Advanced Science and Automation Corporation

DIS/Belt

Solver, Pre-processor, and Post-processor

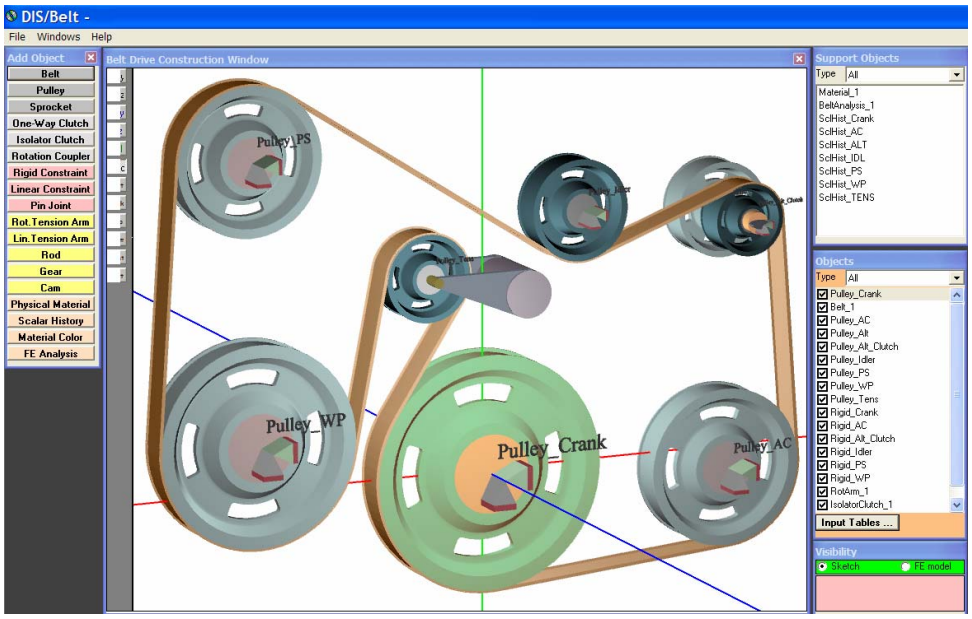
Specialized Dynamic Interactions Simulator for Belt-Drives

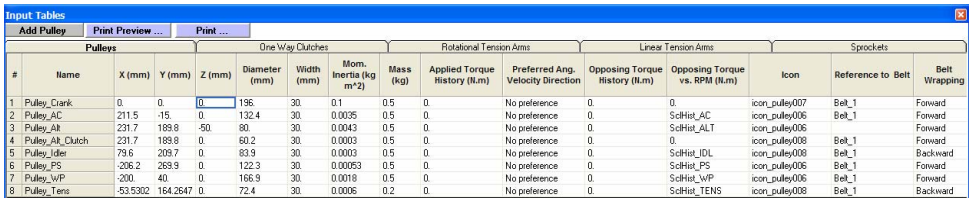
DIS/Belt is a time-accurate advanced finite element code for predicting the dynamic response of belt-drives (such as automotive FEADs) that allows belt-drive designers to quickly build, analyze, and visualize belt-drives in an intuitive object-oriented graphical design environment.

Dynamic Interactions Simulator (DIS) is a general-purpose finite element code with an accompanying pre- and post-processor. DIS was developed specifically to simulate mechanical systems composed of multiple rigid and flexible components, fluid handling components, actuators, controllers, and body-connection elements such as spherical, revolute, cylindrical, prismatic and universal joints.

DIS has been used by researchers and engineers to simulate multi-component machine elements, flexible space structures, space tethers, belt-drives, and other mechanical systems.

Advanced Science and Automation, Corp. developed a specialized version of DIS (DIS/Belt) to simulate automotive accessory belt-drives and timing belt-drives. This DIS version includes the DIS finite element solver and special-built pre- and post-processors which allow belt-drive designers to quickly build and simulate belt-drives in an intuitive, object-oriented graphical design environment. The environment includes a tool-box of objects, including: belt, pulley, sprocket, isolator clutch, material, linear-constraint and scalar history.





#	Name	X (mm)	Y (mm)	Z (mm)	Diameter (mm)	Width (mm)	Mom. Inertia (kg m^2)	Mass (kg)	Applied Torque History (N.m)	Preferred Ang. Velocity Direction	Opposing Torque History (N.m)	Opposing Torque vs. RPM (N.m)	Icon	Reference to Belt	Belt Wrapping
1	Pulley_Crank	0.	0.	0.	196.	30.	0.1	0.5	0.	No preference	0.	0.	icon_pulley007	Belt_1	Forward
2	Pulley_AC	211.5	-15.	0.	132.4	30.	0.0035	0.5	0.	No preference	0.	SclHist_AC	icon_pulley006	Belt_1	Forward
3	Pulley_Alt	231.7	189.8	-50.	80.	30.	0.0043	0.5	0.	No preference	0.	SclHist_ALT	icon_pulley006		Forward
4	Pulley_Alt_Clutch	231.7	189.8	0.	60.2	30.	0.0003	0.5	0.	No preference	0.	0.	icon_pulley008	Belt_1	Forward
5	Pulley_Idler	79.6	209.7	0.	83.9	30.	0.0003	0.5	0.	No preference	0.	SclHist_IDL	icon_pulley008	Belt_1	Backward
6	Pulley_PS	-206.2	269.9	0.	122.3	30.	0.00053	0.5	0.	No preference	0.	SclHist_PS	icon_pulley006	Belt_1	Forward
7	Pulley_WP	-200.	40.	0.	166.9	30.	0.0018	0.5	0.	No preference	0.	SclHist_WP	icon_pulley006	Belt_1	Forward
8	Pulley_Tens	-53.5302	164.2647	0.	72.4	30.	0.0006	0.2	0.	No preference	0.	SclHist_TENS	icon_pulley008	Belt_1	Backward

Object properties can be edited in a table as well as in an individual object dialog box. The user can view an animation of the motion of the belt-drive as well as graphs of various response quantities.

Advanced Science and Automation Corporation
144 Research Drive, Suite 120◆ Hampton ◆ VA 23666
(757) 469-6839
www.ascience.com

Advanced Science and Automation Corporation

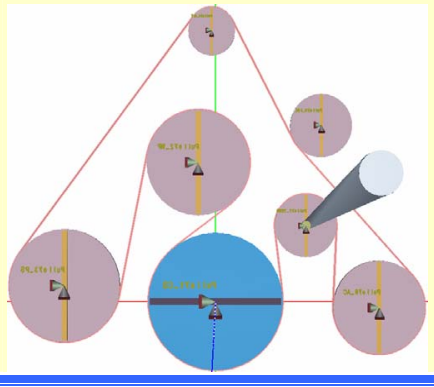
DIS/Belt Highlights

Typical Simulation Types

- Transient dynamic response of the belt-drive due to:
  - Engine startup.
  - Transmission shifts.
  - Cycling of the air-conditioner compressor.
  - Acceleration and deceleration of engine's rotational state.
- Steady-State dynamic response.
  - Engine idling.
  - Cruising engine speeds.
- Natural frequency response.
  - Pulleys/sprockets rotational natural frequencies.
  - Belt-span tension & transverse deflection natural frequencies.
  -

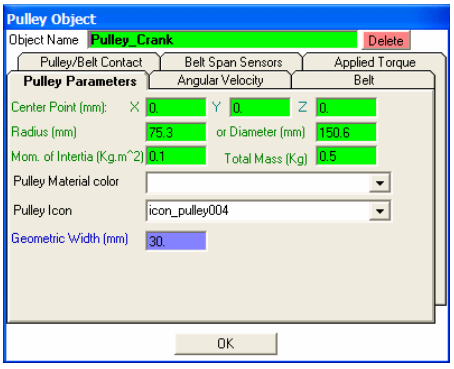
Prediction of the time-history of response quantities of interest, including:

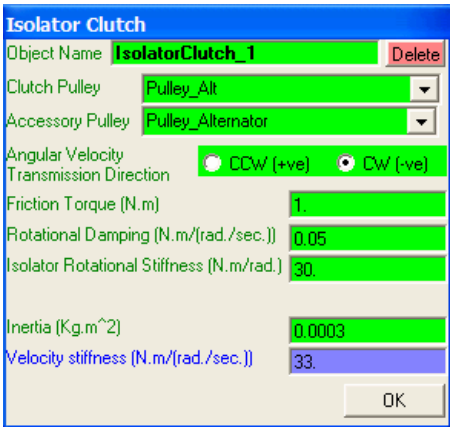
- Pulley/sprocket:
  - Rotational angular velocity.
  - Friction moment.
  - Hub forces.
- Belt-spans:
  - Tension.
  - Transverse deflection.
- Belt-Pulley contact:
  - Normal and tangential forces.
  - Percent slip.
- Tensioner arm motion and load (force or moment).



The following modeling features are incorporated into DIS/Belt:

- Formulation:
  - An explicit time-integration solver accurate for long simulation periods.
  - Equations of motion formulation using a total Lagrangian, total displacement approach.
  - A library of nonlinear large rotation finite elements.
  - Degrees of freedom referenced to a global inertial frame.
  - Gravity field.
  - Ability to specify any system parameter as a constant or a user-defined scalar time-history.
  - Flexibility in specifying scalar time-histories as:
    - Tabular data (cut & paste from Excel).
    - Linear graph segments with superimposed harmonics of specified frequencies and amplitudes.
- Belt Modeling:
  - Truss and beam elements for belt discretization.
  - Linear isotropic belt material model with viscous damping.
  - Support for multiple belts.
  - V/flat belts or synchronous belts.
- Pulley and Accessory Modeling:
  - Driver pulleys/sprockets modeled as circular rigid bodies with prescribed angular velocity profiles (including time-varying excitation), or as freely rotating.
  - Driven pulleys/sprockets modeled as circular rigid bodies with a rotational moment of inertia and an accessory model that can include a prescribed opposing torque, damping, and Coulomb friction.
- One-way clutches, isolator clutches, and rotational couplers that can be used to couple an accessory and a pulley/sprocket.
- Linear and rotational tensioner arms with stiffness, damping, and Coulomb friction force/ moment.
- Contact and Constraints.
  - Penalty contact formulation.
  - Frictional contact between the pulleys and the belt modeled using an asperity-based approximate Coulomb friction model.





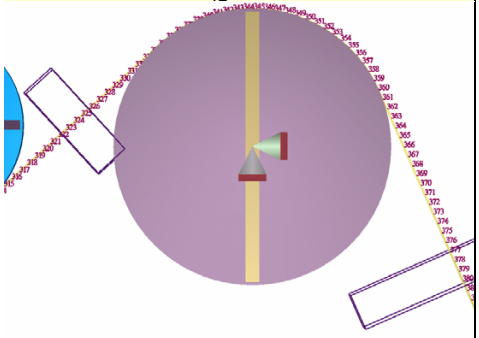
Advanced Science and Automation Corporation
144 Research Drive, Suite 120◆ Hampton ◆ VA 23666
(757) 469-6839
www.ascience.com

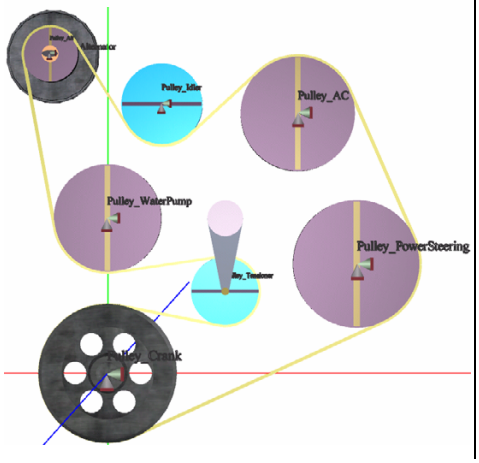
Advanced Science and Automation Corporation

DIS/Belt Highlights

Post-Processor

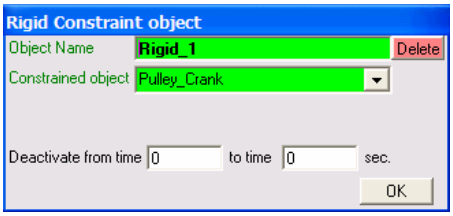
- Display time-history and frequency-response (FFT) graphs:
  - Belt-span tension and transverse vibration.
  - Pulleys' angular velocities.
  - Tensioner arm's motion/forces
  - Pulley/sprocket hub loads.
- Display distributions of the following quantities over the pulley/sprocket contact arc:
  - Contact normal and tangential friction forces.
  - Relative angular velocity between belt and pulley (belt creep in the contact arc).
  - Tooth forces for sprockets.
- Display an animation of the belt-drive motion (generate .

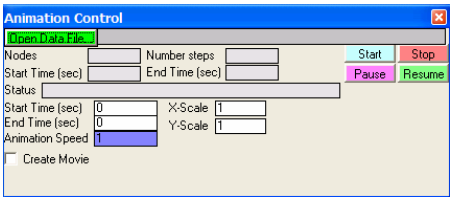


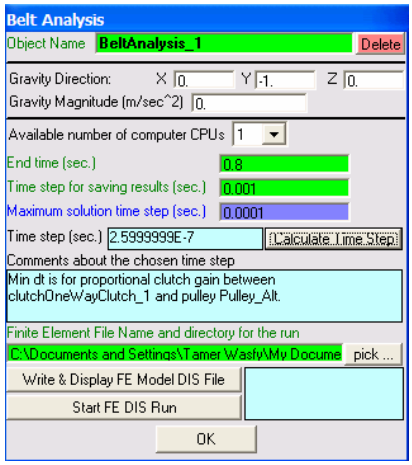


- Ground and linear-sliding elements for constraining pulley centers.
- Accurate toothed-belt model including tooth stiffness, damping, Coulomb friction, trapezoidal angle, and engagement tolerance.

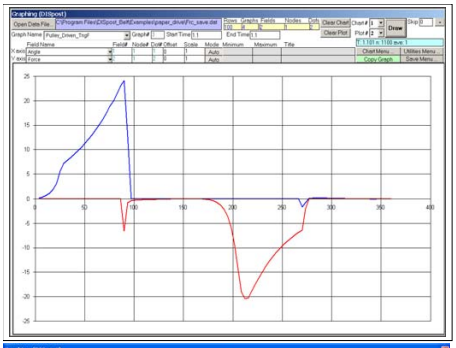
- Analysis and Post-Processing.
  - Simulation of transient and steady-state dynamic response.
  - Animation of the belt-drive motion.
  - Graphing of time-histories of response, including: pulley angular velocities, belt-span tension and transverse vibration, tensioner arm motion, pulley hub loads, and contact forces (normal and tangential) between the belt and pulleys/sprockets.
  - FFT analysis for any response time-history for determining frequency content.

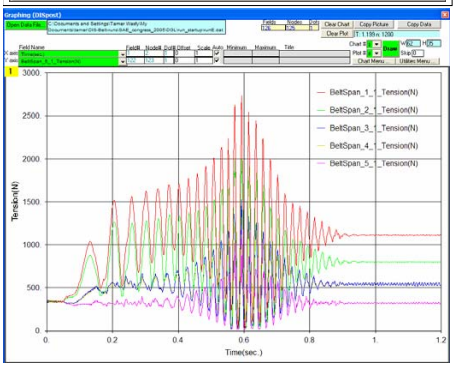


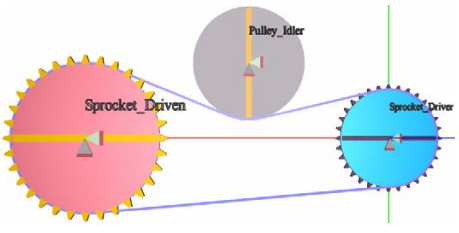




DIS/Belt is the **only** finite element code on the market that can accurately and efficiently model the stick-slip behavior between the belt(s) and the pulleys.







Advanced Science and Automation Corporation
144 Research Drive, Suite 120◆ Hampton ◆ VA 23666
(757) 469-6839
www.ascience.com