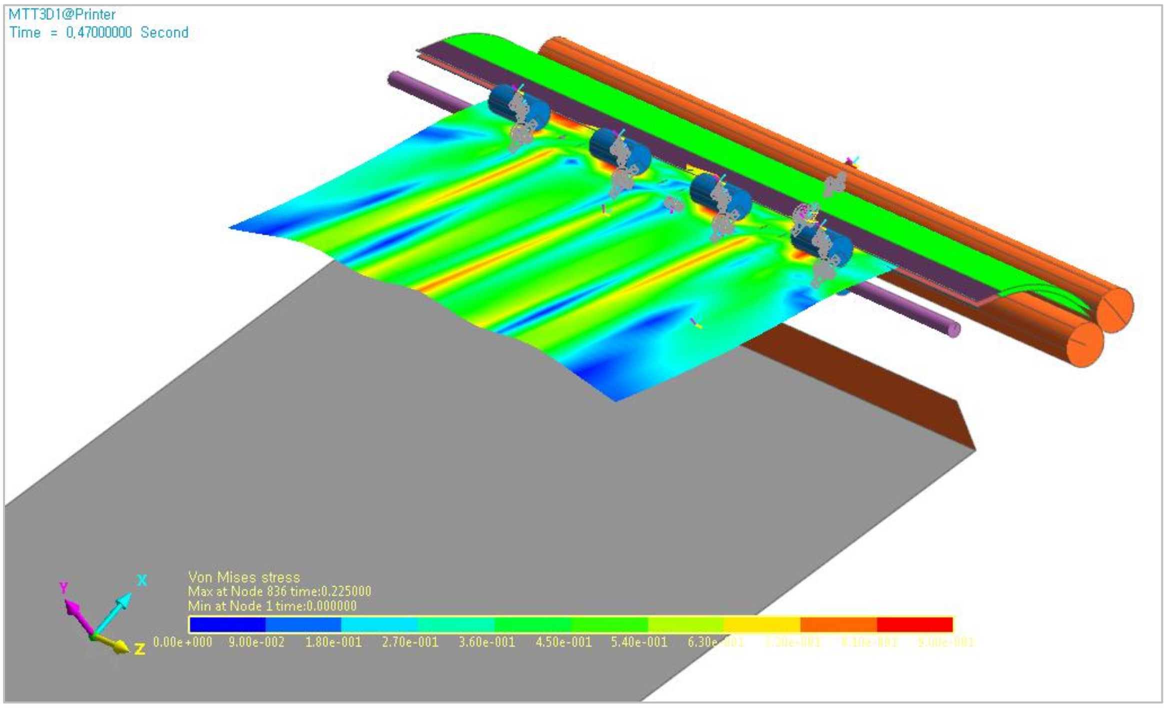
Media Transport Toolkit 3D Tutorial (MTT3D)



FunctionBay

Edition Note

This document describes the release information of **RecurDyn V9R4**.

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Chapter

1

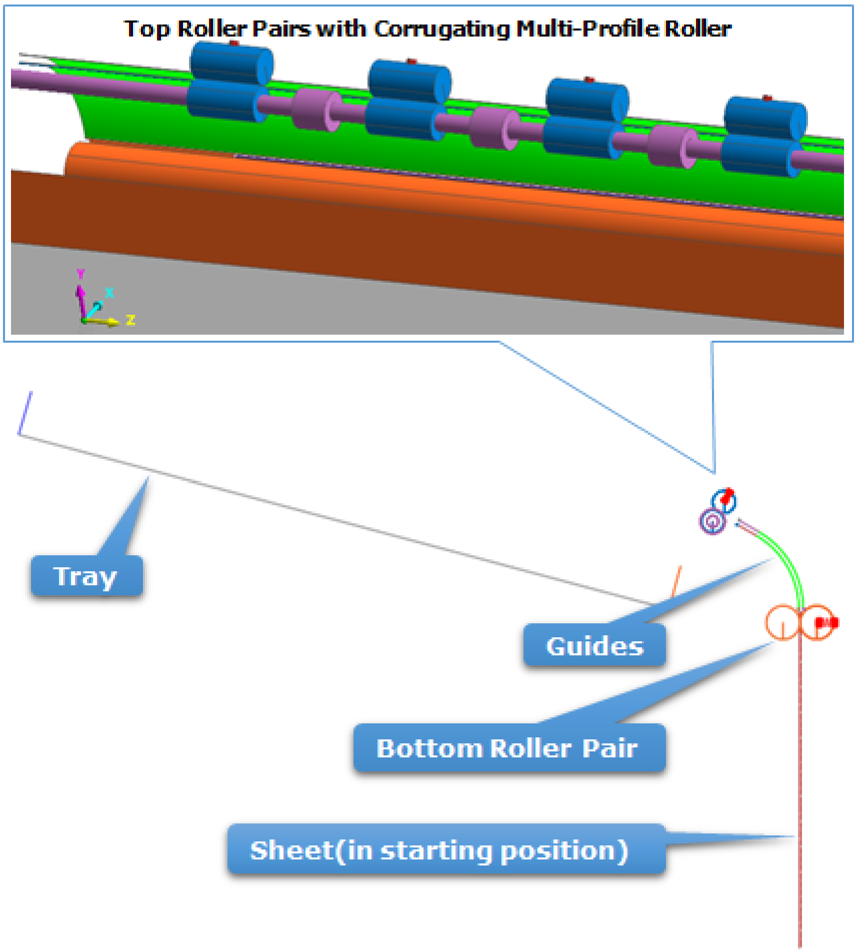
Getting Started

Objective

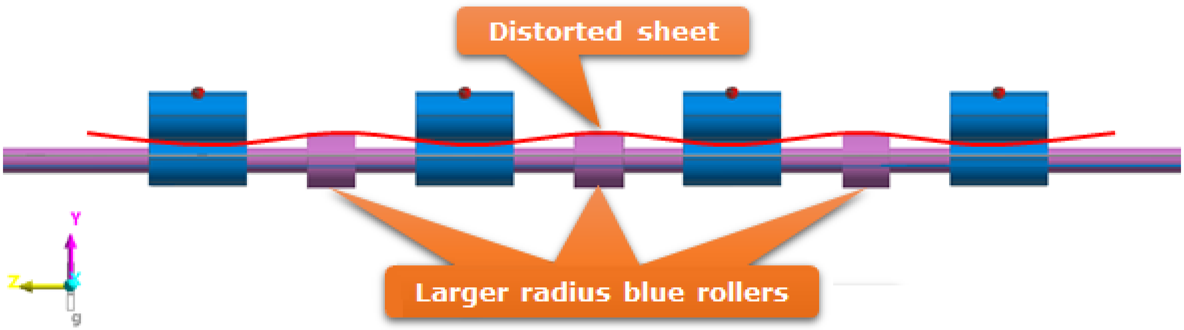
This tutorial introduces you to the special capabilities of the Media Transport Toolkit 3D (MTT3D). MTT3D allows you to model sheets progressing through complex paper paths in three dimensions, allowing you to study 3D phenomena such as sheet corrugation and misalignment. In this tutorial, you will examine sheet corrugation in part of a printer device.

Model Used

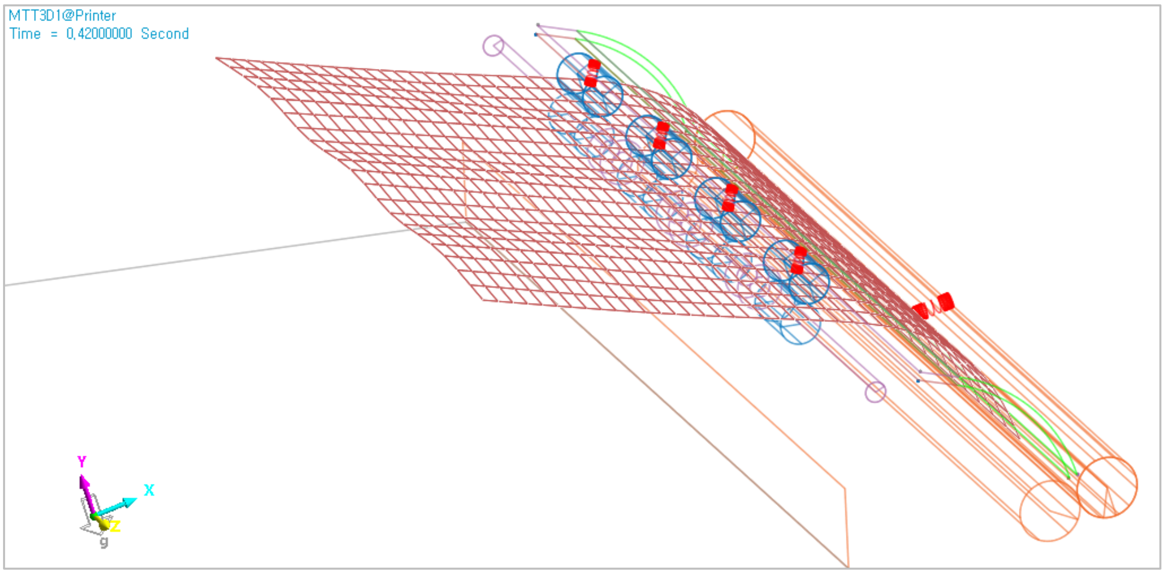
The model used in this tutorial is the final portion of the paper path of a laser printer, namely the path that the sheet passes through before landing in the tray. To prevent paper jams and allow for an orderly stack of sheets in the output tray, a special multi-profile roller is used to corrugate the sheet to keep it straight before falling into the tray. The corrugation of the paper prevents the leading edge of the sheet from hanging down and dragging along the surface of the tray (or the sheets that are already in the tray). A side view of the model is shown below.



As shown below, the corrugation roller works because the blue rollers have a larger radius than the lower purple rollers which rotate about the same axis. Therefore, the blue rollers push the sheet upwards in between the purple roller pairs, distorting the sheet.



If the corrugation effect is strong enough, the folds in the sheet cause it to resist gravity-induced bending, allowing the sheet to remain straight as it exits the printer, as shown below.



Due to the limited time you may have to complete this tutorial, the rest of the printer is not modeled. Also, to simplify the model further, the sheet used is half the size of a standard A4 sheet. Since the sheet is modeled as a mesh, this reduces the number of sheet bodies.

Audience

This tutorial is intended for experienced users of **RecurDyn**. All new tasks are explained carefully.

Prerequisites

Users should first work through the 3D Crank-Slider, Engine with Propeller, and Pinball (2D contact) tutorials, or the equivalent. We assume that you have a basic knowledge of physics.

Procedures

The tutorial is comprised of the following procedures. The estimated time to complete each procedure is shown in the table below.

Procedures	Time (minutes)
Creating the Model	30
Running a Simulation	10
Modifying the Design	10
Total	50

Estimated Time to Complete

50 minutes

Chapter

2

Creating the Model

Task Objective

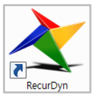
Learn how to define rollers, guides, and sheet bodies.

Estimated Time to Complete

30 minutes

Creating a New Model and MTT3D Subsystem

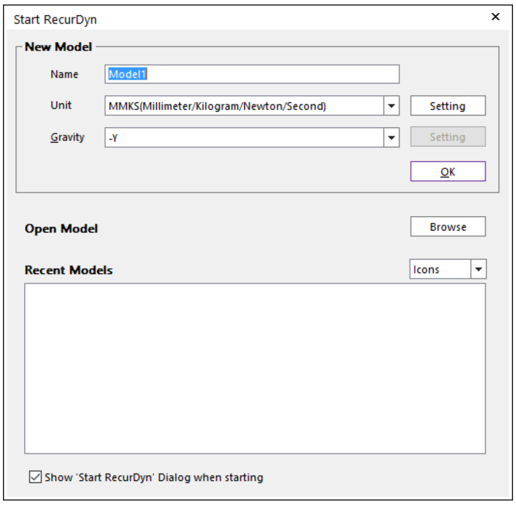
To create a new model:



1. On your Desktop, double-click the **RecurDyn** tool.

   RecurDyn starts and the **Start RecurDyn** window appears.

2. Enter **Printer** as the Model Name.
3. Select **OK**.



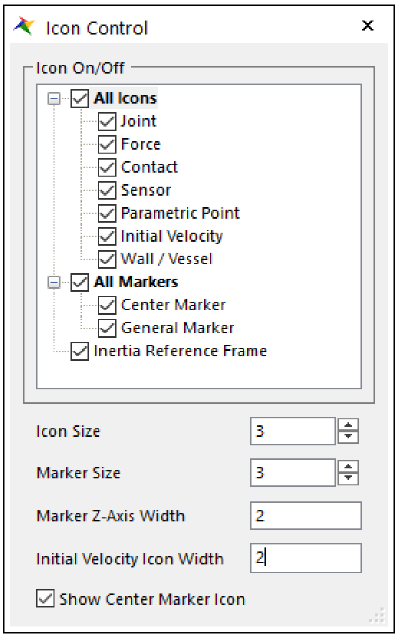
To create a new MTT3D subsystem:

1. From the **Subsystem Toolkit** group in the **Toolkits** tab, click **MTT3D**.

   RecurDyn will bring you into the new **MTT3D** subsystem, and a new **MTT3D** tab will appear in the ribbon for the **MTT3D** functions.

To adjust the Icon Size in the model:

1. From the **Render Toolbar**, select the **Icon Control** tool.
2. Change both the **Icon Size** and **Marker Size** from the default value of 10 to **3**.



To set the render mode to Wireframe:

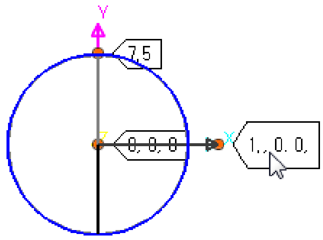
From **Render Toolbar**, select the **Wireframe** rendering tool.

Creating the Bottom Rollers

You will now create the bottom roller pair in which the sheet starts.

To create the bottom roller pair:

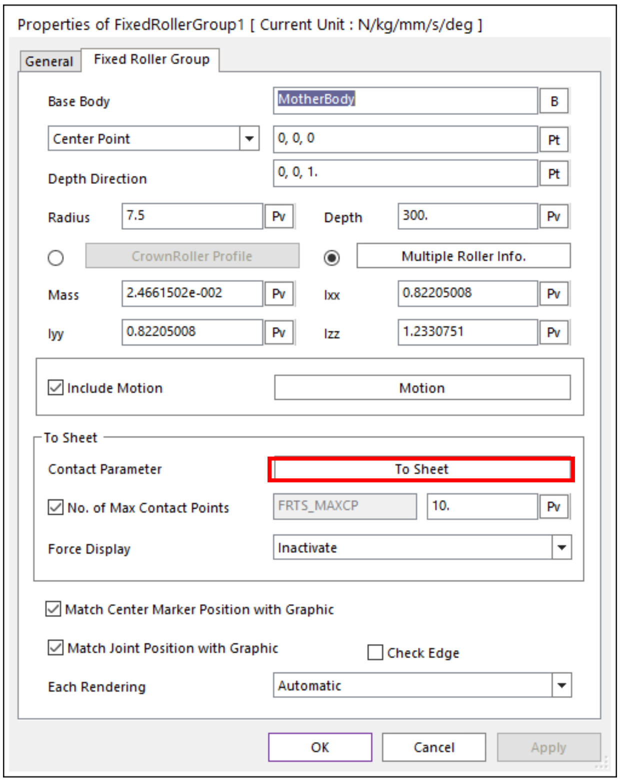
1. From the **Roller** group in the **MTT3D** tab, click **Pair**.
2. Select the point **0, 0, 0** in the **Working Window** to define the center of the fixed roller or type the values into in the **Input Window**.
3. Enter **7.5** in the **Input Window** and press the Enter key to set the radius of the fixed roller.
4. Select the **+X** direction, by clicking on a point directly to the right of 0, 0, 0. The arrow which indicates the direction that will be selected should point directly to the right, as shown at right.
5. Enter **7.5** in the **Input Window** to set the radius of the movable roller.



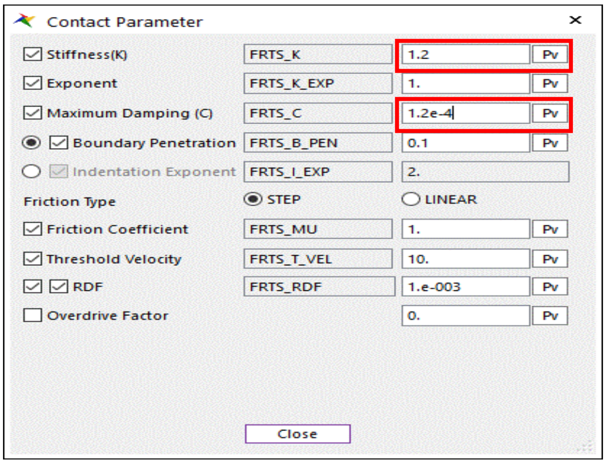
You will now modify the bottom roller pair to have the correct properties.

To edit the bottom fixed roller:

1. From the **Database Window**, open the **Properties** window for **MTT3D1 > Groups > FixedRollerGroup1**.
2. To the right of **Contact Parameter**, select the **To Sheet** button.



3. Make the following settings:
   - **Stiffness: 1.2**
   - **Maximum Damping: 1.2e-4**



Note: If the checkboxes next to a parameter is checked, the value displayed will be considered a Special Parametric Value (SPV) and be used for all other fixed rollers in the model which have the same checkbox checked. There are separate sets of SPVs for movable rollers and other model entities.

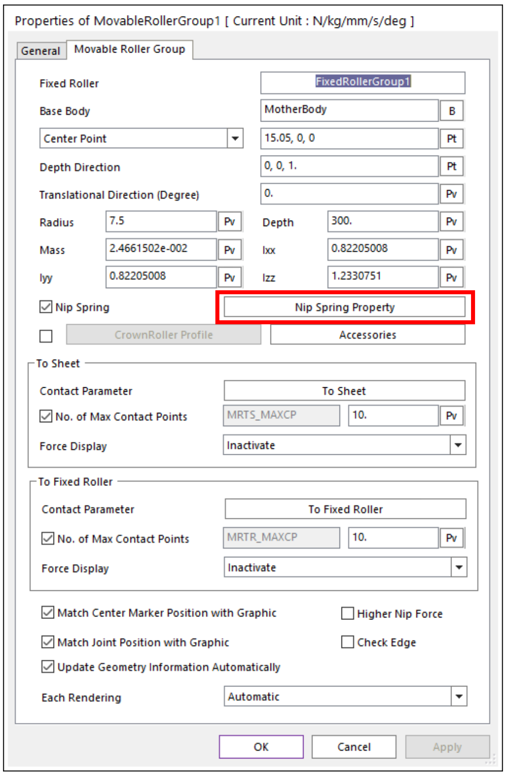
Note: Here, you increased the contact stiffness to prevent the roller from penetrating the sheet excessively, as you will be increasing the nip spring stiffness of the opposing roller from its default value later. Excessive contact penetration reduces the accuracy of the simulation. At the same time, increasing contact stiffness too much will slow down the simulation. Therefore, a general rule of thumb is to allow for penetration which is ~25% the thickness of the sheet.

Also, the damping was increased by the same factor as the stiffness. When adjusting stiffness and damping values, a good practice is to start with the default values and scale them both by the same factor. If necessary, they can be adjusted individually later.

4. Select **Close**.
5. Select **OK**.

To edit the bottom movable roller:

1. From the **Database Window**, open the **Properties** window for **MTT3D1 > Groups > MovableRollerGroup1**.
2. Select the **Nip Spring Property** button.



3. Uncheck the boxes next to **Stiffness, Damping,** and **Pre Load**.

Note: By unchecking the boxes, you are specifying that the parameter values set for this roller will not be linked to the Special Parametric Values used for other movable rollers in the model.

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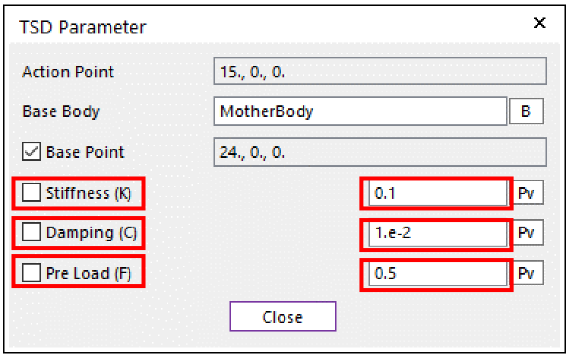
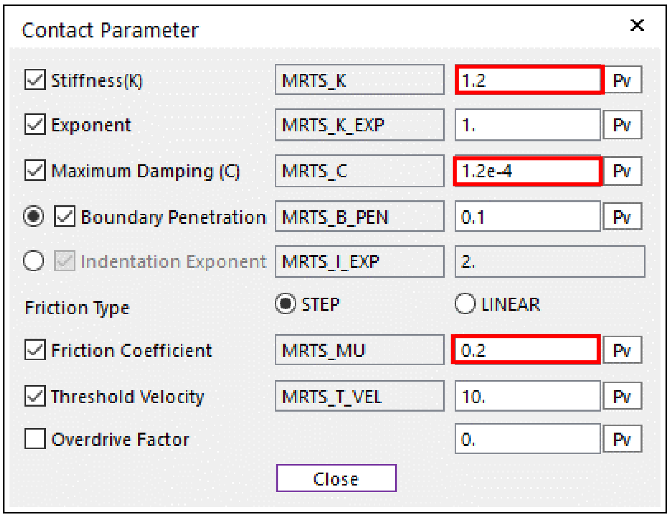
4. Make the following settings as shown right.
   - **Stiffness: 0.1**
   - **Damping: 1e-2**
   - **Pre Load: 0.5**
5. Click the **Close** button to return to the **Properties of MovableRollerGroup1** dialog.



6. To the right of **Contact Parameter**, select the **To Sheet** button.
7. Make the following settings as shown at right.
   - **Stiffness: 1.2**
   - **Maximum Damping: 1.2e-4**
   - **Friction Coefficient: 0.2**



Note: A lower friction coefficient of 0.2 was chosen for this movable roller, because we want to model its surface as plastic. The default friction coefficient of 1.0 was used for the fixed roller, on the other hand, because we want to model its surface as being rubberized so it can grip the sheet.

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8. Click **Close**.
9. Click **OK**.

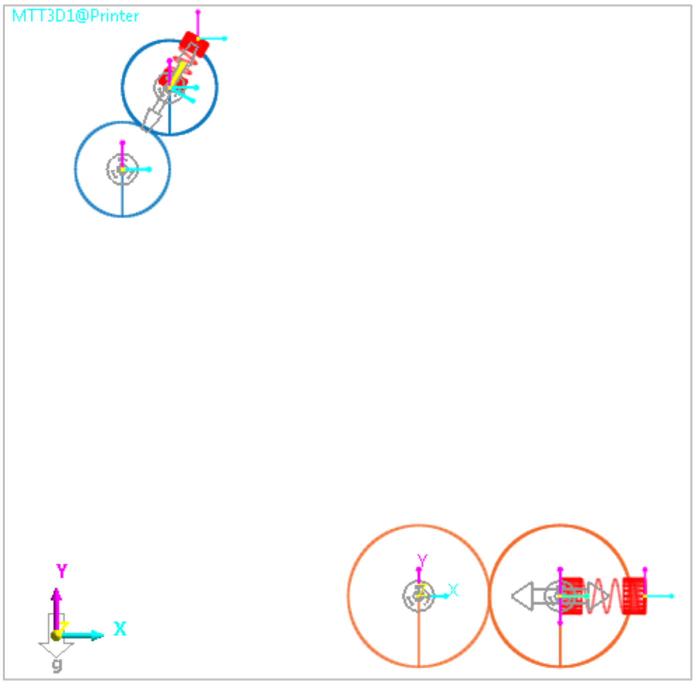
Creating the Top Rollers

You will now create the top rollers, starting with the first top roller pair, which will be duplicated three times for a total of four roller pairs on top.

To create the first top roller pair:

1. Select the **Pair** tool from the **Roller** group under the **MTT3D** tab in the ribbon.
2. Enter the point **-31.446, 45.228, 81** in the **Input Window** for the center of the fixed roller.
3. Enter a radius of **5** in the **Input Window** for the fixed roller.
4. Enter a direction of **1, 1.7321, 0** in the **Input Window** to specify the movable roller location.
5. Enter a radius of **5** in the **Input Window** for the movable roller.

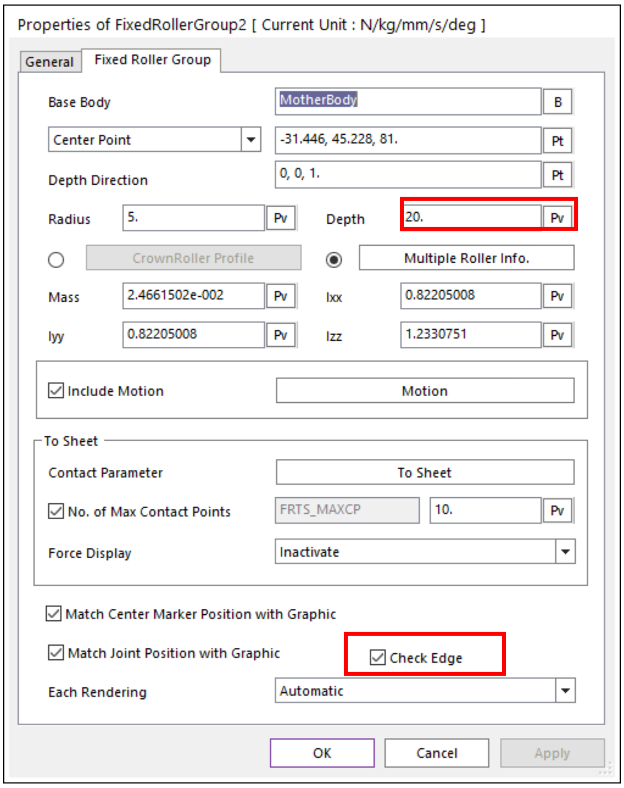
At this point, your model should appear as shown below.



You will now edit the top roller pair to have the correct properties before duplicating it.

To edit the first top fixed roller:

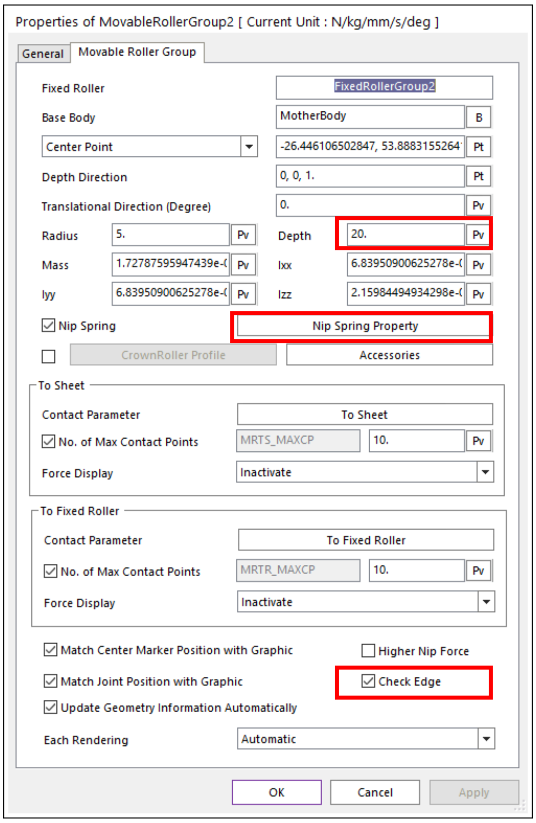
1. From the **Database Window**, open the **Properties** window for **MTT3D1 > Groups > FixedRollerGroup2**.
2. Enter a **Depth** of **20**.
3. Check the box next to **Check Edge** in the lower right of the dialog box.
4. Click **OK**.



Note: The Check Edge option should be selected when a roller's radius is smaller than the length of an individual element in the sheet mesh. When this condition occurs, the contact between the ends of the roller and the sheet must be taken into account.

To edit the first top movable roller:

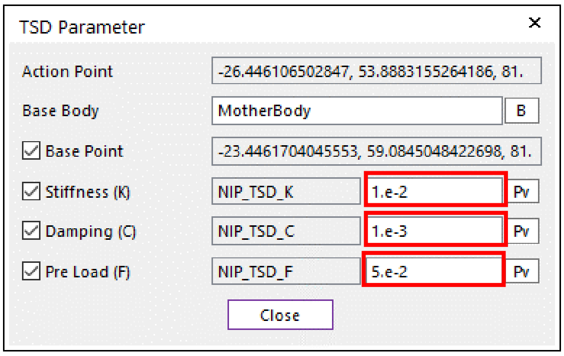
1. From the **Database Window**, open the **Properties** window for **MTT3D1 > Groups > MovableRollerGroup2**.
2. Enter a **Depth** of **20**.
3. Check the box next to **Check Edge**.
4. Select the **Nip Spring Property** button.



5. Make the following settings as shown at right.

- **Stiffness: 1e-2**
- **Damping: 1e-3**
- **Pre Load: 5e-2**

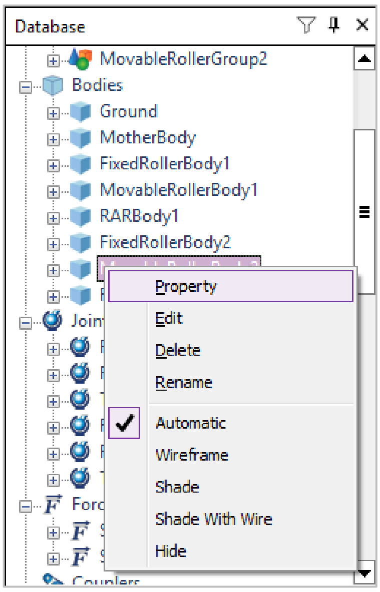
6. Click **Close**.
7. Click **OK**.



Because the top movable rollers are small, spring mounted, and their rotation is not specified with a motion input, their behavior is highly influenced by the sheet and the corresponding fixed roller. Because of this, it is important to set the mass and inertia properties to reasonable values to ensure accurate results. In our model, we will specify that the roller is made of Nylon.

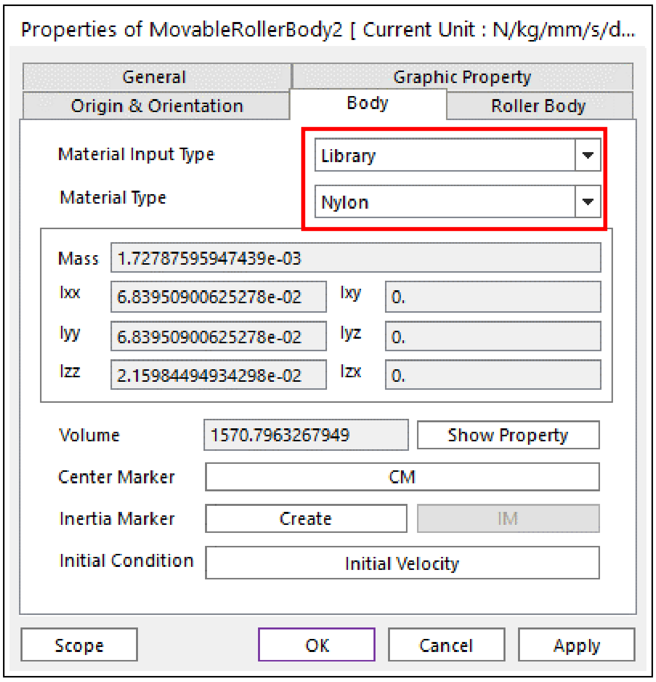
To edit the mass properties of the first top movable roller:

1. To bring up the Properties dialog for the body **MovableRollerBody2** and not the group **MovableRollerGroup2**.
   - In the **Database Window**, locate ***but do not click on*** **MTT3D1 > Bodies > MovableRollerBody2**.
   - ***Without selecting it first***, right-click on **MovableRollerBody2**, and select **Property** as shown at right.



2. Select the **Body** tab.

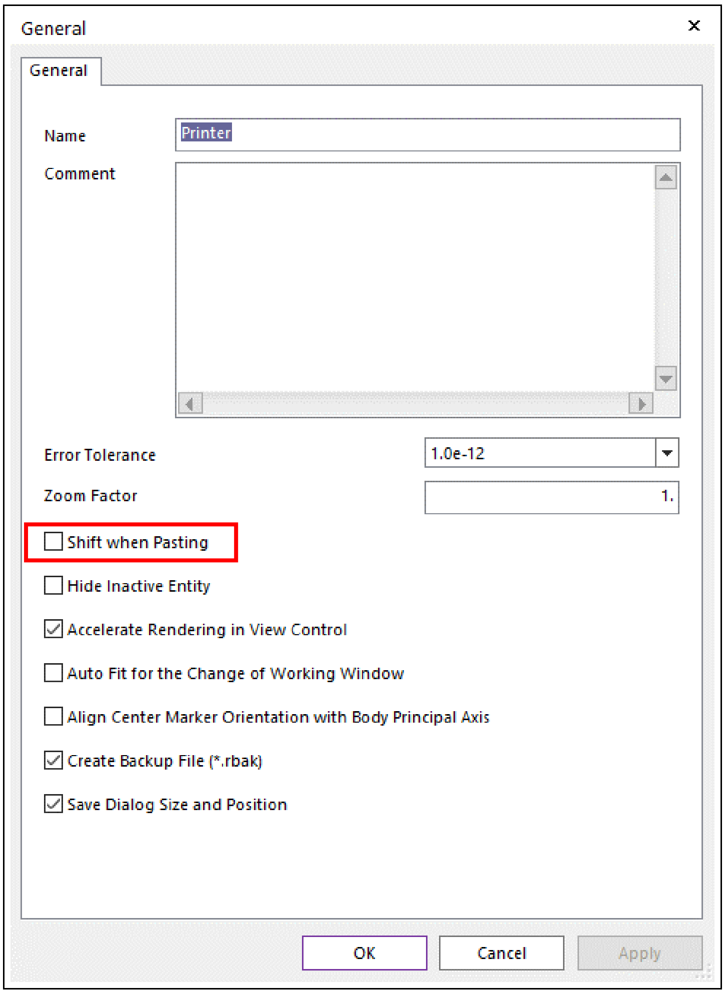
3. For **Material Input Type**, select **Library**. Click **OK** on the warning dialog that pops up.
4. For **Material Type**, select **Nylon**.
5. Click **OK**.



The roller pair is ready to be duplicated. But first, you will want to change some of the program user settings to make copying and pasting easier.

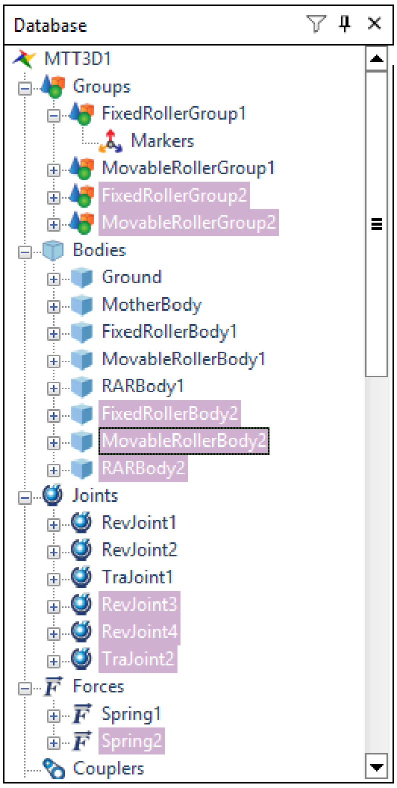
To change the program user copy/paste settings:

1. From the **Home** tab in the Ribbon, select the **General** tool in the **Model Setting** group.
2. Uncheck the box next to **Shift when pasting**.
3. Click **OK**.



You will now make copies of the second roller pair and array them through the -Z direction to create the row of top driving roller pairs.

To duplicate the first top roller pair:



1. In the **Database Window**, select both **FixedRollerGroup2** and **MovableRollerGroup2**:
   - First select **FixedRollerGroup2.**
   - Then hold down the **Ctrl key** and select **MovableRollerGroup2.**

The associated bodies, joints, and forces will be selected automatically as shown at right.

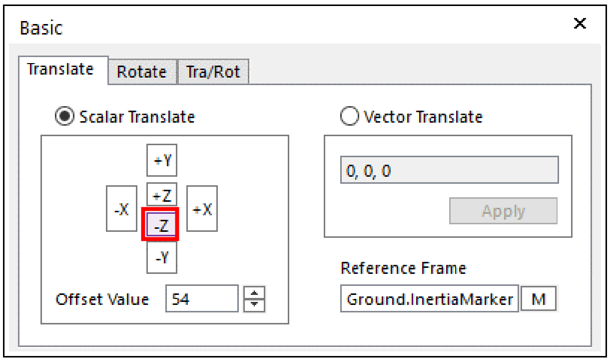
2. From the **Clipboard** group under the **Home** menu, select **Copy**. (Or press **Ctrl-C.**)
3. From the **Clipboard** group under the **Home** menu, select **Paste**. (Or press **Ctrl-V.**)
4. Repeat the previous step (**Paste**) twice, so that there are a total of four identical roller pairs.

To move the duplicated roller pairs into place:

1. In the **Database Window**, use the **Ctrl key** to select **C1_FixedRollerGroup2** and **C1_MovableRollerGroup2.**

2. From the **Advanced Toolbar**, select the **Basic Object Control** tool.
3. For the **Offset Value**, enter **54.**
4. Click the **-Z** button.

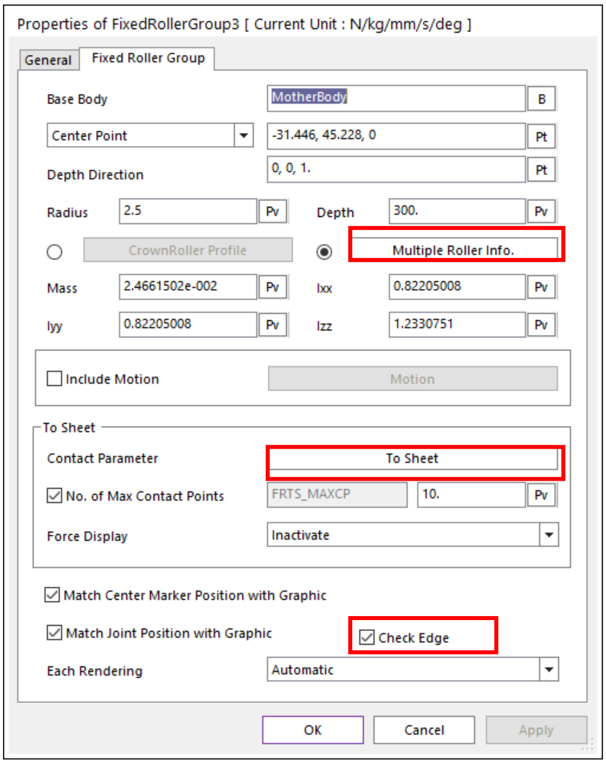
   The first copy of the nip pair should have been translated **54** mm in the -Z direction.



5. In the **Database Window**, use the **Ctrl key** to select **C2_FixedRollerGroup2** and **C2_MovableRollerGroup2.**
6. In the **Basic Object Control** dialog, click the **-Z** button **twice** to move it **108** mm in the -Z direction.
7. In the **Database Window**, use the **Ctrl key** to select **C3_FixedRollerGroup2** and **C3_MovableRollerGroup2.**
8. In the **Basic Object Control** dialog, click the **-Z** button **three times** to move it **162** mm in the -Z direction.

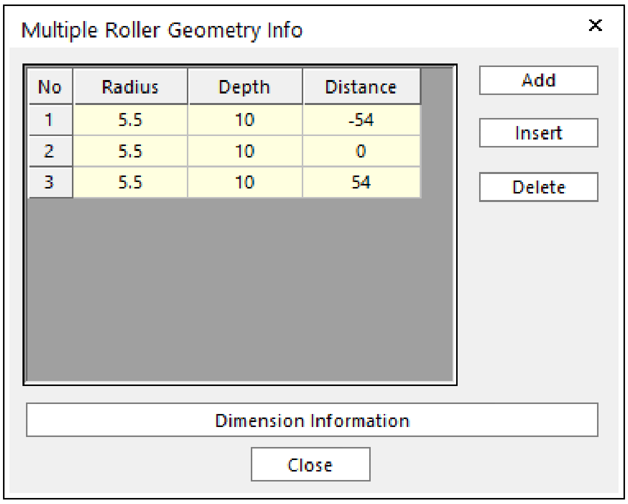
To create the multi-profile corrugating roller:

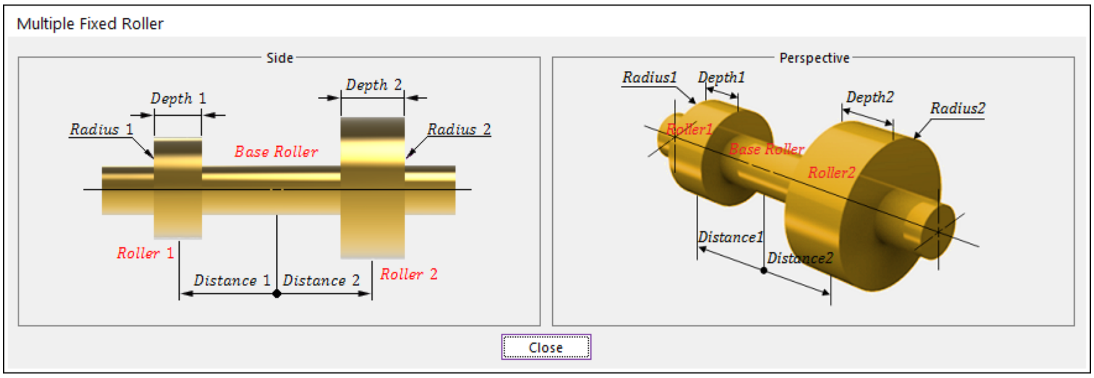
1. Select the **Fixed** tool from the **Roller** group under the **MTT3D** tab in the ribbon.



2. Enter **-31.446, 45.228, 0** into the **Input Window** as the roller center.
3. Enter a radius of **2.5** in the **Input Window** for the fixed roller.
4. Open the **Properties** window of **FixedRollerGroup3**.
5. Check the box next to **Check Edge**.
6. Click the **Multiple Roller Info.** button.
7. Click the **Add** button three times and enter the following roller data as shown at right.

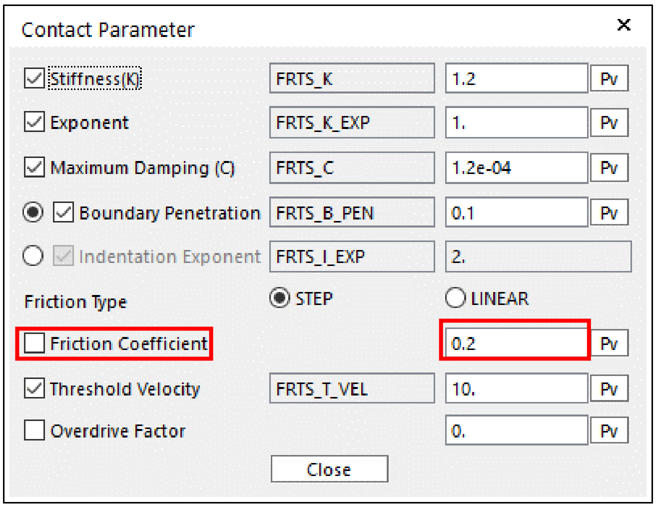
Radius	Depth	Distance
5.5	10	-54
5.5	10	0
5.5	10	54



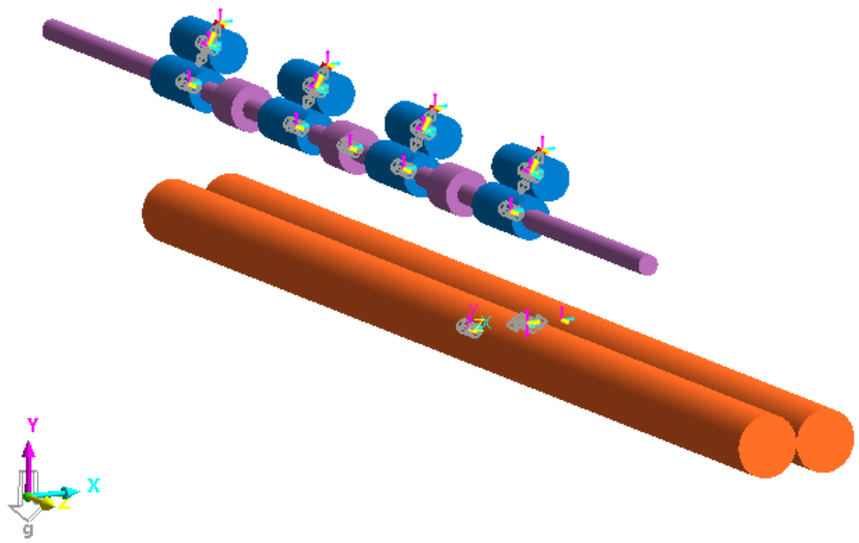


Note: To understand how the above variables apply to the rollers, click the **Dimension Information** button to display the diagram shown at above. When finished, click **Close** to close the window.

8. Click the **Close** button.
9. To the right of **Contact Parameter**, click the **To Sheet** button.
10. Uncheck the box next to **Friction Coefficient**.
11. Enter a **Friction Coefficient** of **0.2**.
12. Click **Close**.
13. Click **OK**.



Your model should appear as shown below (rotated and rendered in the Shaded mode).



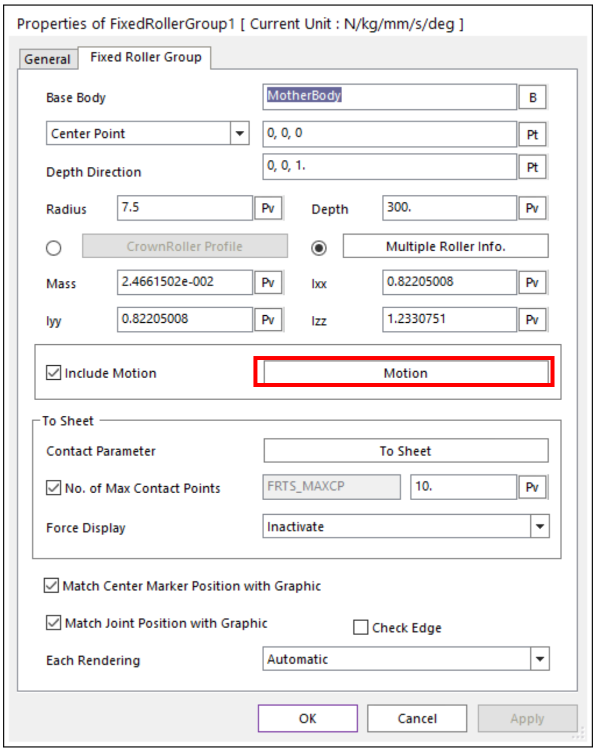
14. **Save** your model.

Adding Motion to the Fixed Rollers

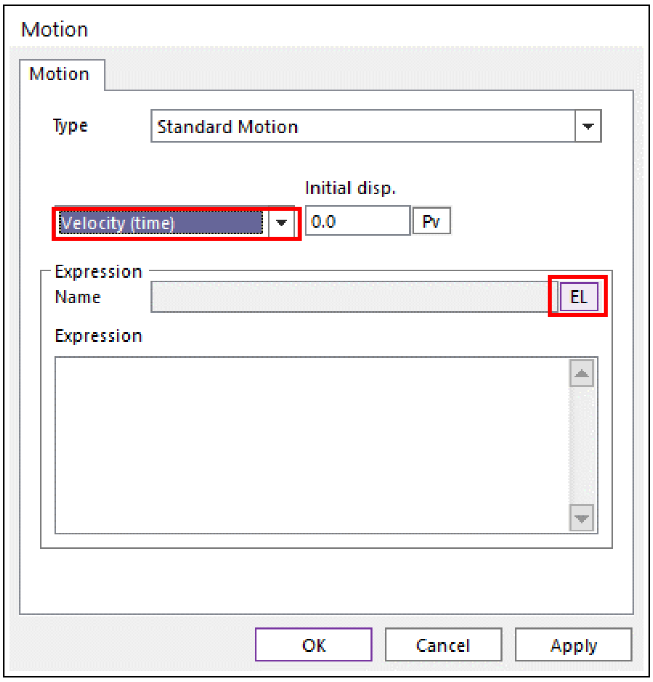
You will now add motion to the fixed rollers, defining expressions which will ramp the rotational velocity up from zero to end values which will move the sheet at a linear velocity of 400 mm/sec. The end values will differ depending on the radius of the roller, but you will enter the expressions in such a way that **RecurDyn** will perform the calculations for you.

To add motion to the bottom fixed roller:

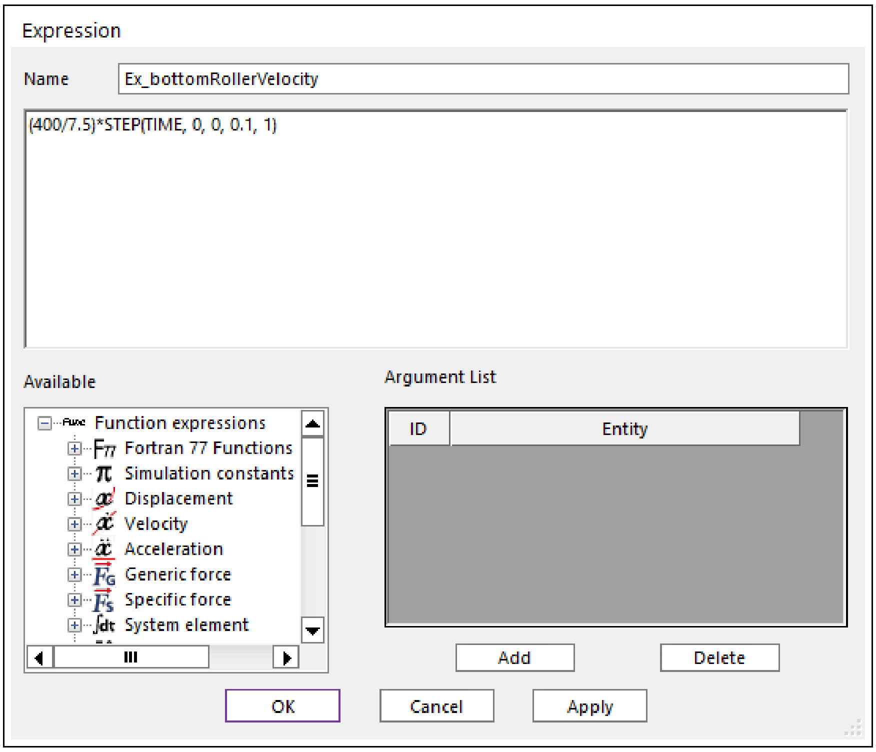
1. From the **Database Window**, open the **Properties** window for **MTT3D1 > Groups > FixedRollerGroup1**.
2. Check the **Include Motion** checkbox and select the **Motion** button next to it.



3. Choose **Velocity (time)** from the dropdown as the variable to control.
4. Select the **EL** button to open the Expression List dialog.



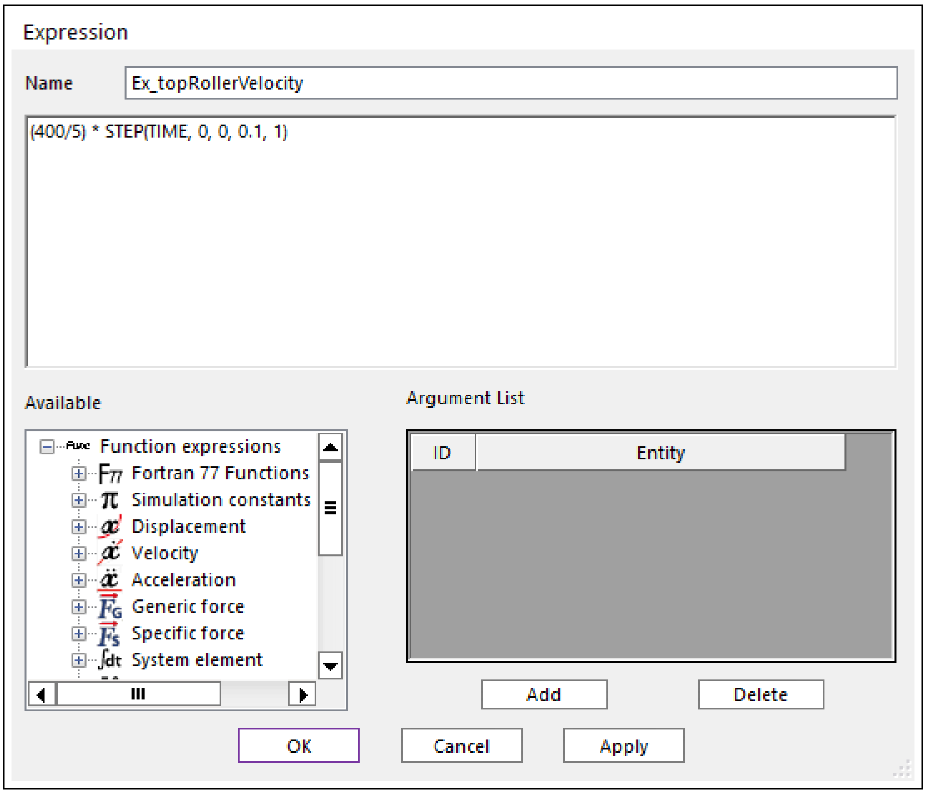
5. Select the **Create** button to create a new expression.
6. As shown below, enter a **Name** of **Ex_bottomRollerVelocity**.



7. Enter the following expression, which references the desired velocity and the roller radius:
   - **(400/7.5)*STEP(TIME, 0, 0, 0.1, 1)**
8. Select **OK** four times.

To add motion to the top fixed rollers:

1. From the **Database Window**, use the **Ctrl key** to select the following.
   - **FixedRollerGroup2**
   - **C1_FixedRollerGroup2**
   - **C2_FixedRollerGroup2**
   - **C3_FixedRollerGroup2**
2. **Right-click** on one of the items and select **Property**.
3. Check the box next to **Include Motion** and select the **Motion** button.
4. Choose to control **Velocity (time)** from the dropdown.
5. Select the **EL** button to open the **Expression List** dialog.
6. Select the **Create** button to create a new expression.



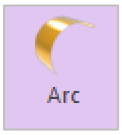
7. As shown above, enter a **Name** of **Ex_topRollerVelocity**.
8. Enter the following expression:
   - **(400/5) * STEP(TIME, 0, 0, 0.1, 1)**
9. Click **OK** four times.

Creating the Guides

You will now create the arc, linear, and edge guides which the sheet will proceed through.

To create the inner arc guide:

1. Return to view the standard X-Y plane. (Shortcut is the **Shift + x** key.)



2. Select the **Arc** tool from the **Guide** group under the **MTT3D** tab in the ribbon.

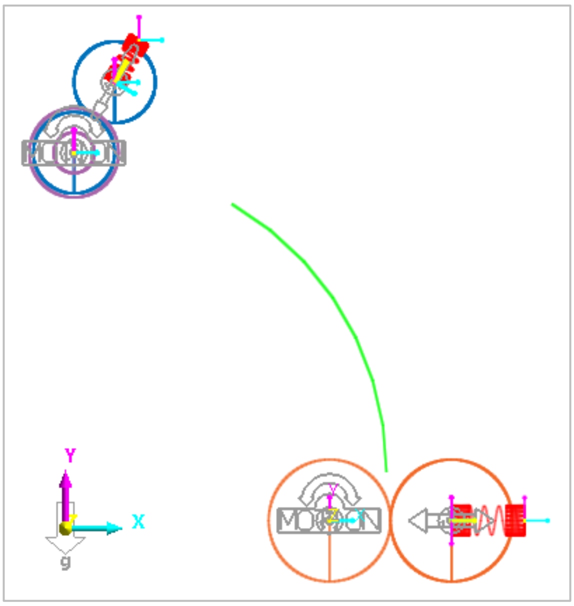
3. In the **Input Window**, enter a center point of **-31, 6**.

4. Enter a start point of **7, 6**.

5. Enter a reference direction of **0, 1**.

6. Enter an angle of **60** degrees.

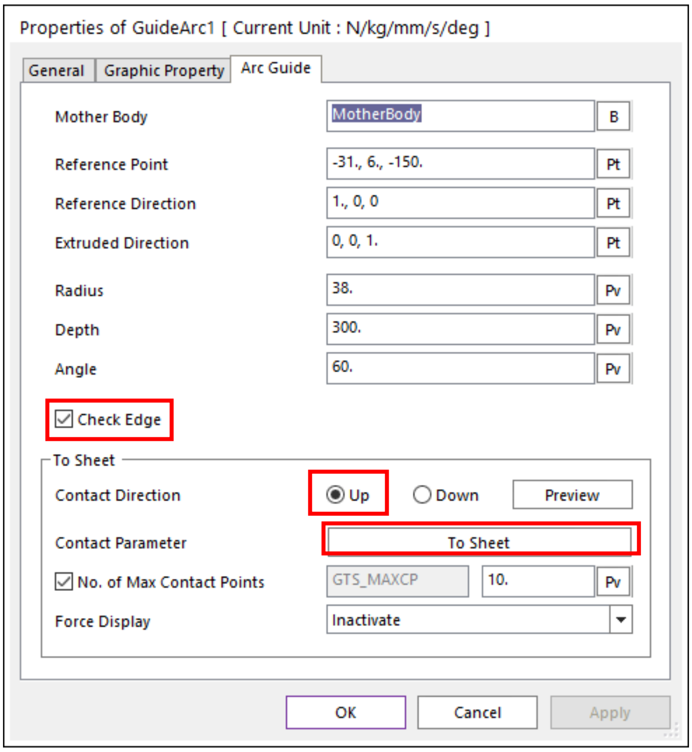
   The first guide should now appear as shown at right. (You will duplicate this inner guide later to create an outer guide.)



7. From the **Database Window**, select **MTT3D1 > Guides > GuideArc1**, and open the Properties dialog.

8. Check the box next to **Check Edge**.

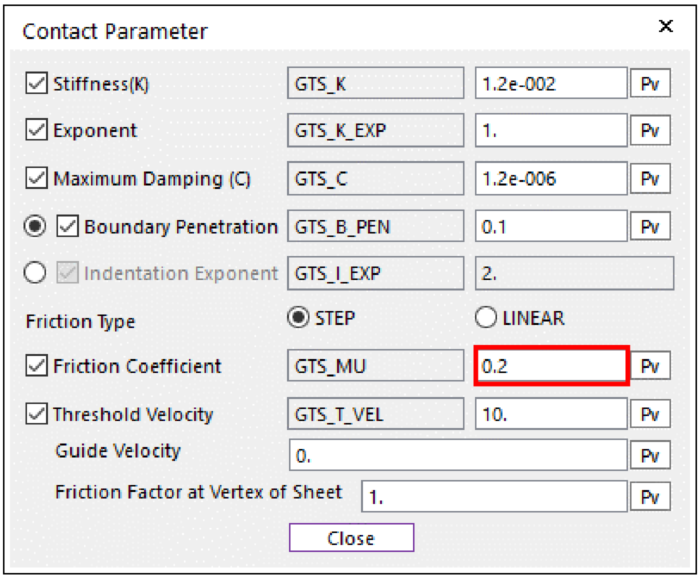
9. To the right of **Contact Parameter**, select **To Sheet**.



10. Set the **Friction Coefficient** to **0.2**.

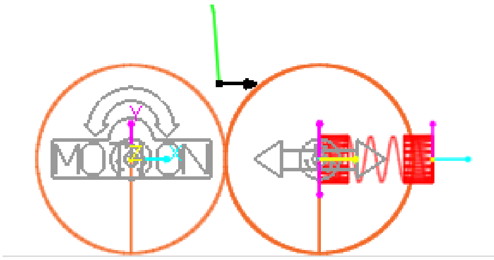
    This will set the default friction coefficient for all guides to this value.

    You will now adjust the contact direction to ensure that it points in the correct direction.



11. Back in the **Properties of GuideArc1** dialog, to the right of **Contact Direction**, click the **Preview** button. Click on the **Up** button.

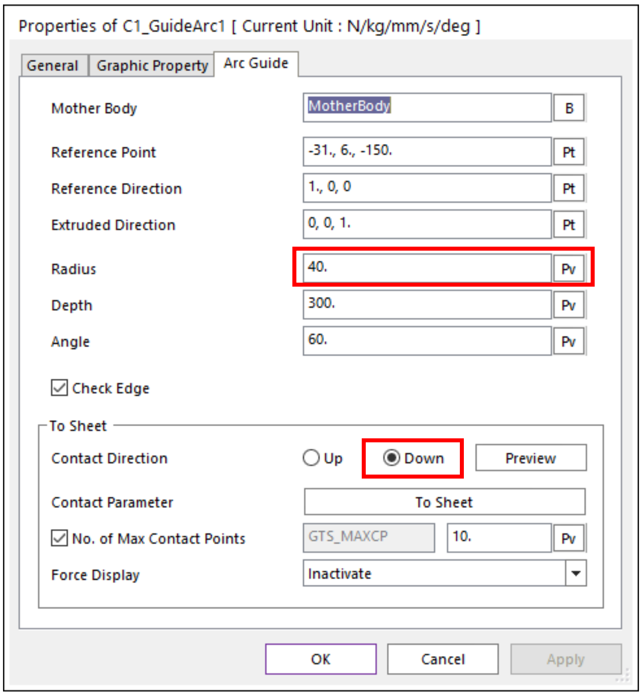
    A small arrow indicating the direction of contact should appear, as shown at right.



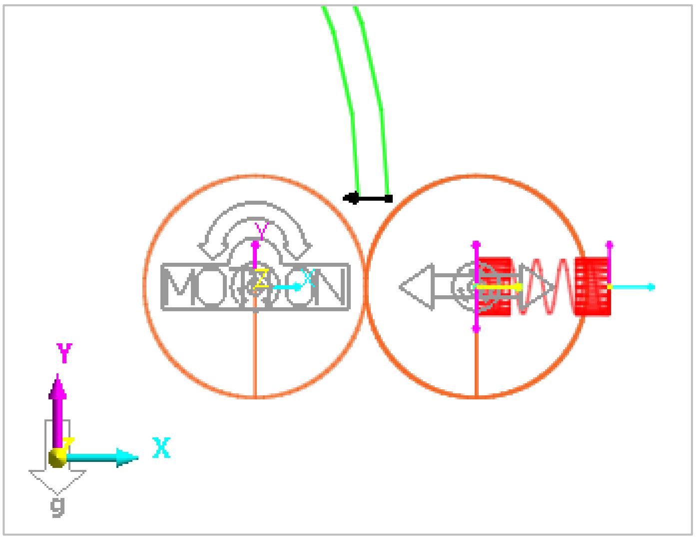
12. Press the **Esc key** to exit the preview mode.
13. If the arrow did not point in the direction shown at right, change the **Contact Direction** using the **Up** and **Down** radio buttons.
14. Click **OK** to exit the **Properties** window.

To create the outer arc guide:

1. In the **Database Window**, select **MTT3D1 > Guides > GuideArc1**.
2. Duplicate **GuideArc1** using the **Copy** and **Paste** commands as done before.
3. From the **Database Window**, select **MTT3D1 > Guides > C1_GuideArc1** and open the **Properties** dialog.
4. Enter a **Radius** of **40**.
5. Select **Apply**.



6. As before, ensure that the contact direction is pointing the right way. It should appear as shown at right.
7. Click **OK**.



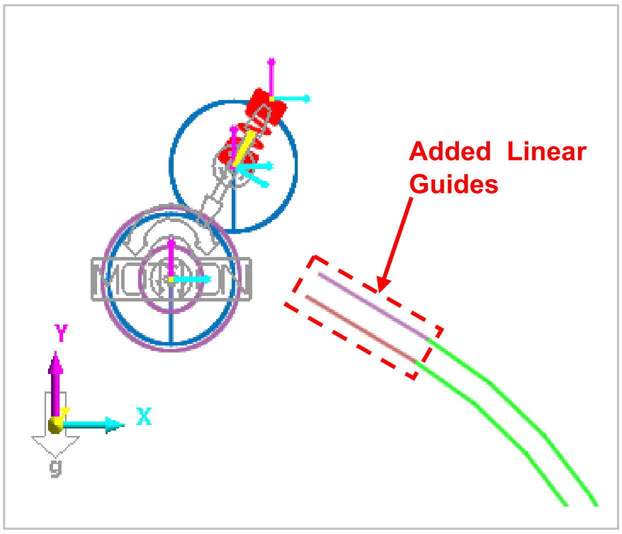
To create the inner linear guide:

1. Select the **Linear** tool from the **Guide** group under the **MTT3D** tab in the ribbon.
2. In the **Input Window**, enter a start point of **-20.660, 43.909**.
3. In the **Input Window**, enter an end point of **-12.000, 38.909**.

To create the outer linear guide:

1. Select the **Linear** tool from the **Guide** group under the **MTT3D** tab in the ribbon.
2. In the **Input Window**, enter a start point of **-11.000, 40.641**.
3. In the **Input Window**, enter an end point of **-19.660, 45.641**.

The model should now look as shown below.



You now need to create small circular guides at the edges of the existing guides. It is always a good practice to do this in order to prevent penetration of the edges of the guides into the faces of the sheet bodies. The reason this is necessary is because the arc and linear guides contact only the edges of the individual sheet bodies, while the circular guides contact both the faces and the edges of the sheet bodies.

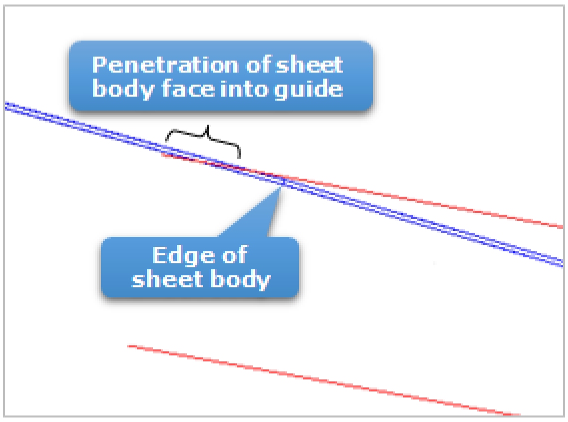


Figure 1: Sheet penetration at guides with no circular edges.

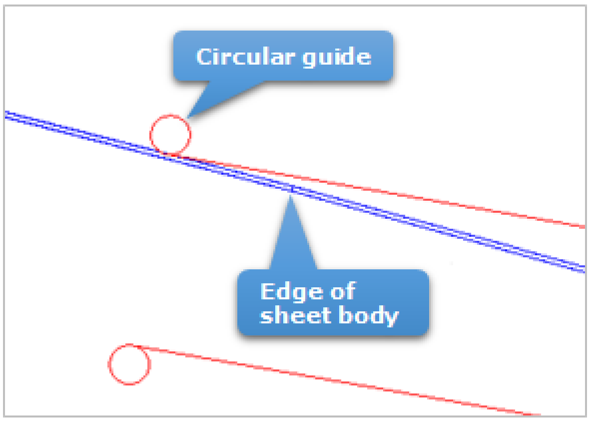
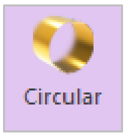


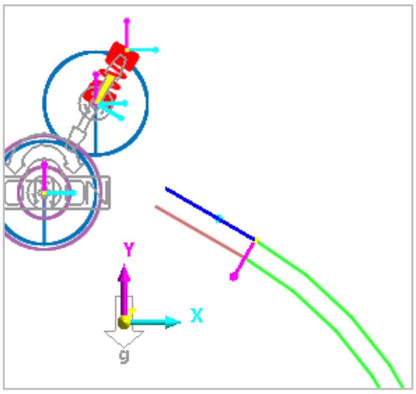
Figure 2: Sheet penetration prevented with circular guides.

To create the circular guides:

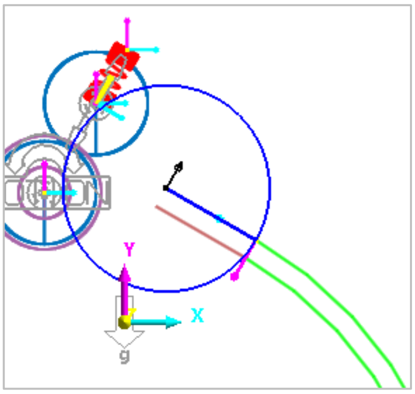


1. Select the **Circular** tool from the **Guide** group under the **MTT3D** tab in the ribbon.

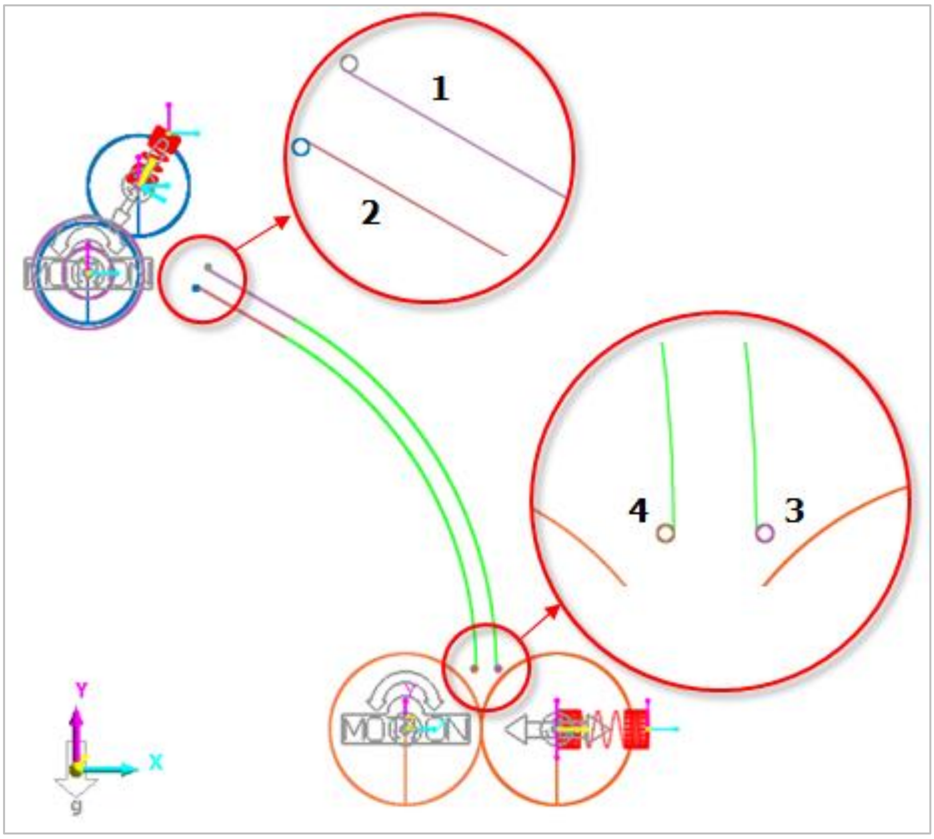
2. In the **Modeling Window**, select the left end of the outer linear guide you just created (GuideLinear2), as shown at right.



3. In the **Modeling Window**, move the mouse pointer above the guide such that the OrthoDirection arrow points upwards, as shown at right, and click.



4. In the **Input Window**, enter a radius of **0.2**.
5. Repeat the steps above for the three other guides as shown below.

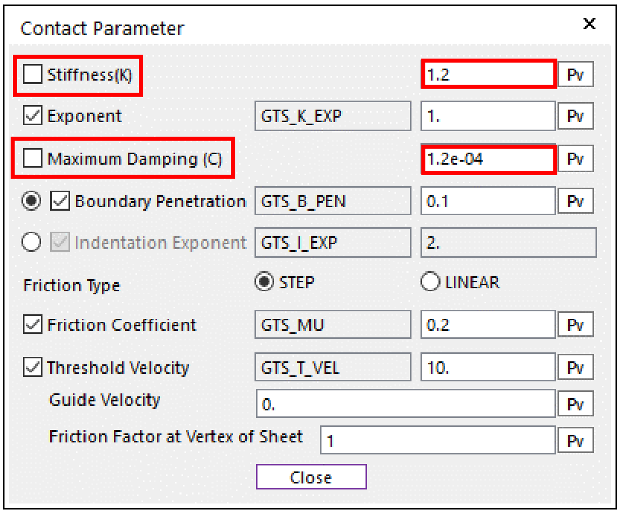


To create the printer tray:

1. Create three more linear guides, using the following start and end points.

	Start Point	End Point
GuideLinear3	-351, 6	-51, 6
GuideLinear4	-351, 26	-351, 6
GuideLinear5	-51, 6	-51, 26

2. Open the **Properties** dialog for **GuideLinear5**, the guide on the right side of the tray.
3. To the right of **Contact Parameter**, select the **To Sheet** button.
4. Uncheck the boxes next to **Stiffness** and **Maximum Damping**.
5. Make the following settings.
   - **Stiffness: 1.2**
   - **Maximum Damping: 1.2e-4**



Note: The stiffness of the contact for GuideLinear5 should be increased to prevent contact penetration of the sheet edge into the guide at the end of the simulation. This can occur because after the sheet lands in the tray, it slides down until it hits GuideLinear5. Only the edge of the sheet contacts GuideLinear5, leaving less sheet bodies to react to the impact, and also the sheet's direction of travel is exactly normal to the guide. Both these conditions make this guide more susceptible to being penetrated by the sheet. Another setting, the Maximum Time Step of the simulation, will also be adjusted later to prevent the same event.

6. Click **Close**.
7. Click **OK**.

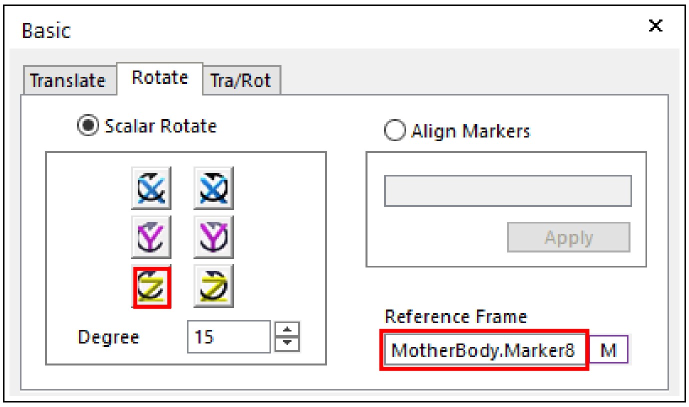
The model should now appear as shown below, with the tray flat. You will next rotate the tray about a reference marker at the right corner of the tray so that it is sloped.

To rotate the paper tray:

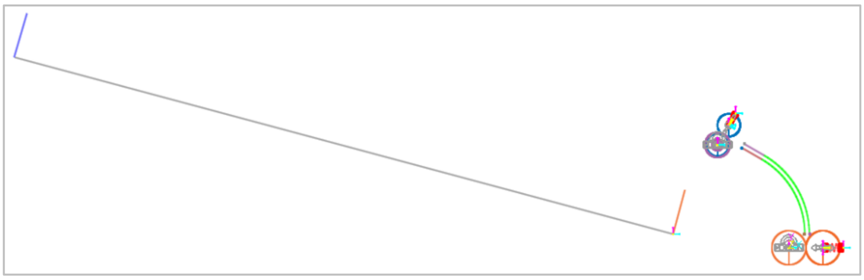
1. Select the **Marker** tool from the **Marker and Body** group under the **Professional** tab in the ribbon.
2. In the **Modeling Window**, click anywhere in the background to associate the Marker with the MotherBody.
3. In the **Input Window**, enter the coordinates **-51, 6**. You will see a new marker at the right corner of the paper tray.
4. Using the **Ctrl key**, select the three guides that make up the tray.

5. From the **Advanced Toolbar**, select the **Basic Object Control** tool.

6. Select the **Rotate** tab.
7. Enter **15** degrees for the angle.
8. Under **Reference Frame**, click the **M** button.
9. From the **Modeling Window**, select **MotherBody.Marker8** (the marker you just created).
10. Click the **Clockwise about Z** button.
11. Close the **Basic Object Control** dialog.



The tray should now appear as shown below.



Creating the Sheet

You will now create the sheet and position the lower rollers around it.

To create the sheet:

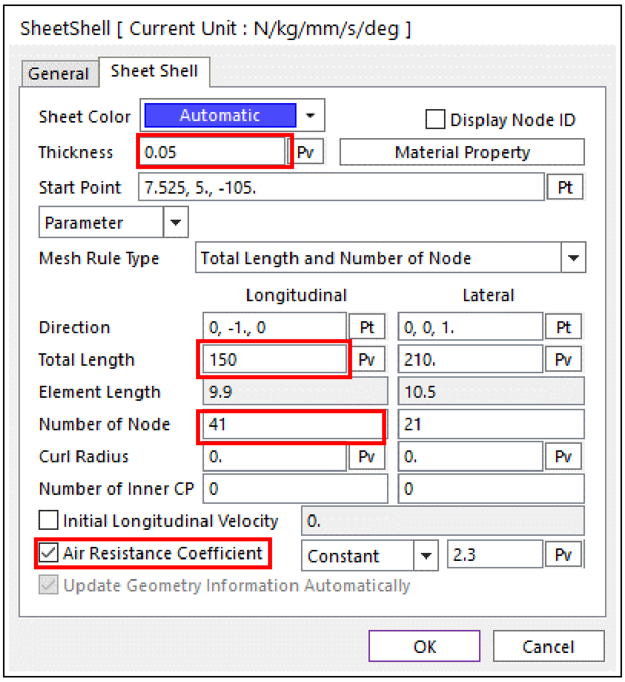
1. Select the **Shell** tool from the **Sheet** group under the **MTT3D** tab in the ribbon.
2. In the **Input Window**, enter a start point of **7.525, 5**.
3. In the **Input Window**, enter a direction of **0, -1**.

4. The **SheetShell** dialog should appear as shown right. If it does not, move the mouse pointer into the Modeling Window and it should appear.

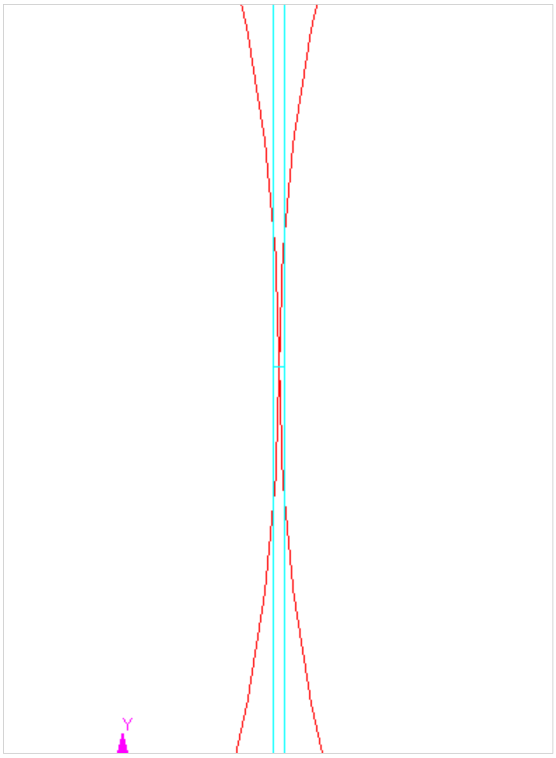
5. Make the following settings in the **SheetShell** dialog shown at right.
   - **Thickness: 0.05**
   - **Total Length (Longitudinal): 150**
   - **Number of Node (Longitudinal): 41**

6. Select the checkbox next to **Air Resistance Coefficient.**

7. Click **OK**.



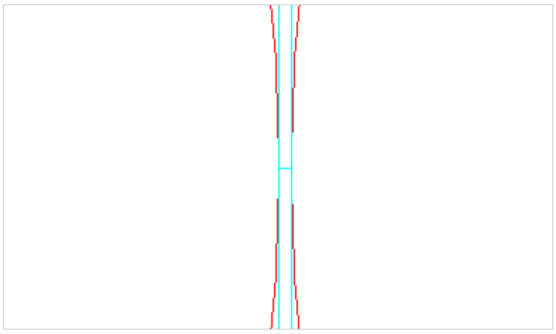
The sheet has been created, but if you were to zoom into the sheet where it is between the rollers, you would see that it is penetrating the rollers and that the rollers have not been separated enough to accommodate the sheet, as shown at right. Therefore, the next step will be to align the sheet and rollers in a reasonable starting position.



To align the sheet within the rollers:

1. Select the **Align** tool from the **Roller** group under the **MTT3D** tab in the ribbons.
2. In the **Modeling Window**, select **SheetShell1**, the sheet group you just created.
3. In the **Modeling Window**, select **MovableRollerGroup1**, the roller to the right of the sheet.
4. Select **OK** when asked whether to align the sheet or not.

   The sheet and movable roller should now have been moved into position as shown at right.
5. **Save** the model.



Chapter
3

Running a Simulation

Task Objective

In this chapter, you will start a simulation and monitor its progress. Later, to save time, you will open a model identical to the one you created which will already have results for a complete simulation loaded and observe the results.

Estimated Time to Complete

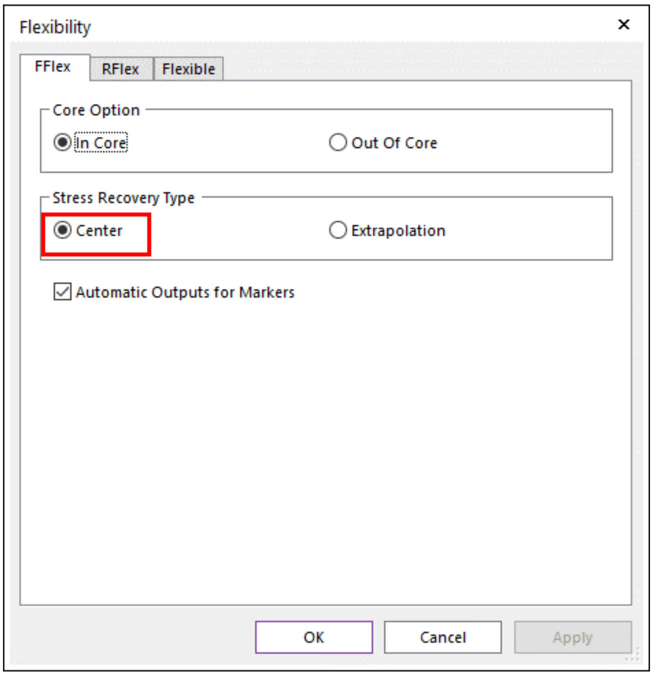
10 minutes

Improving Contour Plot Display

Before running the simulation, you will change the Stress Recovery setting for the sheet body. This setting should be made in most models with flexible bodies for the contour plots to be interpreted correctly.

To set the stress recovery type to center:

1. Select the **Flexibility** tool from the **Model Setting** group under the **Home** tab in the ribbon.
2. Select the **FFlex** tab.
3. In the **Stress Recovery Type** region, select **Center**.
4. Click **OK**.

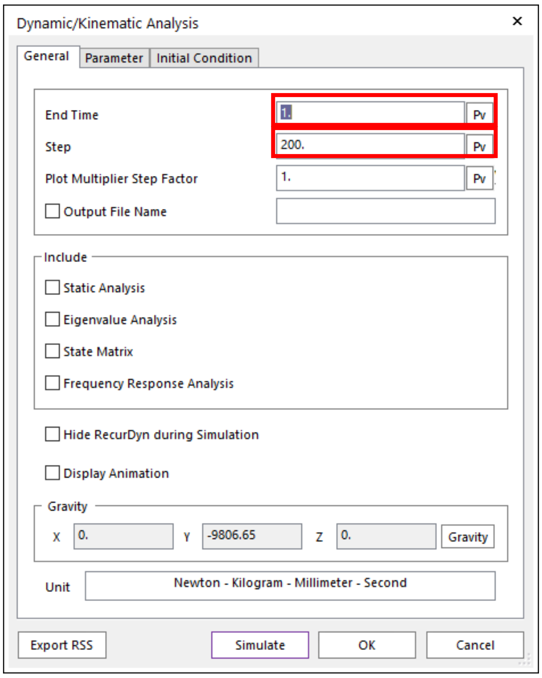


Running a Simulation

You will now start a simulation and monitor its progress.

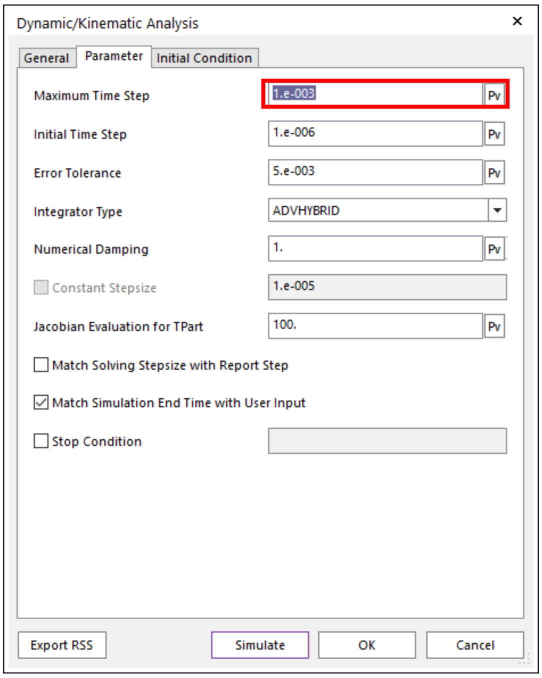
To run the simulation:

1. Select the **Dyn/Kin** tool from the **Simulation Type** group under the **Analysis** tab in the ribbon.
2. Make the following settings, as shown at right.
   - **End Time: 1**
   - **Step: 200**



3. Select the **Parameter** tab.
4. Change **Maximum Time Step** to **1e-3**.

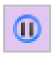
Note: For this simulation, the maximum time step should be reduced to prevent penetration of the sheet edge into GuideLinear5 on the right side of the tray. This can occur because near the end of the simulation, when the sheet is simply sliding down the tray, the integration time step can become too large since the motion of the sheet is very simple. The sheet continues to slide until it hits the bump stop at the right side of the tray, GuideLinear5. If the time step is too large at this point, the simulation can jump too quickly from one state in which the sheet edge is on one side of the bump stop to another in which the sheet edge is on the other side, without registering the sheet-to-guide contact correctly in between.



5. Click **Simulate** and allow the simulation to run for several minutes.

While the simulation is running, you can stop it and play the animation of the completed results to monitor its progress.

To monitor the simulation:

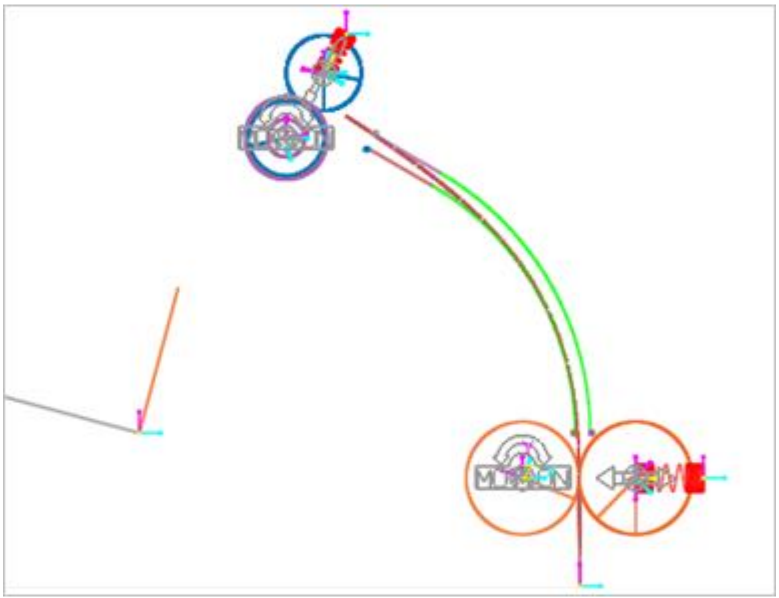


1. From the **Simulation Toolbar**, click the **Pause Analysis** button.

   The animation controls should now become active.

2. From the **Simulation Toolbar**, click the **Play** button. You can use any of the animation controls to view the results as if the simulation were complete.

   With the simulation at about 20% complete, you should see that the sheet has progressed through the guides and has started entering the corrugating roller pair, as shown below. At this point, the simulation will run slower due to the higher amount of sheet deformation and contact which will occur during its corrugation.

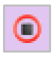


3. From the **Simulation Toolbar**, click the **Resume Analysis** button, in order to continue the simulation.

Viewing the Completed Simulation Results

If you have a powerful desktop computer with multiple processing cores, the simulation can take less than one minute to complete. However, due to the limited time you may have to complete this tutorial, you will now open an identical model which already has results from a complete simulation loaded.

To open the completed model:



1. From the **Simulatoin Toolbar**, click the **Stop Analysis** button.
2. From the **File** menu, select **Open**.
3. Navigate to the tutorial subdirectory labeled **Printer_complete**.
4. Select the file **Printer_complete.rdyn**.
5. Select **Open**.
6. Enter the **MTT3D1** subsystem.
    - In the **Database Window**, right-click on **Subsystems > MTT3D1**, and select **Edit**.

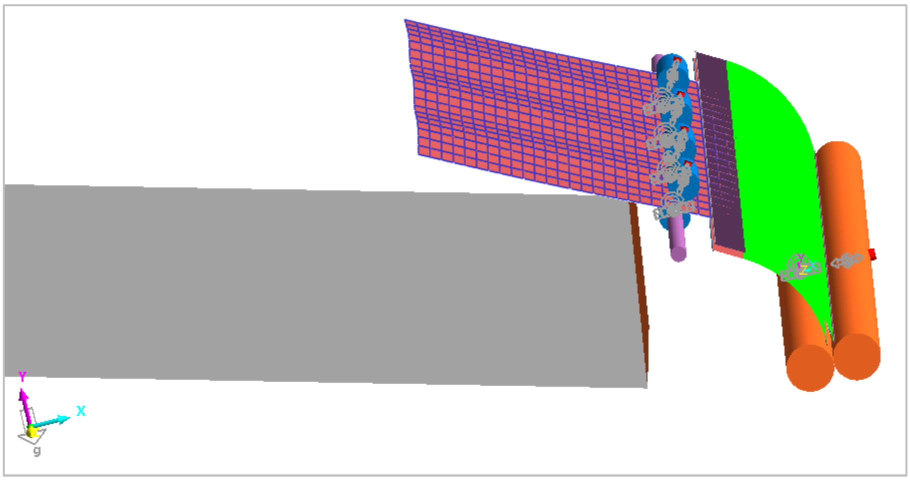
      OR
    - In the **Modeling Window**, double-click on any geometric entity of the **MTT3D1** subsystem.

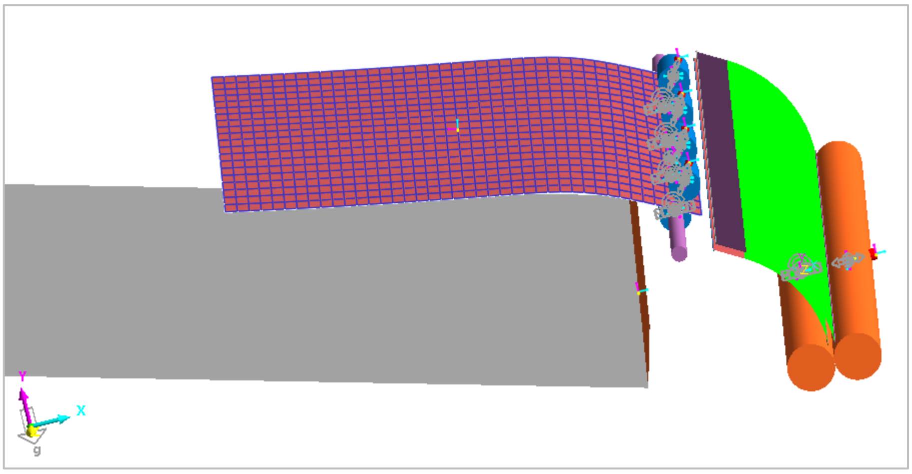
If the animation controls are grayed out, you will need to import the animation results from the previously completed simulation.

To import the animation:

1. From the **File** menu, select **Import**.
2. Select the file **Printer_complete.rad**.
3. Select **Open**.

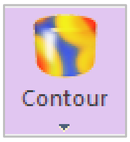
You should now be able to view the results for a complete simulation of the system, by using the standard animation controls. You should see that the paper corrugates, but that it bends downward before exiting the corrugating roller pair, as shown below.   This causes it to land awkwardly within the paper tray.





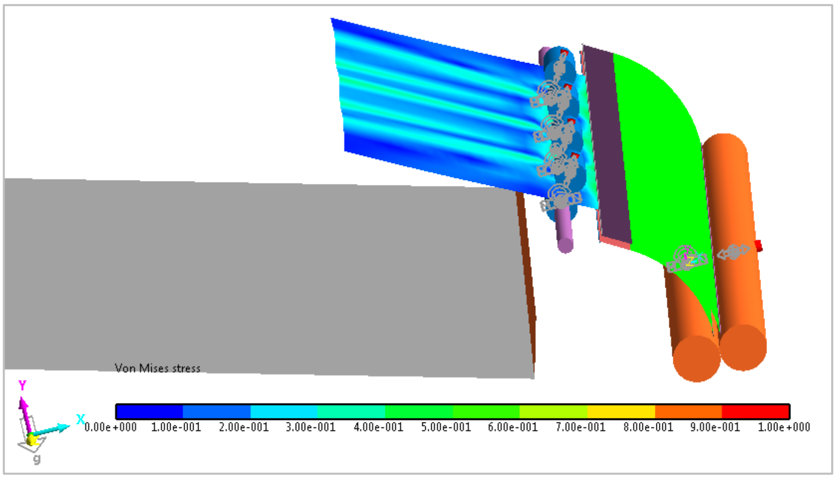
In order to see where the corrugation is occurring more easily, you can display the contour plot of stress within the sheet. To see the contour you need to run the simulation on your own computer so that the .erd, .rfa, and .srd FFlex output files are available.

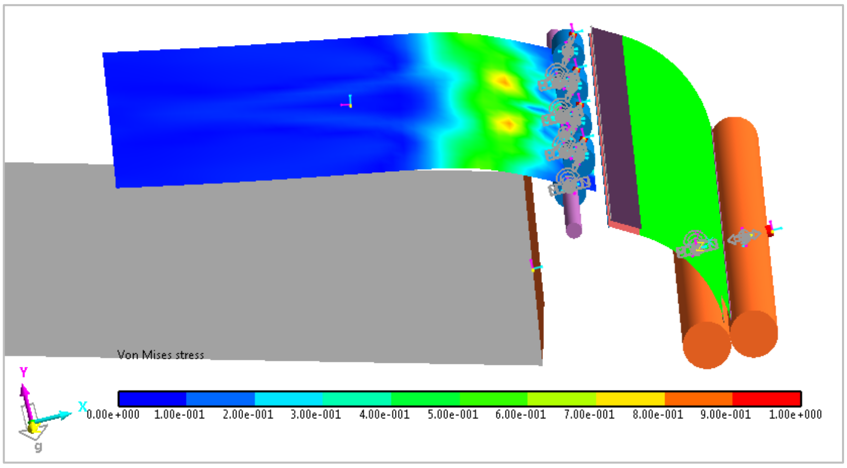
To view the stress contour plot:



1. Select the **Contour** tool in the **Contour** group under the **MTT3D** tab.
2. In the **Contour Option** section, from the **Type** dropdown menu, select **Stress**.
3. Select **SMISES** from the displayed list of data types.
4. In the **Min/Max Option** section, from the **Type** dropdown, select **User Defined**.
5. Enter a **Max** value of **1**.
6. In the **Style Option** section, from the **Style** dropdown, select **Smooth**.
7. Also set the **Text Color** to be black.
8. Click **OK**.

The areas of high stress indicate where the corrugation is occurring as the sheet proceeds out of the rollers. In the second frame below, you can see when the corrugation dissipates due the increasing mass of the sheet away from the rollers, before the sheet is released.





The simulation shows that the design does not maintain the corrugation in the sheet for as long of a time as intended. In the next chapter, you will modify the design to increase the corrugation effect.

Chapter

4

Modifying the Design

Task Objective

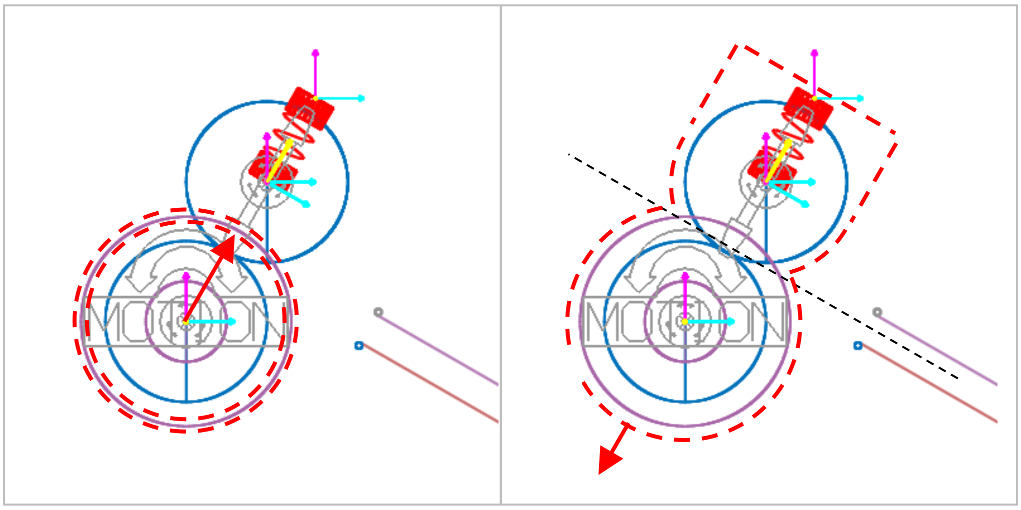
In this chapter, you will modify the design of the corrugation roller to increase the corrugation, in an effort to keep the sheet straight until it exits the printer. You will then import simulation results for the modified design and evaluate its performance.

Estimated Time to Complete

10 minutes

Modifying the Design

In order to increase the corrugation of the paper, the radius of the corrugating rollers will be increased. After that, all the upper rollers will be repositioned such that they remain aligned with the centerline of the linear guides, as shown below.

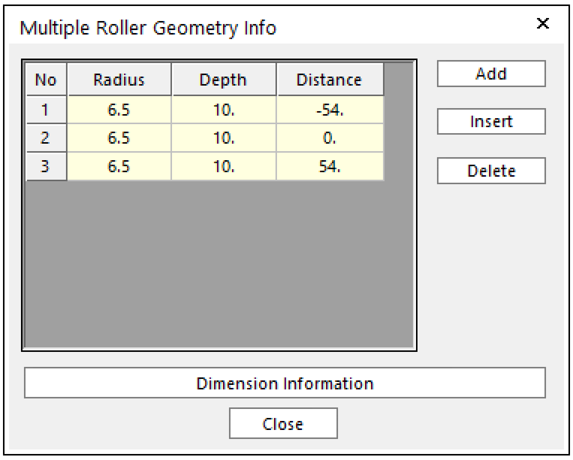


Step 1:
Increase Corrugating Roller Radius

Step 2:
Realign Upper Rollers with Linear Guide Centerline

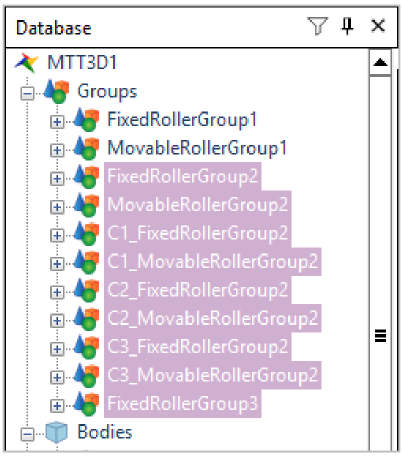
To increase the radius of the corrugating rollers:

1. Return to your model.
2. Open the **Properties** dialog of **FixedRollerGroup3**, the corrugating roller.
3. Click the **Multiple Roller Info**. button.
4. Change the **Radius** values to **6.5**, as shown at right.
5. Click **Close**.
6. Click **OK**.

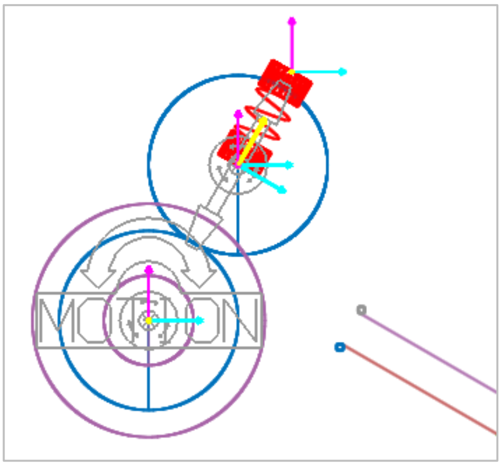


No	Radius	Depth	Distance
1	6.5	10.	-54.
2	6.5	10.	0.
3	6.5	10.	54.

To realign the upper rollers:



1. In the **Database Window**, use the **Shift key** to select all the items under **Groups** except for **FixedRollerGroup1** and **MovableRollerGroup1**.
   - Select **FixedRollerGroup2**.
   - Hold down the **Shift key**.
   - Select **FixedRollerGroup3**.
2. From the **Advanced Toolbar**, select the **Basic Object Control** tool.
3. Enter an **Offset Value** of **0.5**.
4. Under **Reference Frame**, click the **M** button.
5. In the **Modeling Window**, select a marker which is aligned with the axes of the springs, as shown at right.
6. Click the **-Z** button, or whichever button will move the rollers down and to the left.
7. Close the **Basic Object Control** dialog.
8. **Save** the model under a different name, such as **Printer_update.rdyn**.



Evaluating the Design Change

The revised model is ready to simulate, but as before, you can open an identical model with previously completed simulation results, to save time.

To open the previously completed model:

1. Open the file **Printer_update.rdyn**, located again in the **Printer_complete** tutorial subdirectory.
2. Enter the **MTT3D1** subsystem.
3. If the animation controls are grayed out, import the animation file **Printer_update.rad**.
4. Enable the contour plots as done before.

The results should now show an increased amount of corrugation, enabling the sheet to successfully remain straight until exiting the printer, as shown in the following figures.

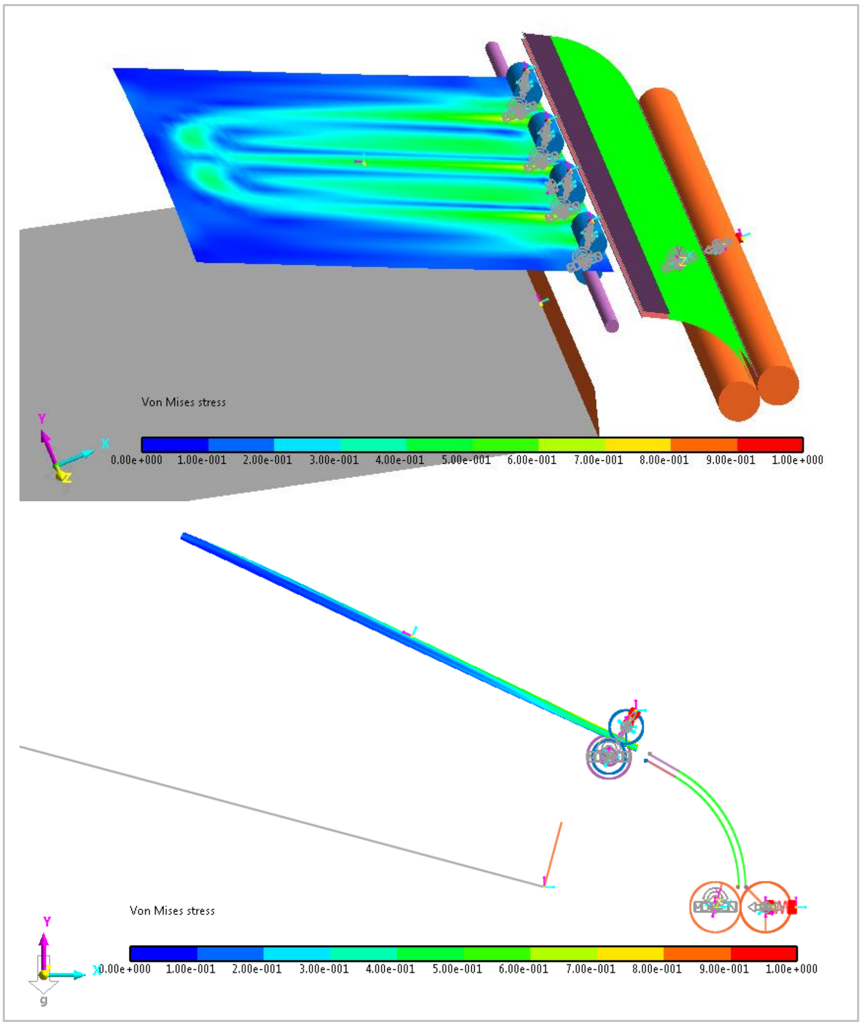


Figure 3: Sheet remains straight as it exits printer.

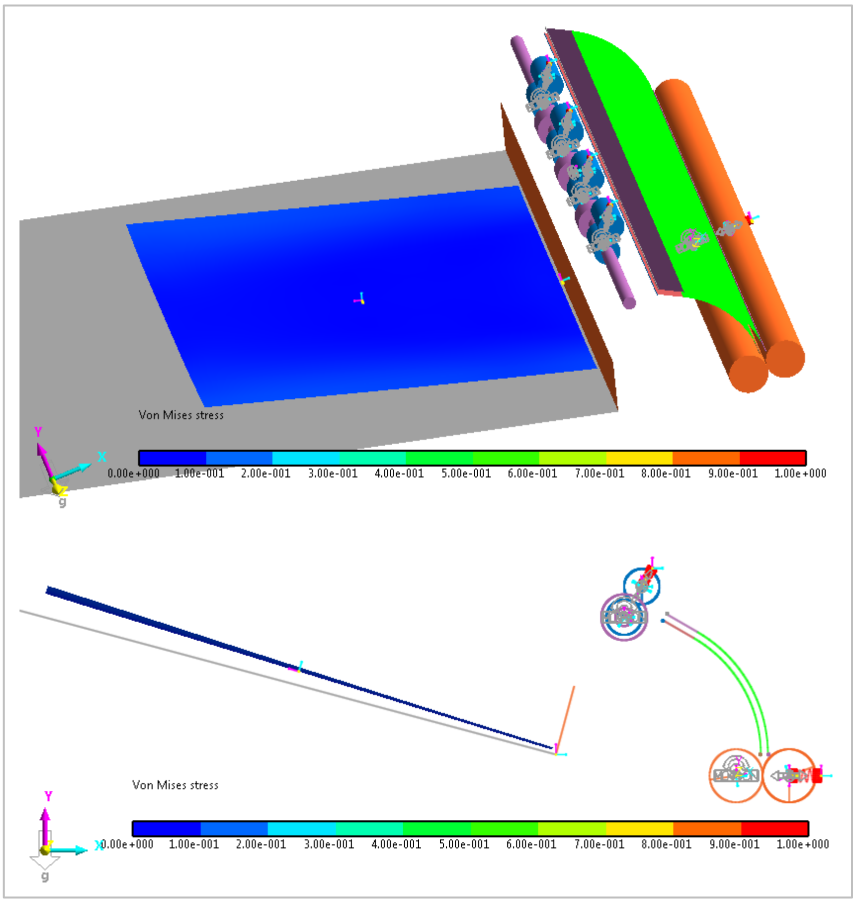
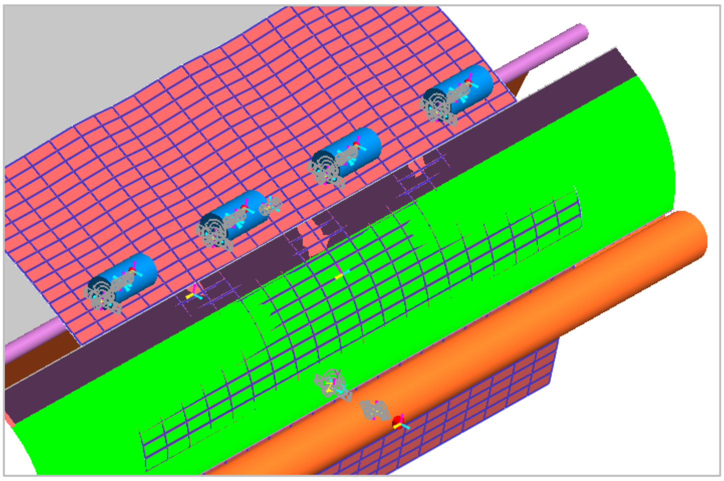
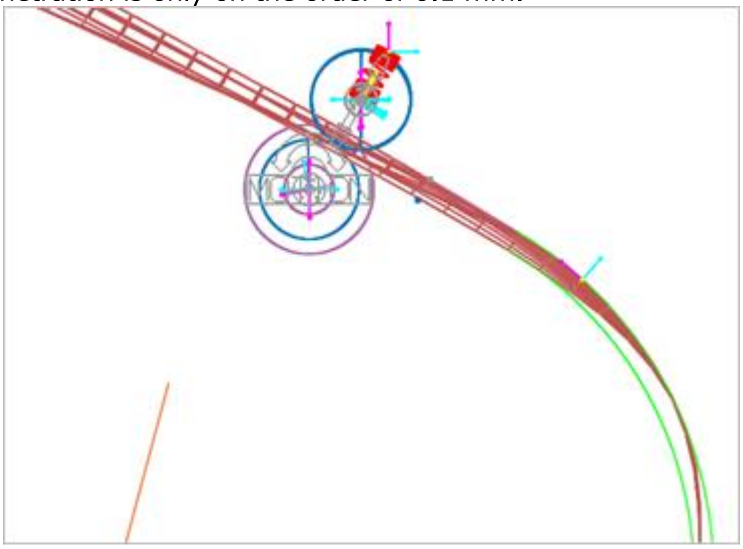


Figure 4: Sheet lands near flat in tray.

Note: In the modified model, you may notice some penetration of the sheet into the outer arc guide, as shown below.



Although this may appear to be a lot of penetration, it actually is not excessive. If viewed from the side, as shown below, you can see that the sheet is staying within the boundaries of the guides and the penetration is only on the order of 0.1 mm.



In addition, this penetration has little effect on the outcome of the simulation as the overall behavior of the sheet is very reasonable.

The penetration could be reduced if the contact stiffness of the guides were increased, however, this would also make the simulation slower by decreasing the integration step size. Therefore, a general rule of thumb is that the contact stiffness should be as low as possible while still enabling the model to behave reasonably.

Thanks for participating in this tutorial!