

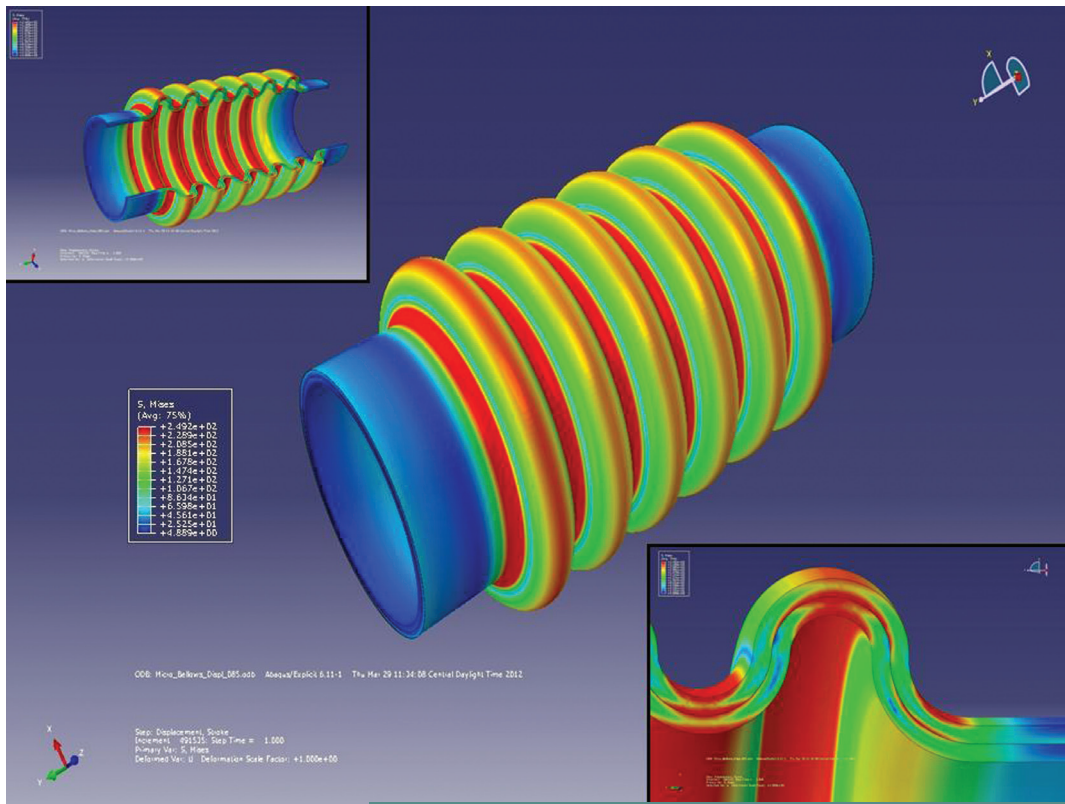
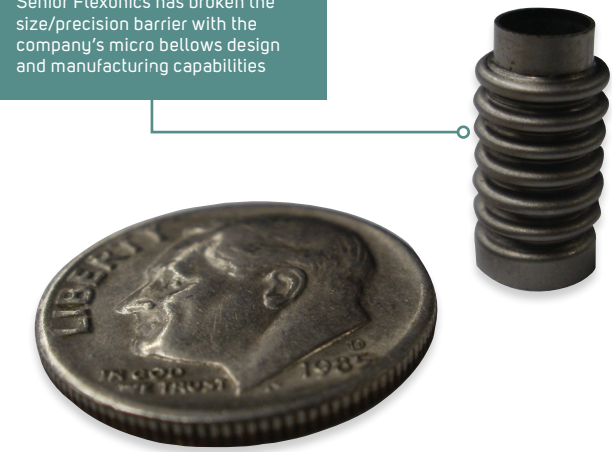
# Micro bellows solutions

A small-scale component for a powertrain application has been designed to withstand extreme requirements as well as heavy vibration and extreme temperature environments

► In today's world, there is a vast amount of interest in issues concerning the environment. Whether one believes in global warming or not, it is constantly being discussed across all forms of traditional and new media. For some, it's a foregone conclusion, and for others it's something to scoff about, with the 'here-we-go-again' crowd cynically reminiscing about Y2K, overcrowding, and the ice-age predictions of the previous generation's doom and gloom scenarios.

Yet regardless of one's personal beliefs, there are more people today entering the middle class on a global scale, which is not necessarily a bad thing, but it will have an impact on pollution and demand for mobility. Leaving the planet cleaner and improving the lives of those transitioning from working poor to middle classes seem to be contrasting goals. However, with the advent of new technologies and innovative manufacturing processes, it is now possible to realize lower emissions while achieving better fuel economy.

Senior Flexonics has broken the size/precision barrier with the company's micro bellows design and manufacturing capabilities



Advanced micro bellows FEA simulations and other validations ensure that automotive engineers can have confidence in Senior Flexonics' designs

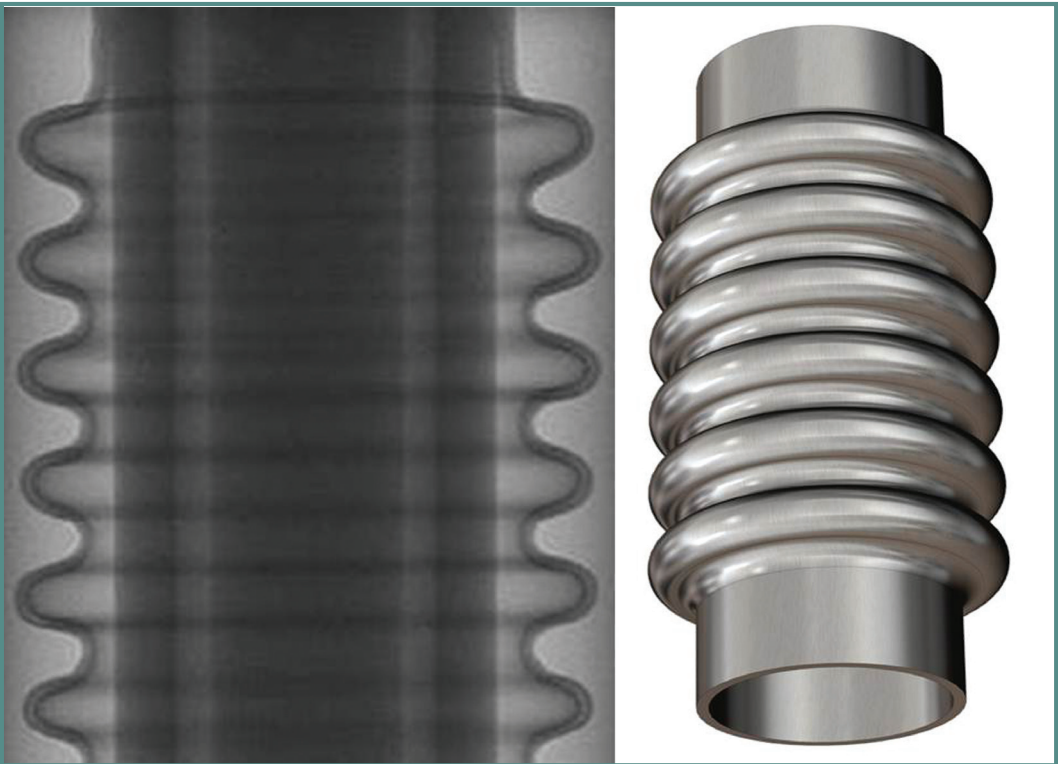
Many of these technologies and innovations are becoming core components in modern engines and emissions technology solutions. One such example is the intelligent fuel injection system that is able to quickly adapt to in-cylinder engine conditions using pressure and temperature-sensing technology. These sensors provide immediate feedback so that the system can adjust the combustion variables to the correct levels required for a cleaner and more efficient engine cycle. Sensor systems and other new technologies are creating a demand for small-scale components that are

able to match any durability level or precision benchmarks.

A micro bellows is one of the small-scale components used to meet or withstand extreme cycle-life requirements, heavy vibration, high pressure, and escalated temperature environments. The core function of a formed metal bellows is to compensate for any axial cyclic loading, while withstanding any harsh operating conditions. As a consequence, designing micro bellows for these tough conditions is challenging, but the ability to manufacture these components in a high-speed,

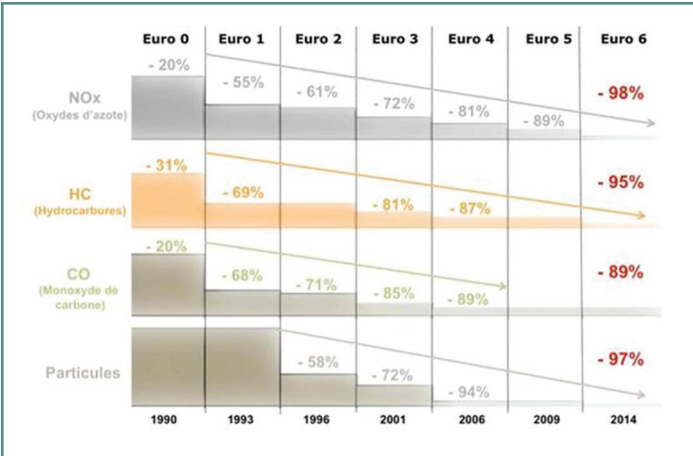
tolerant, and low-cost way far exceeds this initial design challenge.

Senior Flexonics has provided innovative and economic solutions for the design and manufacture of metal bellows and assemblies of all types and sizes for more than 100 years. This expertise has now been applied to an emerging demand for a micro bellows product in a wide range of markets and applications, including modern engine and emissions technologies. Depending on an application's operating and dimensional specifications, the design can be quickly generated to meet all critical requirements. The micro bellows is manufactured to meet these needs by specifying material wall thickness; the number of walls; the number of convolutions; convolution OD/ID size; and many other design variables. These designs are validated using industry standards, FEA simulations, and historical data from previous projects. This design process has a proven history of creating some of the most durable and low-cost bellows solutions available today.



The manufacture of micro bellows is a difficult and complex process, and even in the prototype manufacturing situation, they cannot be made using traditional methods. They have tight tolerances due to their small-scale fit-up requirements, and this is especially the case during later assembly and installation stages. High precision, combined

Micro bellows can be designed and developed for multiple material walls which is particularly useful for high pressure and extreme cycle-life requirements



Stringent environmental directives in Europe and around the globe are necessitating new powertrain and emissions innovations and technologies

with extreme volume and durability requirements, have resulted in the need for new, fast, and lean manufacturing process developments in this market. Senior Flexonics' innovative process for manufacturing micro bellows has reinvented standard practices, while at the same time eliminating the need for high-cost raw materials and secondary processing to increase the micro bellow's durability and cycle life. New high-pressure forming and coining techniques are used to rapidly produce repeatable and precise micro bellows designs with superior quality and cleanliness levels. These new manufacturing processes can be adapted when necessary to meet a variety of application and size requirements.

Core lean manufacturing principles are the fundamental backbone for all processes at Senior Flexonics, and this includes micro bellows products. Standard

Work, SMED, 5S, and many other principles are implemented across a wide range of processes in order to promote continuous improvement and low-cost manufacturing, as well as ensuring future growth and sustainability.

As the world's population continues to grow and impact on the environment, Senior Flexonics is striving to design, develop and manufacture new solutions that will help reduce global emissions. This strategy of using quality manufacturing and innovation to create solutions to global issues should see the company thrive for years to come. ©

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