unit
Pressure	Pa	bar

- 9 Click  **Apply**.

Fluid Pressure (hdb)



- 1 In the **Model Builder** window, under **Results** click **Fluid Pressure (hdb)**.
- 2 In the **Settings** window for **3D Plot Group**, locate the **Data** section.
- 3 From the **Parameter value (W (N))** list, choose **10000**.
- 4 Click to expand the **Title** section. From the **Title type** list, choose **Label**.
- 5 Locate the **Color Legend** section. Select the **Show units** checkbox.

The dependent variable `pfilm` in the default plot does not represent the physical pressure and can have a negative value in the cavitated zone. Use physics scope variable `hdb.p` instead to show the physical pressure in the bearings.

Surface 1

- 1 In the **Model Builder** window, expand the **Fluid Pressure (hdb)** node, then click **Surface 1**.
- 2 In the **Settings** window for **Surface**, locate the **Expression** section.
- 3 In the **Expression** text field, type `hdb.p`.


Contour 1

- 1 In the **Model Builder** window, click **Contour 1**.
- 2 In the **Settings** window for **Contour**, locate the **Expression** section.
- 3 In the **Expression** text field, type `hdb.p`.
- 4 In the **Fluid Pressure (hdb)** toolbar, click  **Plot**.
- 5 Click the  **Zoom Extents** button in the **Graphics** toolbar.


Fluid Pressure (hdb)

In the **Model Builder** window, click **Fluid Pressure (hdb)**.

Table Annotation 1


- 1 In the **Fluid Pressure (hdb)** toolbar, click  **More Plots** and choose **Table Annotation**.
- 2 In the **Settings** window for **Table Annotation**, locate the **Data** section.
- 3 From the **Source** list, choose **Local table**.
- 4 In the table, enter the following settings:

x-coordinate	y-coordinate	z-coordinate	Annotation
H/2	0	2*Rj	Cylindrical
5/2*H	0	2*Rj	Elliptical
9/2*H	0	2*Rj	Split Halves
13/2*H	0	2*Rj	2-Lobe
17/2*H	0	2*Rj	3-Lobe (LOP)
21/2*H	0	2*Rj	3-Lobe (LBP)
25/2*H	0	2*Rj	4-Lobe (LOP)
29/2*H	0	2*Rj	4-Lobe (LBP)

- 5 Locate the **Coloring and Style** section. Clear the **Show point** checkbox.
- 6 From the **Anchor point** list, choose **Center**.
- 7 In the **Fluid Pressure (hdb)** toolbar, click  **Plot**.

Now, follow the instructions below to create a plot that shows the locus curves for the different journal bearings. The instructions below illustrate how to create the plot for the first two bearings. You can repeat the instructions for the remaining bearings, or open the application library model to see how it can be done.


Parameters

- 1 In the **Results** toolbar, click  **Parameters**.
- 2 In the **Settings** window for **Parameters**, locate the **Parameters** section.
- 3 In the table, enter the following settings:

Name	Expression	Value	Description
offset	2.5	2.5	Offset

- 4 In the **Model Builder** window, collapse the **Results** node.

Locus Curves

- 1 In the **Results** toolbar, click  **ID Plot Group**.
- 2 In the **Settings** window for **ID Plot Group**, type Locus Curves in the **Label** text field.

- 3 Click to expand the **Title** section. From the **Title type** list, choose **Label**.
- 4 Locate the **Axis** section. Select the **Preserve aspect ratio** checkbox.

Locus Curve (Cylindrical)

- 1 Right-click **Locus Curves** and choose **Global**.
- 2 In the **Settings** window for **Global**, type Locus Curve (Cylindrical) in the **Label** text field.
- 3 Locate the **y-Axis Data** section. In the table, enter the following settings:

Expression	Unit	Description
$\text{hdb.hjb1.uJz}/C0 + \text{offset}$	1	

- 4 Locate the **x-Axis Data** section. From the **Parameter** list, choose **Expression**.
- 5 In the **Expression** text field, type $\text{hdb.hjb1.uJy}/C0$.
- 6 Click to expand the **Coloring and Style** section. From the **Width** list, choose **2**.
- 7 Click to expand the **Legends** section. Clear the **Show legends** checkbox.

Color Expression 1

- 1 Right-click **Locus Curve (Cylindrical)** and choose **Color Expression**.
- 2 In the **Settings** window for **Color Expression**, locate the **Expression** section.
- 3 In the **Expression** text field, type W .
- 4 Locate the **Coloring and Style** section. From the **Scale** list, choose **Logarithmic**.

Bearing Profile (Cylindrical)

- 1 In the **Model Builder** window, right-click **Locus Curves** and choose **Line Graph**.
- 2 In the **Settings** window for **Line Graph**, type Bearing Profile (Cylindrical) in the **Label** text field.
- 3 Select Edges 1, 2, 4, and 6 only.
- 4 Locate the **y-Axis Data** section. In the **Expression** text field, type $\text{hdb.hB1} * \sin(\text{hdb.Th})/C0 + \text{offset}$.
- 5 Locate the **x-Axis Data** section. From the **Parameter** list, choose **Expression**.
- 6 In the **Expression** text field, type $\text{hdb.hB1} * \cos(\text{hdb.Th})/C0$.
- 7 Click to expand the **Coloring and Style** section. From the **Color** list, choose **From theme**.
- 8 From the **Width** list, choose **2**.

Bearing Profile (Cylindrical), Locus Curve (Cylindrical)

- 1 In the **Model Builder** window, under **Results > Locus Curves**, Ctrl-click to select **Locus Curve (Cylindrical)** and **Bearing Profile (Cylindrical)**.
- 2 Right-click and choose **Duplicate**.

Locus Curve (Elliptical)

- 1 In the **Settings** window for **Global**, type Locus Curve (Elliptical) in the **Label** text field.
- 2 Locate the **y-Axis Data** section. In the table, enter the following settings:

Expression	Unit	Description
$\text{hdb.hjb2.uJz}/C0 + \text{offset}$	1	

- 3 Locate the **x-Axis Data** section. In the **Expression** text field, type $\text{hdb.hjb2.uJy}/C0 + \text{offset}$.

Color Expression 1

- 1 In the **Model Builder** window, expand the **Locus Curve (Elliptical)** node, then click **Color Expression 1**.
- 2 In the **Settings** window for **Color Expression**, locate the **Coloring and Style** section.
- 3 Clear the **Color legend** checkbox.

Bearing Profile (Elliptical)

- 1 In the **Model Builder** window, under **Results > Locus Curves** click **Bearing Profile (Cylindrical) 1**.
- 2 In the **Settings** window for **Line Graph**, type Bearing Profile (Elliptical) in the **Label** text field.
- 3 Locate the **Selection** section. Click to select the **Activate Selection** toggle button.
- 4 Select Edges 13, 14, 16, and 18 only.
- 5 Locate the **x-Axis Data** section. In the **Expression** text field, type $\text{hdb.hB1} * \cos(\text{hdb.Th})/C0 + \text{offset}$.

Bearing Profile (Elliptical), Locus Curve (Elliptical)



- 1 In the **Model Builder** window, under **Results > Locus Curves**, Ctrl-click to select **Locus Curve (Elliptical)** and **Bearing Profile (Elliptical)**.
Add a **Table Annotation** node to the plot to add annotations to the different bearings.
- 2 In the **Locus Curves** toolbar, click  **More Plots** and choose **Table Annotation**.

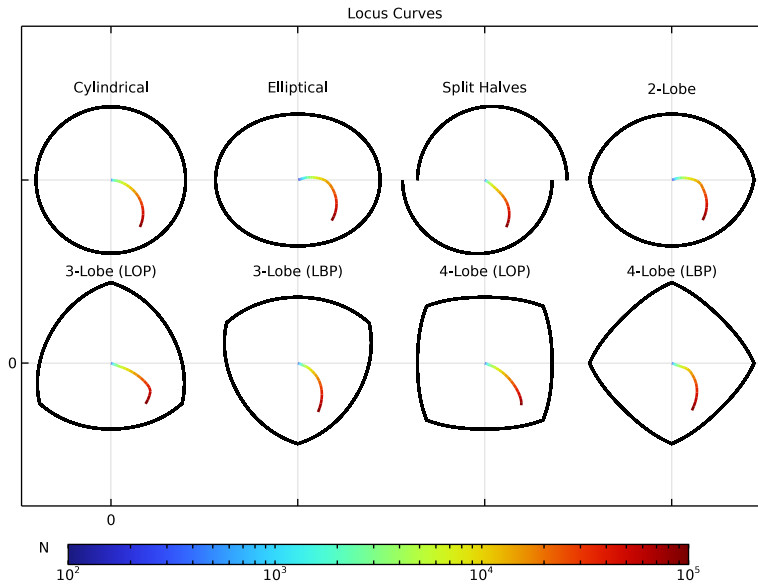
Table Annotation 1

- 1 In the **Settings** window for **Table Annotation**, locate the **Data** section.
- 2 From the **Source** list, choose **Local table**.
- 3 In the table, enter the following settings:

x-coordinate	y-coordinate	Annotation
0	1.5*offset	Cylindrical
offset	1.5*offset	Elliptical
2*offset	1.5*offset	Split Halves
3*offset	1.5*offset	2-Lobe
0	0.5*offset	3-Lobe (LOP)
offset	0.5*offset	3-Lobe (LBP)
2*offset	0.5*offset	4-Lobe (LOP)
3*offset	0.5*offset	4-Lobe (LBP)


- 4 Locate the **Coloring and Style** section. Clear the **Show point** checkbox.
- 5 From the **Anchor point** list, choose **Center**.
- 6 In the **Locus Curves** toolbar, click  **Plot**.

The resulting plot should look similar to the one shown below.



Use the following instructions to plot the eccentricity of the journals against the load as shown in [Figure 4](#).

Relative Eccentricity

- 1 In the **Results** toolbar, click  **ID Plot Group**.
- 2 In the **Settings** window for **ID Plot Group**, type **Relative Eccentricity** in the **Label** text field.
- 3 Locate the **Title** section. From the **Title type** list, choose **Label**.
- 4 Locate the **Plot Settings** section.
- 5 Select the **x-axis label** checkbox. In the associated text field, type **Load (N)**.
- 6 Select the **y-axis label** checkbox. In the associated text field, type **Relative eccentricity (1)**.

Global I



- 1 Right-click **Relative Eccentricity** and choose **Global**.
- 2 In the **Settings** window for **Global**, click **Replace Expression** in the upper-right corner of the **y-Axis Data** section. From the menu, choose **Component I (comp1) > Hydrodynamic Bearing > Hydrodynamic Journal Bearing (Cylindrical) > Eccentricity and attitude angle > hdb.hjb1.ec_rel - Relative eccentricity - I**.
- 3 Locate the **y-Axis Data** section. In the table, enter the following settings:

Expression	Unit	Description
hdb.hjb1.ec_rel	1	Cylindrical

Repeat this for the remaining bearings.


- 4 Locate the **Coloring and Style** section. Find the **Line style** subsection. From the **Line** list, choose **Cycle**.
- 5 From the **Width** list, choose **3**.

Relative Eccentricity

- 1 In the **Model Builder** window, click **Relative Eccentricity**.
- 2 In the **Settings** window for **ID Plot Group**, locate the **Legend** section.
- 3 From the **Position** list, choose **Lower right**.
- 4 In the **Relative Eccentricity** toolbar, click  **Plot**.
- 5 Click the  **Zoom Extents** button in the **Graphics** toolbar.
- 6 In the **Model Builder** window, collapse the **Relative Eccentricity** node.

Use the following instructions to plot the initial thickness profile of the fluid film as shown in [Figure 5](#).

Initial Thickness Profile


- 1 In the **Results** toolbar, click  **Polar Plot Group**.
- 2 In the **Settings** window for **Polar Plot Group**, type Initial Thickness Profile in the **Label** text field.
- 3 Locate the **Data** section. From the **Parameter selection (W)** list, choose **First**.
- 4 Click to expand the **Title** section. From the **Title type** list, choose **Label**.
- 5 Locate the **Axis** section. Select the **Manual axis limits** checkbox.
- 6 In the **r minimum** text field, type 0.7.
- 7 In the **r maximum** text field, type 1.3.

Cylindrical

- 1 Right-click **Initial Thickness Profile** and choose **Line Graph**.
- 2 Select Edges 1, 2, 4, and 6 only.
- 3 In the **Settings** window for **Line Graph**, click **Replace Expression** in the upper-right corner of the **r-Axis Data** section. From the menu, choose **Component 1 (comp1) > Hydrodynamic Bearing > Journal and bearing properties > Film thickness and clearance > hdb.hi_rel - Relative film thickness, initial - I**.
- 4 Locate the **r-Axis Data** section.
- 5 Select the **Description** checkbox. In the associated text field, type Cylindrical.
- 6 Locate the **θ Angle Data** section. From the **Parameter** list, choose **Expression**.
- 7 In the **Expression** text field, type `hdb.Th+hdb.ang_bearing`.
- 8 Click to expand the **Coloring and Style** section. Find the **Line style** subsection. From the **Line** list, choose **Cycle**.
- 9 From the **Width** list, choose **3**.
- 10 Click to expand the **Legends** section. Select the **Show legends** checkbox.
- 11 Find the **Include** subsection. Clear the **Solution** checkbox.
- 12 Select the **Label** checkbox.
- 13 In the **Label** text field, type Cylindrical.

Elliptical

- 1 Right-click **Cylindrical** and choose **Duplicate**.
- 2 In the **Settings** window for **Line Graph**, type Elliptical in the **Label** text field.


- 3 Locate the **Selection** section. Click  **Clear Selection**.
- 4 Select Edges 13, 14, 16, and 18 only.
- 5 Locate the **r-Axis Data** section. In the **Description** text field, type Elliptical.

Line graph Nodes

Similarly add more **Line Graph** nodes using the information given in the following table:

Name	Selection	r-Axis Data: Expression	Legends
Split halves	25, 26, 28, 30	Split halves	Split halves
Two lobe	37, 38, 40, 42	Two lobe	Two lobe
Three lobe LOP	49, 50, 52, 54	Three lobe LOP	Three lobe LOP
Three lobe LBP	61, 62, 64, 66	Three lobe LBP	(As is)
Four lobe LOP	73, 74, 76, 78	Four lobe LOP	Four lobe LOP
Four lobe LBP	85, 86, 88, 90	Four lobe LBP	Four lobe LBP

Initial Thickness Profile

- 1 In the **Model Builder** window, click **Initial Thickness Profile**.
- 2 In the **Initial Thickness Profile** toolbar, click  **Plot**.

Use the following instructions to plot the current thickness profile of the fluid film as shown in [Figure 6](#) using the following instructions.

Initial Thickness Profile I

Right-click **Initial Thickness Profile** and choose **Duplicate**.

Initial Thickness Profile

In the **Model Builder** window, collapse the **Results > Initial Thickness Profile** node.


Current Thickness Profile

- 1 In the **Model Builder** window, under **Results** click **Initial Thickness Profile I**.
- 2 In the **Settings** window for **Polar Plot Group**, type Current Thickness Profile in the **Label** text field.
- 3 Locate the **Title** section. From the **Title type** list, choose **Manual**.
- 4 In the **Title** text area, type Thickness Profile.

Line graph Nodes


1 Edit the existing **Line Graph** nodes under **Polar: Current Thickness Profile** using the information given in the following table:

Name	r-Axis Data: Expression	theta angle data: Expression
Cylindrical	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Elliptical	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Split halves	<code>hdb.h/CO</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Two lobe	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Three lobe LOP	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Three lobe LBP	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Four lobe LOP	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>
Four lobe LBP	<code>hdb.h_re1</code>	<code>mod(hdb.Th+hdb.ang_bearing,2*pi)</code>


- 2 In the **Model Builder** window, expand the **Current Thickness Profile** node, then click **Results > Current Thickness Profile**.
- 3 Locate the **Data** section. From the **Parameter selection (W)** list, choose **From list**.
- 4 In the **Parameter values (W (N))** list box, select **2511.9**.
- 5 Locate the **Axis** section. In the **r minimum** text field, type **0.7**.
- 6 In the **r maximum** text field, type **1.3**.
- 7 In the **Current Thickness Profile** toolbar, click  **Plot**.
- 8 In the **Model Builder** window, collapse the **Results > Current Thickness Profile** node.

RESULT TEMPLATES

Add unwrapped plots for all the bearings, to create the associated datasets.

- 1 In the **Results** toolbar, click  **Result Templates** to open the **Result Templates** window.
- 2 Go to the **Result Templates** window.
- 3 In the tree, select **Study 1/Solution 1 (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb1)**, **Study 1/Solution 1 (sol1) > Hydrodynamic Bearing >**

Unwrapped Plots (hjb2), Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb3), Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb4), Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb5), Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb6), Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb7), and Study I/Solution I (sol1) > Hydrodynamic Bearing > Unwrapped Plots (hjb8).

- 4 Click the **Add Result Template** button in the window toolbar.
- 5 In the **Results** toolbar, click  **Result Templates** to close the **Result Templates** window.

RESULTS

Delete unnecessary plots.

Unwrapped Plots (hjb2), Unwrapped Plots (hjb3), Unwrapped Plots (hjb4), Unwrapped Plots (hjb5), Unwrapped Plots (hjb6), Unwrapped Plots (hjb7), Unwrapped Plots (hjb8)
Right-click and choose **Delete**.

Unwrapped Plots (hjb1)

In the **Model Builder** window, right-click **Unwrapped Plots (hjb1)** and choose **Ungroup**.

Now, create a plot of the unwrapped pressure for all the different bearings. The instructions below illustrate how to create the plot for the first two bearings. You can repeat the instructions for the remaining bearings, or open the application library model to see how it can be done.

Unwrapped Fluid Pressure

- 1 In the **Settings** window for **2D Plot Group**, type Unwrapped Fluid Pressure in the **Label** text field.
- 2 Locate the **Data** section. From the **Parameter value (W (N))** list, choose **10000**.
- 3 Click to expand the **Title** section. From the **Title type** list, choose **Label**.
- 4 Locate the **Color Legend** section. Select the **Show units** checkbox.
- 5 Click to expand the **Plot Array** section. From the **Array type** list, choose **Square**.
- 6 From the **Padding** list, choose **Absolute**.
- 7 In the **Row padding length** text field, type 4*H.
- 8 In the **Column padding length** text field, type 4*H.

Pressure (Cylindrical)

- 1 In the **Model Builder** window, expand the **Unwrapped Fluid Pressure** node, then click **Surface 1**.

- In the **Settings** window for **Surface**, type Pressure (Cylindrical) in the **Label** text field.


Pressure (Elliptical)

- Right-click **Pressure (Cylindrical)** and choose **Duplicate**.
- In the **Settings** window for **Surface**, type Pressure (Elliptical) in the **Label** text field.
- Locate the **Data** section. From the **Dataset** list, choose **Surface (hjb2)**.
- From the **Solution parameters** list, choose **From parent**.
- Click to expand the **Inherit Style** section. From the **Plot** list, choose **Pressure (Cylindrical)**.
- Click to expand the **Plot Array** section. Select the **Manual indexing** checkbox.
- In the **Row index** text field, type 1.




Unwrapped Fluid Pressure

In the **Model Builder** window, click **Unwrapped Fluid Pressure**.

Table Annotation I

- In the **Unwrapped Fluid Pressure** toolbar, click  **More Plots** and choose **Table Annotation**.
- In the **Settings** window for **Table Annotation**, locate the **Data** section.
- From the **Source** list, choose **Local table**.
- In the table, enter the following settings:

x-coordinate	y-coordinate	Annotation
$Rj \cdot \pi$	$-4 \cdot H/2$	Cylindrical
$Rj \cdot \pi$	$6 \cdot H/2$	Elliptical
$Rj \cdot \pi$	$16 \cdot H/2$	Split halves
$Rj \cdot \pi$	$26 \cdot H/2$	2-lobe
$3 \cdot Rj \cdot \pi + 4 \cdot H$	$-4 \cdot H/2$	3-lobe (LOP)
$3 \cdot Rj \cdot \pi + 4 \cdot H$	$6 \cdot H/2$	3-lobe (LBP)
$3 \cdot Rj \cdot \pi + 4 \cdot H$	$16 \cdot H/2$	4-lobe (LOP)
$3 \cdot Rj \cdot \pi + 4 \cdot H$	$26 \cdot H/2$	4-lobe (LBP)

- Locate the **Coloring and Style** section. Clear the **Show point** checkbox.
- From the **Anchor point** list, choose **Center**.
- In the **Unwrapped Fluid Pressure** toolbar, click  **Plot**.
- Click the  **Go to Default View** button in the **Graphics** toolbar.
- Click the  **Zoom Extents** button in the **Graphics** toolbar.

Unwrapped Fluid Pressure

In the **Model Builder** window, collapse the **Results > Unwrapped Fluid Pressure** node.

Next, create a combined unwrapped velocity plot for all the different bearings. The instructions below illustrate how to create the plot for the first two bearings. You can repeat the instructions for the remaining bearings, or open the application library model to see how it can be done.

Unwrapped Velocity

- 1 In the **Model Builder** window, under **Results** click **Unwrapped Velocity (hjb I)**.
- 2 In the **Settings** window for **2D Plot Group**, type Unwrapped Velocity in the **Label** text field.
- 3 Locate the **Data** section. From the **Parameter value (W (N))** list, choose **10000**.
- 4 Locate the **Title** section. From the **Title type** list, choose **Label**.
- 5 Locate the **Color Legend** section. Select the **Show units** checkbox.
- 6 Locate the **Plot Array** section. From the **Array type** list, choose **Square**.
- 7 From the **Padding** list, choose **Absolute**.
- 8 In the **Row padding length** text field, type 2*H.
- 9 In the **Column padding length** text field, type 2*H.

Pressure (Cylindrical)

- 1 In the **Model Builder** window, expand the **Unwrapped Velocity** node, then click **Pressure**.
- 2 In the **Settings** window for **Surface**, type Pressure (Cylindrical) in the **Label** text field.
- 3 Locate the **Plot Array** section. Select the **Manual indexing** checkbox.

Velocity (Cylindrical)

- 1 In the **Model Builder** window, click **Velocity**.
- 2 In the **Settings** window for **Arrow Surface**, type Velocity (Cylindrical) in the **Label** text field.
- 3 Click to expand the **Plot Array** section. Select the **Manual indexing** checkbox.

Pressure (Cylindrical), Velocity (Cylindrical)

- 1 In the **Model Builder** window, under **Results > Unwrapped Velocity**, Ctrl-click to select **Pressure (Cylindrical)** and **Velocity (Cylindrical)**.
- 2 Right-click and choose **Duplicate**.

Pressure (Elliptical)

- 1 In the **Settings** window for **Surface**, type **Pressure (Elliptical)** in the **Label** text field.
- 2 Locate the **Data** section. From the **Dataset** list, choose **Surface (hjb2)**.
- 3 From the **Solution parameters** list, choose **From parent**.
- 4 Locate the **Inherit Style** section. From the **Plot** list, choose **Pressure (Cylindrical)**.
- 5 Locate the **Plot Array** section. In the **Row index** text field, type 1.


Velocity (Elliptical)

- 1 In the **Model Builder** window, under **Results > Unwrapped Velocity** click **Velocity (Cylindrical) 1**.
- 2 In the **Settings** window for **Arrow Surface**, type **Velocity (Elliptical)** in the **Label** text field.
- 3 Locate the **Data** section. From the **Dataset** list, choose **Surface (hjb2)**.
- 4 From the **Solution parameters** list, choose **From parent**.
- 5 Click to expand the **Inherit Style** section. From the **Plot** list, choose **Velocity (Cylindrical)**.
- 6 Locate the **Plot Array** section. In the **Row index** text field, type 1.

Unwrapped Velocity



In the **Model Builder** window, click **Unwrapped Velocity**.

Table Annotation 1

- 1 In the **Unwrapped Velocity** toolbar, click  **More Plots** and choose **Table Annotation**.
- 2 In the **Settings** window for **Table Annotation**, locate the **Data** section.
- 3 From the **Source** list, choose **Local table**.
- 4 In the table, enter the following settings:

x-coordinate	y-coordinate	Annotation
$R_j * \pi$	-H	Cylindrical
$R_j * \pi$	2*H	Elliptical
$R_j * \pi$	5*H	Split halves
$R_j * \pi$	8*H	2-lobe
$3 * R_j * \pi + 2 * H$	-H	3-lobe (LOP)
$3 * R_j * \pi + 2 * H$	2*H	3-lobe (LBP)
$3 * R_j * \pi + 2 * H$	5*H	4-lobe (LOP)
$3 * R_j * \pi + 2 * H$	8*H	4-lobe (LBP)

- 5 Locate the **Coloring and Style** section. Clear the **Show point** checkbox.

- 6 From the **Anchor point** list, choose **Center**.
- 7 In the **Unwrapped Velocity** toolbar, click  **Plot**.
- 8 Click the  **Zoom Extents** button in the **Graphics** toolbar.

Unwrapped Velocity

In the **Model Builder** window, collapse the **Results > Unwrapped Velocity** node.