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PISDYN / RINGPAK

DYNAMIC MODELLING FOR PISTON AND PISTON RING DESIGN

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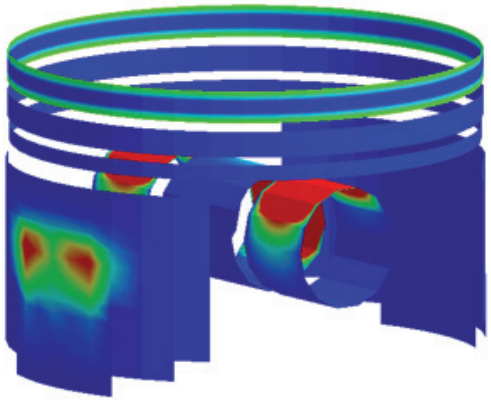
What is PISDYN ?

PISDYN is an advanced three-dimensional simulation package for predicting the dynamics of the piston and connecting rod assembly - enabling the optimization of the piston geometry. PISDYN evaluates the risk of scuffing or extensive wear at various load and speed conditions in a fraction of time when compared to physical testing. It enables optimization of various parameters such as piston skirt profile and ovality, piston pin offset or initial clearance. Based around an advanced lubrication model for simulating the interface between the piston and liner, the engineer can use a hierarchy of structural models to minimize scuffing, wear, friction loss and piston slap.

Key Features

- Advanced EHL mass-conserving lubrication model for piston/liner interface
- Hydrodynamic and boundary lubrication models
- Single piece and articulated pistons
- Hierarchy of rigid, compliant and dynamic structural models
- Integrated FEARCE solver for FE matrix reduction

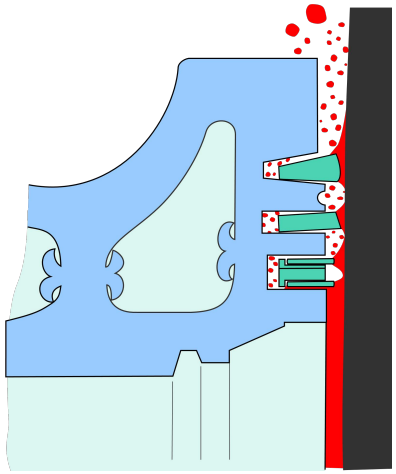


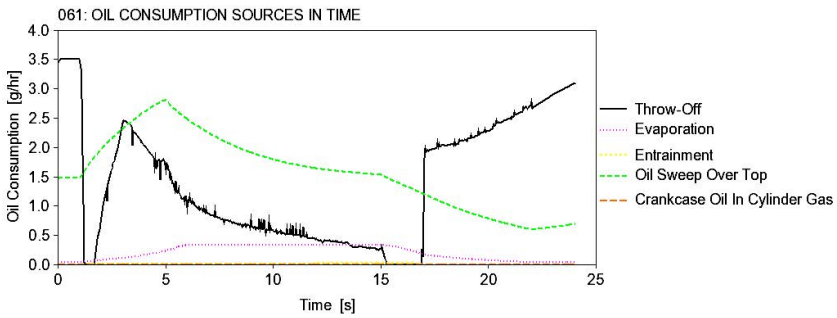
What is RINGPAK ?

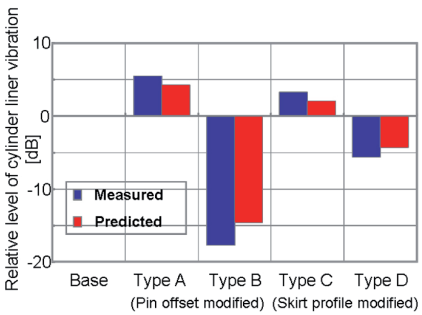
RINGPAK saves significant cost by replacing expensive oil consumption engine tests with simulation making it possible to optimize the trade off between oil consumption, friction and blow-by. RINGPAK is an advanced two-dimensional simulation package for predicting ring pack dynamics, lubrication and gas flow for optimization of the ring pack. Based around advanced lubrication, gas and ring dynamic models, the engineer is able to reduce friction, wear, blowby and oil consumption, minimizing the need for expensive and difficult testing.

Key Features

- Piston ring dynamics
- Gas dynamics shows mass flow of gas passed each ring and inter-ring pressures
- Hydrodynamic and boundary lubrication models
- Advanced oil consumption calculations
- 3D effects of piston secondary motion (PISDYN) and bore distortion (FEARCE)
- Transient duty cycle analysis
- The most advanced and accurate solver on the market.
- Good correlation with experiments
- Transient simulation
- Complex oil transport model – oil sweeping on the crown lands surface
- Advanced three-piece oil control ring
- Predictive and still fast to solve
- Enables parameter sweep
- RDM solution to run multiple cases simultaneously on multiple CPUs







Piston Dynamics

PISDYN calculates the secondary motions of the piston assembly by solving for the forces and moments of the piston/liner system and how these interact with the lubrication at the component interfaces throughout the engine cycle.

The lubrication model includes the effects of both hydrodynamic and boundary lubrication, as well as accounting for the elasticity of the piston skirt and cylinder liner.

PISDYN also allows for a full hierarchy of solution levels ranging from rigid through compliant to fully dynamic components and from dry through partially flooded to full flooded oil supply zones.

- Piston ring dynamics
- Gas dynamics shows mass flow of gas past each ring and inter-ring pressures
- Hydrodynamic and boundary lubrication models
- Advanced oil consumption calculations
- 3D effects including piston secondary motion from PISDYN and bore distortion from FEARCE
- Transient duty cycle analysis
- The most advanced and accurate solver on the market.
- Good correlation with experiments
- Transient simulation
- Complex oil transport model – oil sweeping on the crown lands surface
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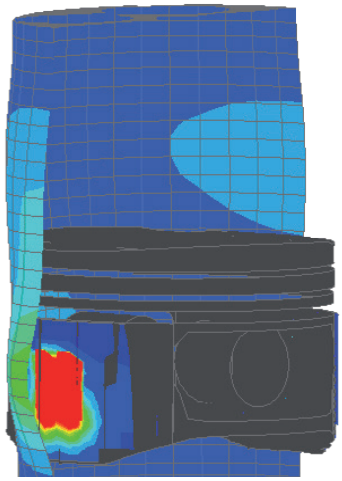
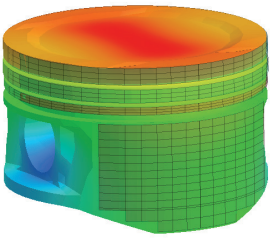


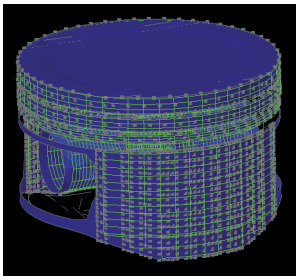
Finite Element (FE) modelling

PISDYN incorporates an advanced interface that allows a user to utilize FE models to calculate the mass and stiffness metrics required for dynamic and compliant analyses, as well as deformations due to thermal, pressure and inertia loads. Any combination of model level can be chosen for either the piston or liner side assemblies.

With its internal FE solver, PISDYN has the capability of performing all of the required analyses, or if the user prefers, it can also set up appropriate analysis decks for the major third-party solvers, including Abaqus®, ANSYS® and Nastran®.

Post solution, the PISDYN FE interface also has the capability of applying the calculated forces onto component FE models to provide boundary conditions for FE stress analyses.





- Interactive 3D graphical user interface
- Automatic selection of sets for loading
- Vectorized Sparse Solver (VSS) Static (Guyan) and dynamic (CMS) reduction
- Thermal, inertial and gas pressure deformations
- Temperature dependent material properties
- Complete piston and liner (or engine block) models with optional half model
- Inertia relief for static models
- Built-in translators from commercially available FE packages
- Pressure loading of cylinder head
- Back-substitution of results for complete piston/liner FE analyses
- Piston and liner dynamic models
- Mass and damping
- User defines modal damping characteristic
- Critical damping ratio against frequency
- Critical damping applied to each mode
- Component Mode Synthesis (CMS) reduction
- User selects number of dynamic modes
- Improved vibration analysis for piston slap prediction

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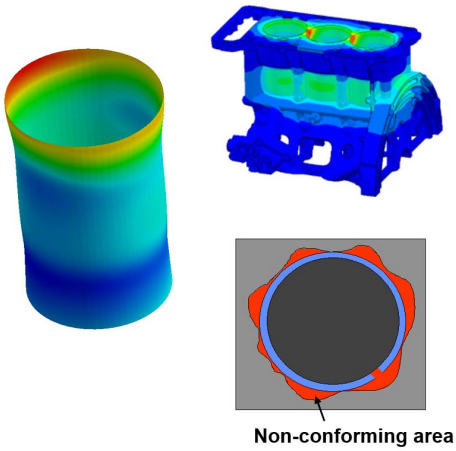
Ring dynamics

RINGPAK simulates the motion of each separate ring on the piston assembly based upon an axi-symmetric assumption. The ring motion is decomposed into twist, axial and radial motions. The effects of the surrounding gas pressure, boundary lubrication, hydrodynamic lubrication, system friction and inertia are taken into account in force and momentum balances.

Sealing calculations can be performed based on detailed gas flow analyses through the ring pack. From these studies, blowby and blow back values can be predicted. Using this methodology, RINGPAK forms an interconnected system of gas volumes. The gas flow between these volumes is controlled by either the ring motion or by the conformability of the rings to the liner body during deformation.

RINGPAK enables to run a transient simulation where engine speed and torque are being change during the cycle. It allows to predict oil consumption during transient parts of a duty cycle.

- Axi-symmetric 2D treatment including 3D features for bore, ring conformability, crown shape, and crown thermal distortion
- Mass conserving hydrodynamic lubrication model
- Boundary lubrication model
- Channel flow and orifice flow inter-ring gas dynamics
- Ring-liner conformability
- Different oil supply modes
- Transient simulation



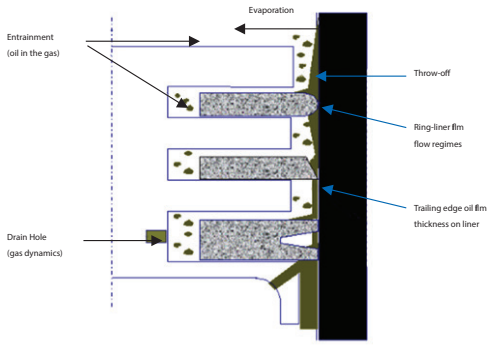
Oil transport and consumption

RINGPAK's oil transport calculations utilize models for the two key effects known to act upon the system.

The ring/liner oil transport model simulates the oil scraping action of the piston rings. It includes the effects of areas of non-conformance, liner honing, ring-liner clearance, axial gas pressure differences and ring end gap size. Oil accumulation at the leading edges of the rings is also calculated.

The oil sweep model simulates the oil transport along the crown surface. Oil attached to the crown surface is exposed to high forces due to piston acceleration and gas flow velocities. The solver analyses the effects of gas flow intensity, oil entrainment into flowing gas and oil accumulation on crown lands and grooves.

Results from the oil transport models are used in the determination of oil flooded areas where hydrodynamic pressure is developed.



- Oil transport modes
- Ring/liner clearance
- End gap
- Liner hone
- Ring non-conformance areas
- Types of Lubricant Oil Consumption (LOC)
- Oil throw-off into combustion area
- Oil sweep from the crown lands surface into combustion area
- Oil entrainment of oil droplets into combustion area
- Oil evaporation from liner surface exposed to hot cylinder gas

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