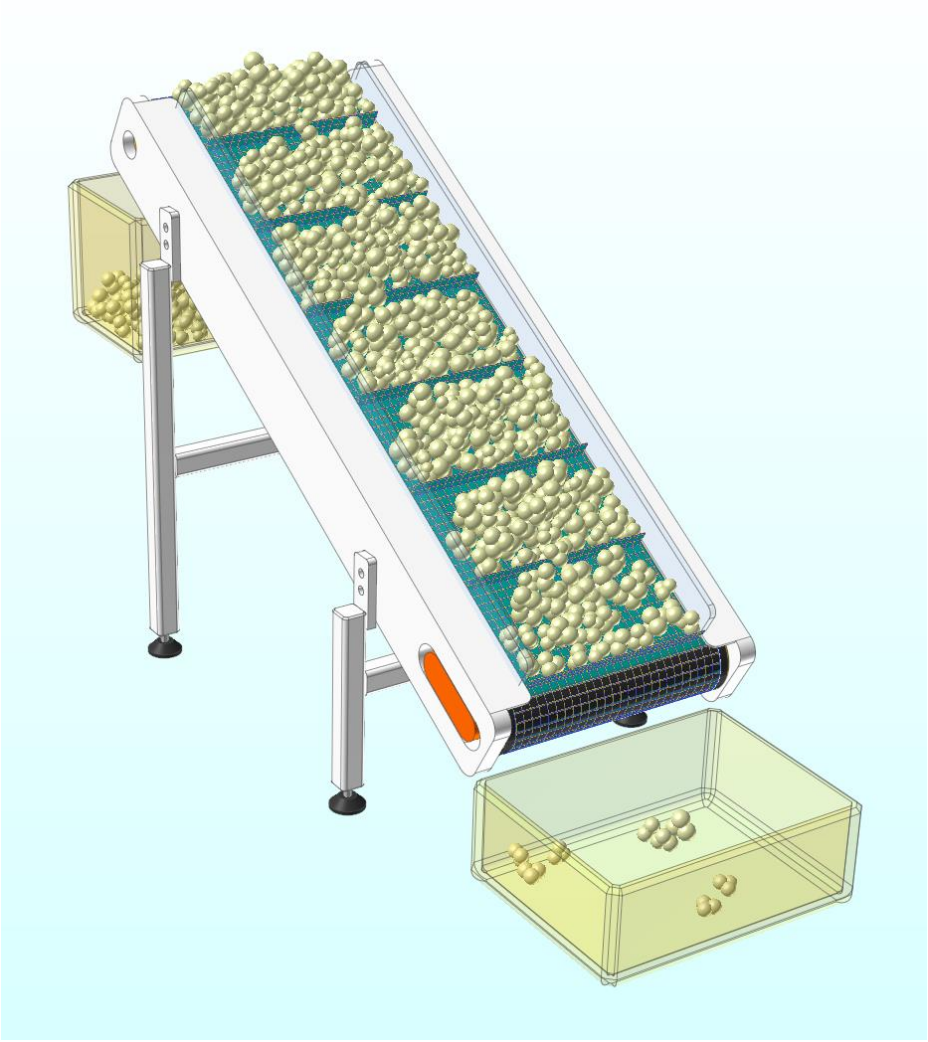
RECURDYN

Cleated Belt Conveyor (EDEM)



FunctionBay

Edition Note

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

Table of Contents

Chapter 1

Overview

This tutorial covers how to perform co-simulation between the two software **RecurDyn** and **EDEM**. **RecurDyn** covers kinematic analysis and flexible body analysis, and **EDEM** the particle analysis using DEM (discrete element modeling). This tutorial will analyze the behavior of particles according to the movement of a flexible body, using the two software.

The model to be covered in this tutorial is a cleated belt conveyor system, which transports the particles coming in at a constant speed upwards along the slope. We will try to figure out the velocity of the belt or the inflow of the particles that ensures maximum efficiency without losing the particles.

Task Objectives

This tutorial covers the following topics:

- How to create walls for a rigid body and a flexible body through **RecurDyn**
- How to export a wall through **RecurDyn**
- How to find properties in **EDEM**
- How to create particles in **EDEM**
- How to perform co-simulation in **RecurDyn**
- How to perform post-processing in **RecurDyn** and **EDEM**

Prerequisites

- This tutorial is intended for users who have completed the basic tutorials provided with RecurDyn. If you have not completed these tutorials, then you should complete them before proceeding with this tutorial.
- The EDEM software must be installed to proceed with this tutorial. This tutorial was created based on the version EDEM 2019.

Task

This tutorial consists of the following tasks. The following table outlines the time required to complete each task.
(* The time required may vary depending on the specifications of the computer and the proficiency of the user.)

Task	Duration (minutes)
Registering EDEM GUI on the RecurDyn ribbon	5
Simulating and analyzing the initial model	15
Creating and exporting a wall	5
Creating an EDEM model	10
Co-simulation	150
Analyzing and reviewing the results	10
Total	195

Chapter

2

Registering EDEM GUI on the RecurDyn Ribbon

The **RecurDyn** Ribbon GUI does not show the **External SPI (EDEM)** GUI by default. You must add the GUI to **RecurDyn** using the **Configuration XML** file provided separately.

Task Objectives

In this chapter, you will learn how to add the **External SPI (EDEM)** tab to the GUI on the **RecurDyn** Ribbon using the **Configuration XML** file provided by the **EDEM** software.

Estimated Time to Complete This Task

5 minutes

Importing the Configuration XML File

To copy the EDEMV1_1_0.xml file:

Copy the **EDEMV1_1_0.xml** file located in the **EDEM** software installation path.

- <EDEM Install Path>\lib\EDEMV1_1_0.xml

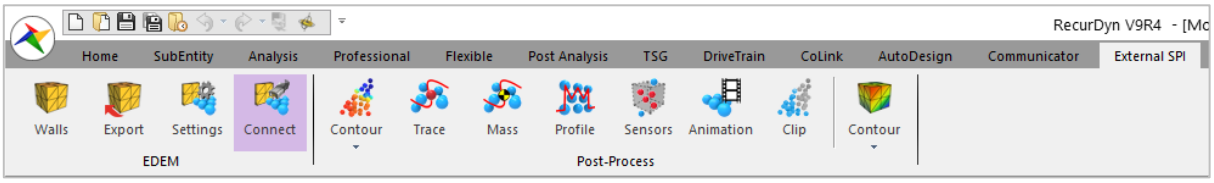
To paste the file into the RecurDyn folder:

Paste the **EDEMV1_1_0.xml** file copied above into the following path:

- <RecurDyn Install Path>\Bin\Solver\CoSim\StdParticleInterface\EDEMV1_1_0.xml

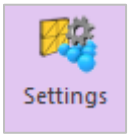
To check the RecurDyn GUI:

When you run **RecurDyn**, you will see that an **External SPI** tab was created in the ribbon GUI as shown below and an **EDEM** group was created in the submenu.

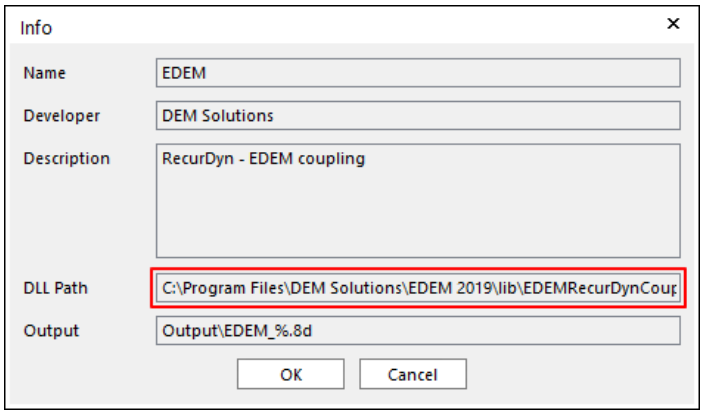


To check the path of Particle Solver DLL:

Check the path where the Particle Solver DLL file should be present.



1. In the **EDEM** group of the **External SPI** tab, click **Settings**.
2. When the dialog window appears, click the **Info** button.



You can check the **DLL Path** in the **Info** dialog window. This path is set to the default installation location of EDEM. So, if you installed EDEM in a different path, you must modify the DLL path in the Configuration XML file.

Tip: Modifying the Particle Solver DLL path in Configuration XML file

(Perform it when the DLL path in the Info dialog window is different from the EDEM installation path.)

1. Open the **EDEMV1_1_0.xml** file.
2. Modify the DLL path following **<Path>** as shown below.

```
<?xml version="1.0"?>
<!-- The first letters of names of elements are capitalized and names of attributes are written in lowe
<!-- Any element for which support is optional must have the attribute "supported" with the value of "t
<!-- If there are multiple supported options of an element, then the element can have an attribute to d
<!-- The names of elements in this file cannot be changed. -->

<!-- Configuration : required -->
<!-- Requires the attribute "type" and "version"-->
<!-- The value of the attribute "type" must be "Embedded" or "Independent" -->
<Configuration type="Independent" version="1010">
    <!-- Details : requred -->
    <Details>
        <!-- Name : required -->
        <!-- This text will be used as the name of Ribbon Group icon in RecurDyn to identify this parti
        <Name>EDEM</Name>

        <!-- Developer : optional -->
        <Developer>DEM Solutions</Developer>

        <!-- Description : optional -->
        <Description>RecurDyn - EDEM coupling</Description>

        <!-- Path : required -->
        <!-- The path of the dll that RD will load to connect to the particle solver -->
        <!-- The path is set during installation -->
        <!-- e.g. C:\Program Files\DEM Solutions\EDEM 2018\lib\EDEMRecurDynCouplingClient1_1.dll -->
        <Path>C:\Program Files\DEM Solutions\EDEM 2019\lib\EDEMRecurDynCouplingClient1.dll</Path>
```

3. Save the **Configuration XML** file.
4. After confirming that the **Configuration XML** has been modified successfully, restart **RecurDyn**.

Chapter

3

Simulating and Analyzing the Initial Model

This tutorial provides a complete **cleated belt conveyor** model. Before proceeding with ED configuration EM and co-simulation, we will simulate the MFBD model alone in **RecurDyn** and analyze the model.

Task Objectives

In this chapter, you will simulate and analyze the **cleated belt conveyor** model provided by **RecurDyn**.

Estimated Time to Complete This Task

15 minutes

Opening the Model

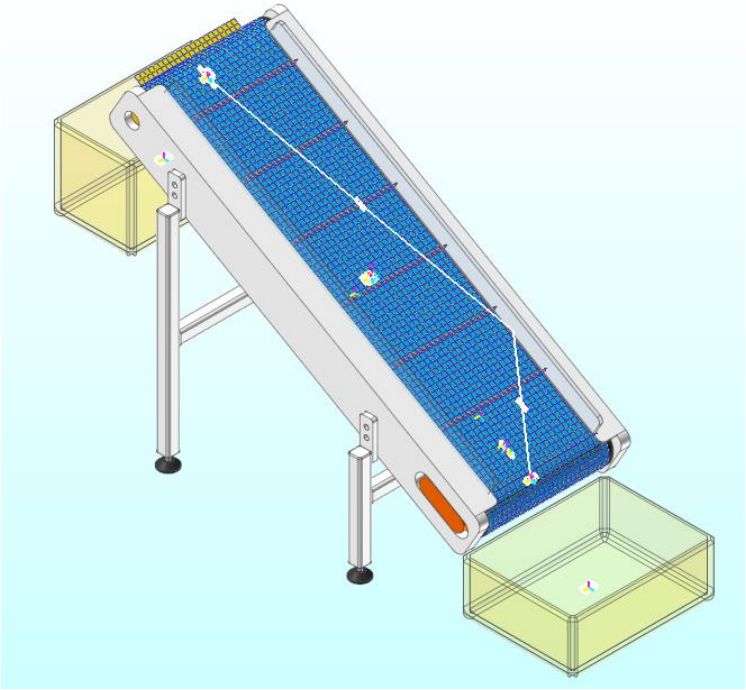
To copy the example model:

- Copy the SPI (EDEM) tutorial example folder provided by RecurDyn to an analyzable location.

  Folder path: <Install Dir>\Help\Tutorial\SPI\EDEM\CleatedBeltConveyor

To run RecurDyn and open the initial model:

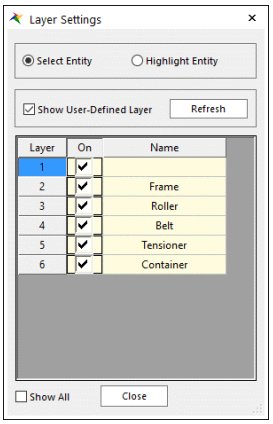
1. On the Desktop, double-click the **RecurDyn** icon to run **RecurDyn**. The **Start RecurDyn** dialog window will appear.
2. When the **Start RecurDyn** dialog window appears, close it.
3. In the **File** menu, click **Open**.
4. In the **CleatedBeltConveyor** folder copied above, select **CleatedBeltConveyor_Start.rdyn**.
5. Click **Open**. The model appears as shown in the following figure.

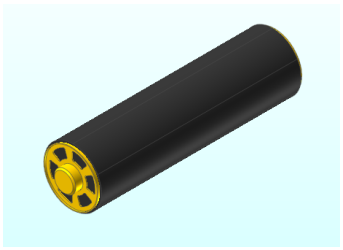


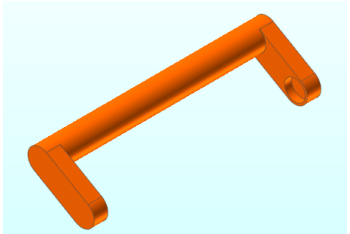
To analyze the model configuration:

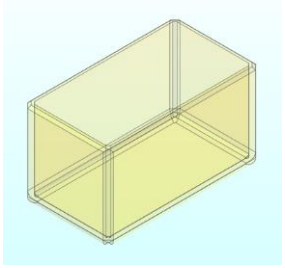
1. Click **Layer Settings** in the **Render Toolbar**.
2. In the Layer Settings dialog window, turn **on** and off each layer to analyze the model.

The following explains the configuration of the model.









The model consists of a belt, frame, roller, tensioner, and container. Here, the belt is modeled as a flexible body. The belt and roller consist with geo cylinder contacts and the roller is rotated by motion.

Performing Simulation

Run the simulation to help you understand the model system.

To run the simulation:

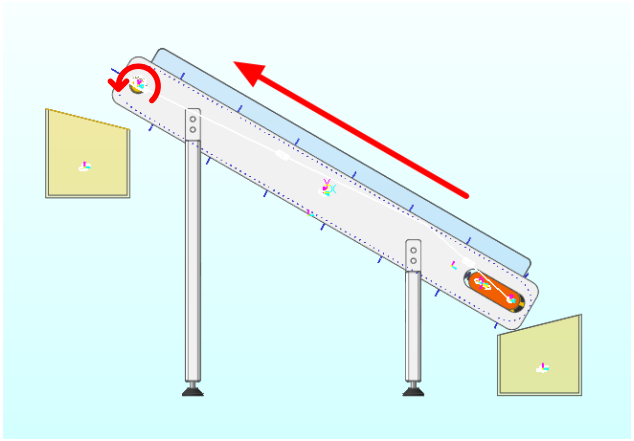
1. On the **Analysis** tab, in the **Simulation Type** group, click the **Dyn/Kin** icon.

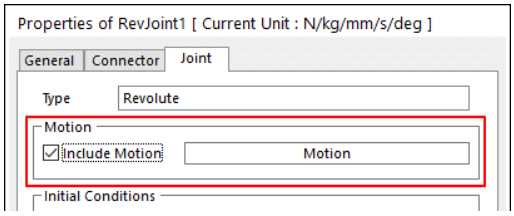
   The **Dynamic/Kinematic Analysis** dialog window appears.

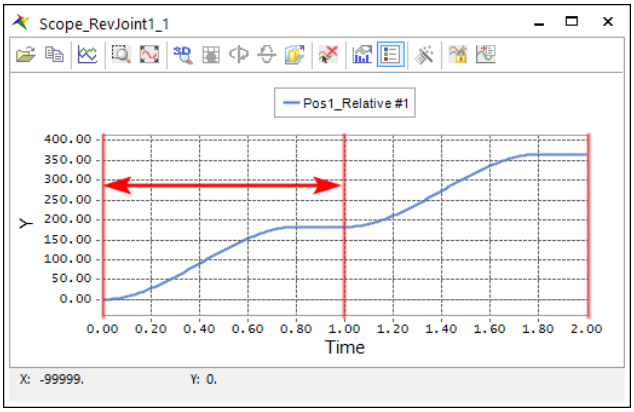
2. After verifying the simulation conditions, click **Simulation**.
   - **End Time**: 2
   - **Step**: 200

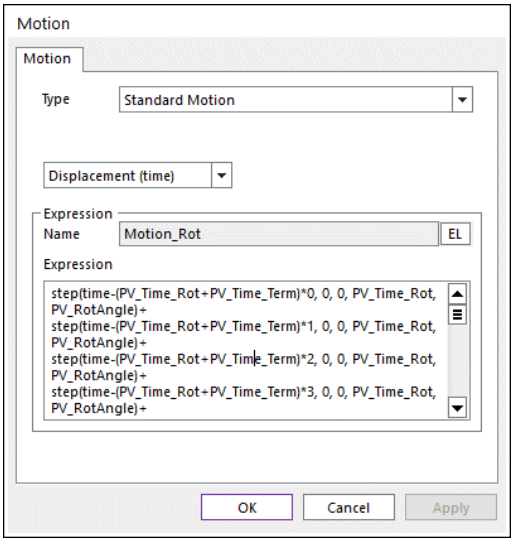
To view the result:

- Under the **Analysis** tab, in the **Animation Control** group, press the **Play** button to check if the system operates as shown in the figure below.
- The belt moves by the motion of RevJoint1, which is attached to the upper roller. If you plot the scope for Pos1_Relative of RevJoint1, you can see that it rotates constantly at a cycle of 1 second.









Chapter

4

Creating and Exporting a Wall

RecurDyn and **EDEM** need a medium called **wall** to exchange data with each other.

Task Objectives

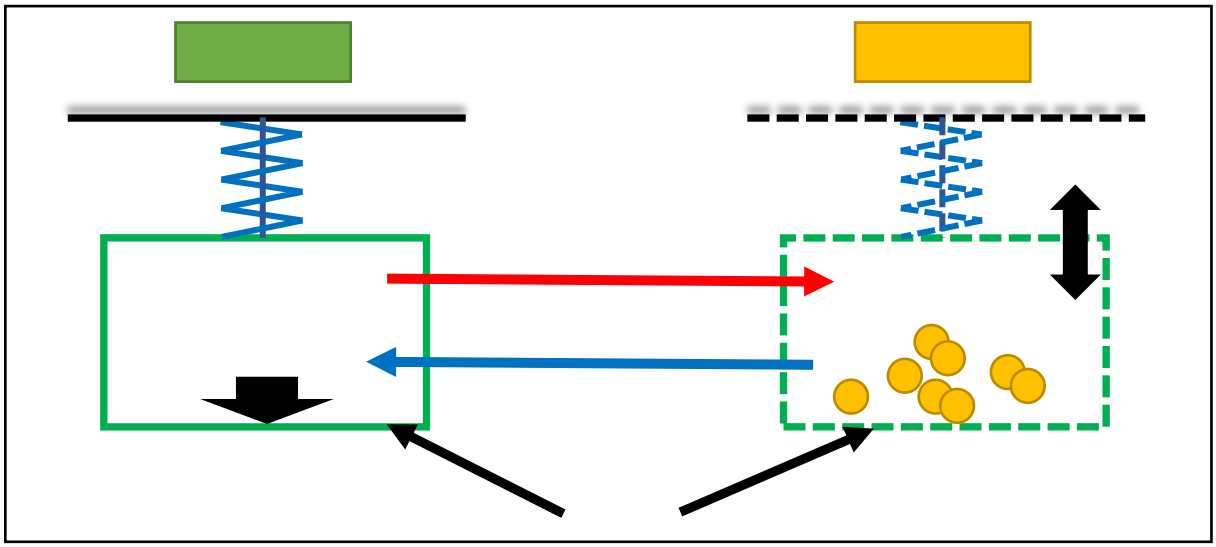
In this chapter, you will learn how to define the geometry to import from **EDEM** in **RecurDyn** and how to export ***.wall** files.

Estimated Time to Complete This Task

5 minutes

Creating walls

Note: What is a wall?
A wall is an entity that defines a geometry that is tangential to the fluid. **RecurDyn** receives data on the external force received from the particle through the wall, and **EDEM** receives data

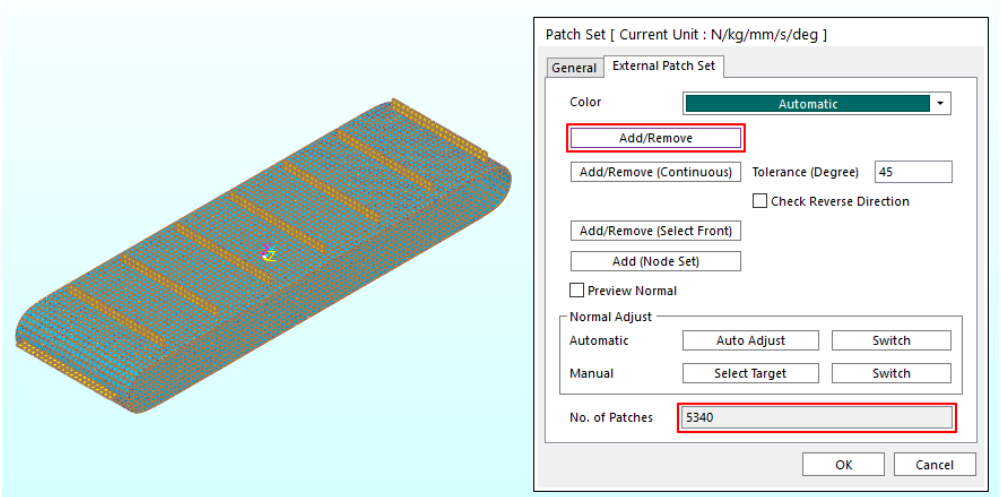


on the movement of the geometry through the wall.

To define a flexible body as a wall, you must define a face to be a wall as a patch set.

To create PatchSet:

1. Enter the **Flex Edit Mode** of **Shell_CleatedBelt**.
2. In the **Set** group of the **FFlex Edit** tab, click **Patch**.
3. Click **Add/Remove** in the Patch Set dialog window.
4. Select all the **patches**.
5. Right-click the working window and click **Finish Operation** in the pop-up menu.
6. After verifying if **No. of Patches** are **5340** and click **OK** to create the **Patch Set**.



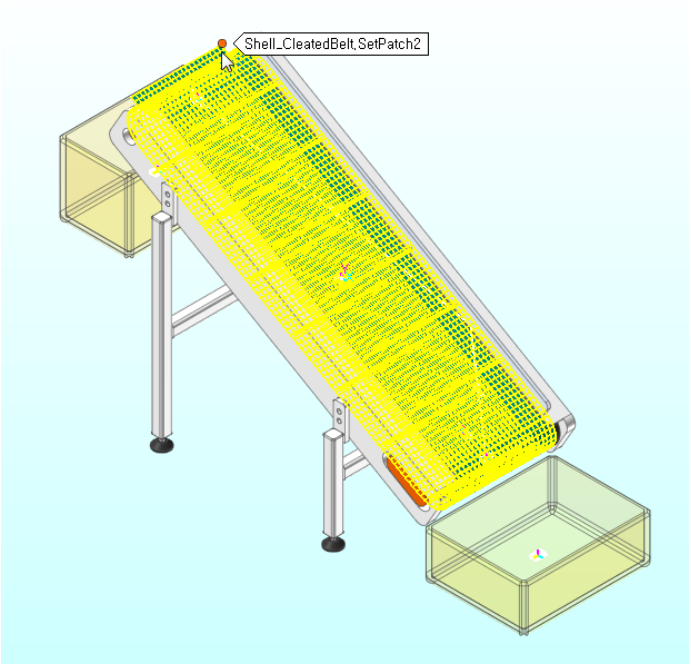
In the Database panel, confirm that **SetPatch2** appears.

7. Click **Exit** to exit the **Edit Mode**.

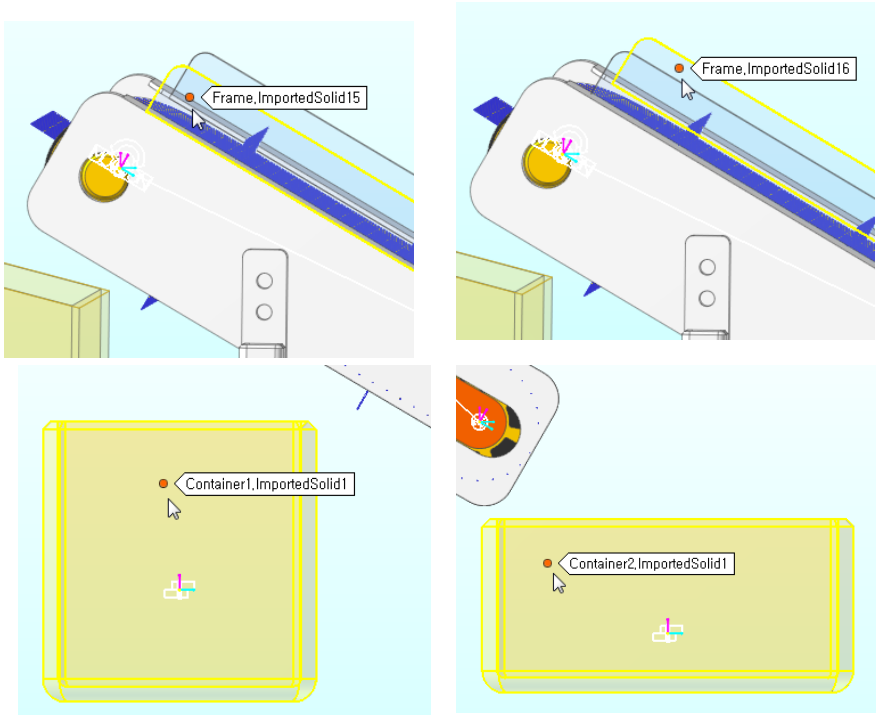
It creates walls in the belt, container, and frame that the particles come in contact with.

To create walls:

1. In the **EDEM** group of the **External SPI** tab, click **Walls**.
2. Click **Shell_CleatedBelt.SetPatch2** on the **working window**.
   Wall1 is created.



3. Repeat steps 1-2 to create walls using geometries.
   - **Frame.ImportedSolid15**
   - **Frame.ImportedSolid16**
   - **Container1.ImportedSolid1**
   - **Container2.ImportedSolid1**



To export a *.wall file:

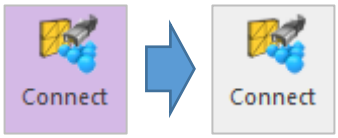
1. In the **EDEM** group of the **External SPI** tab, click **Export**.
2. When the Export dialog box appears, locate the folder you want to save the file to and click **OK** to save it.

   In the saved folder, the **EDEM.wall** file and **Wall1.obj, Wall2.stl, Wall3.stl, Wall4.stl, and Wall5.stl** are created.

Note:
The CAD information of the wall geometry is stored in the files ***.obj** and ***.stl**. And the **EDEM.wall** file contains information about the position and orientation of wall geometries (*.obj, *.stl).
Geometry files always take information in the unit of **Meter** regardless of the system of units of **RecurDyn**.

Tip: Performing standalone analysis with RecurDyn

After the **wall** is created, **RecurDyn** tries to perform co-simulation with **EDEM** when you perform simulation. Therefore, it cannot perform simulation before **EDEM** is connected to it.
If you want to disconnect from **EDEM** and only perform a standalone analysis with **RecurDyn**, deactivate the **Connect** condition.



Chapter 5

Creating an EDEM Model

EDEM can generate particles in many ways. Among them, we will try to generate particles on the belt using the method of generating particles at a constant speed.

Task Objectives

In this chapter, you will learn how to set particle properties and how to create particles using the material models provided by **EDEM**.

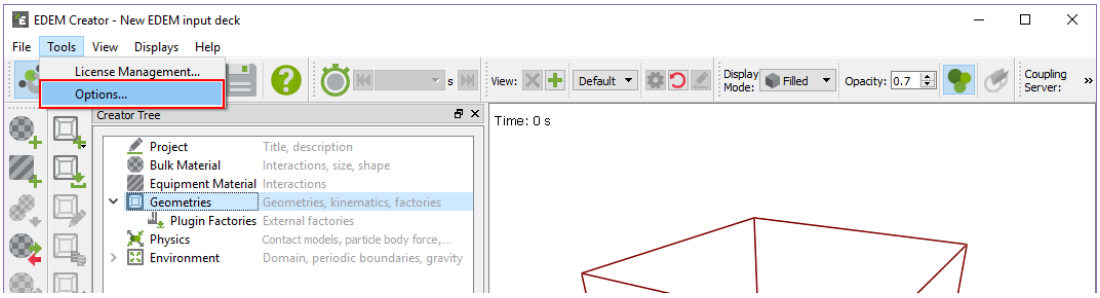
Estimated Time to Complete This Task

10 minutes

EDEM Creator

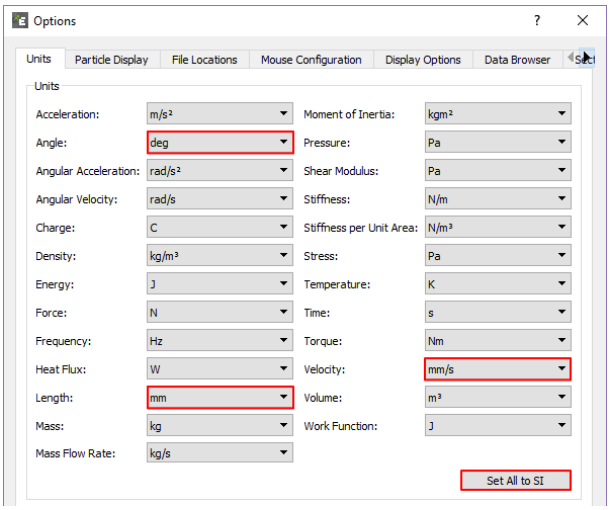
To execute EDEM and set RecurDyn coupling:

1. Execute **EDEM.exe**.
2. After executing **EDEM**, select **Tool > Options**.



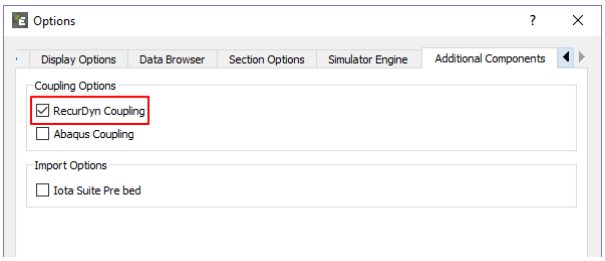
Change the unit settings to match the values entered when simulating the EDEM model later.

3. When the Options dialog window opens, click the **Set All to SI** button on the **Units** tab to reset the system of units.
4. Change the units of angle, length, and velocity as follows.
   - **Angle: deg**
   - **Length: mm**
   - **Velocity: mm/s**



5. Turn on the **RecurDyn Coupling** option in the **Coupling Options** group of the **Additional Components** tab.

   If you do not enable this option, you will not be able to import * .wall files exported from **RecurDyn** later.



6. Click **OK**.

From the **GEMM** database provided by **EDEM**, find and import an appropriate input deck corresponding to the particle properties.

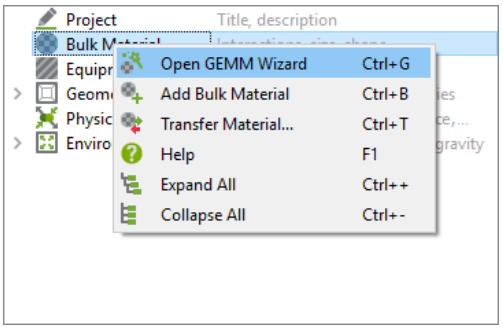
Tip: GEMM (Generic EDEM Material Model) Database

The GEMM database contains thousands of material models representing a wide range of materials including rocks, soil, ore, etc. Users can download input decks for EDEM simulation from the vast amount of material information in the GEMM database.

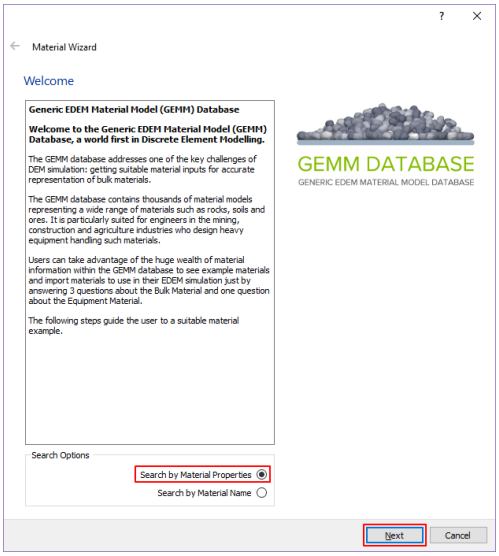
To create material:

1. In the Database panel, right-click **Bulk Material** and click **Open GEMM Wizard**.

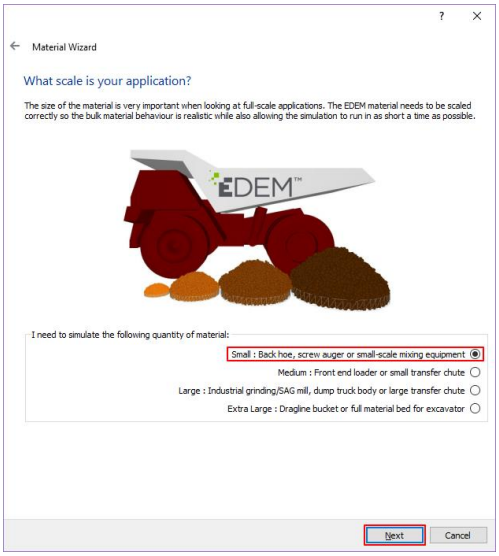
   A Material Wizard dialog window appears.



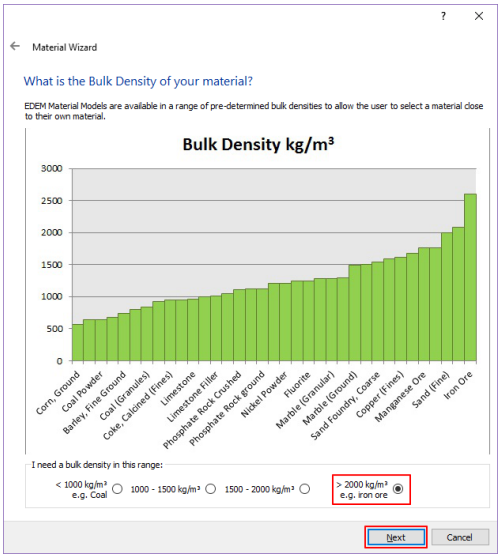
2. After selecting **Search by Material Properties**, click **Next**.



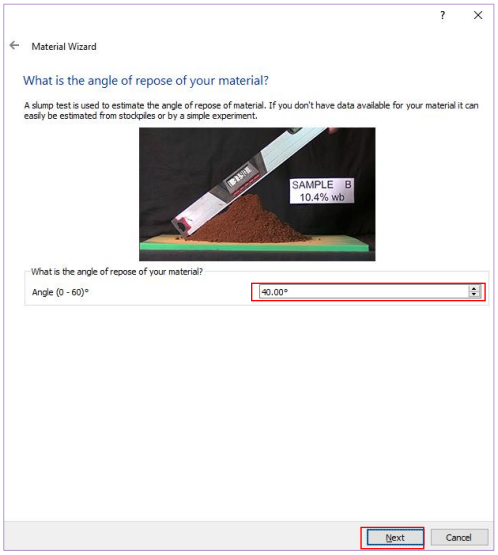
3. After selecting **Small: Back hoe, Screw auger or small-scale mixing equipment**, click **Next**.



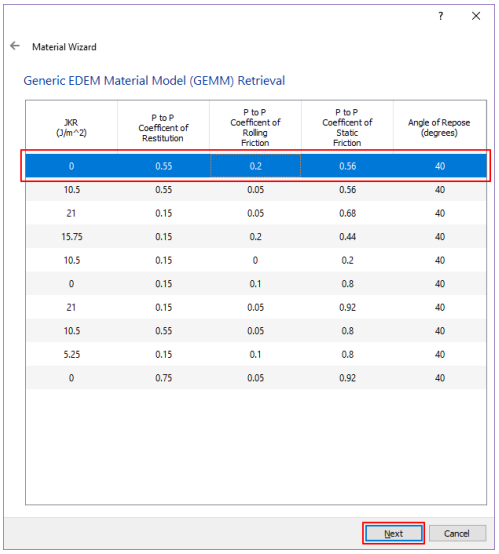
4. After selecting **>2000kg/m^3**, click **Next**.



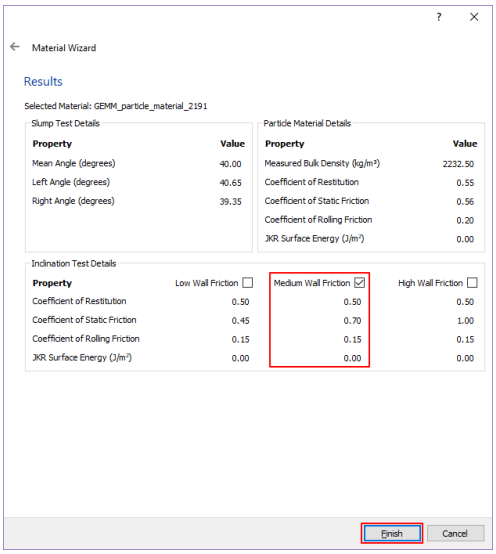
5. Enter **40** for **Angle** and click **Next**.



6. Select the material displayed on the first row and click **Next**.

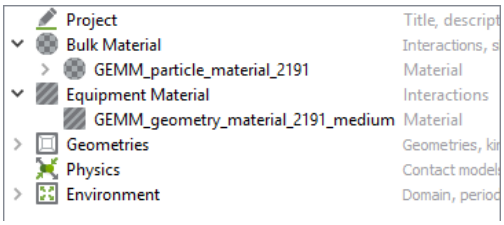


7. After selecting **Medium Wall Friction**, click **Finish**.



Bulk Material is the property value applied to the particles and **Equipment Material** is the property value applied to the wall. Materials with the input values matching the properties selected above are added respectively.

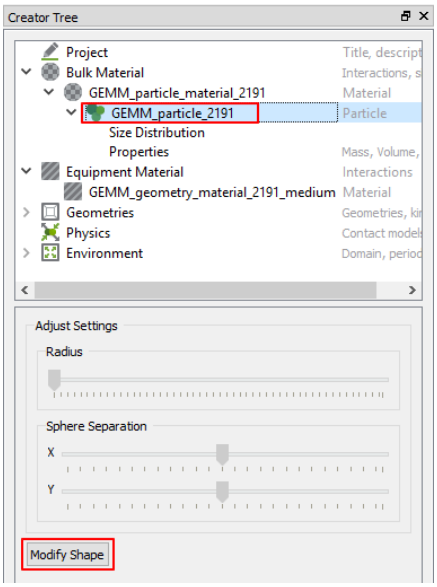
You can see that **GEMM_particle_material_2191** and **GEMM_geopetry_material_2191_medium** are added to **Bulk Material** and **Equipment Material** in the Database panel as shown in the figure on the right.



The child of **GEMM_particle_material_2191** contains the particle information **GEMM_particle_2191**. Try changing the size of the particle by modifying the Property value.

To modify the particle shape:

1. Click **Bulk Material > GEMM_particle_material_2191 > GEMM_particle_2191**.
2. Click **Modify Shape**.



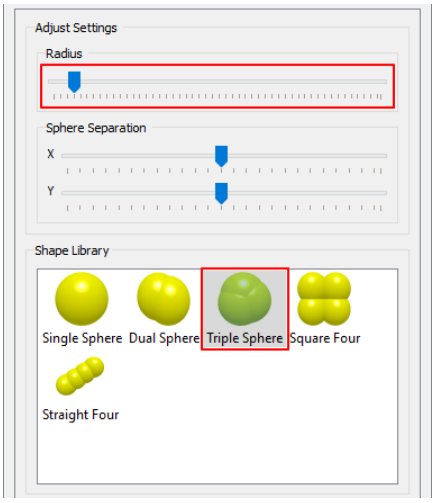
3. After clicking **Triple Sphere**, increase the **Physical Radius** to up to **7mm**.

   Make sure that sphere0, sphere1, and sphere2 are all 7mm as shown in the figure below. If the values are different, modify them as shown below.

GEMM_particle_2191 Spheres

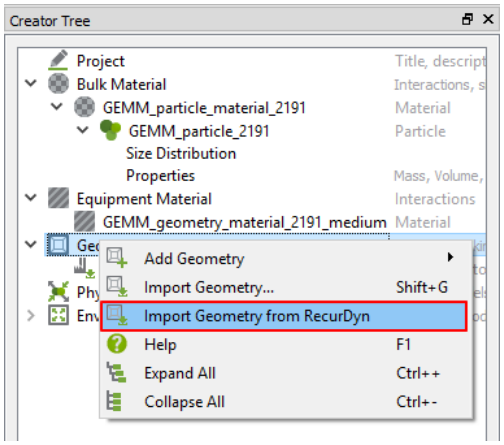
Edit Contact Radius

	Name	Position X (mm)	Position Y (mm)	Position Z (mm)	Physical Radius (mm)
1	sphere 0	-4.97	-2.87	0	7
2	sphere 1	4.97	-2.87	0	7
3	sphere 2	0	5.74	0	7



This finishes the process for setting particles. Now, you have to import the wall exported from **RecurDyn** to **EDEM**.

To open the RecurDyn wall:

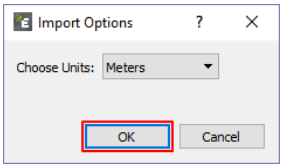


1. In the Database panel, right-click **Geometries** and click **Import Geometry from RecurDyn**.

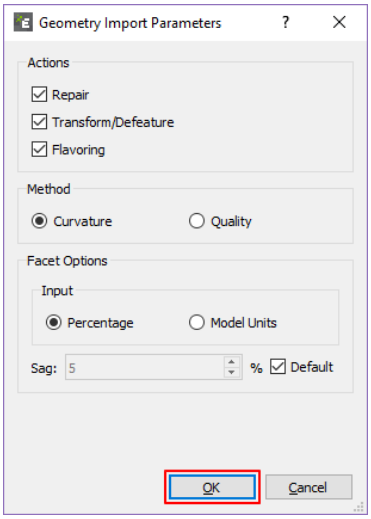
2. Open the **EDEM.wall** file exported from **RecurDyn**.

3. When the Import Options dialog window appears, set **Choose Units** to **Meters** and click **OK**.

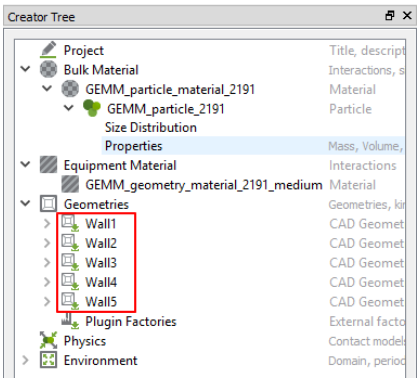
   (As mentioned above, geometry files of the walls exported from **RecurDyn** are written in the unit of **Meter**.)

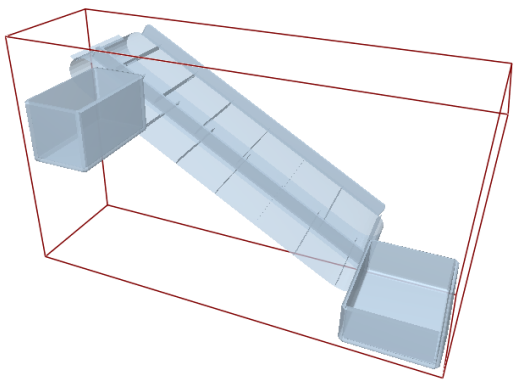


4. When the Geometry Import Parameters dialog window appears, click **OK**.



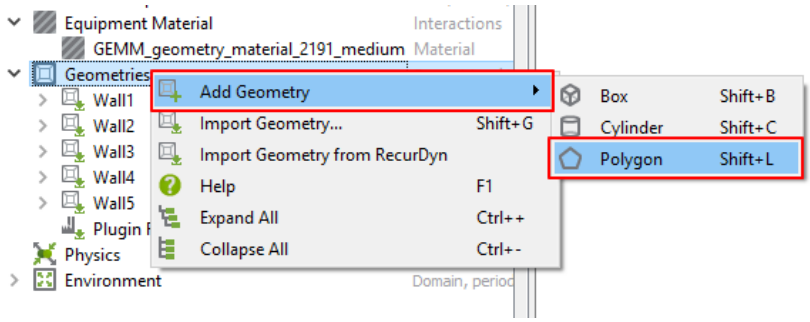
You can see that 5 walls are imported to the Database panel as shown below.





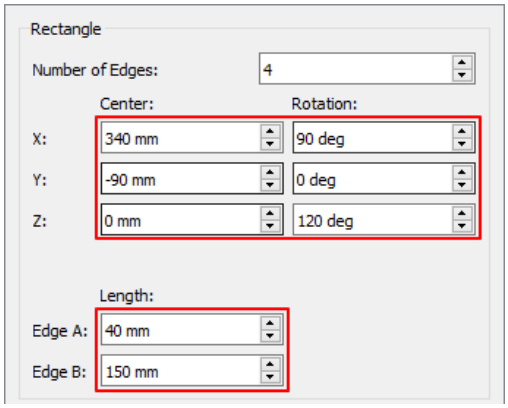
To define the zones created by particles:

1. In the Database panel, right-click **Geometries** and click **Add Geometry>Polygon**.



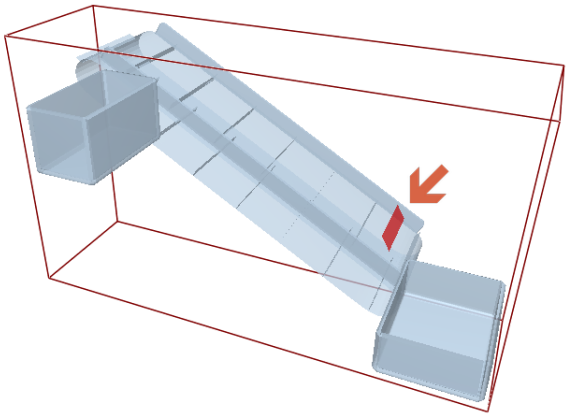
Under **Geometries**, **New Section 5** is created.

2. Under **New Section 5**, click **Polygon** to change its shape and position.



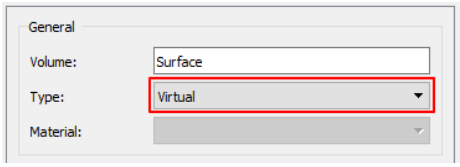
- Center
  - **X: 340mm**
  - **Y: -90mm**
  - **Z: 0mm**
- Rotation
  - **X: 90deg**
  - **Y: 0deg**
  - **Z: 120deg**
- Length
  - **Edge A: 40mm**
  - **Edge B: 150mm**

As shown in the figure on the right, **New Section 5** is defined under the belt.



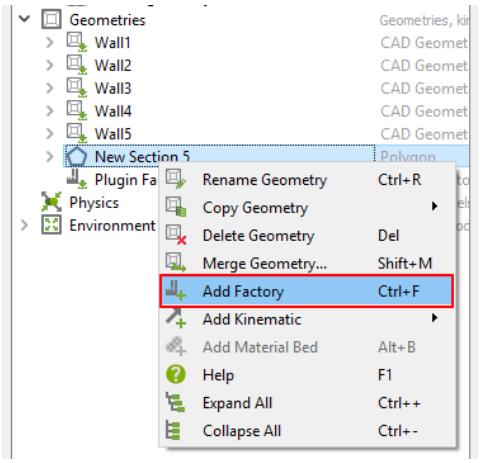
After clicking **New Section 5**, change the type as **Virtual**.

Type must be changed to Virtual to create a **factory**. (A factory is an entity that defines particle generation.)



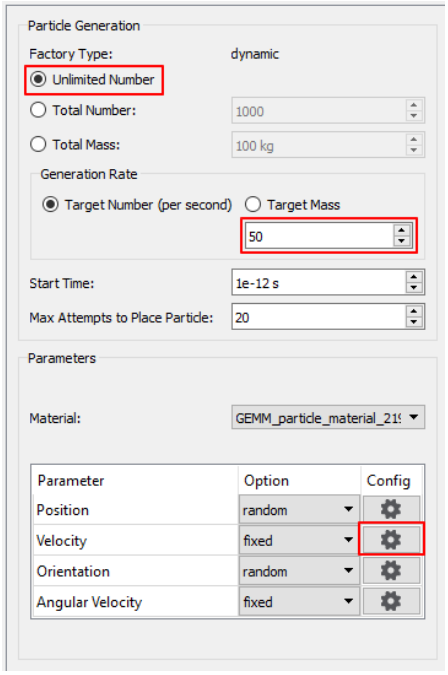
3. In the Database panel, right-click **New Section 5** and click **Add Factory**.

   Under **New Section 5**, **New Factory 1** is created.



4. Click **New Factory 1** to modify as follows:
   - Particle Generation
     - **Unlimited Number**
     - **Target Number (per second): 50**

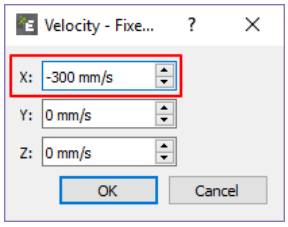
   With these settings, 50 particles are generated per second at the Polygon location.



   - Parameters
     - **Velocity: Fixed**

   It has a constant initial velocity when particles are generated. Try to modify the initial velocity of the particles.

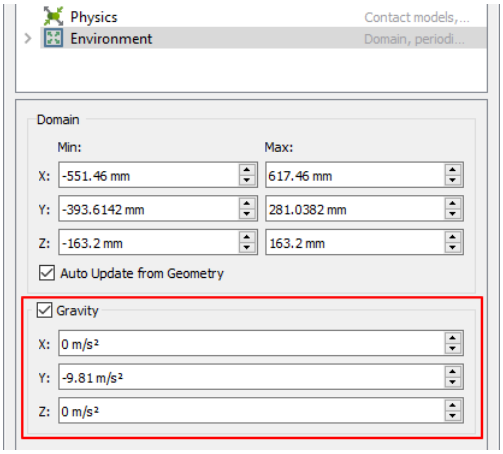
5. Click **Config** next to **Velocity** under **Parameter**.
6. In the Velocity Fixed dialog window, modify **X** to **-300mm/s**.
7. Click **OK**.



The Gravity of **EDEM** should be aligned in the same direction as **RecurDyn**.

To set gravity:

1. In the Database panel, click **Environment**.
2. Modify **Gravity** as follows.
   - **X: 0** m/s^2
   - **Y: -9.81** m/s^2
   - **Z: 0** m/s^2

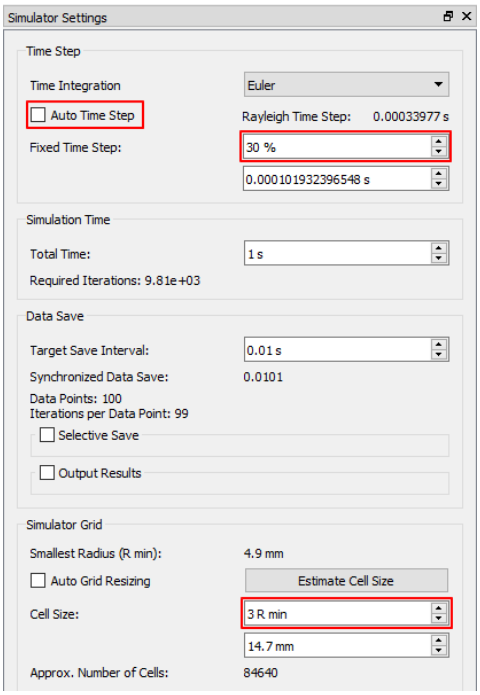


To save the model:

- This completes all the settings related to particle generation in EDEM Creator. Save the EDEM model.

EDEM Simulator

Now, set the elements related to the analysis.



To set the simulator:

1. Click the **Simulator** icon in the ribbon menu.
2. Turn off the Auto Time Step option in the Time Step pane.
3. Set the Fixed Time Step option to 30%.
4. Set the Cell Size option to 3R in the Simulator Grid pane.

To activate coupling:

- Click the **Coupling Server** icon at the top right of the ribbon to activate it.
- When activated, it changes as shown below.

You are now ready for co-simulation. **EDEM** must be turned on for co-simulation with **RecurDyn**. Proceed to the next chapter with the program turned on.

Chapter

6

Co-simulation

In this chapter, we will perform co-simulation using **RecurDyn** and **EDEM** to analyze the dynamic model and the behavior between particles.

Task Objectives

In this chapter, you will learn how to perform co-simulation in **RecurDyn**.

Estimated Time to Complete This Task

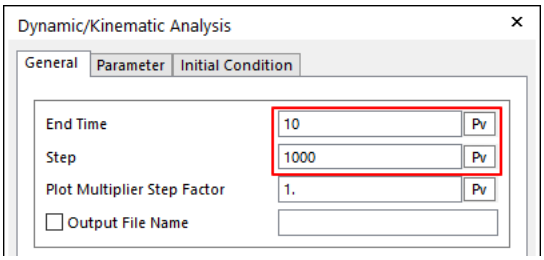
150 minutes

Co-simulation

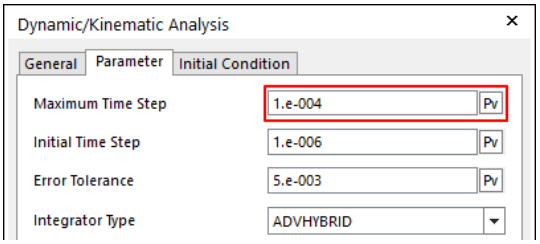
To perform co-simulation in RecurDyn:

1. Run **RecurDyn** and open the model you saved in Chapter **4**.
2. In the **EDEM** group of the **External SPI** tab, activate the **Connect** option.

3. In the **Simulation Type** group of the **Analysis** tab, click **Dyn/Kin**.
4. On the **General** tab, modify as follows.
   - **End Time**: 10
   - **Step**: 1000



5. On the **Parameter** tab, set **Maximum Time Step** as **1.e-004**.

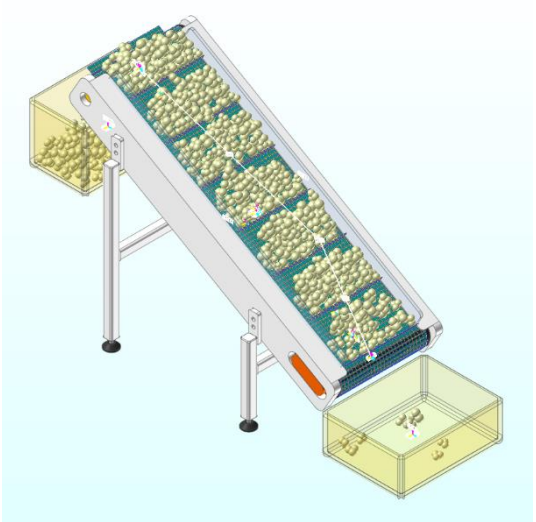


6. Click the **Simulate** button.

   RecurDyn and **EDEM** perform the co-simulation.

To view the result:

- On the **Analysis** tab, in the **Animation Control** group, click the **Play** button to view the animation.

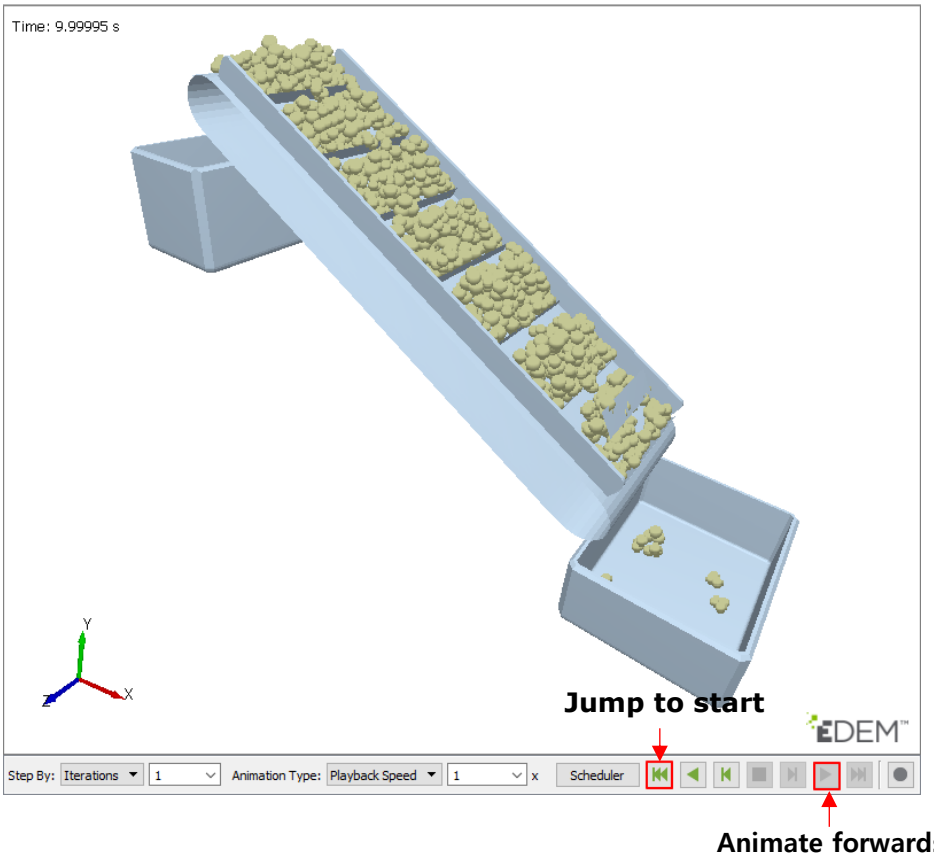


EDEM Analyst

Try to replay the result analyzed by **EDEM**.

To set the simulator:

1. Click the **Analyst** icon in the **EDEM** ribbon menu.



2. Click the **Jump to start** icon to move to 0 frame.
3. Click **Animate forwards** to replay the animation.

   You can see the same animation as in **RecurDyn**.

Chapter

7

Analyzing and Reviewing the Results

In this chapter, we will analyze the results from Chapter 6 using the Post Tool of **RecurDyn**.

Task Objectives

In this chapter, you will learn how to use the SPI Post Tool in **RecurDyn**.

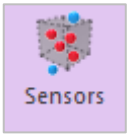
Estimated Time to Complete This Task

10 minutes

Post Process

Analyze the results using the Particle Post function provided by **RecurDyn**.

To create particle sensors:



1. In the **Post-Process** group of the **External SPI** tab, click **Sensors**.
   The Particle Sensor dialog window appears.
2. Click **Add Box**.
3. Enter the following information.
   - **EDEM_1**
   - **Ground**
   - **-540, 330, -160**
   - **606, -387, 160**

   P_Sensor1 is created.
4. Modify the color of **P_Sensor1** to **Blue**.

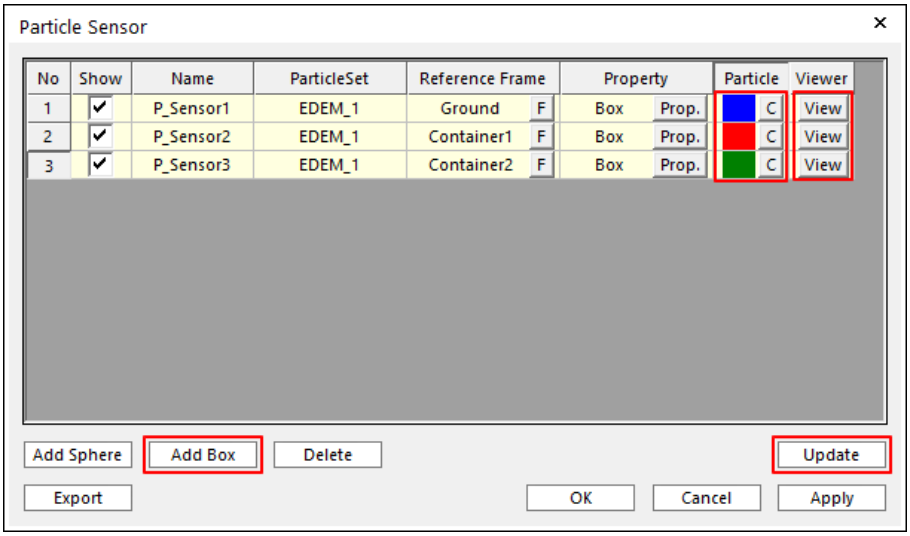
5. Again, click **Add Box**.
6. Enter the following information.
   - **EDEM_1**
   - **Container1**
   - **-530, 110, -150**
   - **-370, -60, 150**

   P_Sensor2 is created.
7. Modify the color of **P_Sensor2** to **Red**.

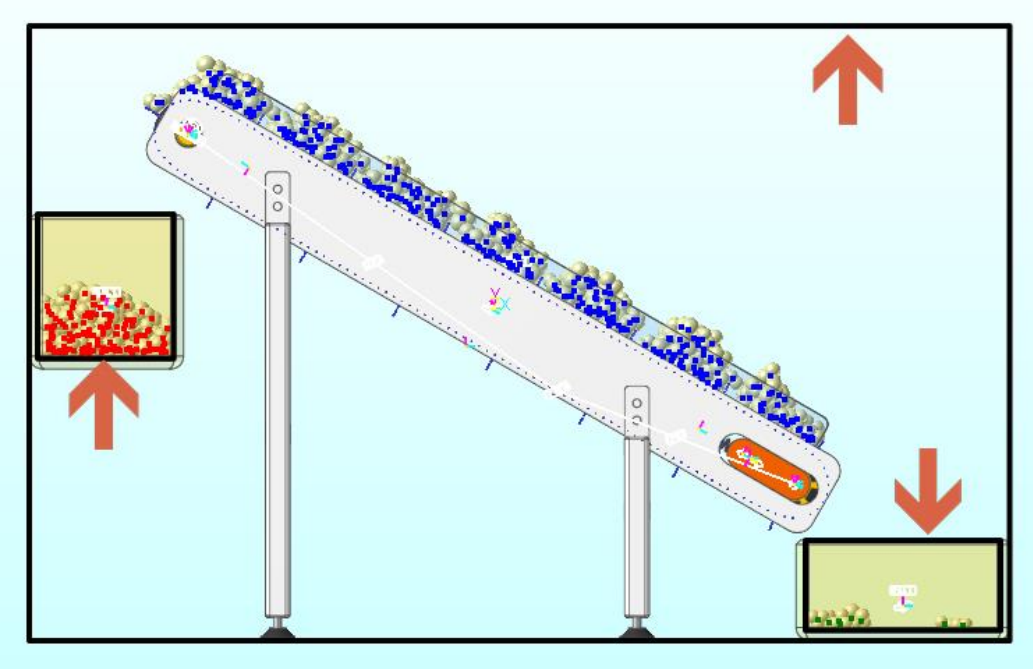
8. Again, click **Add Box**.
9. Enter the following information.
   - **EDEM_1**
   - **Container2**
   - **366, -270, -150**
   - **596, -377, 150**

   P_Sensor3 is created.
10. Modify the color of **P_Sensor3** to **Green**.

11. Click **Update**.
12. Click **View** of **P_Sensor1** and **P_Sensor2** to display the Scope.
13. Click **OK**.

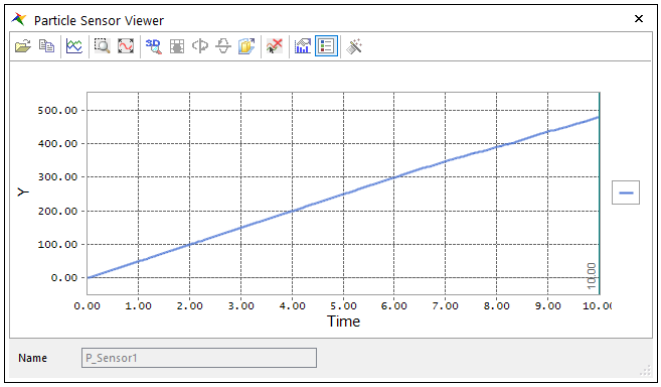


Three box-shaped sensors are created in the same position as shown in the figure. If you replay animation, the sensors will be highlighted when a particle enters the box.

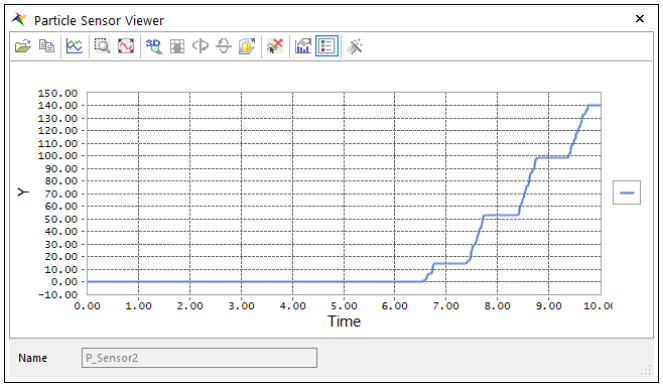


Analyze the Scope results of the Viewer.

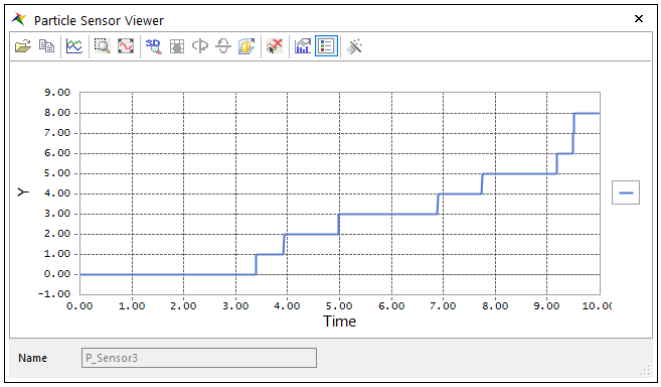
First, the result of **P_Sensor1** is the number of particles in the entire space, which shows the rate of particle generation and inflow. You can see that the value is about 50/sec. and matches the generation rate entered in EDEM.



The result of the second **P_Sensor2** is the number of particles being carried by the belt and entering Container1.



The result of the last **P_Sensor3** is the number of particles entering Container2 instead of being carried by the belt.



For reference, in **EDEM**, particles are set to have a random position and orientation when they are created. Therefore, the results can be slightly different from the results shown above.

Thanks for participating in this tutorial