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MOTOR AND VEHICLE OPTIMIZATION PROCESS MODELING BY USING THE AVL CRUISE IN STANDARD APPLICATIONS

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ABSTRACT: AVL CRUISE is used to perform simulation and analysis of the vehicle propulsion system. It is designed to develop and optimize low-emission engines, power trains and sophisticated engine control systems, cooling systems and transmissions. CRUISE allows modeling the entire optimization process for motor and vehicle in standard applications, such as fuel consumption reduction, acceleration tests, full load tests, traction diagrams and calculation of thermal, mechanical, electrical and control system parameters. In the paper are presented results obtained for a regular simulation of road vehicle behaviour in working conditions.
KEYWORDS: Simulations, vehicle propulsion system

❖ INTRODUCTION

CRUISE allows the simulation of vehicle driving performance, fuel consumption and emissions. This concept can be used for modeling all vehicle configurations with scalable fidelity. This approach allows the reuse of models or sub-systems in different optimization phases of a process in order to improve vehicle performances.

The engine operation optimization is done by calculating and optimizing fuel consumption and emissions, road performances (acceleration and deceleration), transmission ratios, braking performances, in order to determine the load for resistance and vibration calculation.

CRUISE allows modeling existing vehicles and new vehicle concepts with single or double traction (cars, trucks, motorcycles, etc) (Fig. 1).

Fig. 1. Vehicle types that can be modeled with AVL CRUISE

AVL CRUISE simulation platform vehicle emphasizes:

- ❖ Optimization of vehicle and vehicle components (fuel economy, vehicle performance);
- ❖ Extensive range of vehicles and possible propulsion configurations;
- ❖ Assessment of new vehicle concepts (i.e., hybrid, electric vehicles, fuel cells);
- ❖ Transitory propulsion effects analysis;
- ❖ Design of vehicle thermal management systems;
- ❖ Smart driving module to reproduce the real vehicle behavior.

❖ CALCULATION POSSIBILITIES

The software enables simple or mixed kinematic calculation (dynamic modeling) to study low frequencies, vibrations occurred during vehicle running, the axis torque (power shaft or rear and front axles).

Calculations can be made in quasi-stationary regime or allow the engine real cycle simulation, where the throttle shutter position can be controlled. The calculation allows the following:

- Fuel consumption and emissions determination under the next driving conditions:
  - *Running cycle* – for driving, a simulated speed profile is imposed to the vehicle. Driving conditions are specified: runway slope, wind speed, the rolling friction coefficient, etc. Speed profile data can be entered as time and distance dependent values.
  - *Cruise* - running on a real route can be simulated. Speed profile based on distance is defined as the maximum speed that cannot be overtaken. Additional maximum values for acceleration and deceleration can be defined. These values can be used by the driver, but does not interact with the maximum load when the speed profile is suddenly changed.
  - *Constant speed* - involves running in all gears.
- Driving performances determination consists of acceleration behavior calculation which indicates the increase of performances and traction force, by following (Fig.2):
  - Running at constant speed;
  - Performances increase;
  - Acceleration at full load;
  - Maximum traction force;
  - Vehicle handling.

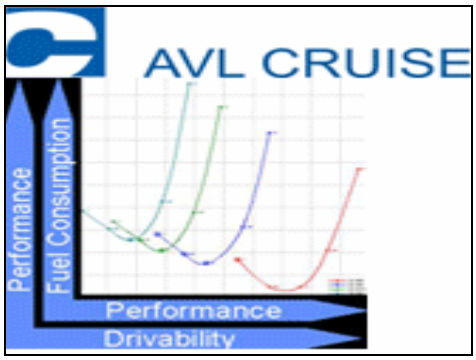

Fig. 2 Fuel consumption, performances and vehicle handling efficiency

CRUISE provides interfaces with MATLAB and Simulink through a DLL created by Real-Time Workshop or through a MATLAB API. The MATLAB API interface enables the user to run Simulink in the background and use scopes as well as variable time step integration methods.

Simulink is an environment for multidomain simulation and Model-Based Design for dynamic and embedded systems.

❖ SYSTEM AND SUB-SYSTEM STRUCTURE

Components and their connections can be grouped into sub-systems and can be activated or deactivated so that side-bar configurations of active sub-system can be defined.

All systems contain the same systems; they differ only by their activation status. The structure of the systems/sub-systems and their activation status is shown in the navigation tree and also in the side-bar systems section of the vehicle modeler (Fig. 3, Fig.4). Correlations between AVL Cruise interface and other programs are very easy and allow too modify and interact all the time in the modellation process. A lot of paremeters can be easly monitorized through the interfaces, either AVL Cruise or the other program that waork together with (Fig.5).

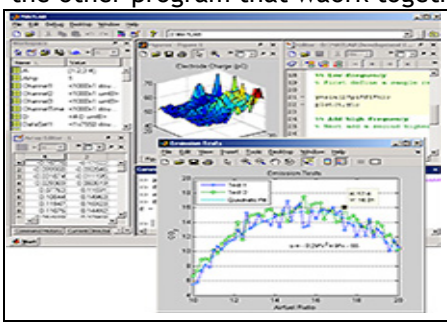
Fig. 3. MATLAB Interface

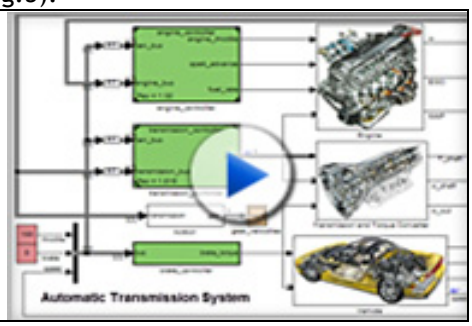

Fig. 4. Simulink simulation environment

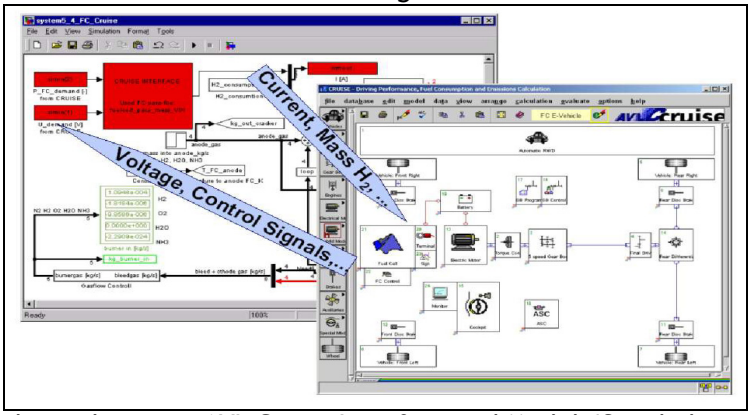

Fig.5. Direct correlation between AVL Cruise Interface and Matlab/Simulink environment

❖ ANALYSIS AND SIMULATION RESULTS

The technical data of a BMW 535i E28 vehicle having above 200000 km run and 11 PTI were used for simulation.

After selecting Vehicle in the Main Window, it can be chosen between the following power train configurations: general, manual standard or automatic standard.

For Vehicle Modeling the components are organized into component groups and they can simply be dragged and dropped onto the working area, where they can be linked together to represent the desired power train configuration (Fig.6).

Each component contains the Properties option as is shown in Fig. 7. The calculation can be influenced in the Properties window. With these settings it is also possible to run a calculation with minimal input data (i.e., in prototype phase), as the input fields of the unavailable data can be switched off.

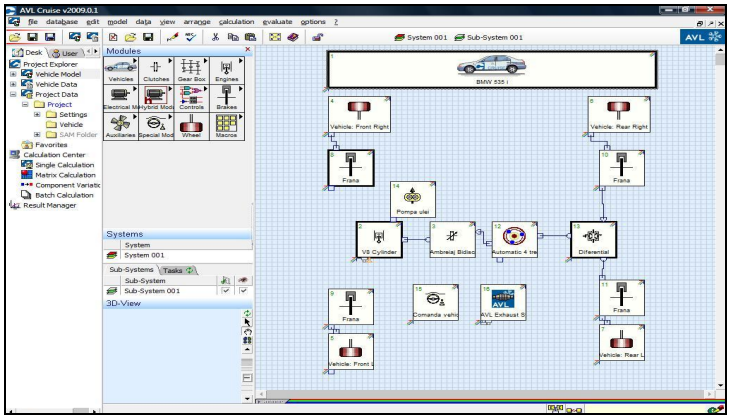

Fig. 6. Vehicle Modeler View

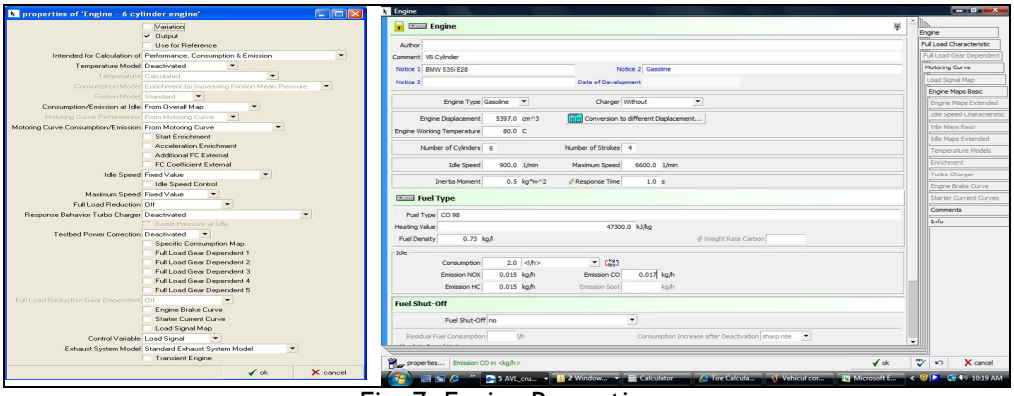

Fig. 7. Engine Properties

After simulation there were obtained: load characteristic (Fig. 8), torque characteristic (Fig. 9) and their dependence in 3D representation (Fig. 10), and also the fuel consumption variation (Fig.11).

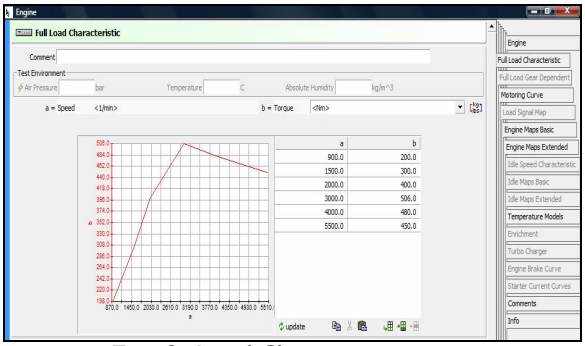

Fig. 8. Load Characteristic

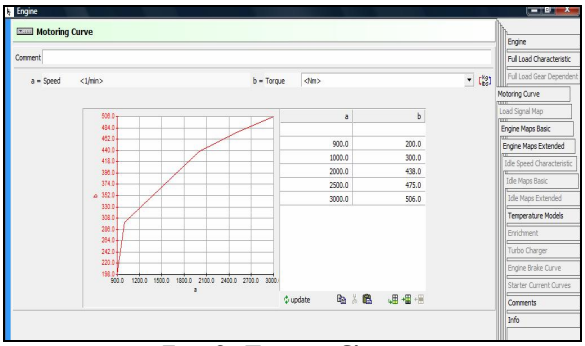

Fig. 9. Torque Characteristic

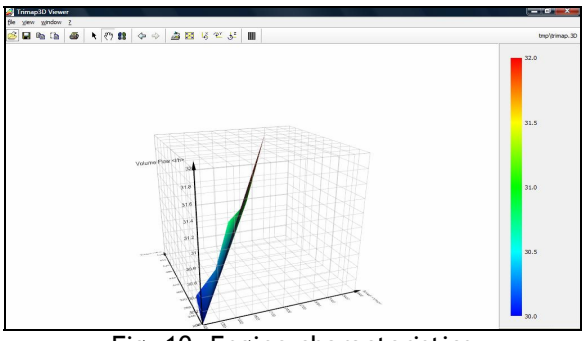

Fig. 10. Engine characteristics in 3D Representation

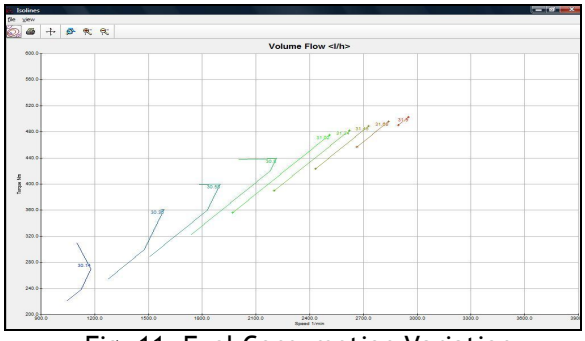

Fig. 11. Fuel Consumption Variation versus Engine Torque and Speed

❖ CONCLUSION

CRUISE allows the calculation of driving performance, fuel consumption and emissions, the various driving cycle evaluation (i.e., FTP72, ECE-R15, HDC), traction curves, acceleration, maximum speed, hill climbing ability, etc.

The characteristics include the modular concept, the implementation of vehicle simulation, elastic shafts torsion and engine cold start.

Its modularity enables modeling of vehicles running on the basis of the available modules (engine, gearbox, clutch, etc.) as well as novel concepts achievement such as hybrid cars or cars with several engines.

CRUISE enables the characteristic curves and maps interactive modification. The data is represented in a graph and table form at the same time. Modifications are possible in either of these representations. Data map can be directly introduced or can be read from ASCII files. The application of arithmetic functions on certain single points or the entire curve is possible.

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