Engine Simulator Reduces Development Time and Expense

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ABSTRACT

Traditionally development of engine-driven products has required testing with an operating engine. Because an operating engine is required, many tests are delayed until operational engines are available for testing purposes. Engines are frequently not available until very late in the development process. Getting a late start on testing naturally limits the amount of testing that can be performed and the number of design alternatives that can be evaluated.

Team Corporation's 900 Series of Engine Simulation Systems reduce development cost and time-to-market for engine-driven systems and components. By providing a programmable and flexible test platform, a Team Engine Simulation Systems enables the development engineer to perform more tests, more accurately, and earlier in the development process.

INTRODUCTION

By using data from similar engines or from CAE models, the Team ESS can be used at the very beginning of the engine development program to evaluate several design alternatives quickly. Results from these tests can be used to narrow the alternatives to the most promising. Subsequent testing that incorporates measured data obtained on prototype engines allows quick and reliable comparison of the performance of the various designs under controlled, repeatable conditions.

The Team ESS uses closed-loop vibration control to provide repeatable test conditions test after test. By eliminating uncontrolled variables such as changes in engine performance over time and variations from engine to engine, the Team ESS brings a higher level of confidence to the testing process.

A typical Team Engine Simulation System with integrated variable speed drive.

The PC-based Engine Simulation Controller (ESSCON) allows the operator to control the amplitude, frequency and duration of vibration. In addition the speed of rotation can be controlled. A test scheduling feature allows for programming of engine duty cycles and looping of test sequences.

Aside from the physical space required, there are numerous safety and environmental issues related to an engine-drive testing facility. Among these are fuel handling, exhaust gas handling, and fire-suppression systems. By eliminating the need for fuel and the production of exhaust gases the Team ESS can significantly reduce facility costs. In addition, the flexibility of the Team ESS further reduces the overall facility investment.

SYSTEM DETAILS

Team Corporation offers ESS systems with dynamic torque capabilities ranging from 1.1 to 4.5 kN-m at frequencies up to 600 Hz and rotational speeds up to 10000 rpm. This wide range of capability allows Team to provide ESS solutions for the full range of passenger car and heavy truck applications.

A complete ESS is comprised of the following sub-systems:

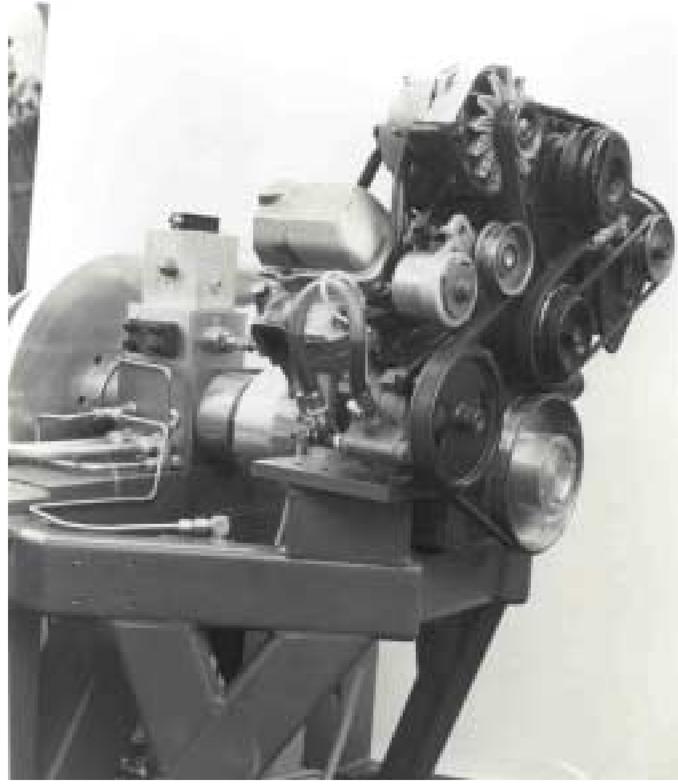
Variable Speed Drive (VSD) – The VSD provides rotary motion and steady state torque for the engine simulation system. Typically a variable speed DC drive, the VSD may be integrated into the ESS (up to 75 kW). For higher power requirements an external drive may be used.

Spinning Rotary Actuator (SRA) – The SRA is the heart of the ESS. It provides the dynamic torsional vibrations to the test specimen. The SRA can be described as a rotary actuator whose housing is allowed to rotate. All dynamic torque, acceleration and displacement are generated relative to the actuator housing. Any steady state torque produced by the VSD also acts through the spinning rotary actuator.

The primary working components of the spinning rotary actuator are the housing and the rotor. The housing is driven by the VSD either directly or using a toothed belt. The rotor maintains its position relative to the housing by means of hydraulic pressure on the rotor's vanes. Modulating the pressure on the rotor vanes produces dynamic torque.

The SRA is supported by two hydrostatic bearings; one each at the front and rear of the SRA. Hydrostatic bearings are used to minimize friction. The front bearing of the actuator assembly also serves as a hydraulic slip ring that allows oil to flow from the stationary servovalves into the actuator.

Attached to the housing are two disks. The larger of the two is an inertia disk that reacts the dynamic torque generated by the rotor. The inertia disk is sized so as to have an inertia that is many times greater than the inertia of the test load to maximize the energy transmitted to the test load. The second disk is a brake disk. The brake is used to automatically or manually stops the ESS in the event of an emergency.



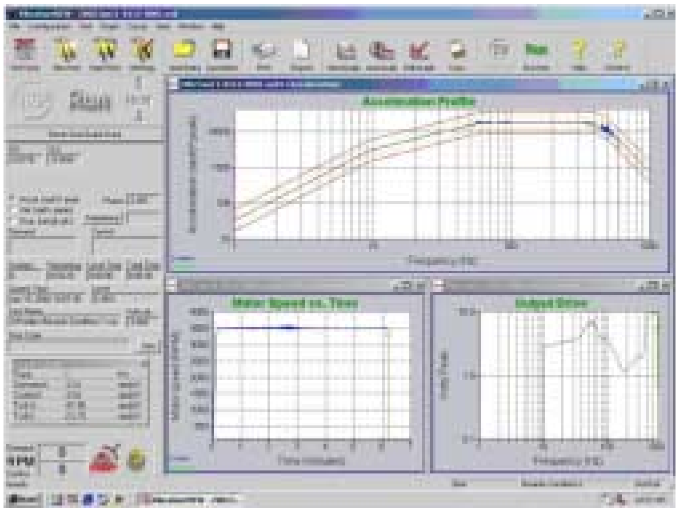
A belt test setup on an early Team Engine Simulation System.

Servovalve Assembly – The servovalve assembly is comprised of a Team high-frequency voice coil driven pilot stage and a Team high-flow slave stage. Optimized for high frequency response, the servovalve assembly enables the ESS to operate at frequencies up to and beyond 600 Hz.

Instrumentation and Control (ESSCON) – The instrumentation and control system controls and monitors the test in progress and the operation of the ESS. The primary control element is the angular acceleration of the rotor. This is measured by means of one or more standard linear accelerometer mounted tangentially to the axis of rotation at a known, fixed radius. Accelerometers are used for low cost, high resolution and the ability to operate at zero speed.

The linear acceleration measured by the accelerometer is converted to angular units using a simple conversion in the control software. The accelerometer signals are routed through a slip ring to the ESSCON inputs.

The VSD is equipped with a tachometer for measurement of rotational speed. Communication between the VSD controller and the ESSCON is by means of a dedicated network interface.



Typical Engine Simulation System Controller (ESSCON) run-time display. All graphs may be customized by the user.

An engine damper test using the Team Engine Simulation System. The sensor on the left is an infra-red temperature sensor.

Hydraulic Power Supply (HPS) – The HPS provides hydraulic pressure and flow to the SRA. Typical capacity for the HPS is 110 liters/min at 210 bar operating pressure.

SAMPLE APPLICATIONS

ENGINE DAMPER TESTING

Engine damper testing is a popular application for the Team ESS. In this application the ESS is used to characterize the performance and durability of the engine damper through a series of application-specific tests. These include: identification of the damper resonant frequency, evaluation of changes in the damper resonant frequency over time and with varying damping material temperatures, and durability testing.

Using sensors on both the hub and ring of the damper the resonant frequency of the damper is determined using a sine sweep test. During the sweep the relative phase and amplitude of the hub and ring sensors are tracked and used to identify the damper's resonant frequency.

With the resonant frequency known several other tests can be performed. One test mode controls the temperature of the damping material to a constant level. This is accomplished by varying the excitation frequency around resonance to generate heat in the damping material. By moving closer to the resonant frequency the material heats up; moving away from resonance allows the material to cool down. Using the damper temperature as the control variable allows the ESS to maintain the material at a constant temperature. Periodic sine sweeps measure the resonant frequency to identify changes over time.

FRONT ENGINE ACCESSORY DRIVE (FEAD)

Team Engine Simulation Systems are often used for testing and development of complete FEAD systems and belt-drives. The programmability of the ESS allows the FEAD to be evaluated under a variety of operating conditions. The Team ESS has been used for durability and noise testing of FEAD systems.

Team Engine Simulation System set up for testing a Front Engine Accessory Drive system. The ESS is behind the wall in the background to facilitate noise mapping of the FEAD during testing.

CONCLUSION

The ease with which the Team ESS can be programmed significantly reduces time and cost for development of products used on multiple engine platforms. The performance of a single test specimen under many different engine conditions can be evaluated entirely from the control station. In traditional testing the product would need to be tested on a sample of each engine platform; thereby requiring multiple time-consuming set-ups or multiple cash-consuming test stations.

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