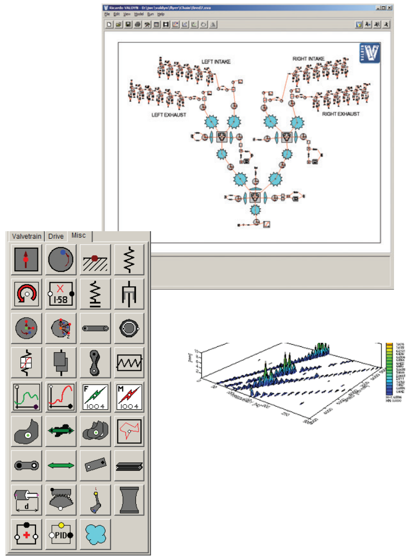
RICARDO

VALDYN

Ricardo Software

Powertrain CAE Solutions

www.software.ricardo.com

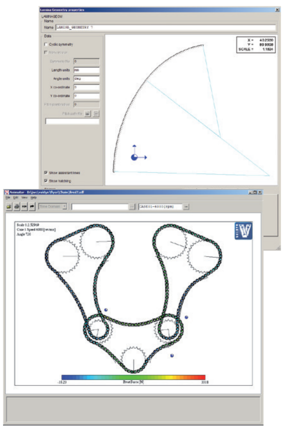


What is VALDYN?

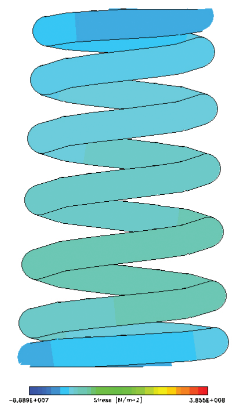
VALDYN is a multi-body dynamic and kinematic simulation package that has been specifically developed for valvetrain and drive system analysis and cam and spring pack design. With its detailed "building block" models of engine components, it is significantly quicker to build models with VALDYN than with general purpose dynamics tools; and quicker to run because model refinement is focussed on the critical aspects related to engines.

Key product features

- "Building block" structure allows modelling of virtually any valvetrain, from individual valvelines to complete systems incorporating crankshaft and camshafts
- Modelling of drive systems, including gears, belts and chains
- Data input using expressions involving case-varying parameters
- Frequency domain solver including forced-damped solution of linear models
- Dynamic and kinematic analysis of valvetrains
- Modelling of VVT and VVA mechanisms
- Animated output in the time and frequency domains
- Automatic plotting of results
- 3D frequency response plots
- Plotting of mathematical expressions involving several outputs
- Run distribution using network computing resources to speed up multi-case simulations
- Links to ENGDYN and FEARCE for engine structural analysis
- Co-simulation with other Ricardo and third-party programmes, such as Simulink



Valvetrain design



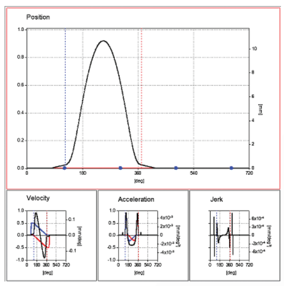
VALDYN Kinematics caters for the design and kinematic analysis of valvetrain systems. Using a building-block approach, VALDYN provides users with a library of select standard and unconventional valvetrains. All valvetrain types can be analysed, including linearly translating and swinging followers with or without a push rod and rocker systems. SABR Kinematics can be used assess an existing cam design or to generate a cam profile using either the Ricardo 'Multipol' method or a general spline method. A number of methods of spring pack design are available to allow combined optimization with cam profile design.

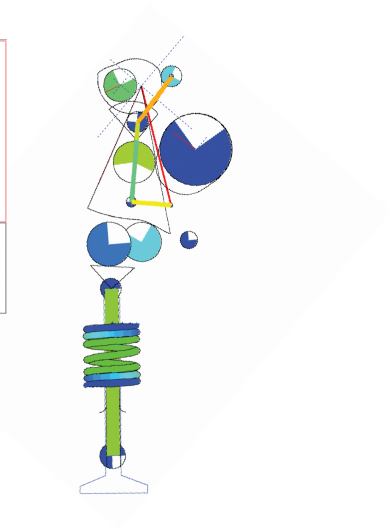
VALDYN Kinematics produces comprehensive outputs to enable assessment of spring/cam design, including cam contact Hertzian stress, oilfilm thickness, cam wear, spring cover, spring stress and spring natural frequency.

Data can easily be transferred to VALDYN Dynamics for assessment of the design in the context of the timing drive and to assess dynamic aspects such as spring surge and valve bounce.

Capabilities

- Building-block approach to model construction
- Caters for novel systems
- Tribological analysis from kinematic and dynamic standpoints
- Detailed spring model including coil clash
- Dynamic analysis in context of complete engine
- Advanced spline methods for cam design
- Arbitrary shaped swinging cam follower
- Spring pack natural frequency

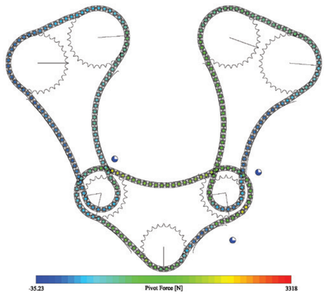




Chain dynamics

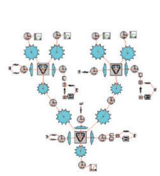
VALDYN can be used to model most types of chain including roller and inverted tooth chains. Generation of chain models is fast and simple with minimal data input and automated wrapping of the chain around the sprockets. Sprocket tooth, link and guide shapes can be built from lines, arcs and involutes or defined by B-splines which can be fitted to measured data.

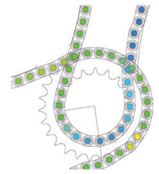
The behaviour of the chain can be viewed as an animation, both in the time domain and as mode shapes in the frequency domain. Comprehensive plotted output of force, friction and power loss is available. The time variation of forces on individual components or at given points in the chain run, and spatial variation of forces around the chain run can also be plotted.



Capabilities

- Simple model generation
- Class-leading simulation speed
- Full capability for modelling tensioner systems
- Ability to model non-circular sprockets
- Interaction of chain with camshaft and crankshaft
- Span flap and system modes by perturbation at any time step
- Automatic model simplification for linear frequency domain analysis
- Results animation
- Comprehensive plotted output





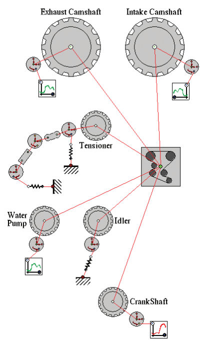
Belt dynamics

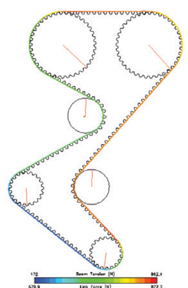
VALDYN can model both timing (toothed) belts and auxiliary drive belts. Timing belts with non-circular pulleys can be modelled, as can "wet" belts using guides. Generation of belt models is fast and simple with minimal data input and automated wrapping of the belt around the pulleys and automatic positioning of the tensioner to achieve a required initial belt tension. Pulley and belt tooth shapes can be built from lines, arcs and involutes or defined by B-splines which can be fitted to measured data.

The behaviour of the belt can be viewed as an animation both in the time domain and as mode shapes in the frequency domain. Comprehensive plotted output of belt/pulley forces, belt internal forces and span flap is available. The time variation of forces on individual pulleys and belt teeth, or at given points in the belt run, and spatial variation of forces around the belt run can be plotted.

Capabilities

- Simple model generation
- Class-leading simulation speed
- Full capability for modelling tensioner systems
- Automated tensioner initial positioning
- Ability to model non-circular pulleys
- Ability to model wet belt guides
- Interaction of belt with camshaft and crankshaft
- Span flap and system modes by perturbation at any time step
- Automatic model simplification for linear frequency domain analysis
- Results animation
- Comprehensive plotted output





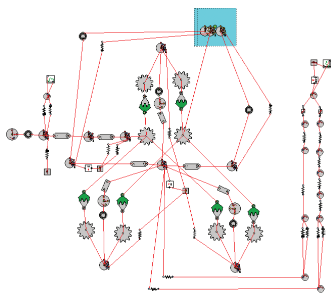
Gear dynamics

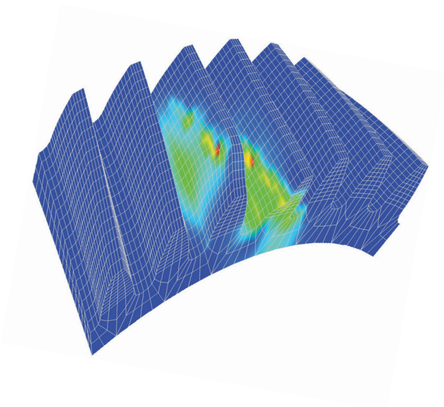
VALDYN can model gear systems at three levels of detail, from 2D involute contact, via 3D involute contact including tip relief, to full 3D using a finite element model of the tooth and tooth surface modification.

The FE model is generated automatically by FEARCE, and results can be back-substituted to obtain tooth displacement and stress which can be animated within FEARCE. Spur and helical gears, including internal-tooth (epicyclic) gears, can also be modelled. When used in conjunction with VALDYN's 3D rolling element bearing and dynamic body (FE) elements, realistic gearbox models can be built to study refinement issues.

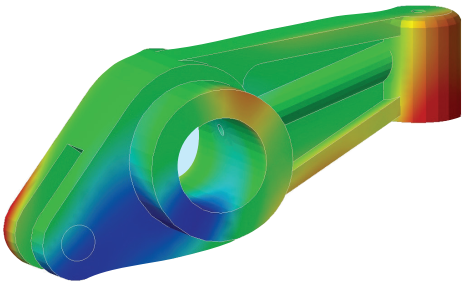
Capabilities

- Optional FE tooth model
- Interaction of gears with complete engine
- Automatic model simplification for linear frequency domain analysis
- Results animation
- Comprehensive plotted output





Finite Element (FE) components

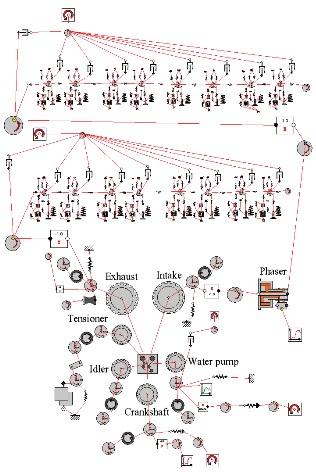


VALDYN has an advanced DYNAMICBODY element that allows FE models to be connected to other modelling elements to form a fully coupled system that can be simulated directly in VALDYN. This is a powerful technique for representing complex component stiffnesses, which would otherwise be difficult to define in a lumped-mass model.

VALDYN uses a reduced FE model which is derived from a full FE model using the Craig-Bampton method for Component Mode Synthesis (CMS). In the FE model, connection nodes are defined, which can be either normal 6-DOF FE nodes or "constrained" nodes representing the average motion of a group of normal FE nodes. All FE nodes that don't contribute to the motion of connection nodes are reduced out. Results can be back-substituted to obtain component displacement and stress that can be animated within FEARCE.

Capabilities

- Simple incorporation of complex geometry
- Can be used in linear frequency domain analysis
- Back-substitution for displacements and stresses
- Animation of results



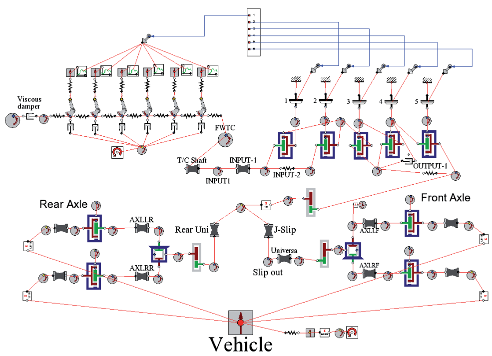
Engine system modelling

VALDYN is ideal for simulating complete engine systems using its wide range of modelling elements. The ease of model construction and high simulation speed mean that models can be assembled and solved quickly. Common engine and driveline components, such as cam followers, hydraulic lash adjusters, cam phasers, chains, belts, gears, gear sets, clutches, brakes and control elements, are provided by VALDYN, and other mechanisms can be assembled from over 30 basic building block elements.

Co-simulation with other Ricardo Software tools, IGNITE and WAVE, or other third-party programmes, such as Simulink, allows the system boundaries to be spread beyond the VALDYN model so that complex interdependencies can be examined.

Capabilities

- Rapid generation of complete engine models
- Parametric input for case-to-case variation
- Run distribution for fast multi-case analysis
- Co-simulation with Ricardo Software's IGNITE and WAVE
- Linear frequency domain analysis including automatic model simplification of non-linear components
- Perturbation analysis to allow frequency domain analysis at a given instant in time



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