

FOR IMMEDIATE RELEASE
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STURMAN RESEARCH MODULE COMMISSIONED AT THE UNIVERSITY OF MICHIGAN

- *Dr. Dennis Assanis chooses Sturman technology for HCCI combustion research at U-M*

The University of Michigan Commissions a Sturman Research Module

This past month, Sturman Industries www.sturmanindustries.com commissioned a Research Module at the University of Michigan Walter E. Lay Automotive Laboratory <http://me.engin.umich.edu/autolab/index.html>. Dr. Dennis Assanis, Director of the Multi-University Consortium on Homogeneous Charge Compression Ignition (HCCI) Engine Research and U-M Professor of Mechanical Engineering, identified the Sturman Research Module as an enabling tool for combustion research. According to Dr. Assanis, "Utilization of the fully flexible Sturman Research Module has opened up a wealth of new horizons for multi-mode combustion. The only limit is your imagination. We are trying to realize the dream of efficiency improvements of 20-40% and simultaneous emissions reduction."

Worldwide Utilization of the Sturman Research Module

Dozens of Sturman Research Modules are currently in use at Research Institutes, universities, and companies worldwide. Eddie Sturman, Innovator and co-founder of Sturman Industries, is pleased that combustion research is finally advancing to include flexibility for air intake and exhaust. Says Sturman, "Much emphasis has been put on the flexibility of fuel injection during the past decades, and that has proven to be extremely beneficial. But the next step must be to achieve complete combustion control. Therefore research must include air intake and exhaust management. The Research Module is the enabling technology to perform such research. Combustion engineers can easily investigate multi-mode combustion schemes by real-time control of air flow and fuel injection to realize lower emissions and higher efficiency. Furthermore, costly and massive aftertreatment systems may be eliminated."

Japan on the Forefront of HVA-based Research

Supported by investors including Toyota, Denso, Bosch, Mitsubishi, Isuzu and Nissan, the New A.C.E. Institute Co, Ltd. <http://www.nace.jp/E-Top.htm> located in Japan utilizes a Sturman Research Module in pursuit of its mission to develop a new diesel combustion concept. According to New A.C.E. Director Dr. Yuzo Aoyagi, "New A.C.E. is conducting research utilizing the Sturman HVA Module on heavy duty diesel engines. Technical papers are available for review." Former New A.C.E. President Satoru further adds that, "Sturman Industries gives our Company, New A.C.E., a great deal of helpful cooperation for our research which decreases

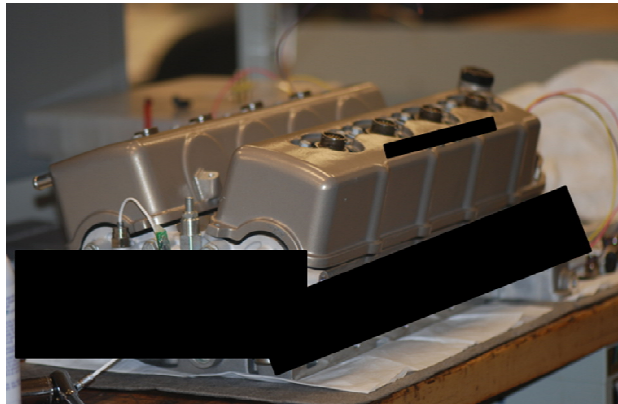
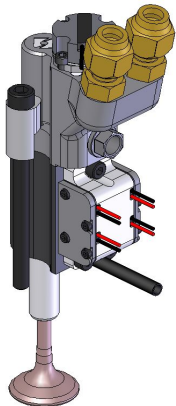
exhaust emission of the diesel engine and improves fuel economy. Consequently we can recommend the concept of the super clean engine to our investors...”

HVA for Gasoline Motorcycles too!

A client-confidential motorcycle manufacturer has been utilizing a Sturman Research Module for gasoline motorcycle engine development. A production packaged HVA system has also been demonstrated with a Japanese engine manufacturer with 12,000 rpm capability.

Background: Sturman Hydraulic Valve Actuation

Sturman Industries is an industry leader in Hydraulic Valve Actuation (HVA) technology, often referred to as “camless” systems. HVA eliminates the mechanical linkage between the engine valves and the crankshaft, allowing for fully flexible engine valve operation and enabling improved engine power, efficiency, and emissions. Since 1996, Sturman has produced systems ranging from basic open-loop single-lift systems to advanced closed-loop systems with variable timing, lift, and multiple event operation. In 2000, a truck retrofitted with HVA was driven to the top of Pikes Pike and completed a 10,000 mile U.S. tour. Additionally, Sturman has equipped a Volkswagen Jetta with HVA and has delivered several other multi-cylinder camless engines to clients.



Research Module Technical Profile, Controls and Graphical User Interface

Initially for research purposes, Sturman developed an affordable HVA Research Module. It is manufactured in two sizes: small for 0.2- 1.0L cylinders, and large for 1.0- 2.0L cylinders. The chart below summarizes the technical profiles of the Sturman Research Modules:

HVA System Parameter	Small Research Module	Large Research Module
Type of engine	Gasoline, Diesel	Gasoline, Diesel
Normal operating speed range	250 - 6000 rpm	600 - 3000 rpm
Maximum operating speed (Over speed)	6500	3300
Typical engine size range	0.2 to 1.0 liter per cylinder	1.0 to 2.0 liter per cylinder
Working Fluid	Engine oil or hydraulic fluid	Engine oil or hydraulic fluid
Lift Range	1.3 mm - 10 mm (Variable)	1.5 mm - 12 mm (Variable)
Lift Accuracy	±0.15mm	±0.15mm
Lift Repeatability	±0.10mm	±0.10mm
Opening and Closing Flank Time	1mm - 90% max lift in <4ms Max velocity ~4.5 - 5.0 m/sec	1mm - 90% max lift in <5ms Max velocity ~4.5 - 5.0 m/sec
Timing accuracy & repeatability	±2°CA @ 600 rpm to ±3 CA° @ 3000 rpm scaled linearly with engine speed	±2°CA @ 600 rpm to ±3 CA° @ 3000 rpm scaled linearly with engine speed
Multiple valve events	Up to 2 events per crank revolution	Up to 2 events per crank revolution
Independent control of valves	Each valve can be controlled individually for lift, timing and duration	Each valve can be controlled individually for lift, timing and duration
Valve Seating Velocity	0.3 - 0.6 m/s (hydraulic rail pressure dependent)	0.3 - 0.6 m/s (hydraulic rail pressure dependent)
System operating temperature	15 to 100° C	15 to 100° C
System supply voltage	+12V DC or 120V AC	+12V DC or 120V AC
Communication Protocol	CAN link between VDM and ECU proposed	CAN link between VDM and ECU proposed
Valve stem diameter	5.0mm	8.0mm
Hydraulic supply	Stand alone pump unit	Stand alone pump unit

Sturman Research Module Design: Production-type System in Flexible Research Packaging

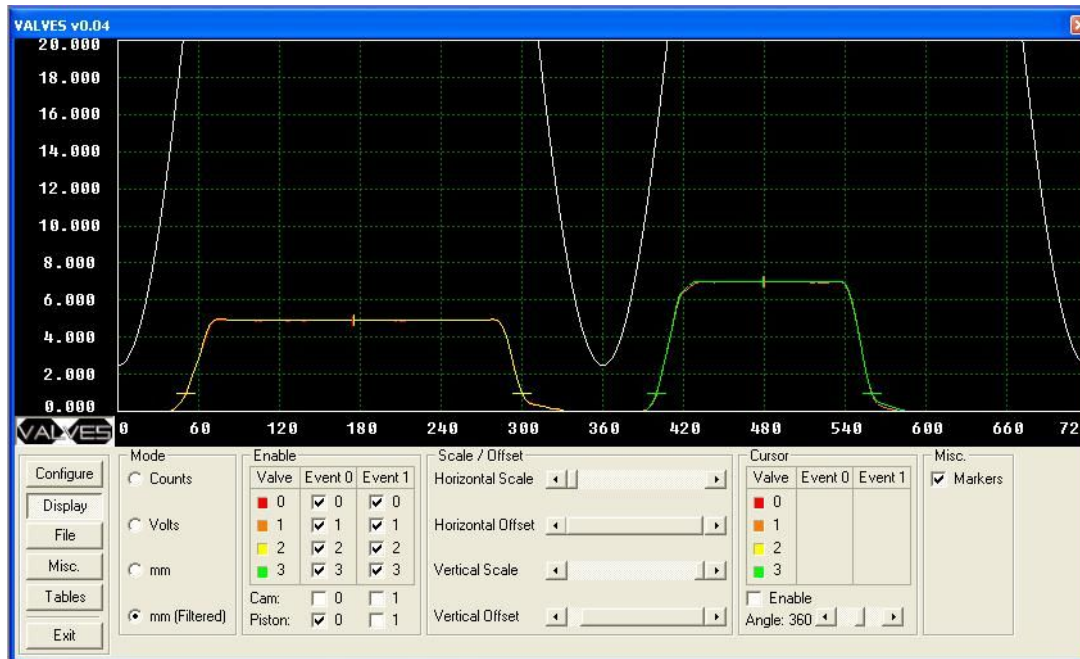
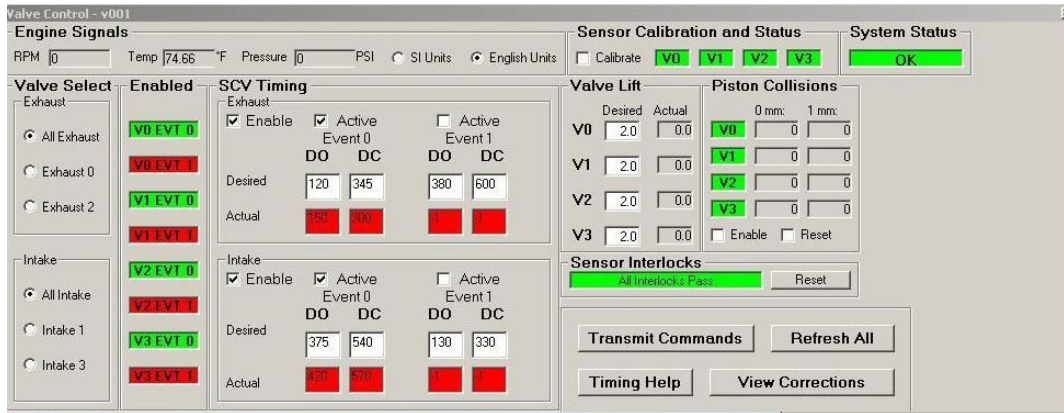
- Module is designed to fit many different applications
- Module is clamped to the cylinder head similar to an injector allowing for various engine and valve configurations
- Actuator is sealed eliminating the need for a valve cover
- High actuator force allows use on a wide range of engines
- Individual lift and timing control of each valve
- Digital Valves and Actuators are the same as used in the target integrated production system
- Robust to disturbances: changing cylinder pressure, wear, etc
- Transient capable

The Condor Controller Box

The Condor is a compact package (a single cylinder application is roughly 310mm x 210 mm x 75mm in size). The Condor electronics are divided into two major components, the Valve Control Module (VCM) and the Valve Drive Module (VDM). Each of these elements is based on a Phycore MPC 5554 processor module. A single Field Programmable Gate Array (FPGA) accompanies the VCM/VDM pair. The FPGA is responsible for monitoring engine position signals, sampling data, current control and communications between the processors. The VCM is responsible for processing the valve position signals for control and the VDM controls the actuation of the valves and the communication with the engine controller or user interface. It connects to a driver board that contains the high power coil drive stages and current safeties.



Also included with research module deliveries is a suite of user interface software that enables calibration editing, user interface/commands, and oscilloscope-like monitoring of the valve performance. Two of the primary user interface windows are shown below: the first enables user commands from a computer connected by Ethernet, and the second shows the valve performance and control parameters in real time as well as acting as a data recorder.



For more information about Sturman technologies – the Sturman Digital Engine, Hydraulic Valve Actuation for Research/Demonstration/Production, Digital Valves and Fuel Injectors – please contact us:

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