SIMULATION AND EVALUATION OF ENGINE FRICTION
EUROPEAN GT CONFERENCE, FRANKFURT/MAIN, OCTOBER 9TH, 2017

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AGENDA

1. Motivation and objective
2. Modelling of friction related components
3. Validation
4. Conclusion and further developments
01
MOTIVATION AND OBJECTIVE
Predictive evaluation of concepts and trends in engine friction reduction. „As simple as possible and as complex as necessary.“
OBJECTIVE

Simulation and Evaluation of Engine Friction | Oleg Krecker | October 9th 2017

Closeness of basic conditions to reality

High

Low

Transient cycles

Total engine fired

1-cylinder fired (floating liner)

Total engine / strip-down

Single components motored

Operating range of model

High

Low

Possible measuring resolution & reproducibility

Fast prediction

Agile transferability

Relative comparison

Physical evaluation

Requirements
02

MODELLING OF FRICTION RELATED COMPONENTS
IDENTIFICATION OF MAJOR FRICTION SOURCES

Chain drive & hydraulic components
- Guides and tensioner
- Oil & vacuum pump
- VANOS
- Chain

Cylinder head unit
- Camshaft bearings
- Valvetrain and VALVETRONIC
- High pressure pump

Crank train
- Piston – Liner system
- Conrod and crankshaft bearings
- Balancer shaft

Front end accessory drive
- Multiple v-belt
- Auxiliaries, e.g. alternator
CAPABILITIES IN GT
SOME EXAMPLES

Complex kinematics (var. valve lift) & independent definition of each friction contact

Surface properties

Inlet camshaft and VALVETRONIC of a 3-cylinder engine

Crank train of a 4-cylinder engine

Dynamic beam modelling and hydrodynamic bearing solution

Detailed piston and liner geometry
VALIDATION
- Friction torque deviation between measurement and simulation is shown (strip-down crankshaft).
- At high speeds >3500 RPM the model lacks in accuracy → more effort in calibration is necessary.
- Good correlation in usual speed ranges (<2500 RPM) of driving cycles → fuel consumption area of interest.
- Model calibration on temperature, oil flow and friction torque.
CRANKSHAFT
MODEL TRANSFERABILITY (CASE STUDY ON BEARING CLEARANCE)

- Investigation on transferability at changing boundary conditions (bearing clearance).
- Experiment on strip-down test rig and variation of clearance:
  - Minimum = 20 µm
  - Maximum = 60 µm
- GT setup:
  - Bearing mobility method
  - Crankshaft 3D beam dynamic
  - Tuning of oil temperature model
- Model shows good agreement of frictional losses with changing clearances.
Study shows the importance of proper geometry definition in the piston-liner system (convexity, ovality, distortion).

Unsteady peaks occur due to high contact pressure on partial areas at the skirt.

Current investigation on thermal FE skirt calculation and development of a work around by modifying skirt geometry. → also V2019 will include an elastic deformation model for the skirt to improve friction prediction.
Camshaft and Valvetrain Friction, exhaust side, 90°C

State of measurement: camshafts are driven by chain, valvetrain rocker arms are partly removed
→ dynamic chain movement might interfere result fidelity (4500/5000 RPM)

Percentage distribution of friction contacts is a current state estimation.
Gap due to:
- Missing simulation of chain friction
- Belt drive friction needs a bit more tuning
- Deviation in piston assembly
CONCLUSION AND FURTHER DEVELOPMENTS
Conclusion

- GT offers a variety of capabilities to model entire engine friction losses.
- Main models of friction related engine components are set up, validated and calibrated → but some effort is necessary for physical reasonable interpretation of simulation results!
- Good agreement on simulation and measurement data correlation.

Sophisticated fusion of subsystem models.

Further measurements for detailed subsystem friction analysis.

Optimizing studies on friction reduction.

Investigation on load and temperature and its impact on overall engine friction.

Slick workflow → model set up, parameter studies and post processing.
THANK YOU!