Customer PTC E-Newsletter
Date: 11/01/02

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PTC Product Focus

Pro/ENGINEER Mechanism Dynamics

By providing an environment specifically tailored to the design and simulation of mechanisms, Pro/ENGINEER® Mechanism Dynamics Option allows engineers to build and test virtual mechanisms early in the design process resulting in fewer prototypes and better products in less time.


In today's competitive environment, companies involved in the design and development of mechanisms face increasing pressure to produce better products in less time. To meet this challenge, companies need specific tools and functionality to accelerate the definition, simulation, and documentation of mechanism designs. By introducing more computer-aided (CAD) simulation into the design process, companies can avoid the time-consuming problems associated with testing of multiple prototype iterations.
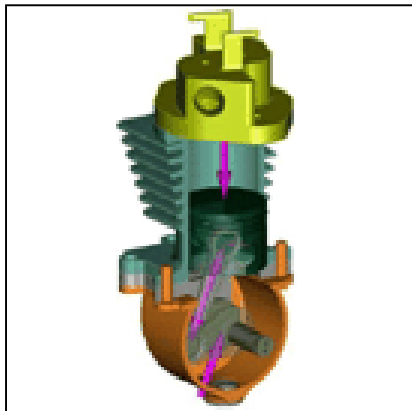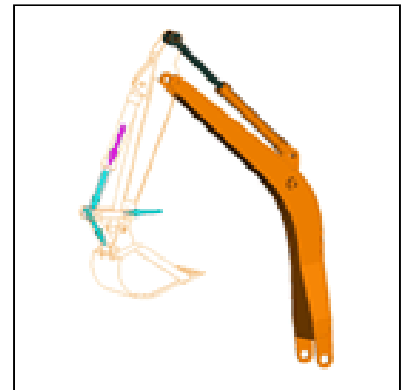
By checking the operation and function of a mechanism during the early design phase using the native CAD data, designers can gain early insight into the performance of the design. This gives the designer more freedom to explore new ideas or alternatives with greater confidence that the design will perform as expected resulting in fewer changes during prototype testing and real world use.

But to make simulation an integrated part of the design process, the simulation tools need to be fast and easy to use. The only way to really achieve this is by completely integrating a comprehensive set of mechanism design and simulation tools within the CAD software used every day by the design engineer.

Pro/ENGINEER Mechanism Dynamics extend the native Pro/ENGINEER environment, using the same user interface, workflow, and productivity tools that the design engineer is already familiar with. Pro/ENGINEER Mechanism Dynamics operates directly on the Pro/ENGINEER geometry and database, so there are no geometry translation or interface problems, and the full power of the proven parametric modeling capability of Pro/ENGINEER can be exploited.
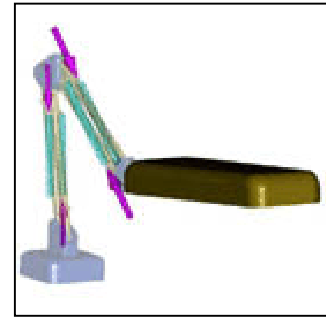
Quality

Pro/ENGINEER Mechanism Dynamics uses proprietary technology and algorithms developed at PTC to give users the fastest and most accurate mechanism simulation possible. PTC has developed this technology in conjunction with major customers around the world whose business is based on the design and manufacture of complex, high-speed mechanisms. PTC provides built-in technology which takes the pain out of virtual prototyping of complex mechanisms by checking the validity of each step in the design process automatically, every time. By partnering with customers who lead the world in this field, PTC has developed the most comprehensive and functional mechanism development environment available in any CAD system.

The Challenge

The acceleration and weight of the parts in a mechanism generate various forces. Designers use devices like motors, springs, and dampers to control those forces and ensure that the mechanism works as intended. In some cases, they use controlled contact (or impact) between parts to make a mechanism work correctly. In these and many other situations, the ability to include dynamic effects in a virtual prototype to accurately simulate mechanism behavior can significantly increase innovation, product quality, and speed to market.

The Solution
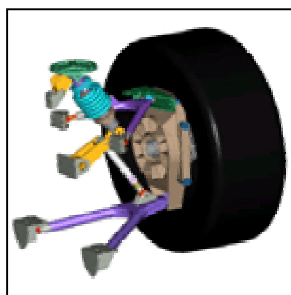
Pro/ENGINEER Mechanism Dynamics adds dynamic functionality to Pro/ENGINEER Mechanism Design to provide a powerful virtual prototyping environment for the simulation and improvement of mechanism operation as part of the design process. Pro/ENGINEER Mechanism Dynamics allows designers to virtually engineer a mechanism without leaving the familiar user interface and workflow of Pro/ENGINEER.

Click Here To See The Animations

Benefits

- Provides up-front virtual prototyping of real-world mechanisms
- Works with Behavioral Modeling to explore design alternatives
- Reduces hardware prototype iteration and test failures
- Helps design faster, lighter, more efficient mechanisms
- Reduces time to market

Capabilities

- Gravity, force motors, point forces, and body torques
- Springs, dampers, cam and slot impacts, and friction
- Dynamic, static, and force balance simulations
- Comprehensive results graphing and animated display of forces

New Capabilities with Pro/E Wildfire

- Usability Improvements
- Gear connections
- True Kinematic Analysis (MDX)
- Motor & Force Profiles specified by user defined function and domain
- Pro/E Parameters as design variables
- Enhanced motion envelope capture

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PTC Product Focus

Windchill ProjectLink – Powerful Project Plans

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Modeling Inverse Dynamics

Introduction

Inverse dynamics forces and torques are the equivalent applied forces and torques necessary to produce mechanism movement otherwise governed by servo motors. These forces and torques reveal how a physical mechanism should be loaded to produce a desired movement and can be used to size motors and components.

The following example demonstrates how Pro/Engineer Mechanism Dynamics Option (MDO) can be used to calculate the torque necessary to keep a bucket level as a front-end loader moves from a lowered position to a fully extended position. Three principles are illustrated:

1. Inverse dynamics forces/torques can only be calculated at joints whose kinematics (positions/velocities/accelerations) are constrained by drivers.
2. The total number of allowable joint drivers must equal the number of the degrees of freedom (DOF) in the model.
3. If the driven joints do not correspond to the joints for which the inverse dynamics forces/torques are desired, graph report files must be generated specifying the position of the joints of interest, the original drivers removed, and then table drivers applied to the desired joints using the graph report files. This is necessary to satisfy the first principle.

The last inverse dynamics principle is not demonstrated in the example but is summarized here. For a closed-loop system, if the number of desired inverse dynamics forces/torques exceeds the number of DOF in the model, then experimentally determined reaction forces must be known at a specific joint in order to solve the problem. The solution of such a problem becomes a two step process. The first step is to define the drivers which constrain the motion of the entire closed-loop model, and then to output graph report files defining the positions of the desired non-driven joints. The second step is to define an equivalent open-loop model where each joint of interest is constrained by a table driver using a graph report file and where the experimentally determined reaction forces are applied to the open end of the linkage. These reaction forces are now treated as applied forces and are the precise forces which will cause the end of the linkage to follow the same trajectory as in the constrained closed-loop system.

Procedure

1. Figure 1 shows a simple, 2 DOF model of a front-end loader. The loader is extended from the lowered position to the raised position with a constant velocity driver on the pin joint which will move the arm 50 degrees. The goal is to determine the torque necessary to keep the bucket level as the arm moves from the lowered position to the fully raised position.
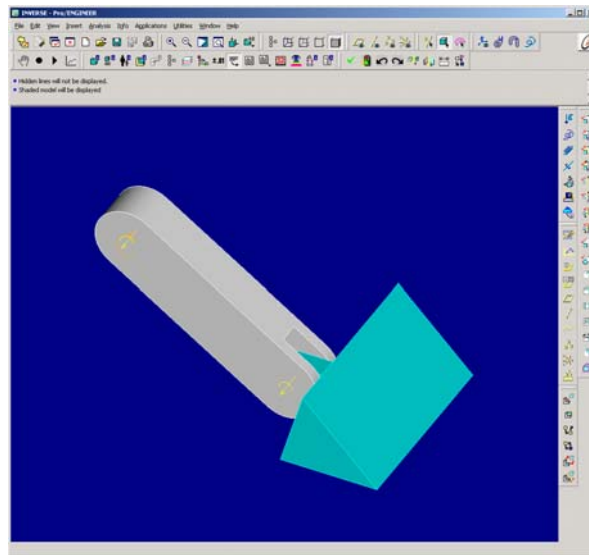
1. Figure 1

2. The first component will be a skeleton model. The skeleton model will simply be a Pro/Engineer part which has three datum planes, a coordinate system and an axis. Assemble the boom arm to the skeleton using a pin joint. Then assemble the bucket to the boom arm with the appropriate pin joint. In addition, create a planar joint between the skeleton and the bucket. Place a zero position driver on the rotational axis on the planar joint as shown in Figure 2 to keep the bucket level as the arm is raised. The goal is to determine the inverse dynamics torque on the pin joint connecting the bucket to the arm, yet the zero position driver is defined for the skeleton-bucket joint. Also create a servo driver for the arm to move 50 degrees. Create a snapshot as well for the initial position of the assembly.
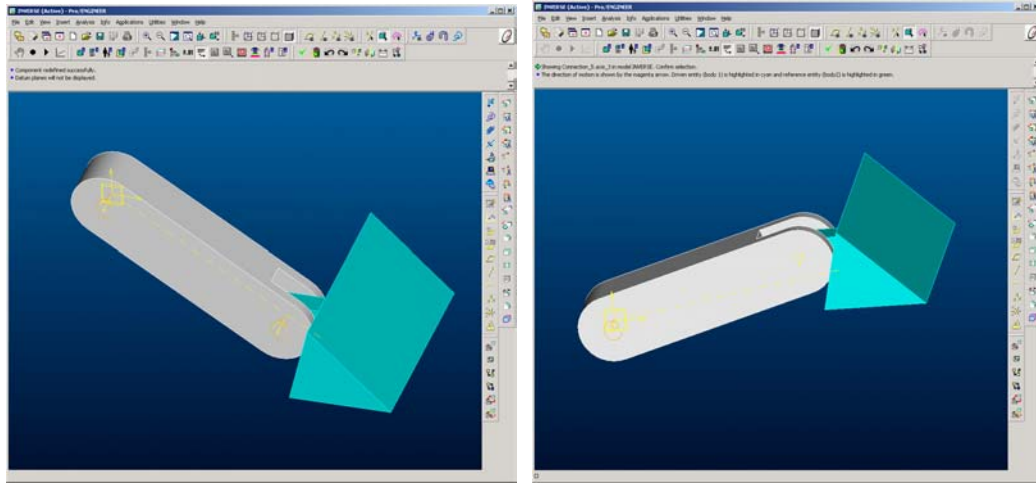
Figure 2

Define an analysis which includes both of the servo motors that have already been defined. Run the analysis. Figure 2 shows the loader in its raised position, the bucket level.

Create a Joint Axis Position measure with Evaluation Type "Each Time Step" on the arm-bucket pin joint axis and name it *arm_bkt_pos*. Output from *arm_bkt_pos* will be used as a table position driver on the arm-bucket pin joint, replacing the necessity for the zero position driver on the planar joint rotational axis.

3. Create a report file of the angular position versus time results for the measure *arm_bkt_pos* by selecting the save to disk option from the results. This will create a file called arm_bkt_pos.tbl. You will need to edit this file and remove the header section, with the numerical data remaining. Figure 4 shows a graph of *arm_bkt_pos* versus time.
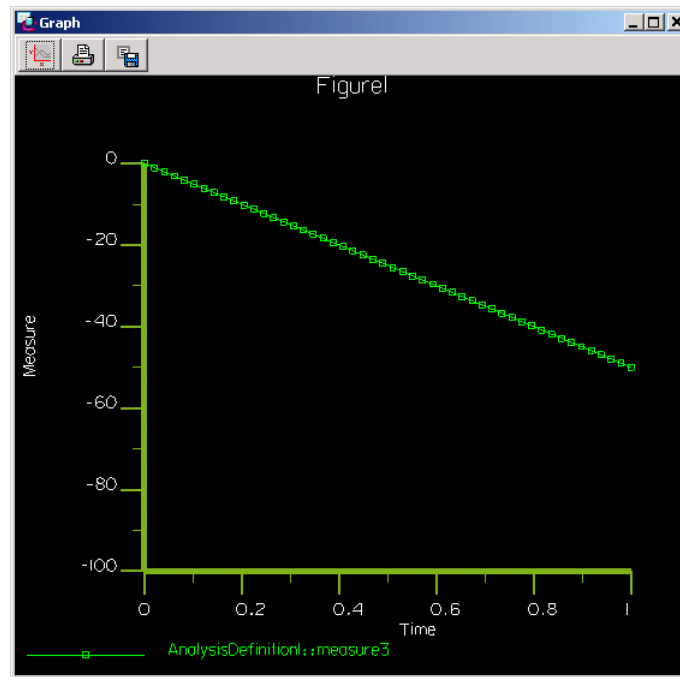
Figure 4

4. Set the model back to its lowered position by selecting the drag snapshot that was created earlier.

   Delete the planar joint connecting the skeleton to the bucket. Place a position table driver on the pin joint connecting the arm to the bucket; use the report file *arm_bkt_pos.tbl* for the table values. Figure 5 shows the loader in the initial position with a table driver on the arm-bucket pin joint.

   Run the motion analysis again. Make sure that both servo motors are turned on in the analysis dialog box. Create a measure called *arm_bkt_load* of the results for the Joint Connection Reaction for the Axial Moment on the joint between the bucket and the arm. Figure 6 shows a graph of *arm_bkt_load* versus time and the dialog box for the definition. This measure yields the inverse dynamics torque required to keep the bucket level as the loader arm is raised. Save the results to file and name it *arm_bkt_load.tbl*.

   Determine the arm-bucket pin joint axis velocity at the first time step of the analysis by creating another measure for the arm-bucket pin joint. Once you graph this measure, note the value of the initial condition of this joint and we'll use it later. The value should be a negative 50 if you set the problem up similar to this example.
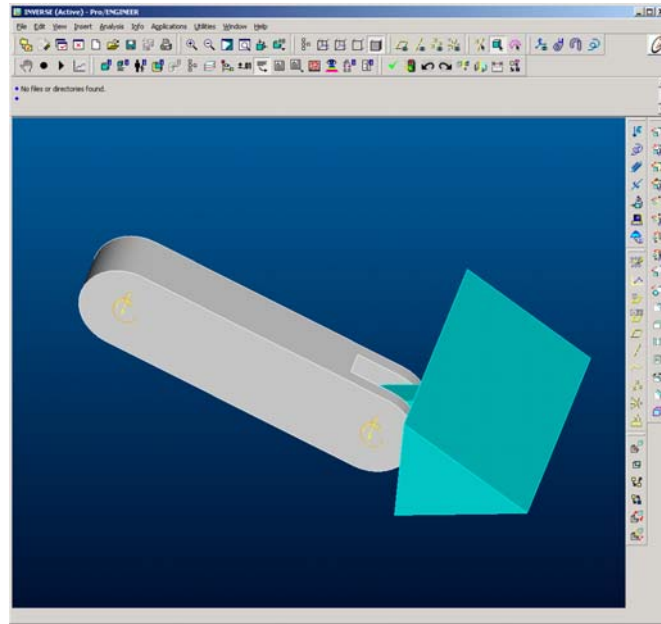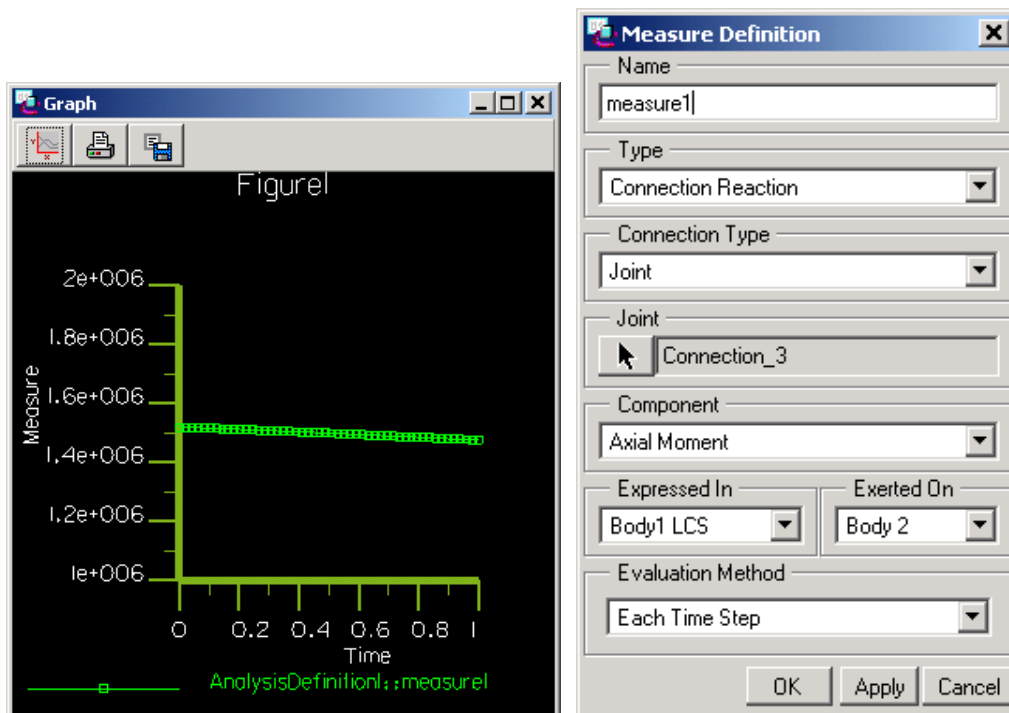
Figure 5

Figure 6

5. Set the model back to its original position as in step 3. Delete the arm-bucket pin joint driver and apply the inverse dynamics torques to the bucket by specifying a joint axis

force motor on the arm-bucket pin joint. Use the *arm_bkt_load* table file for the table values and then apply a Joint Axis Velocity Initial Condition using the velocity recorded in step 4 on the arm-bucket pin joint. Finally, run the analysis with these new settings.

The arm should rotate through its range of positions with the bucket remaining level due to the torques applied to the arm-bucket pin joint. Figure 7 shows the final loader model in its raised position with the bucket level.
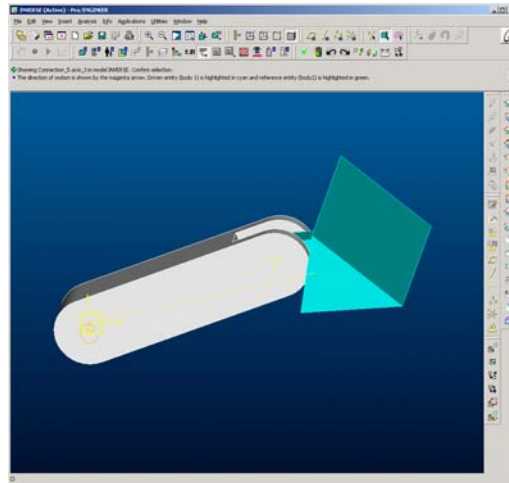.

Figure 7

Summary

Inverse dynamics forces and torques are the equivalent applied forces and torques necessary to produce mechanism movement otherwise governed by drivers. Pro/ENGINEER Mechanism Dynamics Option may be used to extract these forces and torques from any mechanism by following 4 basic principles. These forces and torques reveal how a physical mechanism should be loaded to produce a desired movement and can be used to size motors and components.

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Tips of the Week

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Announcements

Customer PTC E-Newsletter Survey

For the past 2 years I've been sending you our Customer PTC E-Newsletter such as this one.

In an attempt to deliver the highest quality and create the most value we would like to use this survey to further our "Learning" Relationship with you, our Customers. Even if you are a first time recipient of the newsletter, please feel free to share your comments on this one you're reading.

It will not take longer than a few minutes to fill out this quick survey as your input is invaluable and we greatly appreciate your input. Please click on the following link to begin:

To Enter Survey, Please Click

Please note it may be impossible to "Customize" the newsletter to meet every individual request however we will attempt to integrate as many ideas as possible.
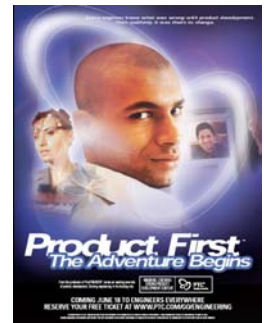
Thank-you very much for your time and feedback as we try to improve this value-added service.

PTC Sponsored Events

Click below to see PTC sponsored events:

http://www.ptc.com/company/news/events/index.htm

Click on the poster to gain access to the Product First Virtual Event resource center!! See the software and pick up a screen-saver or two.

E-PROFILES IS HERE!!
We have been eagerly anticipating the debut of the new electronic version of Profiles Magazine and now it is here! This new web site will supplement the print edition of the magazine and will provide new useful features not feasible with paper media. e-Profiles will provide you with 24x7, worldwide access to key information previously available exclusively in the print version. "Tips & Tricks," a popular feature pioneered by Pro/USER, has also moved to the web and will be expanded as the site matures. Future plans include several foreign-language editions of

Profiles for our many international readers. Currently, Profiles is printed in English and Japanese.

Please take a few minutes to check out this new web site. We don't think you will be disappointed.

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Upcoming Events & Training Class Schedules

Upcoming, 2003   Your local Pro/Engineer User Groups
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Upcoming, 2003   Pro/USER International Conference
http://www.prouser.org/

Please visit the PTC Education Services website for the latest training information including course descriptions, schedules, locations, and pricing.

- Attend a course at any PTC Center and receive a free copy of Pro/E 2001 Student Edition!

http://www.ptc.com/services/edserv/index.htm

PTC

Note: This PTC E-Newsletter will continue to be used for the following:

1) Inform you on events related to PTC products (user groups, conferences, training schedules, etc.)

2) Educate you on products that are available at PTC

3) Tips & Techniques using PTC Products

Note: These messages are compiled in the local PTC office and will be distributed via e-mail.

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