producing medical radio-isotopes with minimal nuclear waste.

HIGH-TECH SYSTEMS

CORE COMPETENCIES

1. Producing radio-isotopes with minimal nuclear waste
2. Using liquid metal as a coolant
3. Running a radiation facility with automated harvesting robots

Radio-isotopes are widely used for medical diagnostics and treatment, predominantly in cancer care. The most commonly used medical radio-isotope is Technetium (Tc) 99m, enabling tens of millions of diagnostic procedures annually. The current production method, based on uranium fission in nuclear reactors, has only a 2% yield of the isotope wanted. The rest is mostly nuclear waste. Demcon helps to realize a radically different production method: producing these important isotopes, with minimal nuclear waste.

Developing a novel production facility

The Belgian organization IRE is one of the four largest suppliers of medical radio-isotopes on the planet. In the SMART project, IRE is developing a novel production facility for Molybdenum (Mo) 99, the 'parent isotope' of Tc-99m. The medically used Tc-99m has a half-life of only 6 hours. Hence, production of this isotope directly is not feasible without it decaying before it reaches the hospitals. The halftime of Mo-99, in contrast, is 66 hours, which leaves just enough room to ship it around the world. At the hospital or treatment centers, it decays into Tc-99m, which is injected for medial use.

DEMCON

The novel production concept is based on the LightHouse Isotopes concept. It relies on exposing a molybdenum-100 target to high-energy electrons to produce Mo-99 by releasing a neutron. A factory is being developed that will supply a large share of the global Mo-99 demand without using a nuclear reactor.

Demcon is developing the exposure and harvesting modules, the very heart of this groundbreaking factory. This comprises the molybdenum irradiation target with the size of a matchbox, around which the entire factory (approximately the size of a soccer field) is built. The target is hit by the 3 Megawatt electron beam. This clash not only leads to the formation of the desired Mo-99 isotope, but also to intense heat. This power can only be removed by liquid metal coolants to prevent the Mo target from melting. The target will remain in the exposure module for a week to reach sufficient levels of Mo-99 activation. The harvesting module includes the systems to extract the activated part and replenish it with fresh molybdenum.

Pushing what is technically possible

The three key challenges in the SMART project arise from the high energy of the electrons and the resulting high power dissipation in the target and surroundings: How can we handle 2 Megawatts of power in a matchbox-sized target? The first issue is cooling the target. The second challenge is handling the intense radiation during exposure. It is not only deadly to humans but also causes all components in the vicinity of the target to deteriorate quickly. Third, given these challenges, how can you operate the factory reliably in a fully continuous process?

The solution of the cooling challenge is found in using liquid sodium as a coolant, which, however, comes with challenges of its own as a consequence of the highly reactive nature of this metal. The radiation issues require thick radiation shielding and as well as the meticulous selection of components and materials. The reliability challenge is tackled by using an automated harvesting process and a modular design, which facilitates component replacement based on predictive maintenance.

Given the novelty and complexity of the challenges, it is difficult to prove the feasibility of our design solutions for the exposure and harvesting modules. Verification experiments are mandatory to quantify the key unknowns. A central role in these experiments plays a miniature (1 in a 1000) version of the full exposure cell. We are very happy that it passed its Site Acceptance Test (SAT) at full power density successfully on the first try.

“using high-energy physics and engineering to reduce the amount of radioactive waste”