VIMPA
NEST ADVENTURE

Elastic combustion chambers could provide several times the power of a conventional lithium battery.

Micro-engines pulsate with power

New sources of portable power for applications from laptop computers to biomedical devices need to provide more energy, for a longer time, and from smaller and lighter systems. A novel concept for a micro-engine design, based on a vibrating structure, could provide several times the power of conventional lithium battery technology from a truly miniature device. Applications for this development could cause a 'buzz' in areas as diverse as autonomous flying, robotics and consumer electronics.

As portable electronic and mechanical systems get smaller and more complex, the requirement for very small, but powerful, energy systems increases. Micro electro-mechanical systems (MEMS) could develop as a new class of high energy and high power density generators, which can be embedded in portable or autonomous devices.

Power MEMS will use combustion to generate mechanical and electrical power. Output densities of many watts per cubic centimetre (W/cc) for power are envisaged, while energy densities could be up to several kilojoules per cubic centimetre (kJ/cc): considerably greater than the current maximum values provided by conventional battery technology, and potentially superior to other emerging technologies including micro fuel cells.

Step change

Developments in this area have traditionally been based on scaling down conventional engine designs or developing micro-turbo-machinery or micro-engines inspired by existing concepts. The VIMPA project is looking to produce a step-change development in MEMS power supply, by developing a vibrating frictionless structure using repeated combustion pulses. The multidisciplinary project consortium from Italy, Sweden and Germany will focus on a design using positive displacement rather than turbomachinery, and will avoid rotary or sliding joints to minimise friction, as well as inertial flywheels, since these types of energy storage become ineffective as machines scale down.

The team, coordinated by the Scuola Superiore Sant'Anna of Pisa, Italy, will bring together skills in combustion research, micro-engineering design and MEMS fabrication, with the ultimate goal of demonstrating a complete working prototype for a VIMPA electric generator of around 10mm size and weighing less than 5 grams.

Design concept

The VIMPA concept consists essentially of two chambers: one in which homogeneous fuel charges are held prior to their introduction to the combustion chamber, and the combustion chamber itself. Combustion in the chamber is achieved by homogeneous charge compression ignition and the engine will work at a frequency

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Applications of portable power could cause a 'buzz' in areas as diverse as autonomous flying robotics and consumer electronics. © European Space Agency

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AT A GLANCE

Official title
Vibrating Microengines for Power Generation and Microsystem Actuation

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of 100 to 1 000 Hz: i.e. 100 to 1 000 compression-combustion-expansion cycles per second.

Energy can be recovered in many ways. An electromagnetic or piezo-electric circuit can be coupled directly to moving parts to produce electricity, or a motion converter can recover mechanical energy whilst the unit can couple to a compressor device for power pneumatics.

Liquid fuels, possibly based on sustainable biomass-derived sources, will be used in the VIMPA prototype. A novel fuel injection system will be related to the technology used for nanolitre liquid delivery. Major research efforts will also be required in materials (both metallic and inorganic), energy conversion in devices, engine control and, importantly, hybrid integration techniques – effective methods for bonding silicon-based materials and non-silicon components. The advances foreseen in these individual areas will in themselves provide significant advantages to European knowledge and competitiveness.

The novel fuel injection systems will be related to the technology used for 'bubble-jet' printers.

Micro power – macro impact

The development of small portable energy sources is a priority for further progress in many technology scenarios. Portable consumer or business electronics, such as laptop computers and camcorders, would benefit greatly from the ability to function for a whole day on a single charge.

A second area is in autonomous devices, including field-based microrobotics, where swimming, locomotive or even flying microsystems for environmental surveying and inspection need improved lightweight power supplies. A third field includes biomedical devices, where devices to assist or replace damaged organs need long-lasting and powerful energy supplies.

The VIMPA participants believe that the prototype device will cause a real stir when it is produced, and have plans to move on to a second prototype – a 10mm-sized wireless flying device. This would be the first autonomous flying micromachine and should be able to fly for several minutes.

Clearly, the VIMPA project team have set their targets high, but they are confident that their novel work will truly astonish the international scientific, technological and industrial community.

SIXTH FRAMEWORK PROGRAMME