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INTERNATIONAL CAE CONFERENCE

33rd INTERNATIONAL CAE CONFERENCE AND EXHIBITION

VIRTUAL DEVELOPMENT OF A CRANK MECHANISM FOR A MotoGP ENGINE USING LATEST MODELING TECHNIQUES

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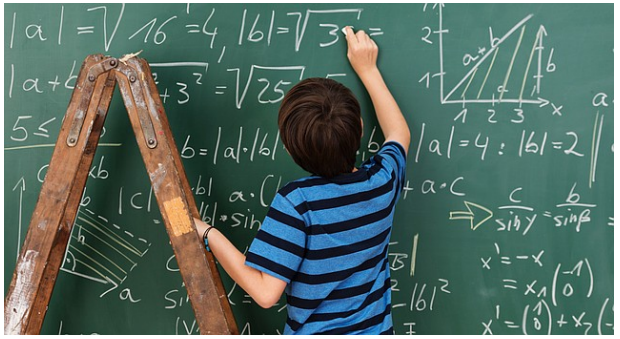
agenda

- Introduction
- D16GP engine
- Preliminary calculations
- Model set- up
- Model validation
- Results
- Future developments
- Conclusions

Introduction

How to produce a new version of crankshaft that is: powerful, safety, in a short time and with reduced experimental tests available?

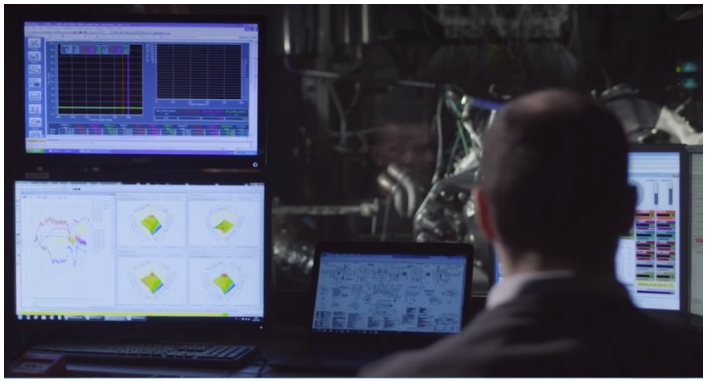
Cranktrain dynamic model



D16GP engine

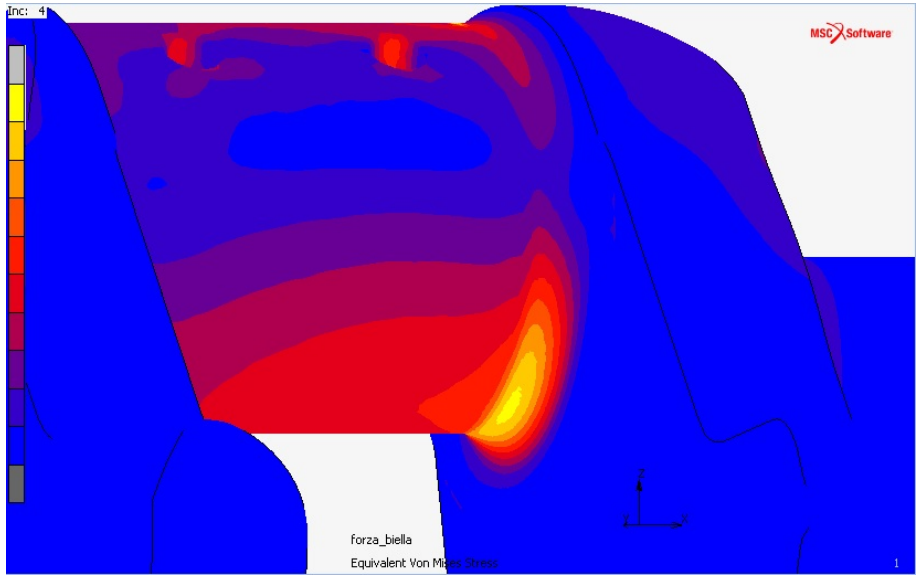
- 4 stroke spark ignition, 1000 cm^3
- 4 cylinders, “V” lay- out
- 90° cylinder bank angle
- Desmodromic distribution

Note: the engine has been simulated as it were installed in the test bench.



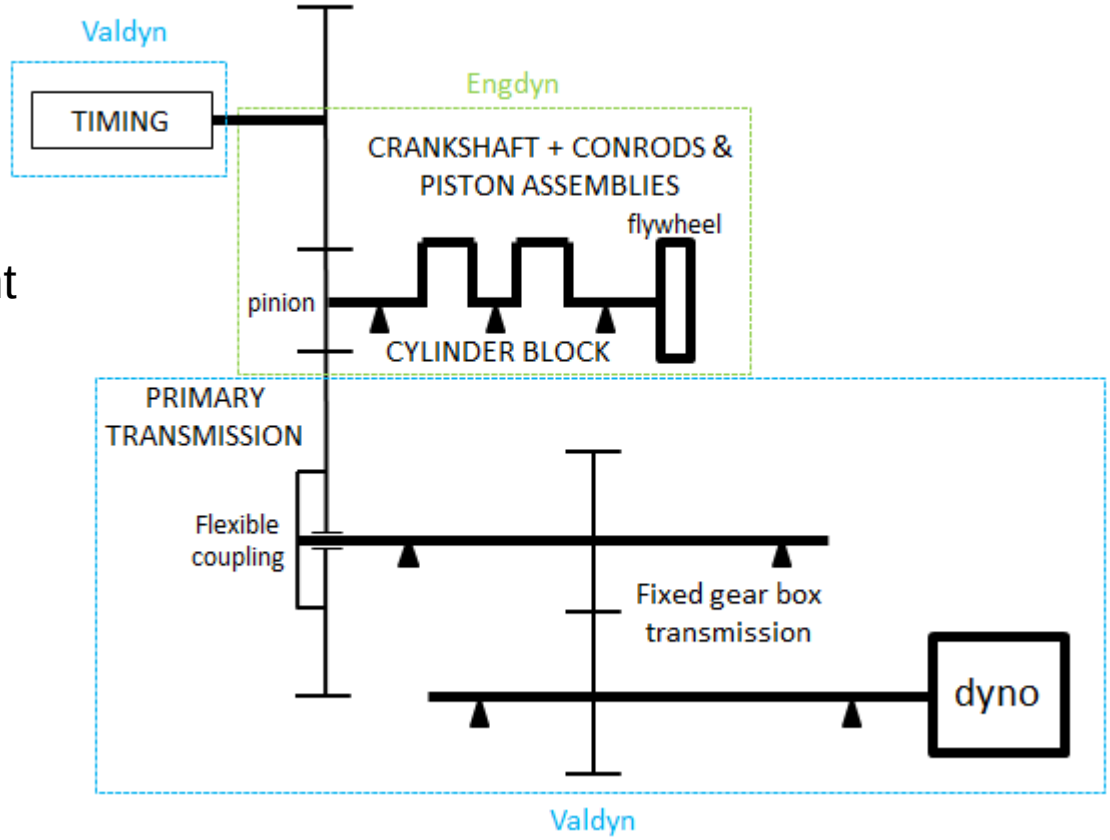
Preliminary calculations

- Simplified FEM model to investigate different crankshaft geometries with MSC Marc.
- Two geometries selected and tested with Engdyn\Valdyn (different main and pin journals radii and thicknesses).



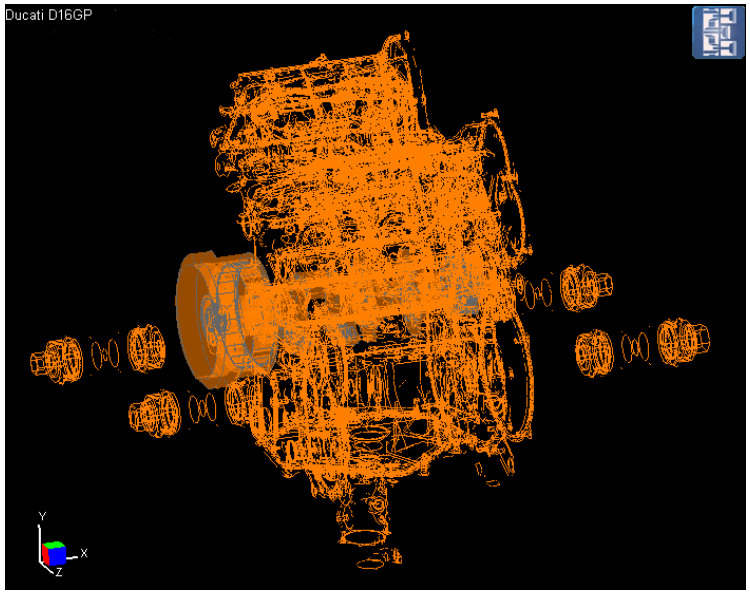
Model set- up

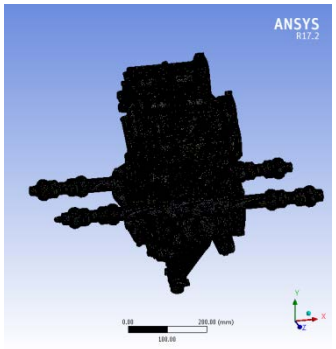
- Motorcycle engine lay-out! → Engdyn\ Valdyn co-simulation.
- Very high engine speed → vibrations predominant (both from cranktrain & engine block).



Model set- up: Engdyn

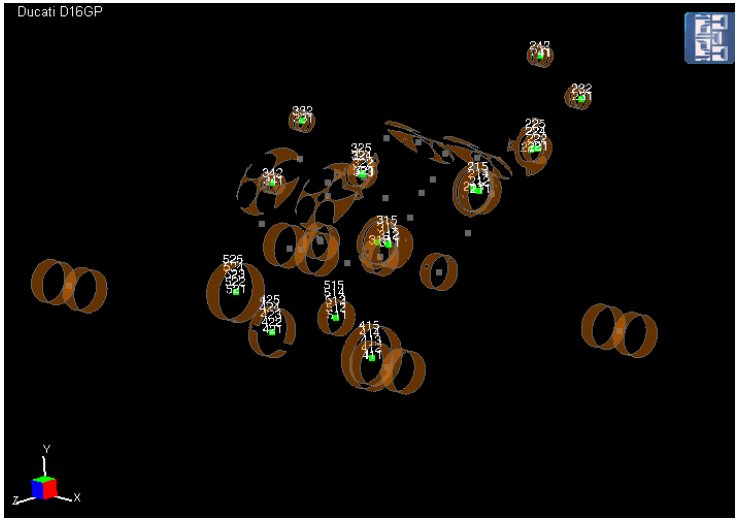
- Crankshaft: dynamic. Mass and stiffness properties derived from a mesh discretization. The assembly includes: crankshaft, pinion and flywheel.
- Cylinder block: component mode synthesis of the first 50th modes. The assembly includes: carters, heads, covers and the test bench frame.
- Meshes obtained with Ansys 17.2.

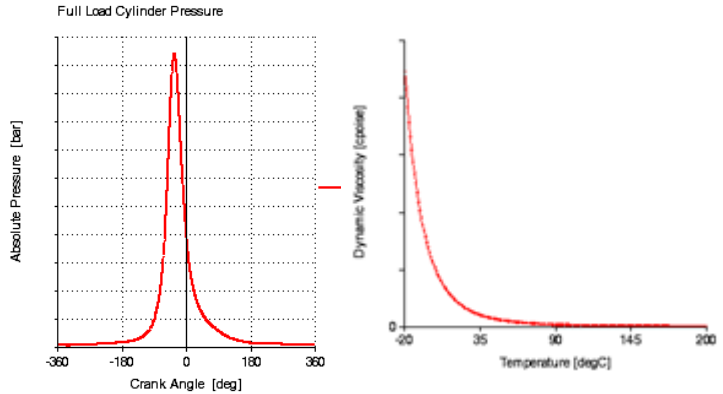




Model set- up: Engdyn

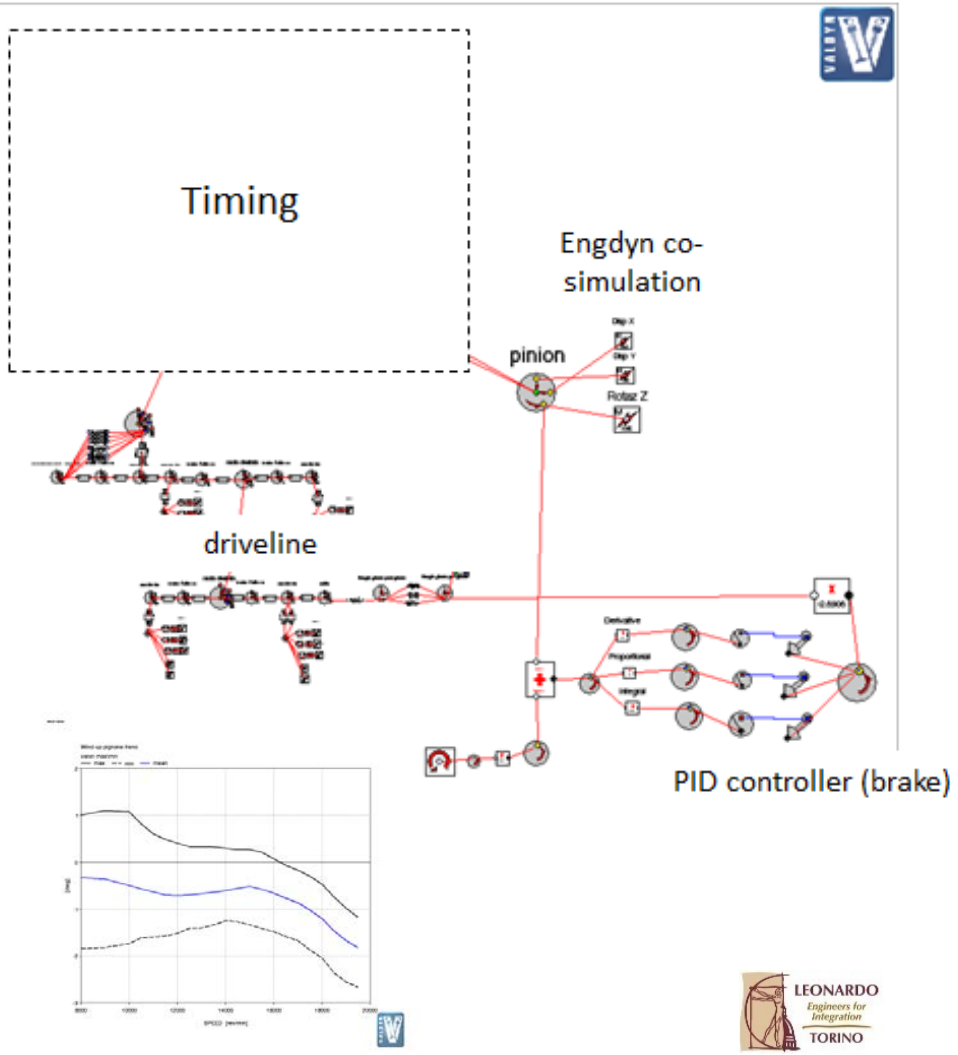
- Mechanical links defined to receive forces and moments from Valdyn and send displacements to Valdyn.
- Interfaces involved with the co-simulation: timing bearings, drive line bearings, pinion gear.
- The cylinder block simulated in Engdyn sees all the main loads, thermal ones excluded for the moment, though they can be added during the modal reduction (planned).
- Oil properties derived from internal data base.
- Cylinder pressure derived from CFD Ducati Corse models.





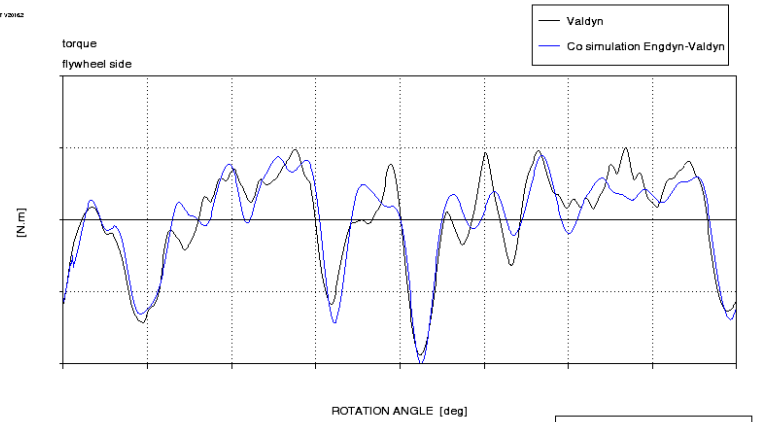
Model set- up: Valdyn

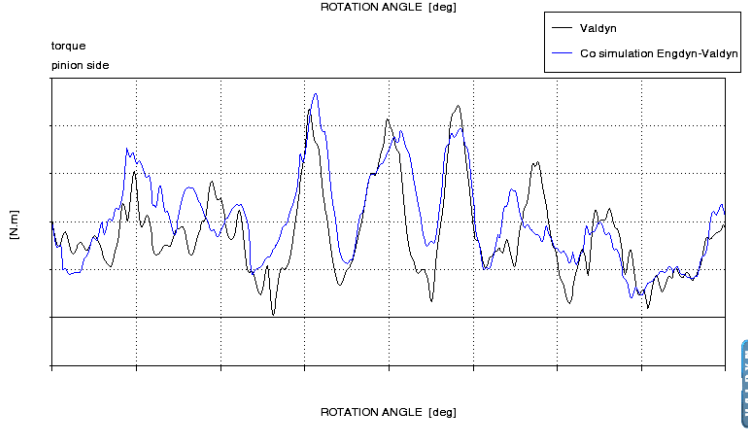
- The pinion\primary gearing influences the crankshaft's behavior.
- A detailed representation of drive line and timing has been set- up.
- A PID controller has been adopted to avoid wind- up problems deriving from lash and low stiffness components (especially brake's elastomeric joint).



Model validation

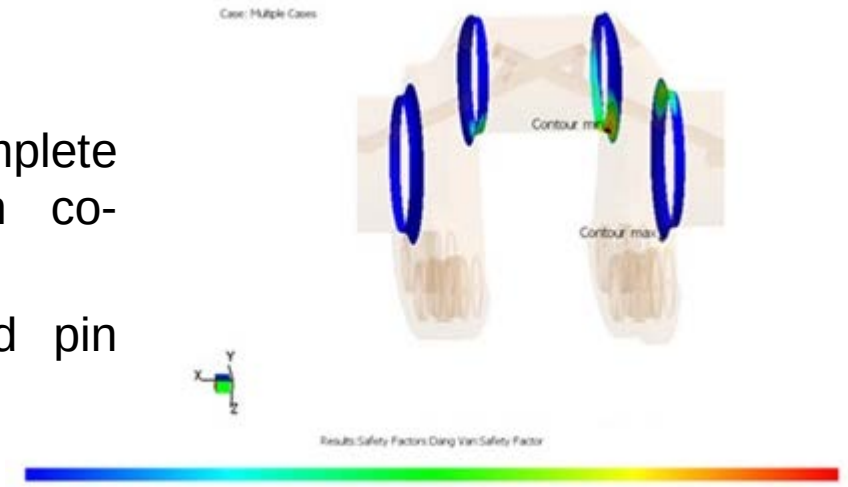
- Checks through kinetostatic model and FEM modal analysis.
- Deeper validation of the model through a numerical comparison with another virtual engine model historically used in Ducati Corse built with Valdyn.
- Direct comparison numerical\ experimental planned.

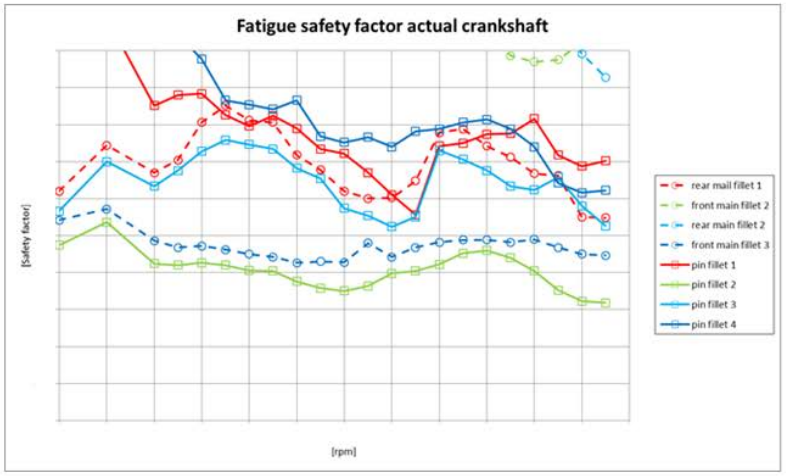


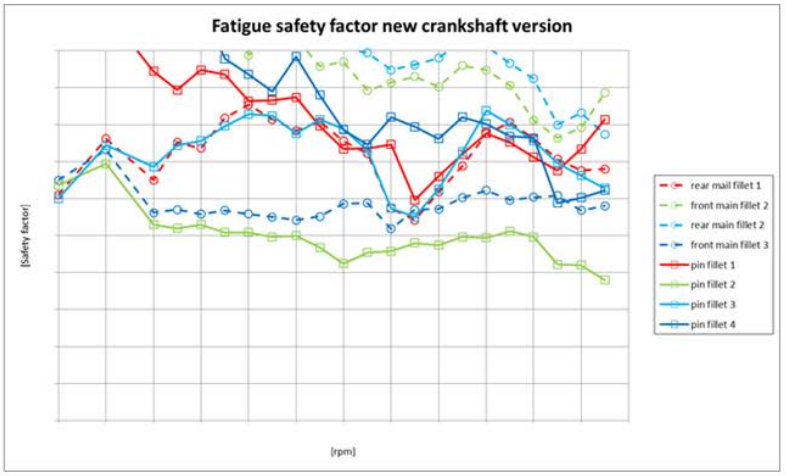


Results

- Time of calculation to do a complete sweep of engine speeds with co-simulation: 18 hours.
- Safety factors in the main and pin journals fillets of the crankshaft.







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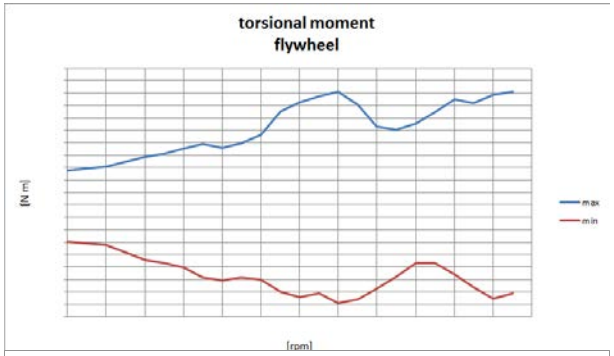
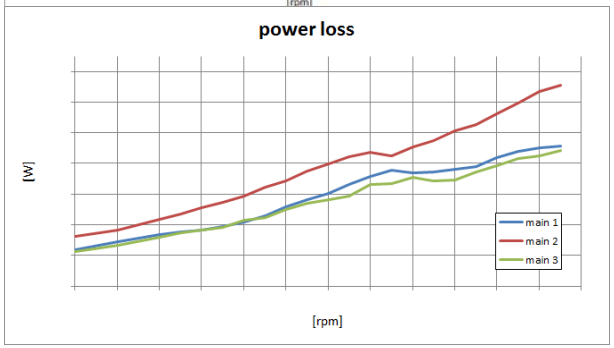
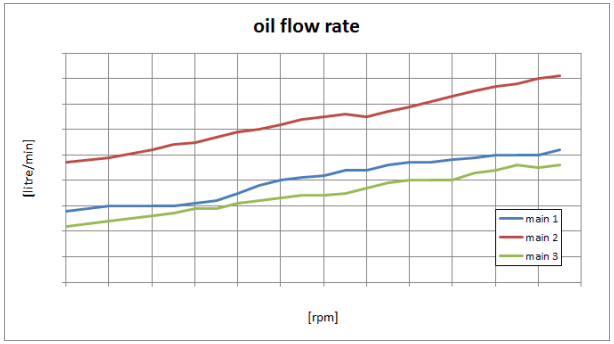
Results

- Huge amount of data extracted with the model, included hardly measurable outputs.
- Torsional and bending moments extracted to generate the boundary conditions of some other FEM analysis (for ex. Flywheel durability).
- Bearings' power loss and oil flow rate: comparison with Ducati Corse's CFD calculation and considerations about frictions' reduction.

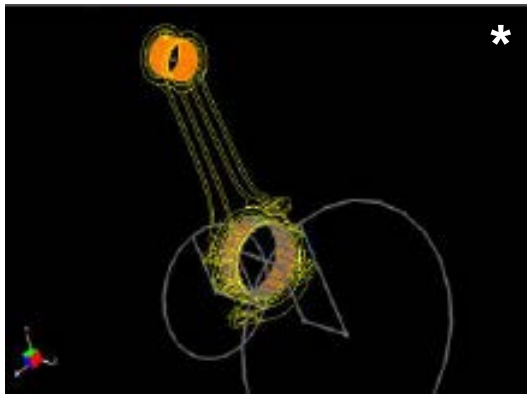


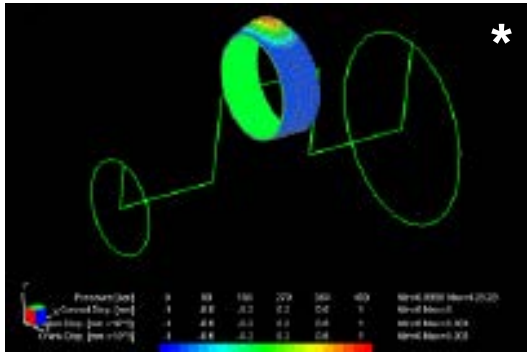




Future developments

- Direct experimental measures to complete the model validation.
- More detailed description of the connecting rod & piston.
- Detailed calculations focused on the bearings → elastohydrodynamic bearing model.
- FEM analysis of the cylinder block using all the dynamic loads calculated by the model + thermal loads → cylinder block safety factors.



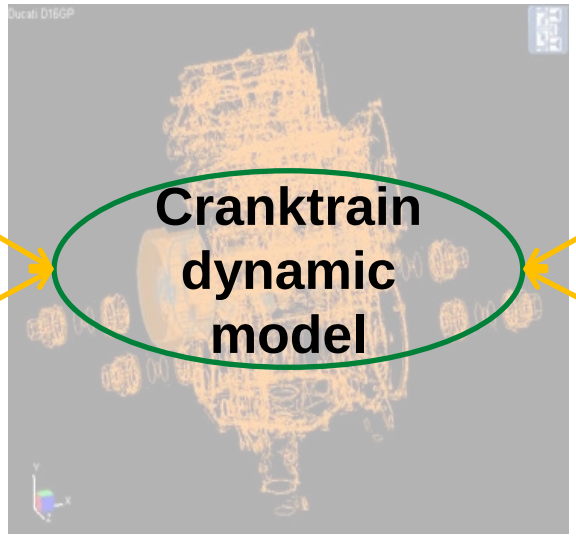


* Courtesy of Ricardo Software

Conclusions

Little time available from CAD to track

Understanding complex engine dynamic behaviors



Performances (Reduction of friction & lightweight)

Safety

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