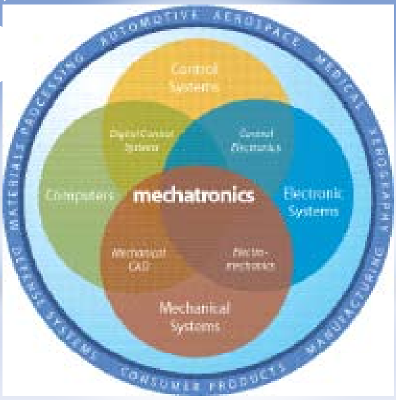
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND COMPUTERS IN DESIGN



Unleashing the Potential of the IC Engine

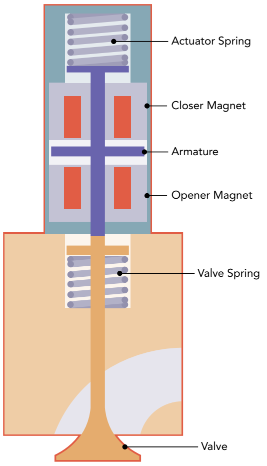
BY KEVIN CRAIG

Despite talk of its demise, the outlook for the venerable internal combustion engine remains sunny. The future lies in mating its proven technology with new mechatronics-related concepts.

To meet demanding challenges in emission control and engine efficiency, while still maintaining high engine performance, today's automobile has already become a comprehensive mechatronic system. More than 80 percent of all automotive innovation stems from electronics. Highly-reliable and fault-tolerant electronic control systems — X-by-wire systems — do not depend on conventional mechanical or hydraulic mechanisms. Such dynamically configurable electromechanical elements are triggering system-wide integration, making vehicles lighter, cheaper, safer, more fuel-efficient and less harmful to the environment.

In fact, mechatronic features have become the product differentiator as consumers demand smarter functions in their cars. Now, the challenge in automotive mechatronic system design is the dramatic jump in complexity (doubling every two to three years), almost comparable to the complexity increase in microelectronics. This added complexity needs to be mastered and managed. That calls for continued innovation to create products with distinctive functionality, better quality, and a cost advantage. At the same time, we need highly efficient processes for product design, manufacturing and calibration.

In the case of the internal combustion engine, many opportunities for innovation remain. Using an analogy to the human body, imagine you inhaled and exhaled the same volume of air with every breath and that there was no such thing as deep or shallow breathing. Somewhere between sitting down and ascending several flights of stairs, your lungs would reach a point where they would be working at optimum capacity. That is the nature of the internal combustion cycle operating with fixed cams that open and close the intake and exhaust valves by the same amount and at the same point in the cycle every time, regardless of engine speed, load, or external conditions.



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However, with increased computer-modeling capability, we now have a better understanding of the IC engine and how to improve it. Engine spark and fuel metering have already escaped their bonds of purely mechanical control; engine respiration will be next. Engine designers love degrees of freedom, and adding on-demand and variable controls to almost any system can improve fuel economy and lower parasitic losses. But the average engine has only two variables: electronic fuel injection and electronic spark timing. Think about the trade-offs a cam has to make on engine performance, high speeds versus idle. An engineer doesn't have to live with compromise. The camless design is the solution.

A camless engine with an electromechanical valve-train actuator adds six degrees of freedom to engine control: three per intake valve and three per exhaust valve, corresponding to a valve's opening, closing and lift. Inefficient throttling would be eliminated, and cylinder and valve deactivation would lead to better fuel economy.

Thanks to mechatronics design, the camless engine is nearing full-scale implementation. The issues still to be addressed in the actuator design include: cost, reliability, packaging, power consumption, noise and vibration. Noise may be the main problem, resulting from high-contact velocities of the moving parts. At 3000 rpm, each electromechanical valve moves a distance about 8 mm, 100 times a second. In moving away from camshafts, engine builders would replace a single reliable component with a complex system with many more components. The essential enabling technologies will be controls, featuring more computing power and speed, along with better and more durable sensors. Modeling will improve sensing through real-time, model-based observers.

Already, we've seen the continuously variable transmission, once just a theoretical vision, become a reality. Through a mechatronic approach, camless engines will follow the same path.

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