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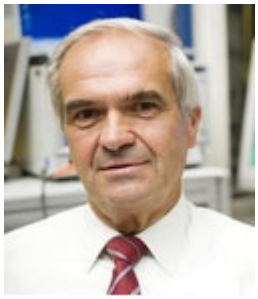

Interview

Technology of the future

Professor Hans Meixner, one of the winners of the German Future Prize 2005, talks about piezo technology.

COMPONENTS: You were awarded the German Future Prize 2005 for the R&D project entitled Piezo injectors: A new technology for clean and low-consumption diesel and gasoline engines. What innovations in particular did this prize honor?

Professor Hans Meixner: Piezo injectors are based on two significant innovations: firstly the development and manufacture of the piezo actuator itself that allows the fuel injection process to be controlled extremely precisely. The second innovation was to use the piezo switching element in the piezo injection system so that its advantages are fully exploited. I believe that the result is convincing. Piezo injectors are significantly superior to injection systems based on conventional solenoids.

In which way?

The piezo-effect is used to activate the mechanism for opening and closing the injection valve in direct injection systems. The piezo-controlled injectors are first extremely fast and second apply an enormous force. With switching times of only about 80 microseconds, piezos are four to five times faster than conventional direct injection systems.

And that means?

Piezo injection valves can dose the fuel with considerably greater precision. And they can also inject it between six and ten times during a combustion cycle. This achieves extremely sensitive control of the combustion process so that exhaust emissions are greatly reduced compared with conventional injection techniques while simultaneously boosting efficiency. And incidentally, piezo injectors would satisfy the currently applicable emissions standards (Euro 4) even without particulate filters.

What does that mean in figures?

Precise piezo injection allows us to reduce pollutants – both nitrogen oxides and diesel particles – by up to 30 percent. Fuel consumption can be reduced by up to 15 percent and engine performance increased by about five percent. In addition, the engine noise is reduced by nearly six decibels.

What role is played by the volume production of piezo actuators, where EPCOS is still the sole player among component manufacturers?

Successful volume production has certainly contributed to the innovative performance for which we received the award. While we research scientists and developers might be able to build a hundred or so actuators of this kind in our laboratories, volume production processes are needed to make the quality significantly better and to cut costs considerably. So the great merit of EPCOS was to develop the piezo actuators for series production. This was indeed an important milestone toward the realization of piezo injectors. And that's also why the cooperation between research and development and the operating units is so important and co-determines whether new products can be successfully established on the market.

Back to your R&D activities, Professor! What were the major technological challenges?

It proved difficult to construct a rugged piezo actuator that could move an injection nozzle. Our first attempt with bonded piezo-disks turned out to be unsuccessful because the cement partially absorbed the expansion of the piezo-material in response to an applied voltage. But we wanted to use precisely this expansion of the piezoelectric material to move the injection nozzle. We finally succeeded in constructing an operational actuator with low switching times by using the piezoelectric transverse effect. But the real breakthrough to volume production finally occurred thanks to ceramic multilayer technology. This technology was already being used to produce other ceramic components in volume quantities at the end of the 1980s in our plant in Deutschlandsberg, Austria, that at that time still belonged to Siemens and is now a part of EPCOS. Material researchers from Siemens and EPCOS have now matched the piezoelectric ceramic to the thermal conditions of diesel and gasoline engines by the addition of lead and zirconium oxides. That worked because the Curie temperature above which the material loses its piezoelectric properties can be extended almost as far as desired. Piezo ceramics are now available in which the Curie temperature has been shifted upwards to as high as 350 degrees Celsius.

Why must the piezoelectric disks be stacked?

Very high voltages must be applied to ensure that larger piezoelectric crystals or ceramic blocks expand significantly. In contrast, no more than 160 volts are needed to trigger the piezo-effect in a single ceramic layer about 80 microns thick. But the layer thickness then changes by only about a tenth of a micron. So the trick is to stack many of these layers together, sinter them monolithically and connect them in parallel. With several hundred piezo layers stacked upon each other, an effective elongation of up to 80 microns is ultimately attained. Such a stack can generate a force of about 2500 Newton.

How much time was spent working on exploiting the piezo-effect for injection in automobiles?

Siemens had pursued its intensive research into piezoceramic materials for decades. The first ideas for a piezo injector were developed as early as 1980, and we presented them to the automobile industry at the end of the decade, almost simultaneously with our colleagues from Bosch. But the time was not yet ripe for this application.

Why not?

Neither environmental awareness nor exhaust legislation had yet become as critical as they are today. A liter of gasoline in Germany cost less than 60 eurocents in today’s money 20 years ago, only a half the current price. The growing frequency of natural disasters shows us that we cannot continue emitting carbon dioxide as in the past. Piezo injection technology makes a significant contribution to the sustainable use of fossil raw materials and reduces the environmental pollution due to combustion gases.

What applications do you see apart from piezo injectors?

Outside the automobile sector, piezoelectric elements are used particularly in communications technology. For example, piezoceramic materials are already being incorporated as microphones and loudspeakers in the mouthpieces and earphones of telephones. And piezoelectric buzzers are used in mobile phones to generate sounds such as the clicking noise made by the keys. A completely different field of application is medical technology, where piezoelectric sensors are used in ultrasound equipment and for measuring the flow of fluids, for example. I also feel that the future belongs to the extremely high-performance piezoelectric motors. They can perform linear and rotary movements and can also be used to control both very slow and very fast movements with precision. And all that without gears.

THE PERSON PROFESSOR HANS MEIXNER

Until the fall of 2004, physicist Hans Meixner headed the Department of Sensor and Actuator Systems at Siemens Corporate Technology. This is where he and his team had carried out the basic research for the development of the piezo injection systems at Siemens. Since starting at Siemens' corporate R&D department in 1973, he had been involved in a wide range of research fields, such as semiconductor laser diodes, semiconducting barium-lead titanate ceramics, new color printing techniques, fundamental applications of piezoelectric materials for sensor and actuator applications, scanning and tunnel microscopy as well as chemo and bio-sensorics. The 67-year old Meixner still acts as a consultant for Siemens Corporate Technology. In the course of his R&D career, he has registered over 300 patents, in particular in 1980 a patent for piezo injectors designed for fuel injection together with his colleagues. This was followed by many more patents in this field.

In addition to his research activities at Siemens, Meixner is also involved with the University of the German Army and the Technical University of Budapest, where he supervises and trains diploma and doctoral students.

He is a member of several committees, such as the Industrial Advisory Board of the Berkeley Sensor and Actuator Center at the University of California, Curator of the Fraunhofer Association and Advisor to the Karlsruhe Research Center.

Since 2006, Meixner has been organizing the cluster platform for sensorics and power electronics in Bavaria that acts within the state's innovation promotion program by networking between business and science.