MVDC MgB_2 superconducting cables for hybrid power transmission

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ABSTRACT

Combining liquid hydrogen and superconducting cables presents a unique opportunity for a more decarbonized world. The European project SCARLET has been launched to demonstrate inter alia the feasibility of an MVDC hybrid system that distributes hydrogen and bulk electricity in the same infrastructure. Liquid hydrogen at 20 K is perfectly suited for cooling MgB_2 compact cables that are superconducting below 39 K.

After a short presentation of the project, designs of MVDC MgB_2 cables systems capable of transmitting 1 GW are discussed. A type test and long-term testing will be conducted to demonstrate the maturity and safety of the system.

KEYWORDS

MVDC cables, MgB_2 wires, superconductivity, liquid hydrogen, hybrid power transmission

INTRODUCTION

Hydrogen (H_2) is foreseen to be an important energy vector for a more decarbonized world. To get its full benefits, it should be distributed to end users such as power plants, energy-intensive industries or fuel cells in buildings or multimodal transportation centres. Liquefied H_2 is regarded as one of the safest ways for its bulk distribution. In fact, to reach half of the density of liquid hydrogen (LH_2) at atmospheric pressure, room-temperature gaseous hydrogen should be pressurized at 600 bar. Beyond the intrinsic hydrogen risks that must be managed, distribution at such high pressure could be the source of many other hazards. An efficient and safe solution for distribution of hydrogen is to deliver its high-density liquid phase at 20-25 K (-250°C) under low pressure (< 20 bar). Inserting an MVDC superconducting cable in the LH_2 pipeline network offers a unique way to benefit from an existing cryogenic pipe network and distribute simultaneously electricity and hydrogen. However, the MVDC cable should be very compact to have a minimum impact on the hydrogen distribution possibilities.

The Horizon Europe project SCARLET has recently been launched to develop MVDC superconducting cable systems in the gigawatt range to ease the injection of renewable energy in the future grid. Its overall scope is presented in a separate contribution at this conference. The project has a duration of 4.5 years and gathers 15 partners investigating different superconducting technologies.

One work package is specifically focussed on developing, manufacturing and testing a full-scale superconducting cable cooled with LH_2 that could deliver 1 GW. Table 1 summarizes the general specifications proposed for the cable system.

Parameters	
Electric power	500 MW per pole
Voltage class	25 kV
Operating DC current	20 kA
Cooling medium	- LH_2 for cooling the superconducting cable and the voltage insulation. - Delivery of H_2 to user from 200 kg/h to 10 t/h *(7 m^3/h-150 m^3/h)* up to 3 to 20 kilometres. - Stored LH_2 in the pipe from 350 to 800 kg/km (5-10 m^3/km) corresponding to stored energy from 11.6 – 26.4MWh/km
Heat load at cryogenic temperature	< 2 W/m at 20K
Current ripples	< 1% amplitude at a few kHz
Fault current	58 kA during 10 ms

Table 1: General characteristics of the MVDC cable in liquid hydrogen for the EU project SCARLET