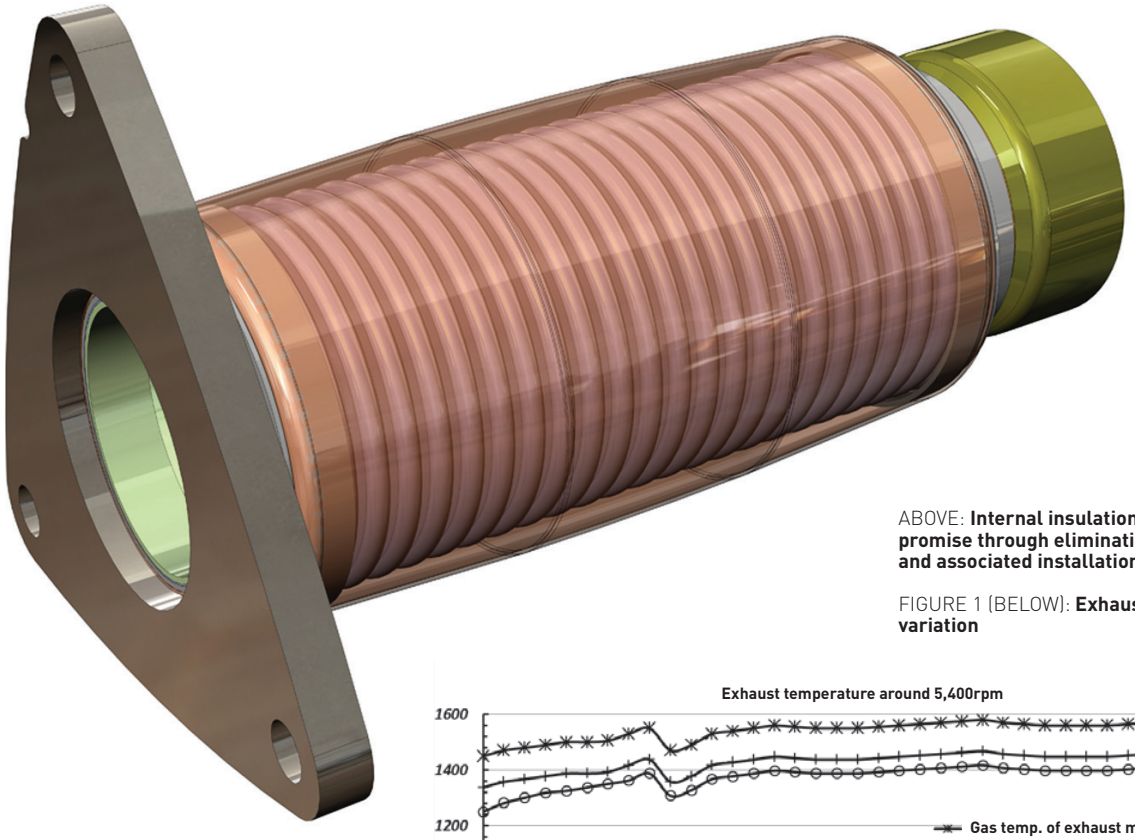
KANGYU HE

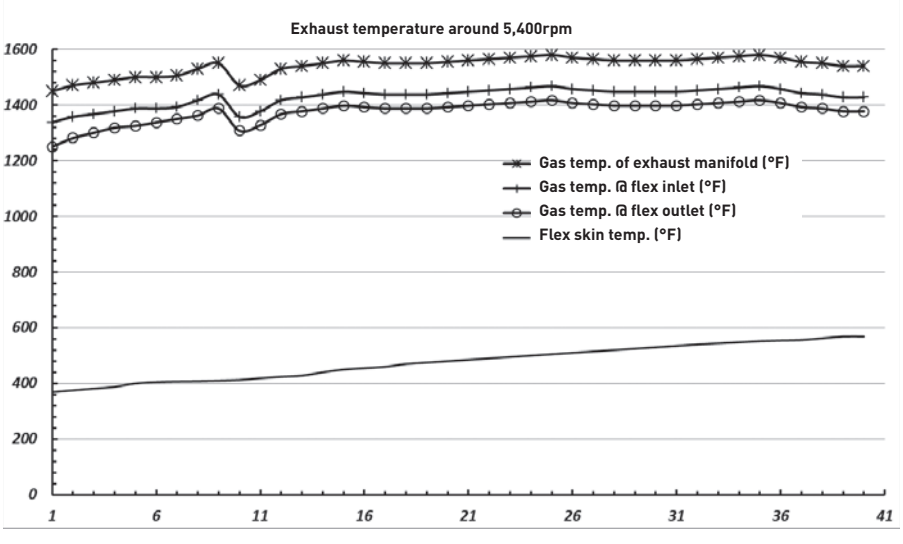
HOT PROPERTY

TIER 4 EMISSIONS STANDARDS ARE RESULTING IN RIGOROUS REQUIREMENTS IN REGARDS TO HEAT LOSS WITHIN THE EXHAUST STREAM – BUT MANY EXISTING SOLUTIONS JUST AREN'T FEASIBLE. SO SEVERAL NEW THERMAL INSULATION TECHNIQUES WILL BE THIS YEAR'S MUST-HAVE ACCESSORIES



ABOVE: **Internal insulation techniques show promise through elimination of bulky wraps and associated installation and wear issues**

FIGURE 1 (BELOW): **Exhaust gas temperature variation**

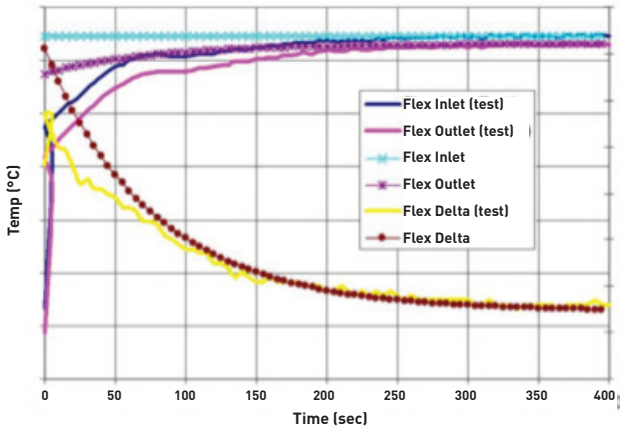


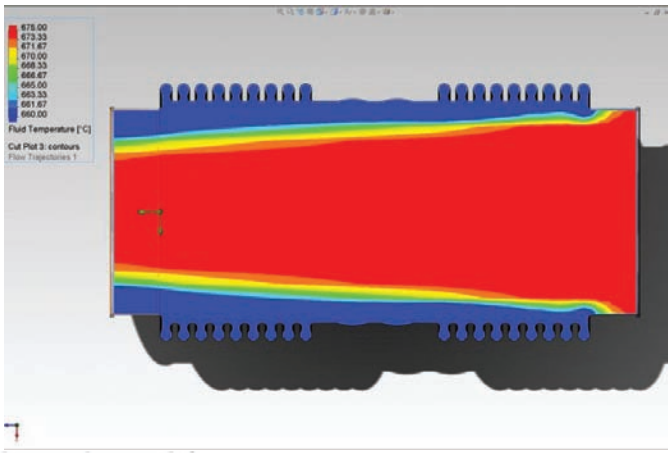
Thermal insulation techniques and solutions are increasingly being used in off-highway engine exhaust systems and other high-temperature areas to reduce material temperatures and prevent heat loss from the pipes and ducts. Insulating heat-dissipating skin is necessary to strengthen material rigidity, to increase fatigue life, to enhance safety, to protect the environment and to improve fuel economy. Thermal insulation applications are seen in many areas of daily life, such as in stationary and mobile diesel engine-generator sets, with the insulation blankets wrapped onto the surface of the entire exhaust system – manifold, pipes, flexes and turbocharger.

In early 1990, when the US Clean Air Act was passed in Congress, air-quality requirements for all on-highway and off-highway diesel engines were established. The development of new aftertreatment for cleaning the diesel engine exhaust was then introduced, such as EGR, DPF and/or SCR; all technologies required to remove NOx and particulate matter.

The Tier 4 emission standards have further tightened exhaust emission control, placing more rigorous requirements on the heat loss from the turbocharger to the diesel particulate filter (DPF) so as to ensure optimal performance of the aftertreatment technologies. The new regulations force stringent conditions on heat loss within the exhaust stream, i.e. temperatures must drop less than 25°F between the turbocharger and DPF.

However, a corrugated thin-wall leak-free metal flex is usually installed between the two to decouple the engine vibration and vehicle body motion, and compensate for any thermal expansion of the entire exhaust system. There are many existing thermal insulation methods for the hard exhaust pipes, such as blanket wrappers and hard coatings – however, should there be constraints on the installation





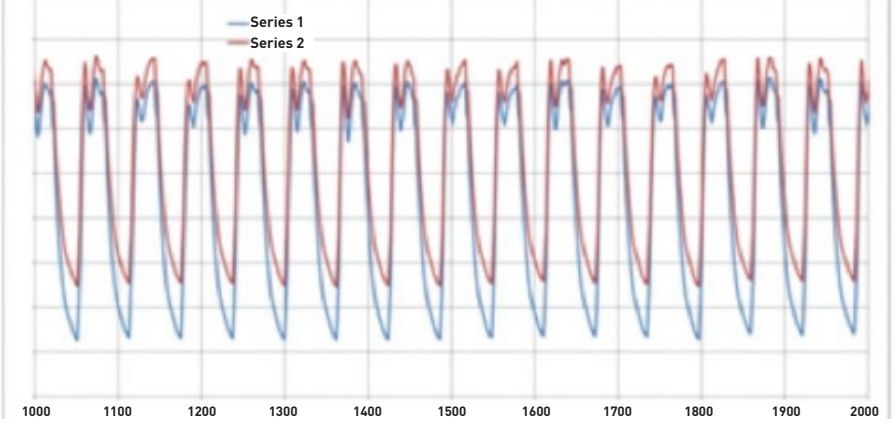


FIGURE 2 (ABOVE LEFT): **Test and simulation of cross-flex temperatures**

FIGURE 3 (ABOVE): **Exhaust gas temperature distribution in a bellows**

FIGURE 6 (LEFT): **Gas temperatures at inlet and outlet of the bellows**

space, environment/health concerns and/or durability considerations, then external wrapping insulation or coating may not be available or feasible. To address these concerns, Senior Flexonics has developed an embedded insulation material located between the RT liner inside the bellows.

New mounting technique

Senior Flexonics has been a pioneer in the diesel industry for researching, developing and manufacturing a wide variety of high-quality metal flexible joints, connectors and hoses with integral thermal insulation techniques and solutions, including a spiral-wound interlocked liner, gas-tight wire-stuffed liner, metal wire braid and hard coating insulation.

The company has used its innovative experimental technologies and numerical simulation methods to develop state-of-the-art techniques and solutions to insulate the bellows skin with a variety of RT liner designs. Figure 1 illustrates one of Senior Flexonics' pioneering thermal insulation developments on a thin-walled corrugated flex applied to a petrol engine, which provides around 10°C of cross-flex temperature drop. Figure 2 shows an experimental test study and numerical simulation on one of Senior Flexonics' bellows, while Figure 3 shows the gas temperature distribution in the bellows.

To meet Tier 4, the company has further studied, researched and developed its state-of-the-art thermal insulation techniques and solutions for both on- and off-highway applications. To date, all thermal insulations for exhaust bellows, whether internal or external, are not suited to high-volume production, or robust enough to resist severe engine vibrations and vehicle movements as a result of rough roads. They use buckles, clamps (wire and band), clippers or wire strings to mount/bind the insulation material onto the outer surface of a liner OD or a bellows OD.

However, all the existing insulation materials, whether ceramic, glass or carbon fibres, are sensitive to skin temperature and the vibration of the bound surface, which are the most critical factors in the ageing and deterioration of the insulation material, causing severe environmental and health problems and potentially shortening the part service life.

To overcome the shortcomings of current thermal insulation solutions for flexible metal bellows applications, the company has developed a new mounting technique to weld the insulation onto the flexible bellows internally and externally with metal wire mesh sock. These metal mesh bags are able to hold the insulation circumferentially; both ends are squeezed by the bellows necks and outer end caps and directly welded onto the connecting hard pipes without changing the current assembly procedures.

To avoid the insulation coming into direct contact with the hot metal surfaces of the bellows for external applications, another metal wire mesh can be added to the internal face of the insulation layer to ensure a gap exists between them. It can also use the inner end caps to create an air gap between the insulation and the bellows skin to reduce possible friction wear and burn on the insulation materials.

These bound solutions can securely and quickly restrict the insulation material and substantially improve reliability and durability. Such mesh bags can additionally be used to confine the insulation to the outer surface of the RT liner and inside the bellows. Figure 4 shows one example of a Senior Flexonics insulated truck bellows.

Wire metal compound insulation

The company has also developed internal insulation technologies for truck and automotive bellows, which can be used for those areas with limited installation space, such as inside engine compartments, or for components with low-grade materials

FIGURE 4: **Senior Flexonics insulated truck bellows**

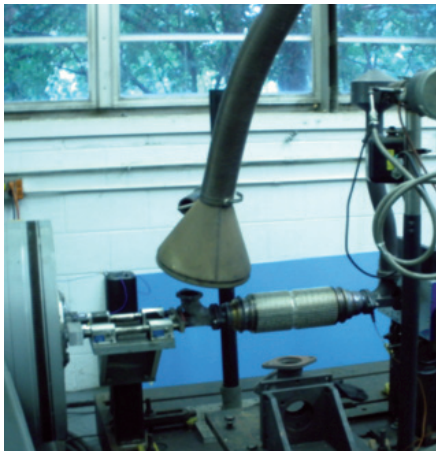


FIGURE 5: (LEFT):
Bellows with partial internal mesh wire compound insulation on shaker

FIGURE 7: (RIGHT):
Diesel engine thermal fatigue test rig

whose endurance limits are particularly sensitive to high temperature.

It has also explored the use of 50% density metal wire compound as insulation through spot welding onto the RT liner OD. Experimental test data shows that this compound can provide great insulation to maintain the bellows skin temperature at less than a quarter of the gas temperature. This metal wire compound layer not only insulates heat energy inside the bellows, but also provides a considerable degree of damping to reduce high-frequency bellows vibration and to greatly enhance the bellows' mechanical fatigue life.

It is also important to realise that the wire compound has 50% metal density and can be used as a wrapper to confine a lower skin temperature fibre material, preventing any fibre debris from penetrating into the liner and migrating into the downstream aftertreatment equipment. As the metal wire compound layer lowers the surface temperature, cheaper insulation materials can be used, such as fibreglass, cellular glass, polyurethane, polyisocyanurate, phenolic foam and elastomeric foam. Figure 5 shows one of Senior Flexonics' bellows with mesh-wire insulation compound tested on a heated vibration shaker.

Senior Flexonics has experimented on its current production bellows with an external insulation blanket under 15-litre engine running conditions. The tested piece can keep the gas temperature drop to below 5°C and has run thermal fatigue life equivalent to 500,000 truck miles, as can be seen in Figure 6. Figure 7 shows Senior Flexonics' thermal fatigue test rig for diesel engine exhaust systems. **iVT**

Kangyu He is a design engineer at Senior Flexonics

CONTACT
www.seniorflexonics.com
beisbrenner@seniorflexonics.com