Implementing AVL Cruise in the DAF Trucks development chain

Authors: M.J.A. Taken, B.A.M. Lipsch, H.J.M. Voets

Company: DAF Trucks NV, Technical Analysis

Keywords: Trucks, fuel economy, CO2, drivability, durability, simulation, database

Abstract:

The role of fuel economy and CO_2 emissions sets ever more severe requirements to trucks. The measures for reducing CO_2 emission and fuel consumption increase significantly and become more complex e.g. due to complex controls. Furthermore trucks are available in a large variety of configurations and are used for very different missions. These missions can vary from long haul to municipal utility with a large range of load conditions. For these reasons simulations are vital in developing new design concepts, optimizing design parameters, validating design and vehicle configurations, support customers in their truck choice and for legal CO_2 declarations in the near future.

DAF Trucks uses 4 dedicated route simulation tools to provide each territory with their own level of detail, automation and calculating speed. AVL Cruise is used for integral vehicle and system validation and verification during the engineering phase of product development

This presentation briefly describes the way DAF implements AVL Cruise into their development process. Specific attention is given to the way DAF uses AVL Cruise to manage model and component properties in a tool-transcending central database.

As the first European truck manufacturer that uses AVL Cruise throughout product development, the presentation will give an insight in some of the specific functionalities that were developed by AVL in cooperation with DAF. Also a view into the future will be given from a DAF point of view on the envisaged functionalities of AVL Cruise for the near future.

Use of CRUISE simulation tool as virtual test bed for deriving Energy Consumption function for different LCV vehicle type (diesel, EV, PHEV)"

Authors (please underline main author): Giorgio Magra, Eugenio Morello

Company/ University, Department: CNH; IVECO

Keywords: simulation, Energy consumption, EV, PHEV

Abstract:

(please use Times New Roman, 12 pt., max. 400 words)

Paper will address the following topics:

- Collections of speed profile typical of driver behavior (from literature and from traffic micro simulation).
- Configuration of Diesel, EV and PHV vehicles within CRUISE simulation Model.
- Enhancement of the CRUISE PHEV model with integration (as DLL) of an external hybrid strategy based on energy optimization.
- The virtual test bed: Simulation with CRUISE of a suitable set of speed profiles for different type of Vehicle (D,EV,PHEV).
- Using best fit techniques, definition of mathematical law of Energy consumption as function of vehicle speed, payload and slope, considering different "aggregation strategy": full trips, trips split in fixed length parts, short trips).
- Comparison and discussion of function related to the different type of LCV vehicles (diesel , EV, PHEV).
- Some conclusions.

Predicting İstanbul Metrobus Line Fuel Consumption By Using AVL Cruise & Ipg Truck Maker Co Simulation

Assoc.Prof.Dr.Muammer ÖZKAN, Ass.Prof.Dr.Orkun ÖZENER, Rsc.Ass.Emre ORAK
Yildiz Technical University– Mechanical Engineering Department, İstanbul
Emre KURAL, Laurent ALLOUCHERY
AVL- System Design Transmission and Hybrid Engineering and Technology Powertrain Systems, Graz
Güneş ACARBULUT
İETT, İstanbul Public Transportation Company

Keywords:

On Road Vehicle Simulation, Fuel Economy, On Board Measurement, Avl Cruise, Ipg Carmaker

Abstract:

Metrobus Line is a strategic dedicated transit bus line planned by Istanbul Metropolitan Municipality which crosses the İstanbul city from Asian to European. Its length is about 52 kilometers and there is more than 500 busses in 24h service which enables mass transit transport (~800.000 passenger daily) between two continents. In public transportation the fuel cost is the most important part of the operating cost which is 125 Million Euro for İstanbul Municipality. On the other hand the amount of greenhouse gas "CO_2" which is emitted to atmosphere from the public transportation is directly related with the amount of fuel consumed during the operation which should be lessened for greener environment. Therefore predicting and optimizing the effects of different bus cruises on fuel consumption over this route is important for establishing more economic and cleaner public transportation.

In this context there are some methods that can be used for calculating the fuel consumption during a specified driving cycle. Among these methods dynamic programming tools can be seen advantageous with their easy and flexible application and relative high accuracy. In order to construct a simulation model that will be representative for real world fuel consumption of metrobus line, AVL Cruise + IPG Truck Maker program co-simulation was realized. A detailed drive train model of Mercedes Capacity articulated bus was created by using AVL Cruise via using the engine dynamometer data. Vehicle model of the bus and the 3D road model of İstanbul Metrobus Avcilar-Zincirlikuyu route which consists 26 stations on it was created by using IPG Truck maker. The co-simulation model was validated with the experimental data collected on the real route with AVL KMA Mobile. Simulation and experiment results were post processed by using MATLAB. The model results showed good accuracy at the specified route compared with the real test data which means that the model can be used for further optimization works.

Complete Vehicle Modeling and Simulation of a Long Haul Truck with Electrified Auxiliaries in the CONVENIENT Project

Authors: Erik Jonsson Holm (Volvo), Olof Lindgärde (Volvo), Herwig Ofner (AVL), Lei Feng (KTH)

Company/ University, Department: Volvo GTT

Keywords: Complete vehicle model, Long haul truck, CRUISE, BOOST RT, Simulink, Fuel consumption simulation, Vehicle energy management, Optimal predictive control, Electrified auxiliaries

Abstract:

This document reports the work within the CONVENIENT project related to the modeling and simulation of the complete vehicle model of the Volvo CONVENIENT truck. CONVENIENT is an EU project with the objective to achieve complete vehicle energy management. The objective with the vehicle model developed in this project is to perform fuel consumption simulations and enable early development of the complete vehicle energy management controller. The Volvo CONVENIENT truck is a modified Volvo FH 13 L with controllable electrified actuators such as electrical cooling fans, radiator shutter, electrical water pump, one additional alternator and electrohydraulic power steering servo. The truck is also equipped with an e-Horizon system and controllable aerodynamic wind deflectors.

The vehicle model includes the cooling system, the electrical system, the chassis and the powertrain. The model was built using the tools AVL CRUISE, AVL BOOST RT and Simulink. In CRUISE, the chassis, powertrain and the engine heat generation are modeled. In BOOST RT, the cooling system, including the oil circuit is modeled. In Simulink, compiled S-functions of the CRUISE and Boost models together with a model of the electrical system are used to simulate the complete vehicle. To build the model, Volvo provided the project partner AVL with component data for modeling and measurement data for model validation. Volvo also made smaller adjustments to the model. Moreover, in order to be able to make comparisons, a reference model of the Volvo FH 13 L truck currently in production was also built.

A simulation study in this paper compares the fuel consumption of the CONVENIENT truck against the reference vehicle. Two comparisons were performed. The first assesses the fuel savings that are due to the hardware changes of the Volvo CONVENIENT truck. Conventional, non-optimal, control was used. The second assesses the fuel savings that are due to optimal predictive control. This analysis used dynamic programming and was based on a vehicle model of reduced complexity. This model was developed and validated based on the complete vehicle model described above.

CONVENIENT is supported by the European Commission within the FP7 research program.

Development of simulation models with modern electrical systems

Authors (please underline main author): G. Triantafyllopoulos, A. Kontses, A. Dimaratos, D. Tsokolis, Z. Toumasatos, N. Pastramas, L. Ntziachristos Z. Samaras

Company/ University, Department: Aristotle University of Thessaloniki, Department of Mechanical Engineering, Laboratory of Applied Thermodynamics

Keywords:

AVL Cruise, electrical system, electrical controller, mild-hybrid, brake energy recuperation system (BERS)

Abstract:

This study presents the development of vehicle simulation models, focusing on the electrical system. Modern vehicles are equipped with advanced electrical components and controllers with different strategies, which strongly affect fuel consumption and CO_2 emissions. Therefore, the correct simulation of the electrical system is important for the overall accuracy of the model.

The current vehicle fleet can be divided in two categories; mild-hybrid and conventional vehicles. The majority of the modern low CO_2 emitting vehicles are considered to be mild-hybrid. These are equipped with technologies such as Start-Stop and/or Brake Energy Recuperation System (BERS) that require special components (battery, generator/starter) and advanced controllers. Other modern electrical systems are much simpler and use conventional components and controllers.

In order to study the influence of the electrical system on CO_2 emissions, full vehicle simulations were conducted using AVL Cruise platform. The models were developed with built-in mechanical and electrical components of Cruise as well as customized controllers. The majority of the necessary input data were provided by the respective OEMs and the rest were derived either from the literature or from measurement data.

Measurement data were also mandatory in order to analyze and develop the controller strategy of each vehicle examined. For this reason, and also for validation purposes, chassis dyno measurements were conducted. During these measurements, the vehicles run a variety of driving cycles, including NEDC and WLTP. Fuel consumption, engine speed, battery current and other useful parameters were recorded. All these data were later used to assess the model accuracy.

In order to evaluate the mild-hybrid technology impact in terms of CO_2 and fuel consumption, for future analyses, two generic electrical submodules were developed; a conventional one and another that incorporated the BERS technology. Each submodule is defined by averaging the electrical component specifications of several conventional and several mild-hybrid vehicles. Also each controller was developed considering an intermediate and simple strategy.

The final results of the simulations indicate that the models can reproduce with satisfactory accuracy the measured data. Therefore, the validated models can be used for further analyses of a vehicle's electrical system or for studying other technologies/strategies and their fuel consumption and CO_2 emission impact.

Balancing CO_2 and driving pleasure in the concept phase

Authors (please underline main author): Mario Oswald, Stefan Kellner

Company/ University, Department: AVL, Driveability & Simulation Department

Keywords:

CO_2, fuel efficiency, driving pleasure, driveability, Model.Connect, VSM, Cruise, Maneuver designer

Abstract:

The speech describes AVL tools and methods for balancing CO_2 and driving pleasure in early development phase – in particular the combined simulation and optimization of fuel efficiency, driveability, handling, performance and ride comfort. CO_2 and fuel efficiency optimization of powertrain and vehicle systems have strong interrelations to the vehicle driving characteristic. Therefore these vehicle attributes have to be balanced in early phases to fulfill worldwide stringent legislations as well as the customer expectations of driving pleasure.

The new AVL co-simulation environment Model.Connect enables the user to (re-) use VSM and Cruise models for a combination of complex vehicle and powertrain simulation. Together with AVL's objective driveability assessment tool AVL-DRIVE, this approach allows the estimation of the vehicle behavior even in the concept phase where no detailed information about the new vehicle is available.

The maneuver and driving cycle definition is done by the VSM Maneuver Designer. This VSM tool extension is fully available in AVL Model.Connect and provides the user an easy and convenient way of maneuver definition and execution through several development steps.

Powertrain Connectivity for Energy Efficient Driving

Authors (please underline main author): Daniel Hübleitner

Company/ University, Department: AVL List GmbH

Keywords:

Abstract:

The AVL software package "upgrade-E" enables the predictive calculation of the expected speed, elevation and tractive power requirements of an unknown driving route. The development platform mainly accesses freely available data formats such as Open Street Map (OSM) and SRTM altitude profiles. The predicted driving route provides a plethora of optimization possibilities for classical vehicle and powertrain functions. The prototype version of the software is implemented in AVL's electric vehicle Coup-e 800 and runs on a conventional 7-inch tablet PC with appropriate data gateways to the vehicle's CAN bus.

Creation of VTMS model of a passenger vehicle and Its Application

Cai Zhiqiang [1)] Zhang Gonghui [1)] Liu Yuebing [1)] Yan Dong [1)] Ye Yisu [1)] Wang Xiaobi [1)] Wang Weimin [1)]

1) Dongfeng Motor Corporation Technical Center

Abstract: In order to discuss the influence of different technology measures to the vehicle fuel consumption, and to define the route of fuel saving, it is necessary to simulate the process of engine warm-up and energy exchange & distribution in the NEDC. The establishment of simulation platform of vehicle thermal management system (VTMS) and its application were introduced in this paper. Engine transient thermodynamic model, engine thermal network model, cooling system model, lubrication system model, vehicle model, engine compartment model and control system model are integrated in the platform and have been validated by experiment results. Some fuel consumption measures were proposed and real effect has been got based on this platform.

Key words: Fuel Consumption, VTMS, transient thermodynamics, BOOST, CRUISE

Friction Clutch Thermal and Performance Analysis on 1D Vehicle Simulation Platform

Authors:

Stefano Carletta [(*)], Eugenio Penazzi [(**)], Daniele Di Rocco [(***)], Emiliano Vitaliani [(***)]

Company/ University, Department:

FCA Methodologies & Harmonization Coordinator [(*)], FCA SDE – Dual Mass Flywheel & Clutch System [(**)], AVL – AST Graz [(***)]

Keywords:

Clutch, Friction Coefficient, Thermal Analysis, Component Extension, Vehicle System, Cosimulation, AVL CRUISE.

Abstract:

Clutch component is of fundamental importance on torque transmission along vehicle driveline layouts. Analysis of its behaviour must be carried out, in order to assess overall vehicle performance and driver feelings.

Two topics, linked to each other, have been analysed in this paper: on one side the energy content, which provides the estimation of the amount of energy wasted during vehicle's manoeuvres and the related raise in temperature; and on the other side the torque transmissibility due to temperature changes affecting the clutch friction coefficient.

On this base, the authors propose a more advanced 1D modelling approach of clutch devices. A model develops the mechanical phenomena, allowing the interaction with the driver pedal, the axial pressure plate movement and the torque transmission to the driveline. An additional model considers the clutch layout on board of vehicle and the thermal transient caused by the heat flow balance. They co-simulate with the main platform AVL CRUISE, which contains the whole vehicle configuration, road definition and driver model.

Furthermore, the developed clutch model is going to be calibrated and validated by means of experimental activities over customised drive cycles.

The aforementioned modelling approach highlights not only a higher quality level on system simulation but also advantages to carmaker companies where developed models – often varying among departments – may be combined together in order to achieve a structured and consistent development process.

A computationally efficient hybrid 3D analytic-numerical approach for system level modelling of PEM fuel cells

Gregor Tavčar, Tomaž Katrašnik

University of Ljubljana, Faculty of Mechanical Engineering

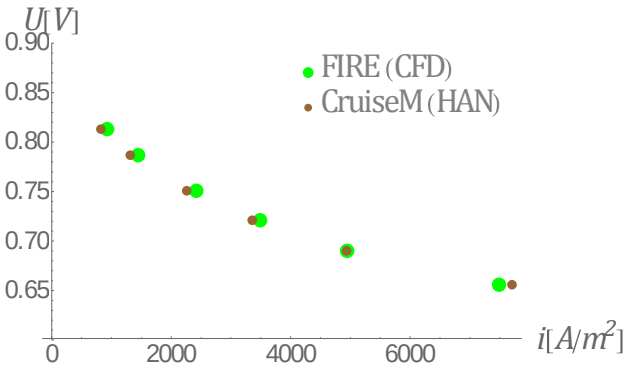
Keywords: Fuel cell, Analytic numerical modelling, System level simulations

Abstract:

System level simulations, which are gaining on importance in the product design process, require models that feature high level of accuracy, high level of predictability and short computational times. While such system level models of e.g. internal combustion engines are commonplace, system level models of fuel cells are only starting to emerge.

The system level fuel cell model implemented in AVL CruiseM is based on an innovative modeling approach. The core principle of this innovative fuel cell modeling approach is taking a 1D numerical model for pipe gas-flow and superimposing onto it a 2D analytic solution for species distribution in the plane perpendicular to the direction of gas-flow together giving a 3D information on species concentration in the fuel cell. The 2D solution is devised on a jigsaw puzzle of multiple coupled domains enabling the modeling of parallel straight channel fuel cells. Electrochemical and other nonlinear phenomena are coupled to the species transport by a routine of Newton-Raphson style. This 1D+2D approach gives the model its name: hybrid 3D analytic-numerical (HAN).

Results of HAN simulations have been comparatively evaluated against AVL FIRE CFD results displaying a very high level of agreement. Furthermore, HAN achieves high accuracy results at very short computational times (as reported in Figure 1). This computational efficiency is owed to the semi-analytic nature of HAN's species transport modeling and to the efficient computational coupling of electrochemical kinetics to this transport.



Model	*No. of iterations per time step*	*CPU time per time step [s]*
CFD	5000	2400
HAN	5	0.03

Figure 1. Left: Polarization plot, brow represents HAN simulation results and green CFD simulation results. Right: Table with computational times on a desktop computer.