

A New Chassis Dynamometer Laboratory for Vehicle Research

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ABSTRACT

In recent years the need for testing, calibration and certification of automotive components and powertrains have increased, partly due to the development of new hybrid concepts. At the same time, the development within electrical drives enables more versatile chassis dynamometer setups with better accuracy at a reduced cost.

We are developing a new chassis dynamometer laboratory for vehicle research, aiming at extending a recently commercially available dynamometer, building a new laboratory around it, and applying the resulting facility to some new challenging vehicle research problems. The projects are enabled on one hand by collaboration with the dynamometer manufacturer, and on the other hand on collaboration with automotive industry allowing access to relevant internal information and equipment.

The test modes of the chassis dynamometer are under development in a joint collaboration with the manufacturer. The laboratory has been operational since September 2011 and has already been used for NVH-analysis for a tire pressure indication application, chassis dynamometer road force co-simulation with a moving base simulator, co-surge modeling and control for a 6-cylinder bi-turbo engine, and traditional engine mapping. We are also looking at projects with focus on look-ahead control, as well as clutch and transmission modeling and control, and driving cycle related research.

CITATION: Öberg, P., Nyberg, P. and Nielsen, L., "A New Chassis Dynamometer Laboratory for Vehicle Research," *SAE Int. J. Passeng. Cars – Electron. Electr. Syst.* 6(1):2013, doi:10.4271/2013-01-0402.

INTRODUCTION

Testing, calibration and certification are vital parts for the development of new automotive technologies. With the development of new hybrid concepts the need for it have also increased. To be able to perform large scale vehicle experiments a chassis dynamometer is an option to use.

This paper presents our new chassis dynamometer laboratory, the design choices that are made and the unique opportunities that are made possible by the implementation. The test modes of the equipment, some of which are newly developed, and some of the projects that have already been performed are discussed together with future projects that we foresee possible having access to our new laboratory. The basis for the laboratory is the development within electrical drives, power electronics and precision motion control of electrical machines also for high torques and powers. This progress has enabled a reduced cost and a versatile setup. In our case the basis for the system is ABB technology, applied by Rototest for vehicle applications. A first glance of the laboratory is seen in [Figure 1](#).



Figure 1. A glance of the new chassis dynamometer lab. A Golf V with a 1.4l multifuel engine has been mounted to the dynamometer units in a 4WD configuration.

The development of our new facility is exciting since it utilizes, combines and enhances new state-of-the-art commercial technology made possible by technological development with several timely automotive research and development projects. On one hand it is curiosity driven, and

on the other hand there is substantial interest from our automotive collaborators since they are facing more and more complex development tasks, and are with interest looking at new possibilities.

BACKGROUND

Chassis dynamometer experiments are good alternatives to road tests since they give a higher repeatability, lower cost, and better experimental control and supervision. Another benefit is that the body of the vehicle does not need to be mounted, which yields, a possibility to test different configurations of the powertrain before a complete vehicle is constructed. Using a chassis dynamometer it is possible to test the whole powertrain of a vehicle as opposed to engine tests benches.

In the past chassis dynamometers usually meant rolls of different dimensions where the surface of the rolls was in direct contact with the tire of the tested vehicle. They were expensive and required complex facilities, and the time to change vehicles is often long. With the use of absorption, and possibly a drive unit, the rolls can be controlled to brake and propel the vehicle while measuring e.g. the speed of the roll and the transferred torque from the tire to the roll.

There are many examples of work where chassis dynamometers have been used. For example, to get an estimate of the pollutant emissions from light-duty trucks, test or driving cycles have frequently been used while measuring the emissions [1]. These driving cycles, which are speed profiles, are mainly performed at a chassis dynamometer. The legislative certification driving cycle in Europe is the NEDC driving cycle, and in [2] on-road emissions and emissions for chassis dynamometer driving NEDC are compared. Another work used transportable chassis dynamometers to compare alternative fuel and diesel fuel heavy-duty vehicles emissions [3]. The chassis dynamometer used in that study used rolls for the driven wheels, but the power was extracted directly from the vehicle hubs instead of extracting power from the rolls that usually is the case. During emission measurements a common practice is to measure the related fuel consumption at the same time. In [4] a statistical approach is used for identifying factors that influence the fuel consumption of a vehicle. Here a 48 inch chassis dynamometer is used and the largest effect was recognized to be a discharged battery.

Except for conducting legislative certification driving cycles for emissions, a chassis dynamometer can also be used for other experiments or tests such as performance tests of the powertrain and noise tests, of vibration and harshness (NVH) to mention a few. In the latter case usually larger diameters of the rolls are required to ensure that the contact surface between the tire and roll are large enough.

LABORATORY OVERVIEW

The vehicle propulsion laboratory is housed in the facility L-huset at Linköping University which was finished mid

2011. The L-huset can be viewed in [Figure 2](#) and contains in total approximately 220 m² laboratory space and also some office space. The focus of this paper is on the vehicle propulsion laboratory being one of three labs in the building. The chassis dynamometer in the propulsion laboratory was chosen because of its flexibility, simplicity, and cost of ownership and installation. Nevertheless, during construction of the lab, some criteria had to be fulfilled to support the chassis dynamometer installation. The main specific criterion during the construction of the lab-building was that the electrical power transmission had to be dimensioned to support the four 160 A 230 V three phase power supplies for the regenerative motor drives and the 125 A power supply for the head wind fan. The second criterion was that the exhaust gases need to be taken care of with suitable ventilation. Other than that, the laboratory building is simply a regular building with garage.



Figure 2. The building L-huset where the vehicle propulsion laboratory is housed.

The Vehicle Propulsion Laboratory

The vehicle propulsion laboratory consists of an 80 m² lab area divided between a control room and the actual lab space. An overview picture of the vehicle propulsion laboratory can be seen to the left in [Figure 3](#). The usable ceiling height is approximately 5 m and the garage doors are of a height of 4 m. This way even light-duty-trucks can be brought into the laboratory. The panoramic window in the corridor, which can be seen to the right in [Figure 3](#), gives spectators and staff a view of the laboratory and yields the possibility to easily demonstrate the facility for visitors. In the control room, which can be seen in [Figure 4](#), a supervisor can control the experiments and at the same time have a visual supervision of the activity in the laboratory.



Figure 3. Left: View of the vehicle propulsion laboratory with four mobile dynamometers, head wind fan and exhaust ventilation. Right: View from the corridor.

Due to that the wheels need to be removed during the mounting of the dynamometers a jack or preferable a lift needs to be used to lift the vehicle. Because the dynamometer units are mobile the choice of lift requires some consideration. The laboratory is currently equipped with a movable hydraulic scissor lift (not shown in the figures) that can be used and stowed away easily, maintaining the flexibility of the dynamometers. One drawback with the current solution is, however, that not all cars have enough ground clearance for the lift.

Because the dynamometer can be used at high vehicle loads for long time measurements the exhaust gases can reach high temperatures. To cope with the high temperatures the ventilation system is dimensioned to suck excess air, thus diluting the hot exhaust gases at the source. Currently a selection of pipes with different lengths and shapes are used to fit the ventilation to vehicles with different exhaust pipe layouts but a more flexible solution is sought for.



Figure 4. View of the vehicle propulsion laboratory control room.

Equipment

The propulsion laboratory is equipped with a chassis dynamometer, as well as a data acquisition hardware, network infrastructure, and communication software. Pictures of the laboratory can be seen in [Figure 3](#) and a schematic overview

of the system can be seen in [Figure 5](#). The main parts of the equipment are

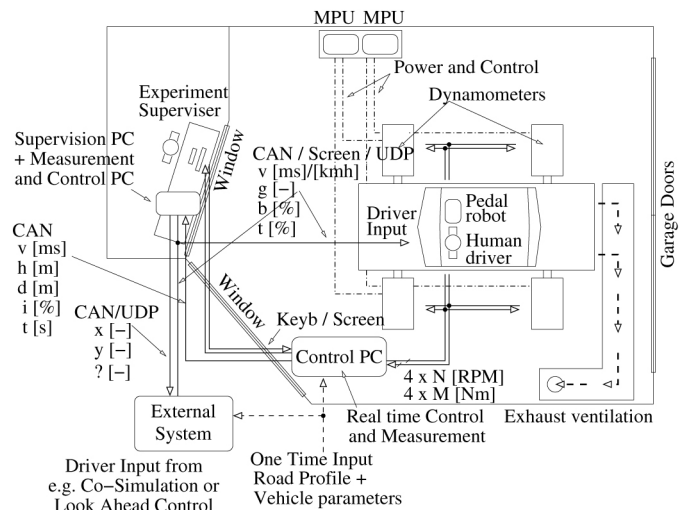


Figure 5. The lab area, where the dynamometer units are located, and a control room, from where an experiment supervisor controls the experiment, are separated with a large panoramic window. The garage doors, shown in the right part of the picture, are large enough to allow full size trucks to enter the lab area.

The chassis dynamometer which is the main equipment of the vehicle propulsion laboratory and consists of four mobile units, as well as other control and supply components. The chassis dynamometer is thoroughly described further down.

A PC for measurement and control located in the control room. This computer is currently running a standard Linux distribution that can be adapted to running real time software, e.g. for look-ahead-control purposes. Measurements are either performed directly at the dynamometer systems Control PC or by this measurement computer through CAN, serial port OBDII or UDP. This way data that is measured by other means than by the dynamometer or vehicle control systems can easily be forwarded to the measurement computer.

A supervision PC located in the control room. This computer is used for supervision and communication using Confero [5] which is a teleconference software which can be used independently without an external Internet connection.

Ethernet connections to a local switch room with single mode fiber to neighboring facilities. The Ethernet network is separated between a local high speed measurement network, also available from the offices, a dedicated single mode fiber extension currently connected to the moving base simulator facility at the Swedish Road and Transportation Research Institute, VTI, as well as a number of standard university networks for use with regular research and student activities.

Direct cable connections between the control room and the lab area for Ethernet, CAN, serial RS232 connections or other equipment suitable for CAT5e cables, e.g. keyboard