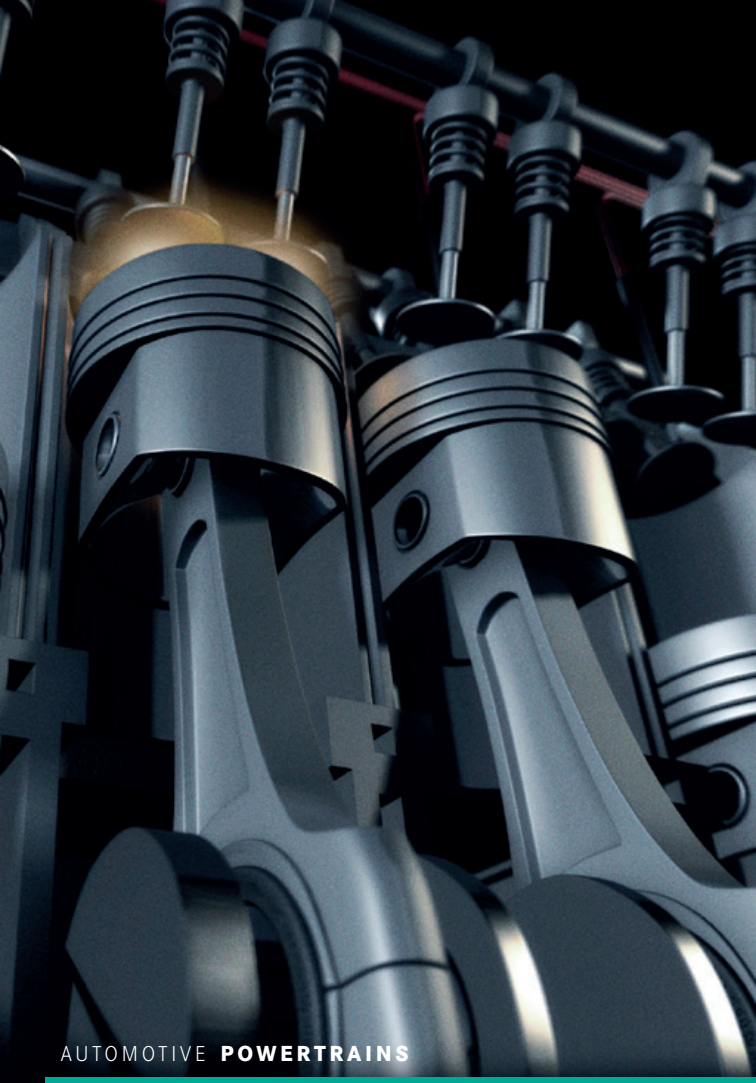


AUTOMOTIVE **POWERTRAINS**

THE FKFS **USERCYLINDER**

Combustion chamber models for GT-POWER

RESEARCH IN MOTION.

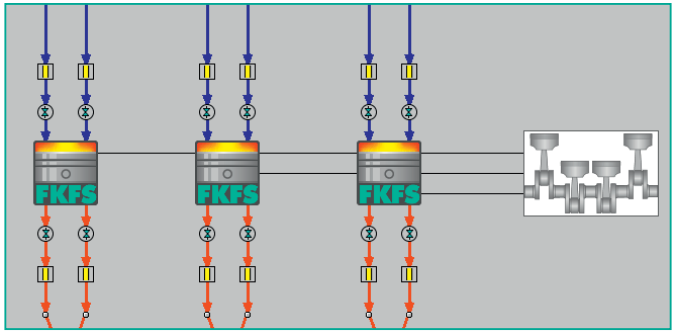
FKFS

THE FKFS **USERCYLINDER**

FKFS UserCylinder plug-in enhances the predictability of the engine combustion

EFFECTIVE COMBUSTION CHAMBER SIMULATION WITH FKFS USERCYLINDER

The UserCylinder is a plug-in for GT-Power and replaces the usual cylinder object there. During a GT-Power simulation, all the high-pressure parts of the cycle in the cylinder (compression stroke and power stroke) will, from then on, be calculated using FKFS in-house code. Within an overall engine model, this enables more detailed and faster predictions about the processes in the combustion chamber. Important result parameters for the cylinder are, for example, combustion profile, fuel consumption, cylinder pressure profile, emissions as well as knocking and cycle to cycle fluctuations.



FKFS UserCylinder replaces the GT-POWER standard cylinder

APPLICATION AREAS OF FKFS USERCYLINDER

The application of UserCylinder is useful in different phases of engine development.

During the concept phase:

- For comparing different turbocharging concepts with regard to fuel consumption and transient behavior.
- For optimizing the compression ratio in the conflict between partial load and full load consumption (knocking).
- For the variation of valve control times or valve lift profiles, by correctly illustrating the effects on combustion.

In the functional development, application and test phases of control units:

- For estimating limits of running smoothness or knock limits.
- For optimizing transient operating states on the gasoline or diesel engine.
- By having the option of testing control unit functions on a virtual engine.

THE FKFS **USERCYLINDER**

FKFS UserCylinder is ideally suitable for transient simulations such as real-life driving including acceleration and breaking exercises

Precise in predicting the capacity of an acceleration

In research projects and for teaching, UserCylinder enables the construction of virtual test vehicles, which react qualitatively and quantitatively to changes in the boundary conditions in a sensible way.

This can be used to gain greater understanding of the processes in the combustion chamber, and the overall interrelationships in the engine. This applies particularly when investigating the effects on combustion and emissions generation when the boundary conditions in the combustion chamber are changed.

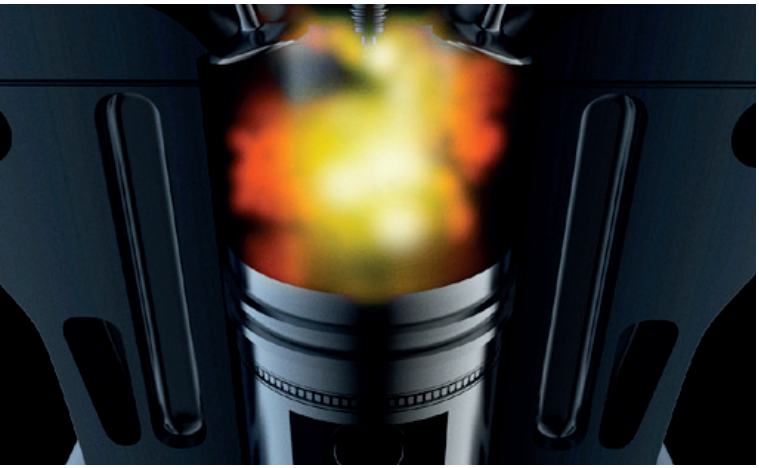
UserCylinder uses the GT interface for entering data, which means even veteran users of GT-Power will quickly feel at home. The cylinder simulation results – extended by the results from the FKFS sub-model – are available in GT-Post. The interface is available in English and German, as is the operating manual, which describes (more than 250 pages) the background to the calculation models included.

To represent the processes in the combustion chamber during the high-pressure cycle as realistically as possible, UserCylinder has different models for calorics, wall heat, injection, combustion and emissions. As these submodels are phenomenological, once they have been calibrated to the relevant engine, any operating state can be simulated, even when no measurement data is available. Despite this prediction capability, the calculation times are extremely short, thanks to excellent optimization of the program coding. There is often no perceptible loss in computing speed compared with a simulation using Vibe (Wiebe) combustion models.

HISTORY

For more than 15 years calculation of in-cylinder processes, phenomenological combustion modelling and 1D flow simulation are cornerstones in the field of automotive powertrains at the FKFS. The development of the UserCylinder started in 2003. It is sold on a bigger scale since 2008. Customers are OEMs, suppliers and simulation service providers within the German-speaking area but also in other European countries and the United States and Japan.

THE FKFS **USERCYLINDER**



SIMULATION OF GASOLINE ENGINES

Phenomenological burn rate model

» Air entrainment with hemispherical flame propagation, in the calculation of which the laminar flame speed and the specific turbulence in the combustion chamber decrease.

» Can be used for both liquid and gaseous fuels.

» Combination of turbulence and burn rate model permits precise representation of the burn rate, depending on the state of the cylinder charge at „intake-closes“.

Quasi-dimensional charge motion and turbulence model

» The stationary tumble figures from the intake ports are used to calculate the tumble generated during the intake (described as Taylor-Green vortex).

» Incorporation of the turbulence generated directly at the valve seat.

» In the combustion chamber, the turbulence is balanced based on production and dissipation terms.

FKFS knock model

» Takes into account the influence of turbulence on the temperature in the uncombusted end gas.

» Sub-model for hotspots on the wall.

» Internal ignition point control permits robust and very rapid adjustment of the 50 % burn point for optimum efficiency at each operating point, taking into account the knocking tendencies of the engine being investigated.

» For transient calculations, the ignition point controller can illustrate the effect of a real antiknock controller (springs back for knocking combustion cycles).

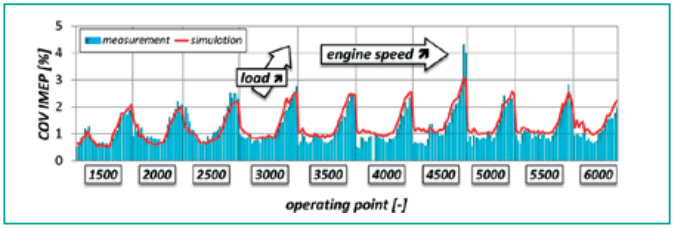
Cycle-to-cycle variation model

» Variation of ignition period and flame propagation in the burn rate model.

» Burn rate model reacts appropriately to the general boundary conditions of the operating point being investigated.

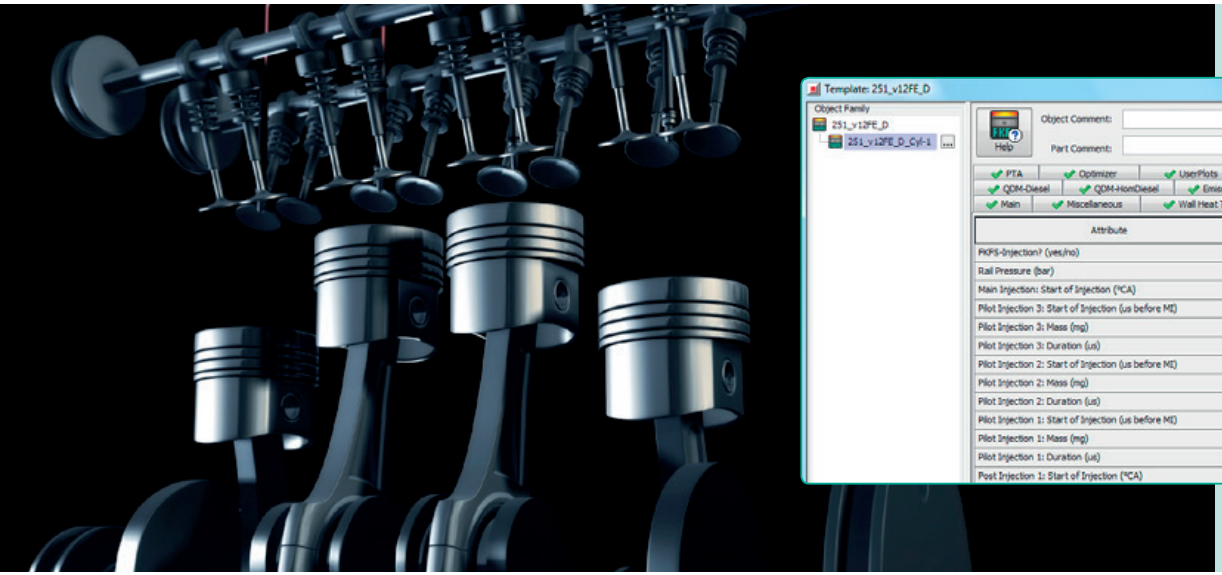
» Evaluation of the effects on integral operating parameters (IMEP, ISFC, pmax, ...). In this way, it is possible to predict fuel consumption while taking cycle-to-cycle fluctuation into account.

» Differences in the results between the results of the average combustion cycle and the average of all combustion cycle variations are represented and can be used as a signal for a throttle controller



FKFS UserCylinder allows a fast and accurate prediction of cyclic variations

THE FKFS **USERCYLINDER**



Individual parameterization of UserCylinder models

SIMULATION OF DIESEL ENGINES

FKFS-Injector

- Enables simple modeling of an additional injection profile as an input parameter for combustion rate and emissions models.
- Parameterization of the start of injection and, optionally, injection quantity or injection period.
- Direct incorporation of injection characteristics from the ECU data is often possible.

Phenomenological burn rate model

- Specification of the injection rate with any number of pre- and post-injections, optionally via GT Injector or FKFS Injector.
- Ignition delay calculation via a coupled Arrhenius and Magnussen approach.
- This is divided into premixed and diffusion components, corresponding to the injection profile and the ignition timing.
- Takes into account the local mixing state for premixed combustion.
- Representation of the mixing of fuel and air during diffusion combustion, via a disk insert with superimposed Lambda distribution.

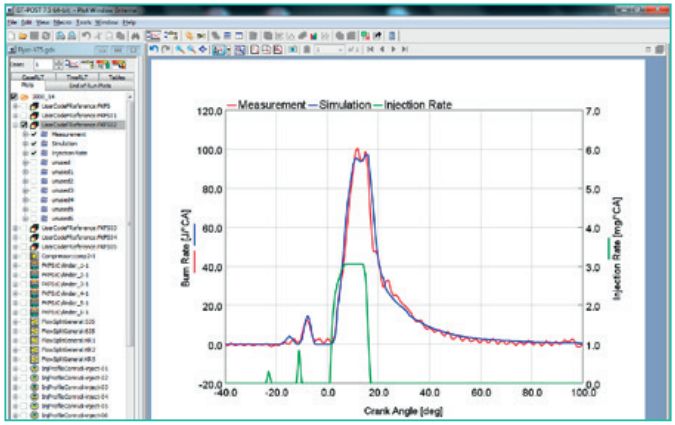
Phenomenological nitrogen oxide and soot particle model

- Physically correct responses to changes in boundary conditions/operating states, for example gas temperature, pressure, injection strategy, EGR, charge motion (swirl).
- Division of the burnt zones into several sub zones, to take into account the influence of wall temperature, as well as reduced NO formation where there is a local lack of air, during transient processes

THE FKFS **USERCYLINDER**

YOUR ADVANTAGES AT A GLANCE

- The UserCylinder provides predictive combustion chamber models for gasoline and diesel engines, which are at the most sophisticated level available in this class of models.
- The models were developed using a great many engines of all different types and are continuously validated: From motorbikes and passenger vehicles right through to commercial vehicles and large engines.
- Simple operation, thanks to full integration in the graphic interface of GT-Suite, including GT-Post.
- Option for automated model adaptation to measured cylinder pressure profiles.
- The software and operating manual are available in English and German.
- FKFS offers rapid and expert support on all aspects of combustion chamber simulation (support@fkfscylinder.de).



Clear overview and access to FKFS UserCylinder results via GT-POST

ADDITIONAL SERVICES

We can answer almost all questions regarding 0D/1D simulation fast, reliable and qualified due to our longtime experience. We realize concept studies for customers or undertake tasks from their day-to-day business. By using the FKFS UserCylinder we often achieve a better understanding of the background which also enables us to illustrate them. The FKFS provides the following services around GT-Suite and the UserCylinder:

- Building GT models by using CAD data or measuring the component parts.
- Creation of fast running GT models (FRM)
- Adjusting of GT-Power models with or without FKFS UserCylinder
- Combustion system development & analysis including emission forecasts
- Gas exchange analysis & development
- Comparison of different charging concepts
- Total vehicle & longitudinal dynamics simulation
- Thermomanagement & Cooling circuit simulation, waste heat recovery
- Building and simulating oil and fuel circuits
- Development of hybrid operating strategies

We will be glad to advise you regarding our simulation services.

RESEARCH IN MOTION.

FKFS THE COMPANY

The Research Institute for Automotive Engineering and Vehicle Engines Stuttgart (FKFS) was founded in 1930.

Its highly qualified staff conducts research and development projects in the fields of powertrains, vehicles and automotive mechatronics. Highly specialized test benches as well as measurement, testing and simulation procedures developed internally at FKFS provide engineers with the means to solve complex and demanding problems.

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