

Cleated Belt Conveyor (EDEM)





Copyright © 2020 FunctionBay, Inc. All rights reserved.

User and training documentation from FunctionBay, Inc. is subjected to the copyright laws of the Republic of Korea and other countries and is provided under a license agreement that restricts copying, disclosure, and use of such documentation. FunctionBay, Inc. hereby grants to the licensed user the right to make copies in printed form of this documentation if provided on software media, but only for internal/personal use and in accordance with the license agreement under which the applicable software is licensed. Any copy made shall include the FunctionBay, Inc. copyright notice and any other proprietary notice provided by FunctionBay, Inc. This documentation may not be disclosed, transferred, modified, or reduced to any form, including electronic media, or transmitted or made publicly available by any means without the prior written consent of FunctionBay, Inc. and no authorization is granted to make copies for such purpose.

Information described herein is furnished for general information only, is subjected to change without notice, and should not be construed as a warranty or commitment by FunctionBay, Inc. FunctionBay, Inc. assumes no responsibility or liability for any errors or inaccuracies that may appear in this document.

The software described in this document is provided under written license agreement, contains valuable trade secrets and proprietary information, and is protected by the copyright laws of the Republic of Korea and other countries. UNAUTHORIZED USE OF SOFTWARE OR ITS DOCUMENTATION CAN RESULT IN CIVIL DAMAGES AND CRIMINAL PROSECUTION.

Registered Trademarks of FunctionBay, Inc. or Subsidiary

RecurDyn is a registered trademark of FunctionBay, Inc.

RecurDyn/Professional, RecurDyn/ProcessNet, RecurDyn/Acoustics, RecurDyn/AutoDesign, RecurDyn/Bearing, RecurDyn/Belt, RecurDyn/Chain, RecurDyn/CoLink, RecurDyn/Control, RecurDyn/Crank, RecurDyn/Durability, RecurDyn/EHD, RecurDyn/Engine, RecurDyn/eTemplate, RecurDyn/FFlex, RecurDyn/Gear, RecurDyn/DriveTrain, RecurDyn/HAT, RecurDyn/Linear, RecurDyn/Mesher, RecurDyn/MTT2D, RecurDyn/MTT3D, RecurDyn/Particleworks I/F, RecurDyn/Piston, RecurDyn/R2R2D, RecurDyn/RFlex, RecurDyn/RFlexGen, RecurDyn/SPI, RecurDyn/Spring, RecurDyn/TimingChain, RecurDyn/Tire, RecurDyn/Track_HM, RecurDyn/Track_LM, RecurDyn/TSG, RecurDyn/Valve

are trademarks of FunctionBay, Inc.

Edition Note

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

Table of Contents

Overview	4
Task Objectives	4
Prerequisites	5
Task	5
Registering EDEM GUI on the RecurDyn Ribbon	6
Task Objectives	6
Estimated Time to Complete This Task	6
Importing the Configuration XML File	7
Simulating and Analyzing the Initial Model	9
Task Objectives	9
Estimated Time to Complete This Task	9
Opening the Model	10
Performing Simulation	12
Creating and Exporting a Wall	13
Task Objectives	13
Estimated Time to Complete This Task	13
Creating walls	14
To export a *.wall file:	17
Creating an EDEM Model	18
Task Objectives	
Estimated Time to Complete This Task	
EDEM Creator	19
EDEM Simulator	
Co-simulation	29
Task Objectives	
Estimated Time to Complete This Task	
Co-simulation	30
EDEM Analyst	31
Analyzing and Reviewing the Results	32
Task Objectives	32
Estimated Time to Complete This Task	32
Post Process	33



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



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:

Settings

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.

	C 🚺 💾 I	🖹 🔥 🥎 -	ê - 🧕 🚸	. .							Recurl	Dyn V9R4 - [Mc
	Home	SubEntity	Analysis	Professional	Flexible	Post Analysis	TSG	DriveTrain	CoLink	AutoDesign	Communicator	External SPI
Walls	Export	Settings	Connect	Contour	Frace Mass	Profile	Sensors	Animation	Clip	Contour		
		EDEM		•		Post-	Process			•		

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.

Info	×
Name	EDEM
Developer	DEM Solutions
Description	RecurDyn - EDEM coupling
DLL Path	C:\Program Files\DEM Solutions\EDEM 2019\lib\EDEMRecurDynCour
Output	Output\EDEM_%.8d OK Cancel

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 -->
                   C:\Program Files\DEM Solutions\EDEM 2018\lib\EDEMRecurDynCouplingClient1 1.dl1 -->
          <!-- e.g.
         <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**.



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.





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.



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**.

Patch Set [Current Unit : N/kg/mm/s/deg] General External Patch Set Color Automatic Add/Remove
Add/Remove (Continuous) tolerance (Degree) 45 Check Reverse Direction Add/Remove (Select Front) Add (Node Set) Preview Normal Normal Adjust Auto Adjust Switch Manual Select Target Switch No. of Patches 5340

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**.
- 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:

- In the EDEM group of the External SPI tab, click Export. 1.
- Export

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:

2.

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.







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**.



10 minutes

EDEM Creator

E

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

È	Option	ns						?	×
	Units	Particle Display	File Locations	Mouse	Configuration	Display	Options	Data Browser	4sect
	Units								
	Accele	ration:	m/s²	•	Moment of Iner	rtia:	kgm²		•
	Angle:		deg	-	Pressure:		Pa		•
	Angula	ar Acceleration:	rad/s²	•	Shear Modulus		Pa		•
	Angula	ar Velocity:	rad/s	•	Stiffness:		N/m		•
	Charge	e:	С	•	Stiffness per U	nit Area:	N/m³		•
	Densit	y:	kg/m³	•	Stress:		Pa		•
	Energy	y:	J	•	Temperature:		к		•
	Force:		N	•	Time:		s		•
	Freque	ency:	Hz	•	Torque:		Nm		•
	Heat F	lux:	W	•	Velocity:		mm/s		•
	Length	1:	mm	•	Volume:		m³		•
	Mass:		kg	•	Work Function:		J		•
	Mass F	Flow Rate:	kg/s	•					
								Set All to SI	

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.

Options				?	×
Display Options	Data Browser	Section Options	Simulator Engine	Additional Components	
Coupling Options	_				
🗹 RecurDyn Coupli	ng				
Abaqus Coupling					
Import Options					

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:

Next.

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

A Material Wizard dialog window appears.

	🖉 Projec	t	Title, description		
	Bulk N				1
	Equipr	8	Open GEMM Wizard	Ctrl+G	
>	Geom	0	Add Bulk Material	Ctrl+B	ies
	X Physic	e	Transfer Material	Ctrl+T	ce,
>	Enviro	0	Help	F1	gravity
		٤	Expand All	Ctrl++	
		E.	Collapse All	Ctrl+-	
		_			_

Material Wizard

Welcome

×

7

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

					? ×
←	Material Wizard				
(Generic EDEM M	aterial Model (GE	MM) Retrieval		
	JKR (J/m^2)	P to P Coefficent of Restitution	P to P Coefficent of Rolling Friction	P to P Coefficent of Static Friction	Angle of Repose (degrees)
	0	0.55	0.2	0.56	40
5	10.5	0.55	0.05	0.56	40
	21	0.15	0.05	0.68	40
	15.75	0.15	0.2	0.44	40
	10.5	0.15	0	0.2	40
	0	0.15	0.1	0.8	40
	21	0.15	0.05	0.92	40
	10.5	0.55	0.05	0.8	40
	5.25	0.15	0.1	0.8	40
	0	0.75	0.05	0.92	40
				N	ext Cancel

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

Property	Value	Property	Va
Mean Angle (degrees)	40.00	Measured Bulk Density (kg/m³)	2232.
Left Angle (degrees)	40.65	Coefficient of Restitution	0.
Right Angle (degrees)	39.35	Coefficient of Static Friction	0.
		Coefficient of Rolling Friction	0.
		JKR Surface Energy (J/m ²)	0.
Indination Test Details			
Property	Low Wall Friction	Medium Wall Friction 🗹	High Wall Friction
Coefficient of Restitution	0.50	0.50	0.
Coefficient of Static Friction	0.45	0.70	1.
Coefficient of Rolling Friction	0.15	0.15	0.
JKR Surface Energy (J/m²)	0.00	0.00	0.

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:

- Click Bulk Material > GEMM_particle_material_2191 > GEMM_particle_2191.
- 2. Click Modify Shape.

🖉 Project	Title, desc
🗸 🛞 Bulk Material	Interaction
 GEMM_particle_material_2191 	Material
✓ W GEMM_particle_2191	Particle
Size Distribution	
Properties	Mass, Volur
' 💹 Equipment Material	Interaction
💹 GEMM_geometry_material_2191_mediu	um Material
Geometries	Geometries
🔀 Physics	Contact mo
Environment	Domain, pe
Adjust Settings	
Adjust Settings Radius	
Adjust Settings Radius Sphere Separation	
Adjust Settings Radius Sphere Separation X Y	1 1 1 1 1 1

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.

1	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				

1																									-
Sp	he	re	Se	pa	ara	tio	n																		
x	1	1	1	1	1	1	1		1	1	1	ļ	1	1	1	1	1	1	1	1	1	1	1	1	-
Y	1	1	1	1	1	1			1	1	1	ļ	1	1	1	1	1	1	1	1	1	1	1	1	-
Sin	gl	e S	ipł	ne	re	D	ual	Sp	ohe	ere	T	irip	le	S	oh	er	e	Sq	ua	ire	F	ou	ır		

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**.

📧 Import Option	ns	?	×
Choose Units: Me	ters	•	
	ок	Cancel	

E Geometry Import Paramete	rs ? ×	
Actions ☑ Repair ☑ Transform/Defeature ☑ Flavoring		
Method © Curvature	Quality	
Facet Options Input Percentage	Model Units	
Sag: 5	🔹 % 🗹 Default	
<u></u>	K <u>C</u> ancel]

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**.

~	Equipment Ma	terial hometry_material_2191_medium N	nteractions Material			
~	Geometries			~		
	> 🖳 Wall1 🔚	- Add Geometry		\otimes	Box	Shift+B
	> 🖳 Wall2 🖳	🛃 Import Geometry	Shift+G		Cylinder	Shift+C
	> 🖳 Wall3 🛛	Import Geometry from Recur	Dyn	\Diamond	Polygon	Shift+L
	🔿 🖳 Wall4 🛛 💡	Help	F1			
	> 🖳 Wall5 🙀	Expand All	Ctrl++			
	📲 Plugin f					
	💥 Physics 🛛 🛤	Collapse All	Ctrl+-			
>	Environment	D	omain, period	_		

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.

Rectang	gle		
Number	r of Edges:	4	-
	Center:	Rotation:	
X:	340 mm	후 90 deg	•
Y:	-90 mm	🗘 0 deg	• •
Z:	0 mm	🔹 120 deg	▲ ▼
	Length:		
Edge A	: 40 mm	÷	
Edge B:	: 150 mm	-	

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.

General	
Volume:	Surface
Type:	Virtual 🔻
Material:	v

	_		-		-		1
~	旦	Geo	metries			Geometries, k	cir
	>	ĽЦ,	Wall1			CAD Geome	÷t
	>		Wall2			CAD Geome	÷t
	>		Wall3			CAD Geome	÷t
	>		Wall4			CAD Geome	٤t
	>		Wall5			CAD Geome	ŧ
	>	Ô	New Secti	on 5		Polvaon	
	_		Plugin Fa	o,	Rename Geometry	Ctrl+R	0
	X	Phy	sics	9	Copy Geometry		el
>	25	Env	ironment		Delete Geometry	Del	d
					Merge Geometry	Shift+M	
				Щ.,	Add Factory	Ctrl+F	
				4	Add Kinematic	+	
				d_{+}^{0}	Add Material Bed	Alt+B	
				0	Help	F1	
				۲ę.	Expand All	Ctrl++	
				E.	Collapse All	Ctrl+-	
				_			1

Particle Generation		
Factory Type:	dynamic	
Unlimited Number		
O Total Number:	1000	* *
Total Mass:	100 kg	* *
Generation Rate		
Target Number (per second	d) 🔘 Target Mass	
	50	-
Start Time:	1e-12 s	• •
Max Attempts to Place Particle:	20	¢
Parameters		
Material:	GEMM_particle_mate	erial_21 : 🔻
Parameter	Ontion	Config
Position	random	
Velocity	fived T	- M
Orientation	random -	*
Orientation	ranuom	- 14

📧 Velocity - Fi	xe ?	Х
X: -300 mm/s	•	
Y: 0 mm/s	-	
Z: 0 mm/s	* *	
ОК	Can	cel

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/s²
 - Y: -9.81 m/s²
 - **Z: 0** m/s²

🔀 Physics	Contact models,
Environment	Domain, periodi
Domain	
Min:	Max:
X: -551.46 mm	€17.46 mm
Y: -393.6142 mm	▲ 281.0382 mm
Z: -163.2 mm	▲ 163.2 mm ▲
Auto Update from Geo	metry
Gravity	
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.

Simulator Settings	5 ×
Time Step	
Time Integration	Euler 🔻
Auto Time Step	Rayleigh Time Step: 0.00033977 s
Fixed Time Step:	30 %
	0.000101932396548 s
Simulation Time	
Total Time:	1s 🔹
Required Iterations: 9.81e+03	
Data Save	
Target Save Interval:	0.01s
Synchronized Data Save:	0.0101
Data Points: 100 Iterations per Data Point: 99	
Selective Save	
Output Results	
Simulator Grid	
Smallest Radius (R min):	4.9 mm
Auto Grid Resizing	Estimate Cell Size
Cell Size:	3 R min
	14.7 mm
Approx. Number of Cells:	84640

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.

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**.

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-

L	Step	1000	PV			
l	Plot Multiplier Step Factor	1.	Pv			
l	Output File Name					
	L					
	Dynamic/Kinematic Analysis		×			
General Parameter Initial Condition						
	Maximum Time Step	1.e-004	Pv			

10

×

Pv

Dynamic/Kinematic Analysis

End Time

General Parameter Initial Condition

Dynamic/Kinematic Analysis						
General Parameter Initial Condition						
Maximum Time Step	1.e-004 Pv					
Initial Time Step	1.e-006 Pv					
Error Tolerance	5.e-003 Pv					
Integrator Type	ADVHYBRID 🔻					

To view the result:

simulation.

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.

Animate forwards

- 2. Click the **Jump to start** icon to move to 0 frame.
- Click Animate forwards to replay the animation.
 You can see the same animation as in RecurDyn.

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**.

10 minutes

Post Process

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

To create particle sensors:

- 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, 16**0**
 - 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**.

Partic	Particle Sensor										
No 1 2 3	Show V V	Name P_Sensor1 P_Sensor2 P_Sensor3	ParticleSet EDEM_1 EDEM_1 EDEM_1	Reference Fra Ground Container1 Container2	me F F	Prop Box Box Box	Prop. Prop. Prop.	Particle	Viewer View View View		
Add	Sphere (port	Add Box	Delete			ОК	Can	cel	Update Apply		

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.

 Particle Sensor Viewer 🚔 🖻 🗠 🔍 🍕 🏽 🗘 🕀 🌠 🔝 🐇 500.00 400.00 300.00 — ≻ 200.00 100.00 0.00 7.00 8.00 1.00 2.00 3.00 6.00 9.00 10.0 0.00 4.00 s.'oo Time Name

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