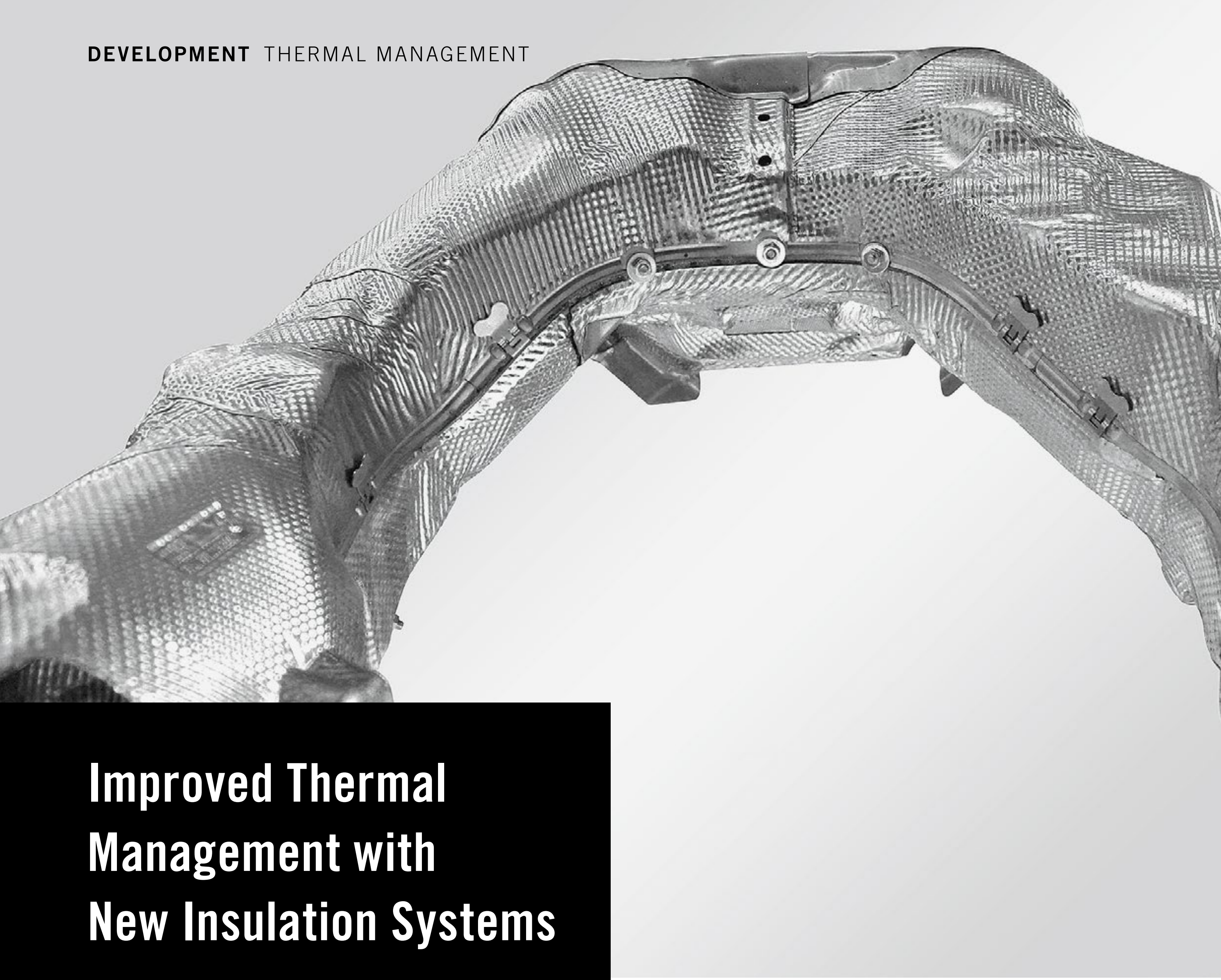

Improved Thermal Management with New Insulation Systems

The developments with regard to emission regulations are constantly facing automotive manufacturers and suppliers with new challenges. To reduce emissions, these are increasingly focusing on the optimization of thermal management too. The Isolite GmbH is developing intelligent systems to support the thermal management of vehicles in all operating modes with the necessary solutions.

NEW LEGISLATION – NEW REQUIREMENTS

Each new European standard presents manufacturers and suppliers with greater challenges. With the emission standards Euro 6c and Euro 6d TEMP in place since September 2017 in the EU, the permissible limits for the emission of carbon monoxide, nitrous oxide and hydrocarbons as well as the mass and number of particulate matter for PCs are again reduced. As a result, the exhaust gas aftertreatment systems necessary in order to comply with the legally required maximum values for polluting emissions have to become more and more complex. All components involved in aftertreatment are reliant on a minimum working temperature – the so-called light-off temperature. Regular removal of the individual pollutants through filtering can only be guaranteed when the individual components of the aftertreatment system involved – a particle filter as well as a storage-type, an oxidation-type and an SCR(Selektive Catalytic Reduction)-type catalytic converter – display a working temperature of between 250 and 400 °C. In the past, this problem was mainly restricted to diesel vehicles, which are not able to

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realize aftertreatment correctly and consistently due to their low exhaust temperatures of 250 °C in idle mode and 800 °C in the full-load range. As a result of heat conduction and convection, considerable heat losses occur in the vicinity of the components conducting the exhaust gases, causing the temperature of the latter to fall below the minimum values necessary for aftertreatment. This effect is countered by insulation on the one hand and energy input in the form of fuel injection on the other.

As a result of the emission standard which recently came into force, gasoline engines are now affected by this subject too, and they are currently being equipped or retrofitted with a gasoline particulate filter. To ensure that the aftertreatment system functions correctly, the filter is ideally positioned immediately adjacent to the engine. This is not always feasible due to restricted installation space, with the result that the exhaust gases can undergo temperature losses on their way to the aftertreatment system. In consequence, the automobile manufacturers increasingly require insulation systems to heat up the components of the aftertreatment system as consistently as possible with the help of heat conservation and the corresponding conservation of energy.

The insulation is another element which can only realize its full potential when completely heated through. According to the heat requirement calculation $Q_{iso} = m \cdot cp \cdot \Delta T$, the heat dissipated Q_{iso} is only reduced (and consequently retained in the exhaust system) when the smallest possible difference between initial temperature and final temperature ΔT has been reached. This shows that even a passive system can have an effect on the aftertreatment process. It is important to keep this necessary heating-up phase, also known as light-off phase, as short as possible according to the above formula during cold starts of the vehicle and in start/stop operation. This is because, at these two operating points in particular, the exhaust emissions are currently still very high as the necessary temperatures are not reached there. To counter this effect as well as the – admittedly slight – increase in consumption due to additional fuel injection, Isolite is working successfully on the implementation of appropriate solutions.

CHOICE OF MATERIAL FOR THE INSULATION

Today's PC engines can generate exhaust gas temperatures of between 800 and 1050 °C. This means that the materials required in the hot-end area must display the necessary heat resistance, and Isolite is working on all aspects of optimizing their use. All insulation materials matching the requirements are used in conjunction with an insulating liner made from austenitic corrosion-resistant steel to protect the surface and shield the surrounding components, thus ensuring heat conservation. A special moulding process brings forth the three-dimensional fibre moulding on which the systems described in the following are based. Using additives, a fitting solution is created according to the customer requirements, which, in addition to the thermal and acoustic properties, also ensures stability and durability.

Depending on the application, the insulation material for the insulating component of the system can be chosen as required according to the field of application and the application temperature. Silicate fibres display the highest stability at a temperature of 1000 °C in continuous use. Alternatively, ECR (Electro-Glass Corrosion Resistance) fibres which are stable up to 800 °C or so-called E-Glass (Electro Glass fibres, stable up to 600 °C) can be used.

FIGURE 1 With iTex Econ insulation system, groove-type cavities run through the area between filler insulation and metal lining for additional energy conservation (© Isolite)

INNOVATIVE INSULATION SYSTEMS

To better meet the new challenges, Isolite has developed a passive insulation system called iTex Econ which has been in use in a similar form for several years now as iTex Ref-Iso. It is based on a three-dimensional fibre moulding with a radiation-reflecting surface which is given an increased TSR (Total Solar Reflectance) value with the help of a special coating, thus allowing energy to be conserved effectively by reflecting the heat radiation.

To fully optimize the existing system for exhaust gas aftertreatment, Isolite developed the basis of the Ref-Iso patent further and put the result on the market in early 2017. The passive insulation system iTex Econ differs from its predecessor mainly with regard to structure and operating principle, but it is comparable in terms of fibre moulding and installation. Under the metal lining, a filler insulation made of fibre material ensures a low thermal conductivity. In contrast to the old design, the insulation displays a uniform structure, so that groove-type cavities come into being in conjunction with the component to be insulated, **FIGURE 1**. These stores of air running along between the filler insulation and the contact surface promote additional energy conservation. Air heats up using a much lower amount of energy than conventional insulation materials do, causing the energy loss to drop in heating-up phases in particular. The cavities also permit very little convection, with the result that virtually all of the heat energy is trapped in the insulated area. At the same time, the thermal conductivity of the overall system necessary for thermal management, **FIGURE 2**, stabilizes between that of air and that of the relevant filler insulation (in this case silicate fibre). iTex Econ technology is already in use in this form in the fields of commercial vehicles and PCs.

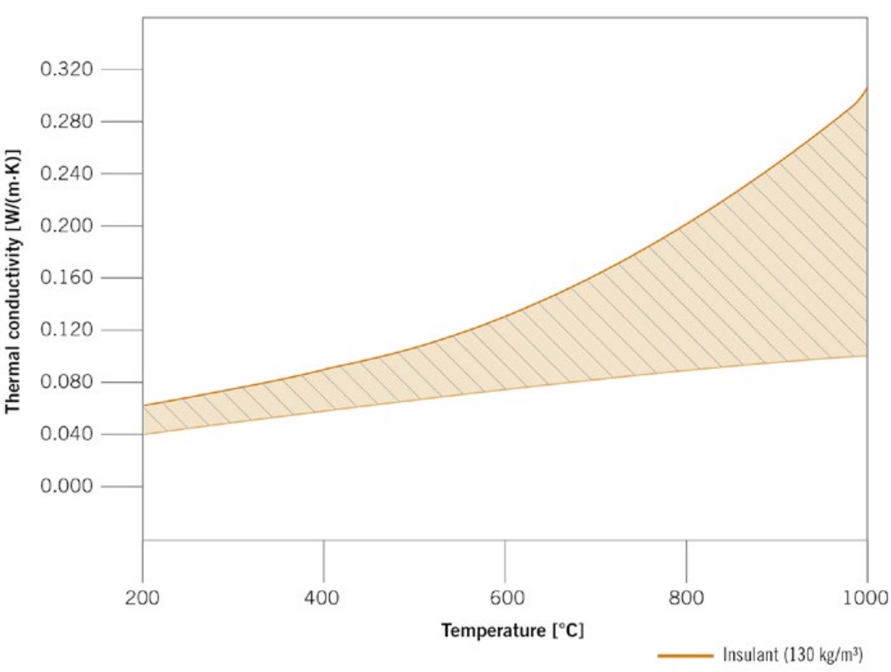

FIGURE 2 Comparison between the thermal conductivity of silicate fibre and that of stationary air (© Isolite)

ACTIVE THERMAL MANAGEMENT

In addition to the iTex Econ technology, Isolite provides an active regulation of the thermal management in the insulation system. The specially developed so-called Heatpack is a component whose approach to insulation differs from that of iTex Econ. In terms of its operating principle, it can be compared with a heater, as it converts electrical energy into thermal energy using an integrated heating element, **FIGURE 3**. A control circuitry allows the exhaust gases to be monitored constantly, and it transmits real-time data to the system,

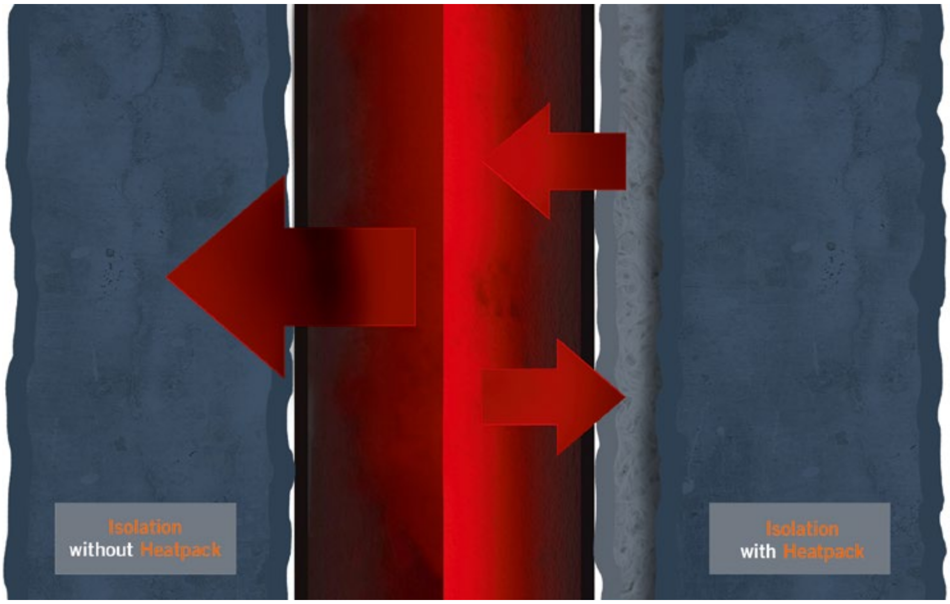

FIGURE 3 Insulation in the heat management system with and without Heatpack (© Isolite)

which switches on immediately when the temperature falls below the minimum working temperature. Subsequently, the temperature in the exhaust system rises, allowing the temperature difference ΔT to be compensated within an extremely short time in the cold start phase, **FIGURE 4**, or the instationary phase, **FIGURE 5**, of the vehicle. In addition, the inversion of the direction of heat flow while Heatpack heats up makes it possible to reduce the light-off phase still further. Depending on the requirements, the Heatpack can either be used as a stand-alone element or integrated into the system. In this way, it can be used in all areas requiring active energy input.

In addition to the passive or active solutions for the direct insulation of individual components of the exhaust system, Isolite has developed a semi-active modular system, the so-called thermo air duct, for insulating entire component assemblies, **FIGURE 6**. This is currently installed in a model series of a German premium manufacturer, and a universal version is now in the development stage. The thermo air duct consists of two deep-drawn stainless steel sheets. The structure is based on two separate half-shells with a filler insulation inserted between them in a sandwich design. Specially developed connection and closure elements as well as a high-temperature sealing system link them with one another as impermeably as possible and prevent leaks.

Depending on the operating point of the vehicle in each case and the amount of energy required, the existing quantity of heat has an active effect on the subsequent exhaust gas aftertreatment system. The thermo air duct is positioned in the immediate vicinity of the engine manifold, surrounding the components conducting the exhaust gases as well as the aftertreatment components and contributing to the optimization of thermal management close to the engine. It can be used effectively for all high-performance engines with a large number of additional aggregates or for engines displaying increased heat development due to downsizing. Depending on the requirements, the engine fan allows trapped heat to be conserved or dissipated by regulating the electrical control unit, thus minimizing any temperature fluctuations in the engine area. Thanks

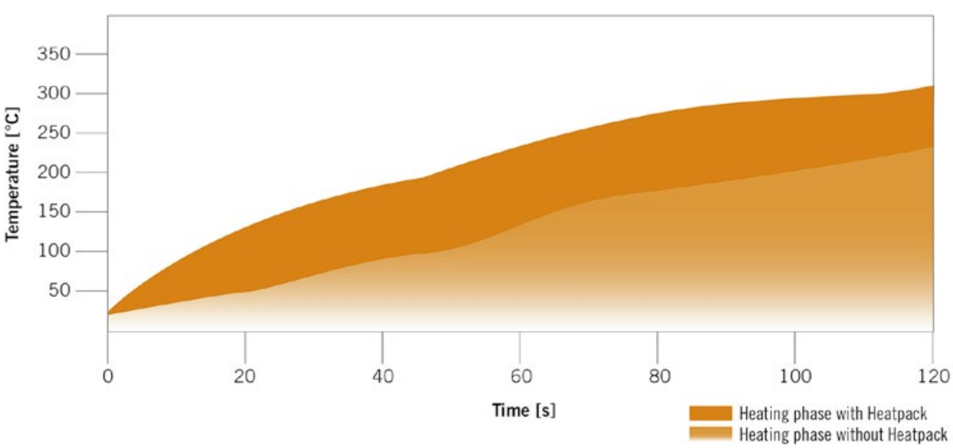

FIGURE 4 Simulation of a cold start: the measurement of the light-off temperature with and without Heatpack shows a clear increase in the temperatures, allowing the exhaust gas aftertreatment system to function more effectively (© Isolite)

FIGURE 5 Simulation of the start/stop phase: with an active Heatpack, the exhaust gases display a constant temperature in the exhaust pipe, and this allows the aftertreatment system to function in accordance with the regulations at all times (© Isolite)

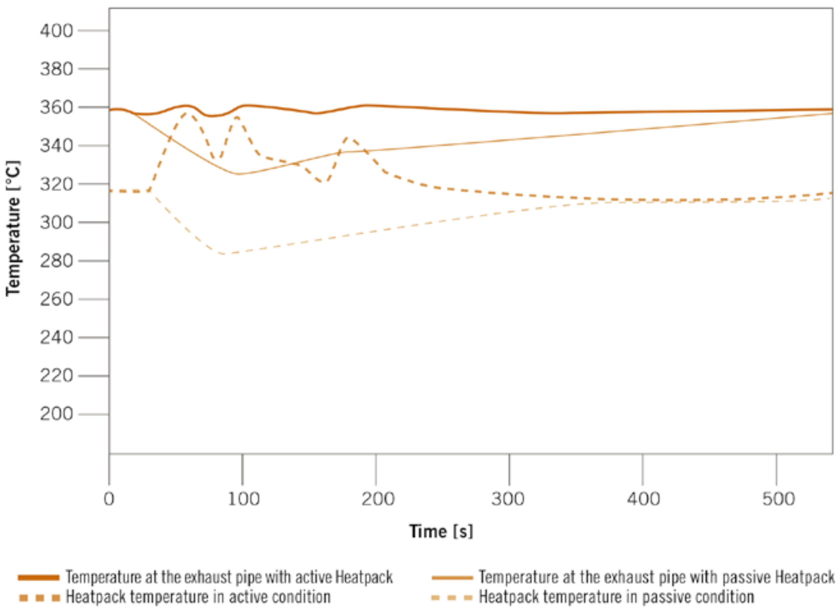

FIGURE 6 The thermo air duct surrounds the section between the components conducting the exhaust gases and the aftertreatment components (© Isolite)

to these possibilities, excess thermal energy in the vicinity of the engine block, the turbochargers and the manifolds can not only be suitably dissipated as thermal losses through cooling – the structure surrounding this heat quantity also allows it to be transferred to areas of the exhaust system with increased energy requirements.

OUTLOOK ON FUTURE DEVELOPMENTS

With the experience in the field of high temperature insulation, Isolite is continuously developing existing systems with regard to current and future market developments. At present, for example, the company is carrying out various test series on the use of the Heatpack in the high-voltage area and on a version of the thermo air duct made of polymer to optimize its weight, thus increasing the range of possible applications for it.

Also, the current trends and developments towards electric mobility in the automotive industry will require insulations too. Exhaust gas aftertreatment systems will no longer play a role in CO_2-neutral individual traffic, but thermal management will continue to be of central importance. In the future, too, intelligent insulation systems will be the fundamental requirement for regulating the heat flows in electric vehicles as efficiently as possible, so they will also be a factor affecting the performance. The relevant technologies are essential for the management and transport of the heat and cold occurring in the vehicle. Thus, a high-performance thermal management system plays a similarly important role for ensuring the availability of the battery under all operating conditions in electric vehicles as it does for the reduction of the energy required. For example, a suitable insulation helps the battery to retain its optimum operating point, and this is an essential aspect affecting its performance. The range plays a significant role in the current discussion too, and it can be extended considerably using a suitably dimensioned thermal management system. Isolite is currently looking into the transferability of the existing systems and designing new solutions to meet future customer requirements.