Dynamic Assembly Constraints

By Bill Fane

I assume you have a working knowledge of the basic assembly constraints in Autodesk Inventor® software. In this tutorial, you'll learn how to use this product's dynamic assembly constraint analyzer to:

- Determine if your assemblies are working properly.
- Evaluate whether your assemblies are properly constrained.
- Create an AVI file that demonstrates how the assembly works.

In the process, you're going to improve your efficiency, your productivity, and the quality of your designs.

For starters, the analyzer has no update function for handling changes to an assembly. (This is a good thing.) Instead, this tool analyzes changes continuously, and any necessary updating takes place in real time. For example, you can use your mouse to grab onto any partially constrained component and drag it to a new location—and any other components constrained to it follow along. You don't have to stop working to update other components.

But let's work on a cylinder assembly file and you'll see what I mean.

1. Download the drawing file, which works with Autodesk Inventor 5 and later.

Download (zip - 572Kb)

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Figure 1: The cylinder assembly.

2. Unzip it into a suitable folder.

3. Start Inventor, and open the assembly file BF-01-Cylinder.iam. It should look like Figure 1.

4. Position the cursor within the circular end of the gold crank pin.

5. Hold down the left mouse button and move the cursor in a circular motion.

6. Keep the cursor more or less within the circular end of the crank pin, and move it around the

main bearing portion of the crankshaft.

Observe how the black connecting rod and the aluminum piston obediently follow along with proper rotary-to-oscillating and oscillating motions respectively. The assembly is functioning as it should and having that information sooner rather than later saves you the costs of redesign™time, money, and less than satisfied clients.

You can also use the analyzer to determine if a model is properly constrained. For example, in an engine the crankshaft, connecting rods, and pistons should all move properly. On the other hand, you probably do not want the cylinder head to move relative to the block. Use the analyzer to see if the head moves, and if it does, add more restraints.

Let's look in more detail at using the analyzer to test assembly design.

First, an observation. When you were moving around the cursor just now, did you notice that the piston pulls completely clear of the green frame as it approaches the bottom of the stroke, but reenters the bore properly on the way back up? I applied a mate constraint between the centerlines of the piston and the bore, so that they remain aligned, regardless of whether the cylindrical portions remain engaged. Obviously, the real world does not work this way.

We can deduce a fundamental rule from this: Just because an assembly model works properly does not necessarily mean that the real mechanism will work too.

Let's Go for a Drive...

Having said that, I still believe that creating an assembly model is a very valuable tool both for analysis and demonstration purposes. Let's start with demonstration mode.

Once you have designed an assembly, you usually have to demonstrate how it functions to other people. Since a word is worth .001 of a picture, an animated demonstration is usually better than a verbal description. Try this:

1. In the browser window, the entries for the frame and the crank should already be expanded to show the constraints. If they aren't, go ahead and expand them.

2. (Optional) Select the Angle (325.00 deg) constraint, which is under the Crank entry (see Figure 2a). The relevant faces are highlighted in a cyan color (see Figure 2b).

Notice that this constraint is shaded out in the browser window indicating that it is currently suppressed. If it were active, you would not have been able to rotate the crankshaft with your mouse earlier. This optional step doesn't affect the process we're exploring, but it highlights the constraint that will be driven.

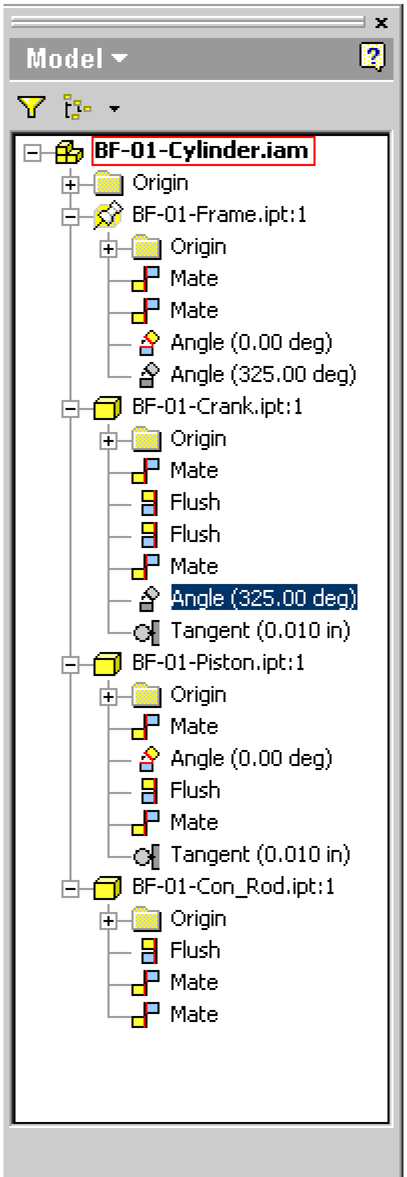
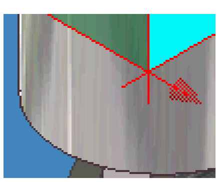


Figure 2a: The browser window with the Angle constraint selected.

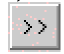


View Larger

Figure 2b: The Angle constraint connects the indicated faces.

3. Now right-click the Angle (325.00 deg) constraint.

4. Select Drive Constraint from the context menu that opens.

5. When the Drive Constraint dialog box appears (see Figure 3a), click the double-chevron button in the lower-right corner to fully display the dialog box 

(see Figure 3b).

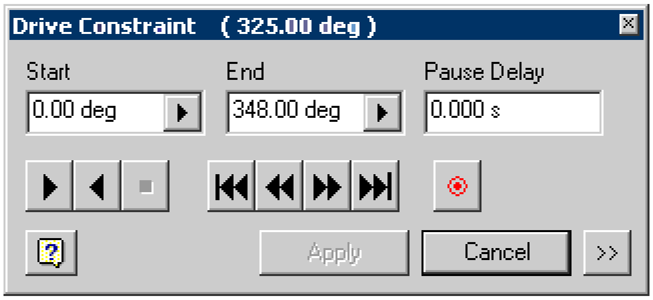


Figure 3a: The Drive Constraint dialog box.

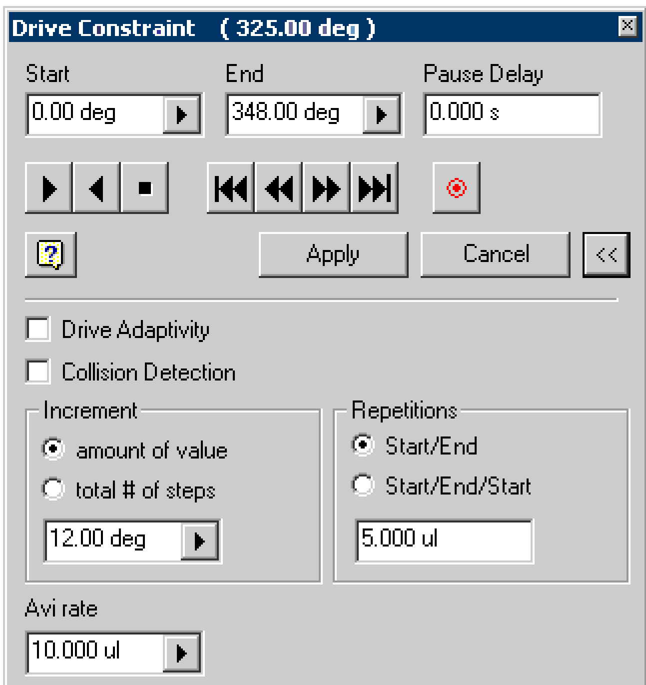
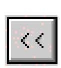


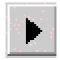
Figure 3b: The expanded Drive Constraint dialog box.

6. Fill in this dialog box as indicated below, starting at the upper left:

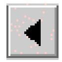
- Start = 0.00 deg
- End = 348 deg
- Pause Delay = 0.000 s
- Clear the Drive Adaptivity and Collision Detection check boxes.
- Select the amount of value radio button on the Increment pane and set its value to 12.0 deg. Select the Start/End radio button on the Repetitions pane and set its value to 5.0.
- Ignore the AVI rate box for now.

7. Click the double-chevron button 

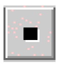
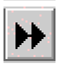
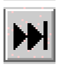
again to return to the Drive Constraint dialog box of Figure 3a.

8. Click the Forward button  under the Start box, and watch in amazement as the mechanism automatically runs until the crankshaft completes five revolutions.

9. To slow it down, enter a small number, for example 0.100 s, in the Pause Delay box.

10. Click the Reverse button  under the Start box, and the mechanism runs backward for five revolutions.

11. The remaining buttons perform the indicated actions. Try them all:

-  Pauses the current operation. Click the Forward or Reverse button to resume the operation.
-  Resets to the start position.
-  Single-steps in reverse.
-  Single-steps forward.
-  Advances to the end position.
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Closes the Drive Constraint dialog box and resets the constraint to the current value.
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Closes the Drive Constraint dialog box and returns the constraint to the value it had before you started driving it.

Animating a mechanism like this is obviously an easy way of demonstrating it to other people.

Now let's move on to the analysis functions.

Captain, Sensors Indicate a Collision...

We have done things a little out of the normal sequence. Usually, you would want to analyze the mechanism and have it working properly before you demonstrated it. For tutorial purposes, however, I started with the animation demonstration because you should know how to make the mechanism operate before you analyze it.

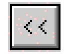
Now try this:

1. Right-click the Angle (325.00 deg) constraint again.

2. Select Drive Constraint from the context menu that opens.

3. When the Drive Constraint dialog box appears (see Figure 3a), click the double-chevron button in the lower-right corner to fully display the dialog box (see Figure 3b).

4. Select the Collision Detection radio button.

5. Close the lower portion of the dialog box using the  button, or simply drag the dialog box out of the way.

6. Click the Forward button, and watch in amazement as the assembly completes only part of a revolution. It grinds to a sickening halt and the Collision Detected alert box opens. The offending parts are highlighted in red, indicating that the piston skirt is striking the crankshaft, which means the connecting rod is too short. Click OK to exit the alert box.

7. Click the Cancel button in the Drive Constraint dialog box.

We Must Adapt to Survive...

Now what? How about this:

1. In the browser window, right-click the Con_Rod entry. When the context menu opens, select Adaptive. (The context menu closes.)

2. Locate the shaded (that is, suppressed) Tangent (0.010 in) constraint under the Crank entry and right-click. When the context menu opens, select Suppress to unsuppress the Tangent constraint. (The context menu closes.)

Now the piston moves until its skirt edge is tangent to the crankshaft, and the connecting rod changes length as required.

3. Right-click our favorite Angle constraint under the Crank entry and select Drive Constraint from the context menu that opens.

4. Expand the Drive Constraint dialog box, clear the Collision Detection radio button, and select the Drive Adaptivity radio button.

5. Click the Forward button , and watch in even more amazement as the crankshaft completes five revolutions.

This time, the piston does not reciprocate. Instead, the connecting rod lengthens and shortens to adapt to the changing geometry.

6. Single-step the constraint until the connecting rod reaches its maximum length, which is when the Angle constraint equals 180 degrees.

7. Click Apply to accept the current values. (This action also closes the Drive Constraint dialog box.)

8. Suppress the Tangent constraint under the Crank entry, and turn off the Adaptive option for the connecting rod.

9. Drive the crank's Angle constraint again, with Drive Adaptivity cleared and Collision Detection selected.

No more collision!

Now you are ready to demonstrate a finished version of the assembly. The problem is, the people who should see it do not have Autodesk Inventor. So why not just create an AVI file that demonstrates the assembly and e-mail it to them?

No problem. Simply move on to the next step of this tutorial.

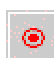
You Send Me...

Autodesk Inventor software includes a feature for recording an AVI animation file while a constraint is being driven. You can play back this file using the Media Player program that automatically ships with Windows.

We could spend an entire tutorial studying AVI files, but this time we will just hit the high spots to get you started.

1. You should still be in Drive Constraint mode on the Angle constraint. If not, restart it.

2. Shrink the Inventor graphics window to about half size to avoid generating monster files.

3. Click the red Record button  in the Drive Constraint dialog box.

4. Supply a suitable file name when the standard File dialog box opens, and then click Open. (The File dialog box closes.)

5. If a Video Compression dialog box opens, click OK to accept the defaults.

6. Click the Forward button.

This time the animation runs somewhat slower because the software is producing and compressing a frame-by-frame video as it goes.

If you slowly pan, zoom, or orbit as the operation is proceeding, those actions are also recorded.

> **Warning:** Do not switch to another application while the video is recording. If you do, that excursion will be included in the video!

7. The recording operation stops when the animation completes, if you click the Record button again, or if you cancel the Drive Constraint operation.

8. Use the Windows Explorer to browse for your AVI file. Double-click it, and Media Player should start displaying it.

Now just e-mail the file to people who do not have Autodesk Inventor software. They can play back the AVI file, witness the true genius of your design, and send you the inevitable changes.

And in Conclusion...

In this tutorial, you explored some of the power of the dynamic assembly constraint analyzer in Autodesk Inventor. You've learned how to use the analyzer to evaluate and correct an assembly and to create an AVI file to demonstrate how the assembly works for people who don't have Inventor.