Accelerators to reduce pollution of maritime traffic

A crazy idea that may actually work?

Can you imagine trying to convince a ship's captain to trust a team of physicists, even being part of a mulidisciplinary group of engineers and technicians, to make the engine of his ship available for what one could call a futuristic experiment? Namely, to use a particle accelerator to clean the exhaust gas of his ship's diesel engine.

What is a particle accelerator?

The result of an internet search for "particle accelerator" is basically: "a device that accelerates particles". According to Wikipedia it is: "a machine that can propel charged particles to very high speeds and energies, and confine them in well-defined beams using electromagnetic fields.

What particle accelerators are used for?

Many people, nowadays, associate "particle accelerators" with research laboratories such as CERN , near Geneva, Switzerland, where large accelerators are used for fundamental research in particle physics. However, it comes as a surprise, even to scientists, that in fact, currently, there are more than 30,000 accelerators in operation around the world and only a small fraction, about 6%, is used for research. The vast majority are actually used for societal applications, for example, in industry, for medical applications and even art authentication. Accelerator experts are constantly adapting the developed technologies to bring to existence compact, modular, flexible, and even portable accelerators for the benefit of society.

An unusual application of particle accelerators

But who would have thought that accelerators could be used to clean the exhaust gases of ships' diesel engines aiming at reducing the content of pollutants. What a remarkable example of how society could benefit from particle accelerator technologies. Indeed, maritime traffic is referred to, by far, as the largest contributor to air pollution. In fact, a single cruise ship can do so much damage to the environment as one million cars by emitting substances which contain microscopic solids or liquid droplets, among them sulphur and nitrogen oxides, that are so small that they can be inhaled and cause serious health problems.

The development and innovationn environment

Such an *innovative* idea was explored and developed in the fertile environment fostered within the "Accelerator Research and Innovation for European Science and Society" ARIES EU-funded project and its collaborators leading to a real-scale prototype test publicized in an Accelerating News article.

How it works

The solution, proposed by the ARIES accelerator scientists, combined irradiation by an electron-beam accelerator followed by purification in a "wet scrubber", as shown in the images below. The accelerated electrons induce processes called "molecular excitation, ionization

and dissociation"; these are interactions of the electrons with the molecules that break down the larger molecules of harmful pollutants (sulphur and nitrogen oxides) into smaller molecules. These are no longer harmful, and then can be easily treated. This enables their removal in a small scrubber placed after the accelerator. This scrubber, simply washes them out using alkaline water.

The actors

The real-life test-bench was the old and rusty Latvian tugboat Orkans moored at the Riga shipyard on the Baltic Sea which provided its old but powerful engine for the test. A long pipe, equipped with several detectors, connected the tugboat to an accelerator which was installed on a truck. A specially built chamber allowed the exhausts of the ship engine to be treated, then passed through the small scrubber and finally released into the air.

Did it work? Results

The measurements from this first exploratory experiment confirmed the expectations by showing a significant reduction in pollutants. Based on these encouraging results a roadmap is now laid out with the goal of installing and testing a specially designed compact accelerator on a real cargo ship. In this way, accelerator technologies, initially developed for fundamental research, contribute to non-invasive, green methods, for treating maritime pollution.

Connection to IPPOG

The project leader from the Riga Technical University, Toms Torims, who supervised the test, was instrumental for the Baltic countries joining CERN and IPPOG, and also for promoting IPPOG masterclasses and other activities. With his father working in the shipyards and his own over 20 years of maritime engineering career, it was only natural for him to become interested in the relevant technologies, which originated at the INCT institute in Warsaw, Poland, and then to find ways to turn them to reality within the ARIES project.

As an excellent story teller, he can share his experiences while his enthusiasm can be contagious.

As he said "The long pipe from the ship to the truck actually connected two totally different worlds: the world of shipping and the scientific world of particle accelerators. Their technologies and their languages are entirely different, but having them working together may potentially boost such applications for the benefit of the environment and society".

The ARIES project coordinator, Maurizio Vretenar of CERN, fervent advocate of bringing particle physics technologies to society, played an important role in supporting IPPOG activities, and, in particular, the Particle Therapy MasterClasses in their first steps. As he said "Technology leaps always appear at the boundaries of different disciplines. By connecting accelerator physics, chemistry and engineering, we created the conditions for substantial progress towards the preservation of our environment".

Contributors

The origin of this technology is the Institute of Nuclear Chemistry and Technology (INCT) of Warsaw, which was adopted by the ARIES project, funded by the EU Horizon 2020 programme. A collaboration within the ARIES project was formed, aiming at a real-life test, bringing together all the necessary actors and competences of the ARIES partners.

The Riga Technical University (Latvia) organized the experiment and secured the ship. The Institute of Nuclear Chemistry and Technology (Poland) contributed to the scrubber and carried out the tests. The Fraunhofer FEP company (Germany) provided a movable electron beam accelerator on a truck, routinely used to sterilize crops, and contributed to the tests. CERN, the European Organization for Nuclear Research (Switzerland), provided support and consultancy.

Further reading

This endavour was made known to the wider accelerator community through the Accelerating News. The scientific results were published through a dedicated ARIES deliverable. For further details on accelerators' developments, within the ARIES project, and their usage for societal applications, the ARIES Monograph can be consulted.

Images

The images below, taken from the ARIES repository and published via the Accelerating News give a feeling of how a "crazy idea" was brought into reality!

The captain of the Orkāns on the bridge. (Image: ARIES)

The tugboat Orkāns. (Image: ARIES)

The test area, with the tugboat on the right, the accelerator truck in the center and the scrubber on the left. (Image: ARIES)

The connecting pipe and the accelerator on truck. (Image: ARIES)

Measurement of exhaust composition. (Image: ARIES)