Temperature Measurement

Powertrain Validation in Forklifts

Whenever extensive design updates are made to current production vehicles, validation testing is needed in order to ensure that the updated vehicle still meets regulatory requirements. This article illustrates how this was achieved using CSM measurement technology on a forklift that incorporated new engine options.

Background

Manufacturers of material handling equipment, like their counterparts producing passenger and commercial vehicles, are constantly developing their products in order to meet changing legal standards such as exhaust regulations, and to be able to offer the benefits of innovations to their customers. The forklift manufacturer, Linde Material Handling, integrated new gas and diesel engines into two of their forklifts, one with load capacities up to 2,000 kg and the other with capacity up to 5,000 kg. The engine integration required design adjustments to hose routings and the electrical system. This project, including the subsequent functional validation, was contracted to EDAG Engineering. EDAG is a global engineering service provider with approximately 8,600 employees and 60 locations worldwide. They specialize in vehicle development as well as associated production facilities. For validation testing following the integration of new components, the Gesamtfahrzeugabsicherung (GFA) department at the Fulda site is available.

After integrating the new engines into the forklifts, a comprehensive functional validation of the overall system must be carried out to ensure that the requirements for type approval (ECE homologation) are met. Without a successful verification of compliance with all relevant regulations, approval for production of the new generation of forklift trucks cannot be granted.

In order to validate the performance of the system, numerous tests are carried out under a wide range of conditions, such as in a climatic chamber, at high altitude in the Alps, and also on the EDAG test track.

On EDAG's outdoor test track, the vehicle undergoes defined driving cycles with a payload at 80% of its maximum capacity. The forklift maneuvers forwards and backwards, at various speeds, while lifting and lowering the load. Various performance characteristics were measured:

- pressures in the fuel and cooling systems,
- flow rates in the cooling circuit,
- currents and voltages of the battery and the starter,
- temperatures at numerous locations throughout the engine compartment.

Fig. 1: In the high altitude test, a forklift truck is tested at 2,400 m in the Alps. After engine integration, the vehicle must function perfectly and still meets regulatory requirements.

Because the ambient temperature cannot be controlled outdoors, this is also recorded during the test and the results are extrapolated to the specified temperature limits of the vehicles. Appropriate safety limits can therefore be defined for the cooling system and motor.

Challenge

The EDAG team needed a measurement system that was flexible and scalable in multiple ways. Due to the large number and different types of tests to be performed, the measurement system had to be capable of being rapidly moved and re-used from one test to another. In addition, the measurement technology needed to be robust and compact in order to be installed within the limited space available in a forklift. In addition to being compact, the system had to accommodate 90 measurement channels, of which 70 were for temperature. The system needed to obtain data from ECUs simultaneously via the CAN bus and be easily integrated with the existing Vector Informatik data acquisition software in use at EDAG Fulda.

CSM Measurement Solution

For the necessary temperature measurements, K-Type thermocouples are installed at the specified points within the engine compartment and connected to CSM THMM 16 pro measurement modules. Multiple measurement modules are connected, and all measurement data is communicated via CAN bus. These temperature modules are equipped with internal cold junction compensation and offer high accuracy over the entire temperature range for each measurement channel. The hardware is designed for minimal temperature drift and simple sensor integration, thus providing reliable measurement results.

Other measurements, such as the pressures in the cooling and fuel systems, flow rates in the cooling system, and currents and voltages in the battery and starter are recorded with suitable standard sensors. CSM's AD8 pro MC2 measurement modules read the signals and also supply the sensors with the required excitation voltage. As with the multiple temperature modules, these ADMM modules are connected via CAN bus to the Vector network interface.

A Vector Informatik interface VN1640 simultaneously collects the additional data required from the ECUs to be included in the measurement data stream.

All measured values are stored with a UniCAN 3 data logger from CSM and analyzed later with software tools from Vector Informatik. For direct monitoring during the test drive, the measurement data is also displayed on a tablet with Vector CANape software.

Fig. 7: The temperature and pressure sensors are installed in the specified locations in the engine compartment. The green cabling shows routing of the Type K thermocouple sensors to the measurement modules located outside the confined engine compartment.

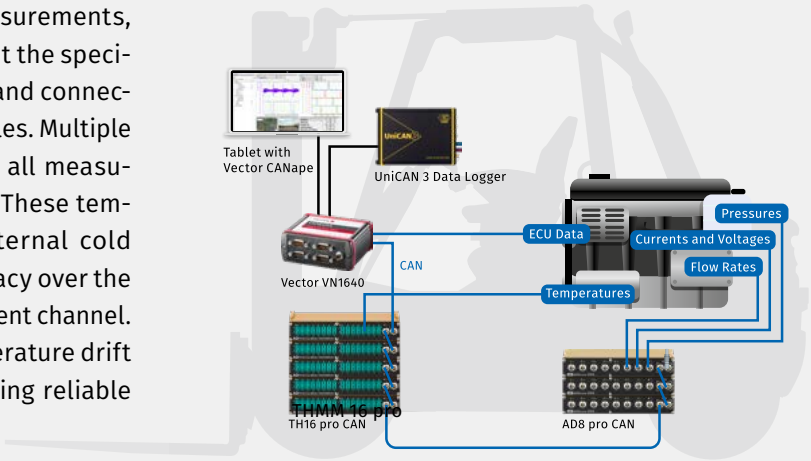

Fig. 2: THMM 16 pro Temperature measurement modules acquire the temperatures at different points in the engine compartment. Additional parameters are measured using AD8 pro MC2 modules. The measurement data is collected simultaneously with information from the ECU with the Vector interface VN1640, and is passed to a UniCAN3 data logger, as well as to a tablet for live display.

Measurement modules are preconfigured in the laboratory using CSMconfig software. This provides the test staff with the necessary flexibility to prepare the measurement system. As Thomas Schenk, Team Leader, GFA-NVH-Measurement Technology at EDAG Engineering GmbH describes:

» We start with the measurement scheme. This file contains the type and name of each sensor, a short description of the location, and the channel name used in the CSM module. The exact measurement location is usually decided during installation of the sensors. In the case of temperature and pressure sensors, however, the engine manufacturer often specifies where to install the sensors.. « (Fig. 3)

The measurement scheme can be easily imported into CSMconfig software as a .csv file and the configuration of the entire measurement system is completed automatically. This saves significant preparation time, especially when the same measurement scheme is to be replicated on other forklifts.

CSM's module housings are available as slide cases, enabling secure attachment to adjacent modules and to CSM's adapters and angle plates. The entire, interlocked set of modules is then mounted on a carrier (Fig 4). This compact structure is installed either in the driver's cab or behind it, depending on the forklift (Fig 5). For Mr. Schenk's team, the time required for installation is considerably reduced compared to competitors' systems. Once the predetermined driving cycles are completed, all required measured values are collected from the UniCAN3 data logger (Fig. 6).

During the test, LEDs on the front of the measurement modules display the status of each channel, enabling a quick visual check. This facilitates efficient monitoring of multiple channels. For example a defective sensor or faulty connection can be identified with a red LED.

According to Mr. Schenk, the simultaneous acquisition and evaluation of data from the ECUs and the measurement modules is well integrated:

» We use various tools from Vector Informatik that work very well with CSM's products. The measurement data can be easily linked to CAN timestamps and CAN data. This allows us, for example, to record motor and hydraulic data via the CAN bus in parallel with the measurement data and thus see at which load point the motor is currently working. «

Fig. 3: With CSM's unique Slide Cases, all of the measurement modules are locked together to make a compact hardware system in the cabin.

Fig. 4: This image shows the compact measurement modules in the cabin, located directly above the instrumented engine compartment.

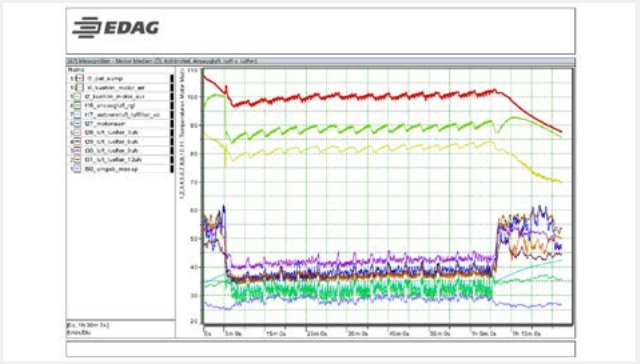

Fig. 5: Readings of the entire measurement system.

Benefits

With the Vector-CSM measurement system, functional verification can be carried out quickly and easily after new engine integration. The ease of handling and compact size of CSM's measurement modules offer advantages during setup, installation, and testing, as Thomas Schenk makes clear:

» We particularly liked the compact size and flexibility of the measurement technology products from CSM, which allows for easy scalability. It is also very helpful for us that the modules can be networked via the CAN bus and are easily integrated into the Vector Informatik software that we use. «

Featured Products

THMM 16 pro

THMM 16 pro enables precise distributed temperature measurements with K, J or T type thermocouples. Thanks to its low temperature drift, it delivers very accurate measurement results over the entire operating temperature range.

ADMM pro

The AD pro MiniModules (ADMM) allow a wide range of applications for the measurement of signals from sensors with analog voltage outputs (voltage, current, pressure, flow rate, etc.). A status LED for each channel makes it easy to verify proper operation. An extended scaling with 32 axis points per channel facilitates sensor linearization.

UniCAN 3

The data logger UniCAN 3 was developed especially for the use in the automotive sector: Up to 12 CAN interfaces, freely configurable inputs and outputs, Wake-on-CAN, LAN and WLAN, support of CAN FD. In addition, data transmission via LTE modem or WLAN allows worldwide use.

CSM provides you with comprehensive complete packages consisting of measuring modules, sensors, connecting cables and software - customized to your individual needs.

Further information on our products are available on our website at www.csmproductsinc.com or via e-mail info@csmproductsinc.com.

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