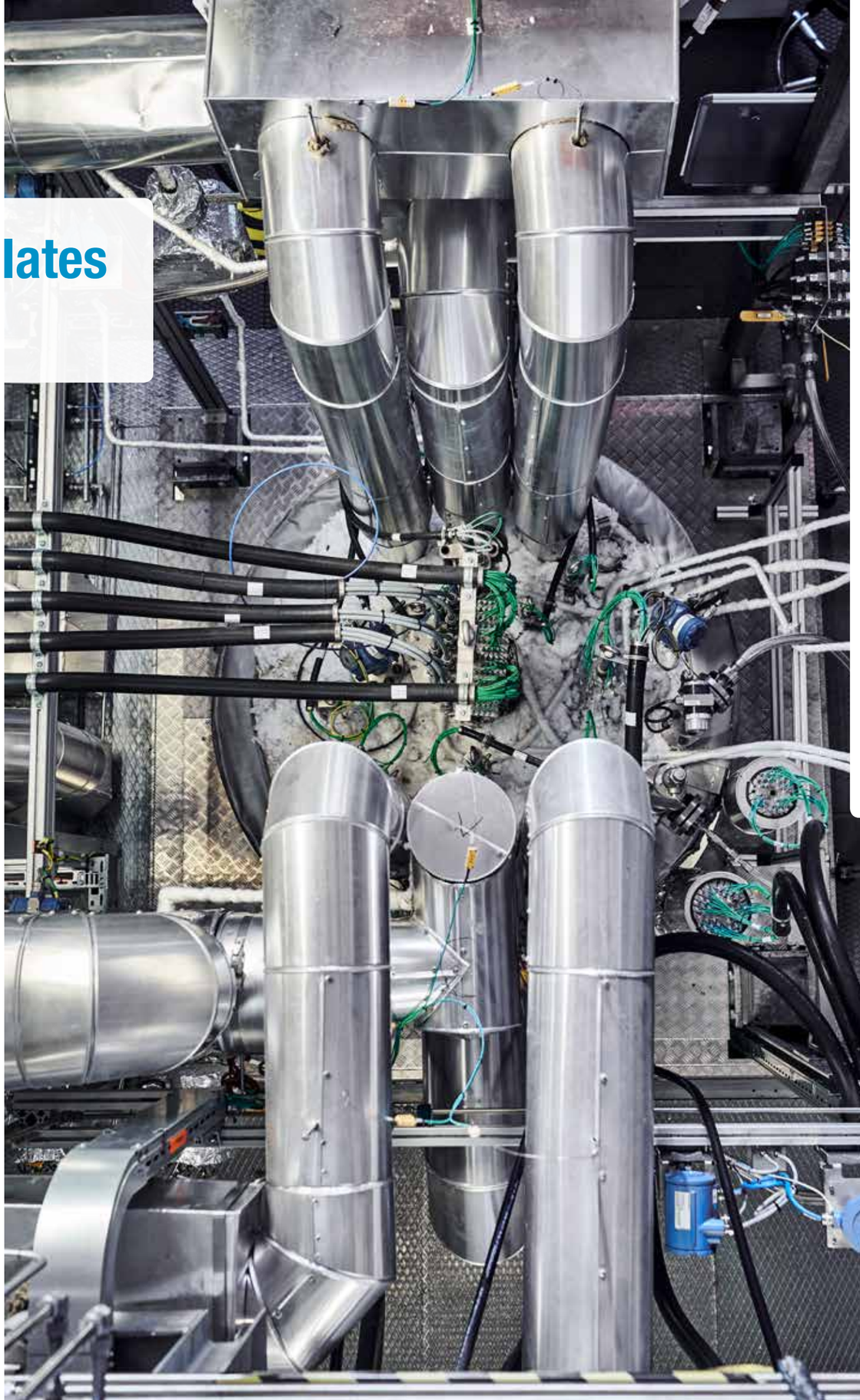
Mini-MYRRHA simulates cooling in reactor

In Mol, you will find the world's only complete scale model of a nuclear reactor cooled with a liquid lead-bismuth alloy: E-SCAPE. With the 1:6th scale model, researchers study the cooling of innovative research reactor MYRRHA. With positive results. Cooling remains guaranteed.

MYRRHA will produce medical radioisotopes, facilitate material research for fission and fusion reactors and take a big leap forward in closing the nuclear fuel cycle. For the latter, SCK•CEN implements the transmutation principle. "Through nuclear fission, transmutation transforms long-lived, highly radiotoxic residue – the so-called minor actinides such as neptunium, americium and curium – into less radiotoxic elements, which also have a shorter half-life", explains nuclear engineer Katrien Van Tichelen. As such, transmutation lightens the requirements for geological disposal, but it doesn't work in existing water-cooled reactors. In these reactors, the probability of absorption, whereby the atom absorbs the neutron and becomes heavier, exceeds the probability of fission for certain atoms. "It is precisely these heavier atoms that contribute most to the radiotoxicity of nuclear waste and have a longer lifecycle. Faster neutrons do manage to split those heavier nuclei", says Katrien.



Water moderates, slows down fast neutrons and hampers the splitting of minor actinides. "Transmutation cannot occur in these circumstances", explains Katrien. In the MYRRHA design, a eutectic alloy of lead (44.50%) and bismuth (55.50%) will cool the core without slowing down the fast neutrons. "The coolant flows through the reactor core, absorbs heat, rises and sheds this heat in the heat exchangers before dropping back down into the core. This cools the core."

Natural convention cooling

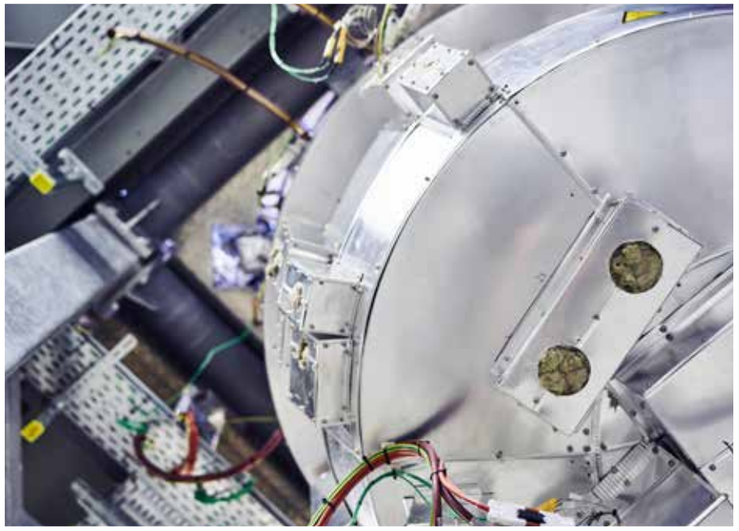
In all circumstances, temperatures must be contained in the reactor core. "To test this, we designed E-SCAPE: an experimental 1:6th scale model of MYRRHA, a.k.a. mini-MYRRHA", says Katrien. The configuration of E-SCAPE is – just like MYRRHA itself – of the so-called pool type. This means that all parts – reactor core, pumps and heat exchangers – are submerged in the coolant. "To simulate the heat of the reactor core, we installed electrical heating elements in E-SCAPE. These heating units are positioned in five rings and have a total capacity of 100 kilowatt in a volume of 30 litres. With about 300 probes, we monitor and map out the temperatures in the tank", explains researcher Fabio Mirelli. All components of the scale model are switched off systematically to simulate accidental circumstances. "What if a pump suddenly fails? What if a heat exchanger doesn't work properly? Does the mechanism of natural convection kick in? Can we guarantee the cooling of the core? That is the important information for the design and safety analysis of the MYRRHA research reactor."

Fabio Mirelli, researcher at SCK•CEN

“Our experiments produce essential information for the design and safety analysis of MYRRHA.”

Natural convection means the flow of a fluid that results from a difference in density caused by a difference in temperature. “A hot liquid has a lower density and floats upwards, while a cold liquid sinks because of its higher density”, explains Katrien. In 2018, the first results of the large-scale experiment rolled off the press. “The system works. Natural convection cooling is more than enough to evacuate residual heat. Even when we switch off the pumps, cooling remains guaranteed”. Both researchers are beaming. In the coming months, the research team will be scrutinising the results.

Katrien Van Tichelen, nuclear engineer at SCK•CEN



Reassuring noise

Last year, both researchers spent a lot of time near E-SCAPE. “In the summer, it is about 30 to 35°C in the room”, says Fabio Mirelli knowingly. A sweltering temperature, accompanied by the uninterrupted droning of the pumps. “This humming sound becomes reassuring after a while. It is like the engine in your car. The noise tells you if everything is running smoothly. I really do want to hear the pump noises.” Once the experiment is running, the researchers only need to keep an eye on things and analyse the recorded data. In order to have a better idea of the flow patterns of the lead-bismuth alloy, researchers are planning measurements with ultrasonic velocimeters in 2019. Longer-term, the researchers will also test the chemical conditions of the liquid alloy in E-SCAPE. “Then, we will have a wealth of information, essential data that will enable us to assess what to expect of the working of the MYRRHA research reactor”, concludes Fabio.

Technology

Playing a pioneering role

SCK•CEN is home to technology and innovation. Thanks to our unique installations, we can conduct ground-breaking experiments and develop state-of-the-art technologies. However, innovation is not only the result of acquired knowledge or developed technologies. Innovation also relies on the creativity and motivation of our staff. They are paramount to inspire and create opportunities in order to develop efficient solutions for our society.

Marc Schyns
Institute Director
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