High-temperature superconductivity and hydrogen-based technologies for aircrafts

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Successes in high-temperature superconductivity (HTSC) hydrogen power engineering have accelerated substantially, first in the USA, the researches aimed at the development of all-electrical airplane, including the transport aviation. Extremely good specific rating indexes of superconducting electric power equipment (up to 40 g/kVA), not possible for conventional equipment, permit to develop airplanes with-high rated electric power on board, capable to provide electric propulsion systems and obtain higher coefficient of utilization of potential of prime mover, thus excluding huge and complex pneumatic systems [1]. First airplanes, including pilotless ones, are to be built in the nearest 5–8 years.

Possibility of application of superconductivity, HTSC included, and high-purity metals for airborne electric power equipment is being investigated in our country for more than 20 years. There were developed and experimentally investigated main units of high-speed alternators rated from several kW to 1 MW [2]. During the last years we are examining the possibility of application of a new metallic superconductor MgB2. There are being produced in the world massive bulks operating with "frozen flux" and wires of circular and rectangular cross-sections. The manufactured wires in copper-niobium matrix have the length up to several kilometers and critical current densities around $5 \cdot 10^8$ A/m^2 in 2.4 T magnetic field (liquid hydrogen temperature 20 K) [3]. The wire is characterized low cost and only its low critical temperature (less than 40 K) opposes to its application in electric power industry. At the same time exactly this material allows to solve many problems associated with the development of highly efficient electrical generators and motors with small specific mass indexes for application on aircrafts.

Liquid hydrogen simultaneously provides a possibility to store energy with high specific energy capacity (up to 40 kW/kg), serves a coolant for electrical generators and motors and operates as a working substance in high-speed gas turbines.

Application of HTSC motors as prime mover of air propeller is of big interest. In Saint-Petersburg there is developed and tested a multi-disk HTSC motor with axial magnetic flux rated at 50 kW (Fig.1) [4]. The machine rating may be varied by increase or decrease of a number of rotor disks. Moreover, change of rotor and stator disc diameters permits to develop electrical motors with pre-determined outer-frame geometry. The advantages of such design are evaluated not only by Russian but by foreign specialists as well [1].

As for airborne electrical generators intended for different purposes the design with radial magnetic flux and superconducting rotor and stator windings is preferable. Development of HTSC armature (Fig. 2) permits to simplify the alternator design and its cooling scheme, to decrease additionally the mass and size indexes and to improve efficiency. Such generator may be used in the propulsion system of the plane and as sources of power supply of high-rated pulse loads on board a plane.

Therefore, the last achievements in the area of HTSC and hydrogen technology developments allow to apply them successfully to improve different types of aircrafts.

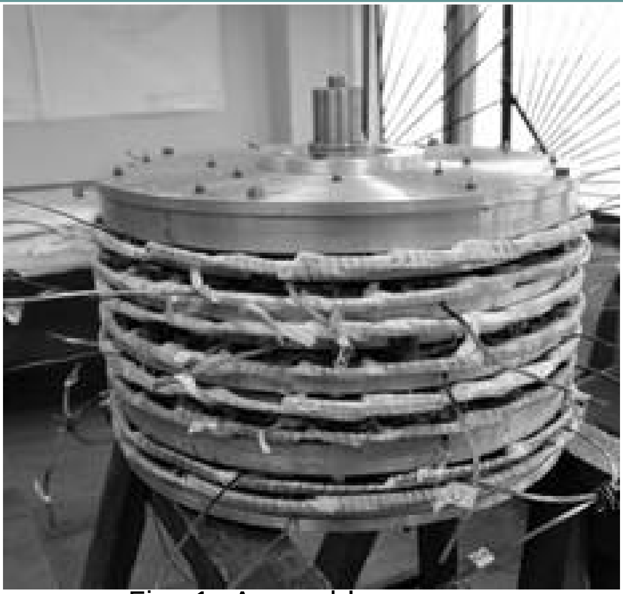

Fig. 1. Assembly process
of multi-disc cryogenic motor

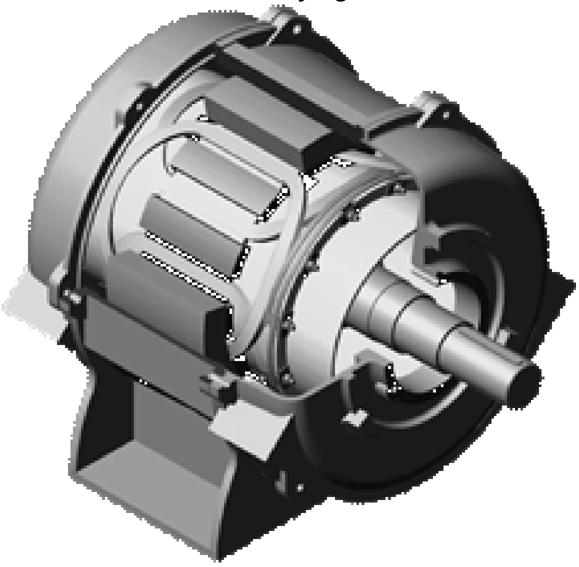

Fig. 2. Synchronous generator rated
at 50 kVA with HTSC armature winging

Literature

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