12th CIMAC CASCADES 2021

22 SEPTEMBER 2021 | GRAZ, AUSTRIA

On the Way towards Decarbonization – Green Fuels, Hybridization and Digitalization in Large Engine Applications

Hybridization and Electrification of propulsion systems for Inland Water Ways

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On the 1st of January 2020, the EU Stage V emission standards entered into force for non-road main and auxiliary engines with a reference power above 300 kW, being effective for internal combustion engines installed in non-road mobile machinery (NRMM) like inland waterway vessels.

The Stage V regulation calls for limit values for emissions of nitrogen oxides (NOx) of 1.80 g/kWh, hydrocarbons (HC) of 0.19 g/kWh, carbon monoxide (CO) of 3.5 g/kWh and particulate matters (PM) of 0.015 g/kWh. Additionally, for engines with a reference power ≥ 300 kW, Stage V introduced particle number (PN) emission limits (1x1012 #/kWh).

Furthermore, the European Union aims to be climate-neutral by 2050. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement.

The European inland waterway network covers a length of over 41.500 km, divided into navigable rivers, lakes and artificial canals. In this network, more than 17000 vessels are in operation and especially for longer distances it is challenging to find a zero-emission propulsion solution. Pure battery-electric propulsion systems can be a solution for e.g. ferries covering short distances. But insufficient local grid capacity for charging the batteries within the required time as well as weight limitations for some applications can be barriers for this technology.

For some applications, such as inland waterway transportation and for coastal and short sea shipping, fuel cell technologies for propulsion and auxiliary power are seen as one of the most promising solutions to address not only decarbonization, but also other emissions reduction targets in maritime transportation.

Proton Exchange Membrane Fuel Cell Systems (PEM FCS) with its high power density, high dynamics and efficiencies of >60 % at low loads and ~45…47 % at rated power (efficiencies based on lower heating value of H2) are a proven technology from automotive and heavy duty applications. Adapted to marine requirements and regulations, PEM FCSs are a perfectly suited power source within an electric marine powertrain, especially in a hybrid configuration with e.g. batteries. Although hybridization leads to a higher system complexity it also offers more degrees of freedom for optimization to adapt to the requirements of a specific vessel.

In the presentation the following topics will be addressed:

- Overview about European inland waterway transportation and its legislation
- Introduction to PEM fuel cell stack and fuel cell system technology
- PEM fuel cell systems within a hybrid propulsion system
- Overview of hydrogen fuel cell vessel projects
- Challenges for fuel cell systems in marine applications.