THE PROOF-OF-CONCEPT RESULTS: DEVELOPMENT OF HYBRID ELECTRON ACCELERATOR SYSTEM FOR THE TREATMENT OF MARINE DIESEL EXHAUST GASES

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This paper provides comprehensive analysis of the proof-of-concept results and for the very first time offers complete picture of the novel hybrid e-beam technology capabilities to successfully remove multitude of the hazardous pollutants from the marine diesel engine off-gases. It confirms the feasibility of the particle accelerator system application within the real marine environment. Substantial abatement of the undesirable diesel engine exhaust gases, such as the nitrogen oxides (NO_x) and sulphur oxides (SO_x) as well as particulate matter (PM) and volatile organic compounds (VOC), has been achieved by using electron beam accelerator in combination with the simplified wet scrubber.

Relevance of this research is grounded not only in the effective demonstration of the particle accelerator societal application, but in the knowledge that this can be a tangible technological solution to address the pertinent needs of the maritime industry at large. Today international, regional and national legislation is imposing firm restrictions to the allowed NO_x and SO_x levels, literary within all major maritime trade routes. According to Annex VI of the MARPOL convention [1] SO_2 maritime emissions are limited to 0.5% sulphur content in fuel. In number of major trading areas these emissions are even stricter - 0.1%. Consequently, maritime industry is ensuring its compliance with the regulatory requirements by choosing between:

(a) expensive and in the long run unproven shift form the heavy fuel oil to the marine gasoline (which solves SO_x problem, with NO_x issue remaining); or

(b) by installing on-board exhaust gas abatement systems – scrubbers for SO_x and fuel combustion process modification (engine modifications) or catalytic reduction (SCR) devices for NO_x removal.

Both options are technologically challenging and very expensive. Thus, it is by no means a universal panacea for some 60 000 sea-going ships of the world merchant fleet. The hybrid technology which is being described here, can be viable and cost-effective alternative to the ship owners. Furthermore, virtues of this technology, calculations and empirical results are indicating that also other GHG (e.g. CH_4, N_2O and even CO_2) could be successfully removed from the marine diesel engine exhaust gases. This is very promising avenue since reduction of the GHG is one of the paramount EU priorities within the Green Deal and other similar international initiatives.

Additionally, new restrictions for the PM and VOC levels are in the sight and currently being considered by the global policy makers. Considering global efforts to fight climate change and to significantly reduce pollution caused by the ever-growing maritime traffic, clearly it is just a question of time when stricter GHG emission levels will come in along with requirements to cap the PM and VOC pollutants.

The proof-of-concept pilot project was successfully carried in Port of Riga in Latvia. It was a world premiere where operational sea-going ship exhaust duct was connected to the hybrid off-gases cleaning system, comprising an electron beam accelerator system and sea water scrubber. This was conceivable thanks to the collaborative effort between Riga Technical University, Institute of the Nuclear Chemistry and Technology, Fraunhofer FEP, CERN, Remontowa Marine Design, Milgravja Tehnologiskais Parks - Riga Ship Yard and Biopolinex, within the EU co-funded ARIES proof-of-concept project [2]. This multidisciplinary team embraced know-how and advanced accelerator technology expertise, combined with technical integration and high-end engineering knowledge as well as maritime industry capability.

The conference presentation and eventual scientific paper will explain all technological aspects of the test installation and will outline in detail the obtained results in the NO_2 [3] and SO_2 reduction with the special emphasis to the VOC removal [4]. Economical feasibility results will complement the promising conclusions of the ARIES proof-of-concept project. The next steps will be discussed and potential opportunities shall be delineated.

REFERENCES

[1] IMO MARPOL Annex VI, Resolution MEPC.259(68)
[2] CERN, https://aries.web.cern.ch/aries-proof-concept-fund
[3] NUKLEONIKA 2021; 66(4):227-231, doi:10.2478/nuka-2021-0033
[4] NUKLEONIKA 2021; 66(4):193-199, doi:10.2478/nuka-2021-0028