

FAST

PREDICTING MECHANICAL FRICTION EFFECTS ON ENGINE PERFORMANCE

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What is FAST ?

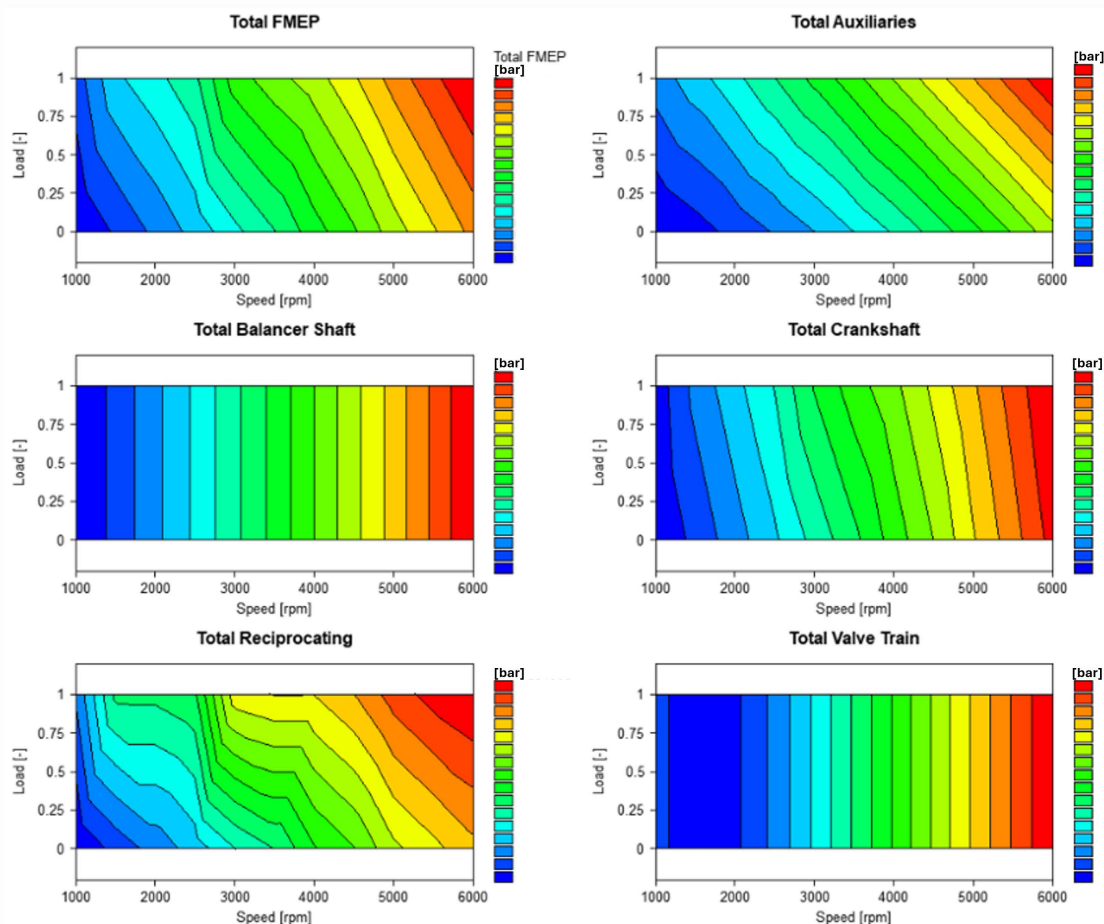


FAST is a predictive friction analysis tool for rapidly estimating mechanical friction in internal combustion engines. It provides fast, practical friction predictions from a limited set of input data, using empirical and semi-empirical calculations validated against motored teardown test data.

FAST helps engineers understand friction losses early in development without needing to build higher-fidelity models for every study. It can be used stand alone, where the solver reports a detailed breakdown of total engine friction, or coupled with WAVE to predict FMEP in engine performance simulations.

Key features

- Predicts Friction Mean Effective Pressure (FMEP) during engine development to meet required performance and fuel economy targets
- Accounts for major sources of loss in IC engines, including auxiliaries, windage and friction at lubricated contact points
- Provides a detailed breakdown of total engine friction using a limited set of input data
- Supports input generation for engine performance simulation models
- Enables comparison of alternative engine architectures at feasibility and concept stage
- Helps define friction targets during engine development
- Supports interpretation of motored friction teardown tests
- Enables evaluation of friction reduction measures and assessment of downsizing or rightsizing concepts
- Produces predicted friction maps that can be included in real-time engine plant models for vehicle system modelling and virtual calibration



When to use FAST

Use FAST to predict mechanical friction earlier, understand engine loss contributors faster and make better-informed decisions before committing to hardware or detailed CAE.

FAST gives engineers a rapid predictive view of friction behaviour, helping them focus development effort on the systems with the greatest impact as well as delivering accurate friction inputs to improve the quality of engine performance simulation.

Rapid FMEP prediction for complete engine friction assessment

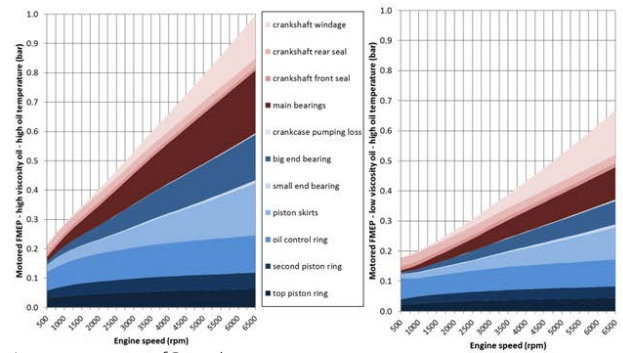
FAST provides a practical way to predict mechanical friction across the complete engine. It calculates Friction Mean Effective Pressure (FMEP), the theoretical mean effective pressure required to overcome engine friction, and reports the contribution of the key systems that make up total engine friction.

The tool is designed for use early in development, when only limited design information may be available, but engineers still need a reliable view of likely friction losses. FAST uses a mixture of empirical and semi-empirical formulae, with separate calculations for each engine subsystem, making it more predictive than simple correlation-based approaches while remaining much faster than detailed CAE.

What FAST predicts

FAST includes empirical models for the main contributors to engine friction, including:

- Piston rings and piston skirt
- Main bearings and big end bearings
- Valvetrain
- Timing drive
- Crankshaft seals
- Crankshaft windage
- Oil pump, water pump and other driven auxiliaries
- FEAD belt losses
- Crankcase pumping losses for applicable wet sump engines



Piston ring and skirt friction

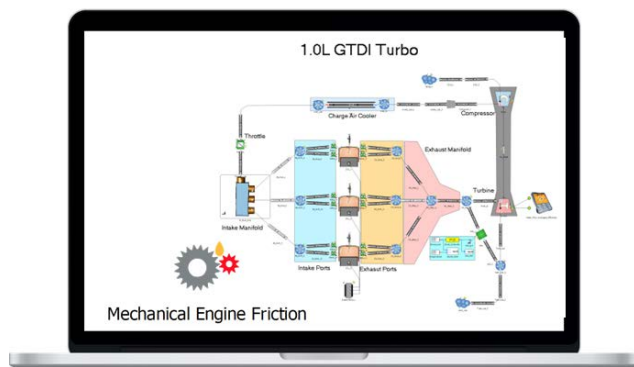
FAST calculates piston ring and skirt friction across the crank angle using the relationship between contact force, sliding speed and friction coefficient. For piston rings, the model accounts for ring tension and, under fired conditions, the effect of cylinder pressure on the top and second rings. For piston skirt friction, the model accounts for inertial effects under motored conditions and gas force effects under fired conditions. The friction coefficient is calculated from sliding speed, force and oil viscosity using a Stribeck-type relationship.

Valvetrain, timing drive and bearings

FAST uses semi-empirical formulae for valvetrain and timing drive friction. Valvetrain calculations reflect the valvetrain type, cam-follower contact type, camshaft arrangement and lash adjustment approach, while timing drive calculations account for drive type and layout. Bearing losses can be calculated using simplified equations, while more detailed bearing analysis can be introduced if required.

Seals, windage, pumps and FEAD

FAST accounts for friction and parasitic losses that are often missed by component-level analyses. These include crankshaft seal loss, crankshaft windage, oil pump and water pump drive power, unloaded alternator and Air-Conditioner (A/C) losses and FEAD belt friction, a more complete prediction of whole-engine mechanical friction.



Typical uses

FAST supports engineering tasks such as:

- Comparing alternative engine architectures at feasibility and concept stage
- Setting friction targets for new engine development
- Interpreting motored friction teardown test results
- Evaluating claims for friction reduction measures
- Understanding the friction impact of downsizing and rightsizing concepts
- Identifying the main contributors to friction in production engines

Predicting mechanical friction effects on engine performance

Mechanical friction changes with speed, load, temperature, oil viscosity, cylinder pressure and engine architecture, and those changes can have a significant effect on predicted fuel economy, performance and calibration decisions.

FAST brings predictive mechanical friction directly into the engine performance modelling workflow. It enables engineers to generate operating-condition-specific FMEP data quickly, either as a stand alone friction analysis or coupled with WAVE to support engine performance simulation. This allows friction effects to be represented earlier and more realistically, without requiring higher-fidelity component models for every study.

By providing rapid friction maps and subsystem-level friction behaviour, FAST helps performance teams move beyond broad assumptions or fixed friction factors. It supports better architecture comparisons, more representative virtual calibration and more confident assessment of how design choices influence overall engine efficiency.

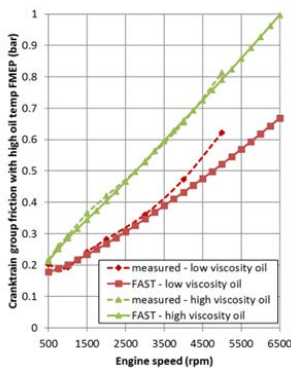


Image courtesy of Ricardo

Friction maps for simulation and calibration

FAST can generate predicted friction maps for use in engine and vehicle system modelling. These maps can be included in real-time engine plant models for vehicle system simulation and virtual calibration.

This makes FAST valuable where friction cannot simply be treated as a fixed value. Engine friction changes with speed, load, temperature, oil viscosity and operating condition, and those changes can have a significant impact on performance and fuel economy predictions.

Fired engine FMEP prediction

FMEP under fired conditions is often required as an input to engine performance simulation models. Under fired operation, cranktrain friction rises above motored friction because gas forces act on the piston rings, piston skirts, small end bearings, big end bearings and main bearings. FAST supports this type of prediction by using cylinder pressure data within the friction calculation.

Performance-led design decisions

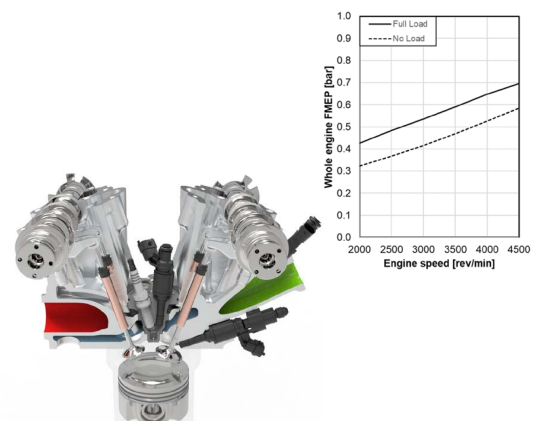
FAST enables engine performance development by helping teams assess how friction changes across operating conditions and design choices. It can be used to:

- Provide friction inputs for engine performance simulation models
- Compare engine architectures during feasibility and concept development
- Assess the friction impact of downsizing and rightsizing concepts
- Support target setting for performance and fuel economy
- Investigate the influence of oil viscosity on cranktrain friction
- Provide subsystem-level friction response across operating conditions

Hybrid engine performance

FAST is used in hybrid engine development, where the emphasis shifts from conventional downsizing towards rightsizing for higher brake thermal efficiency. In hybrid applications, friction prediction helps assess the impact of choices such as small bore / long stroke architecture, crank offset, rod length and bearing diameter. Long stroke designs can increase piston speed in the mid-stroke region, raising piston ring and piston skirt friction, while larger crank bearings can increase bearing friction.

FAST supports analysis of hybrid-specific configurations, including mild hybrid layouts with belt-driven electrical machines, plug-in hybrid concepts with no belt drives, engine friction under different temperature conditions, and hybrid control strategies under battery and engine operating conditions.



Ricardo Magma xEV engine © SAE 2022-01-0422