Seminar Report: High Temperature Superconductivity for Electric Aircraft

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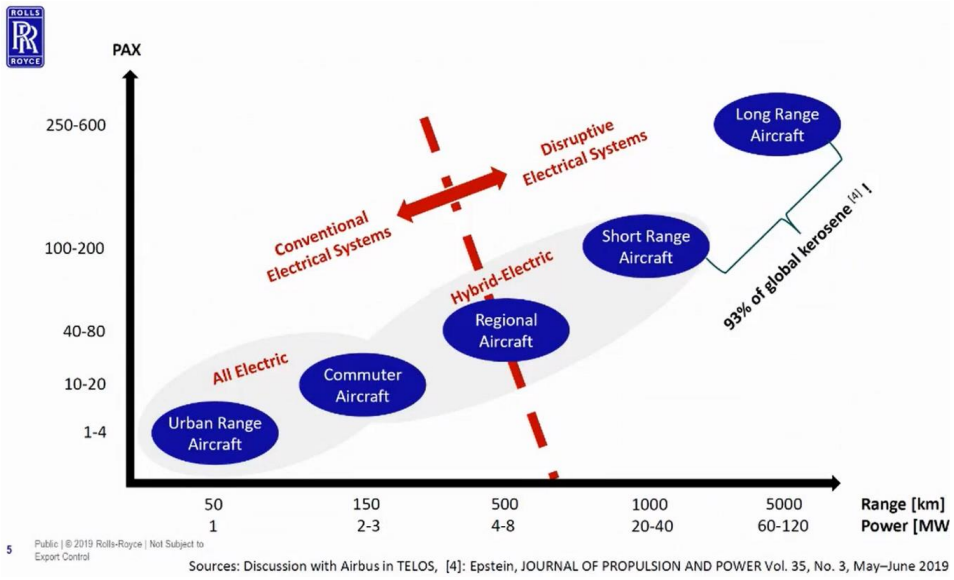
This seminar on *High Temperature Superconductivity for Electric Aircraft* was the Society's first online seminar using the hopin platform, attracting almost 50 attendees from UK and Europe companies and universities.

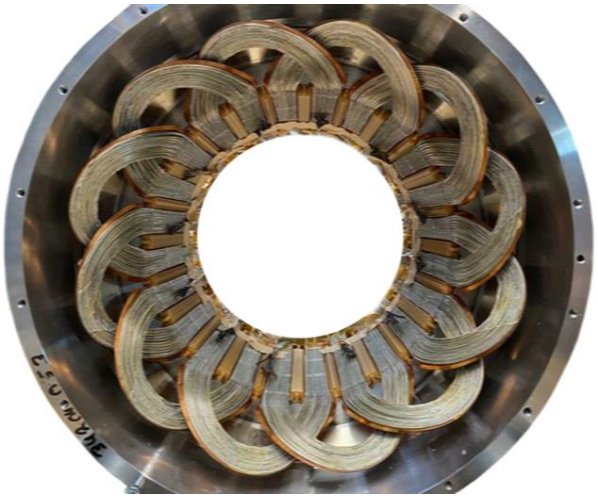
Superconductivity will play an important role in future electric aircraft due to its high power density and high efficiency, in particular the recent development of high temperature superconductor (HTS) materials. The seminar was organised in three sessions, the first session was on superconducting power systems for future aircraft, the second session was focused on detailed design of cryogenic electric propulsion systems and fully superconducting machines for electric aircraft, and the third session was panel discussion with the speakers chaired by Dr Xiaoze Pei from University of Bath.

Mr Ludovic Ybanez, Head of ASCEND project from Airbus UpNext, France, announced the *Advanced Superconducting and Cryogenic Experimental powertraiN Demonstrator (ASCEND)* project at the beginning of the seminar. His talk introduced the challenge that aeronautics industry is facing as new regulations will require a challenging reduction of CO_2 and NO_x emission as a result of ecological and sustainable development obligations. He emphasised that HTS and cryogenics seemed to be one of the options to significantly increase the performance of electric propulsion systems. The objective of the ASCEND demonstrator is to evaluate the potential and feasibility of these technologies for aeronautical applications.

The second speaker was Dr Francesco Grilli from the Institute for Technical Physics of KIT, Germany, who is currently the leader of the group 'AC Losses in High-Temperature Superconductors'. Dr Grilli gave a talk on the European Union funded *Advanced Superconducting Motor Experimental Demonstrator (ASuMED)* project. His talk started with the topology of superconducting motor. The ASuMED project aims at a motor power density of 20 kW/kg using a HTS stator. The rotor will use HTS stacks operating like permanent magnets. He introduced the experimental characterisation of superconducting tape and analysis of AC loss in the stator coils. The dual-cryostat concept with an integrated

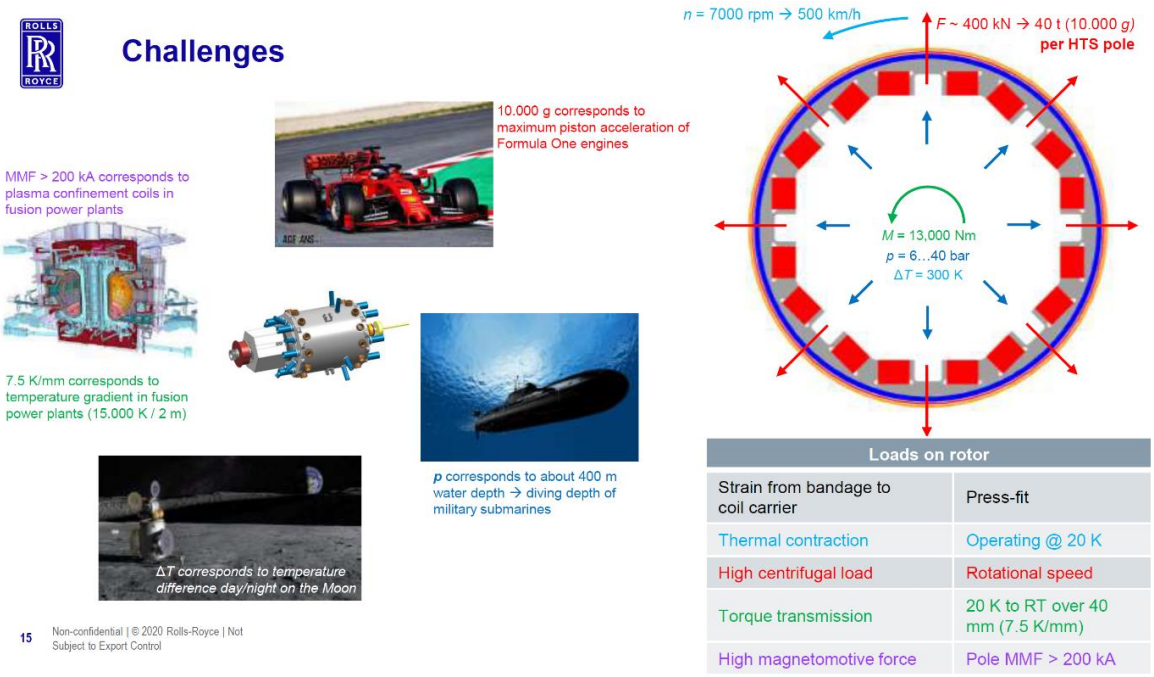


cryogenic cooling system for superconducting motor was also introduced. The prototype is currently being assembled and that will be tested soon.



Stator windings on the ASuMED motor

Dr Martin Boll, R&D project leader of Rolls-Royce Electrical, Germany, gave a presentation on *Design of 10 MW HTS Generator for Hybrid Electric Aircraft.* He presented the feasibility study of re-equipped 200 seater aircraft using serial turboelectric propulsion, with the centre tanks replaced by liquid hydrogen tanks. The feasible study demonstrated that such a propulsion system is only be possible if cryogenic cooling liquid acts as energy source. He then talked about the design of proof-of-concept 10 MW HTS generator. The specification is the power density is higher than 20 kW/kg and speed of 7000 rpm. The 10 MW HTS generator used a synchronous machine with HTS DC coils, see Figure 3. Dr Boll pointed out that new materials and manufacturing methods were needed for the prototype. The relevant mechanical material characteristics have been validated in



Technical challenges for Rolls Royce' 10 MW HTS generator, typical of the challenges faced by any HTS machine

this project. Unfortunately, Dr Boll's talk was abruptly cut short in the middle of a thunderstorm, but we heard later this was a fault on his phone rather than anything more serious.

Prof Peter Malkin from the Centre for Advanced Electrical Drives, University of Newcastle, is a long-time proponent of electrification of aircraft and has specialised in cryogenic and superconducting applications. Prof Malkin's talk *Superconducting Power Systems For Future Electric Aircraft*, gave an overview of the need for superconducting techniques and the potential advantages as well as the need for new network design techniques and approaches. He summarised the key issues of electric power network for aircraft application, which include fault management and breakdown in high altitude. Power density and efficiency are obviously the biggest challenges. The performance of superconducting power network for aerospace has significant benefits and address all the above problems. As liquid hydrogen is moving to be the top fuel of choice, this makes superconducting power network a practical solution.

After the coffee break, there was a panel discussion with Mr Ludovic Ybanez, Prof Peter Malkin and Dr Francesco Grilli. All the speakers agreed that HTS technology is critical in delivering the high-power density and high efficiency required for electric aircraft. In order to advance HTS technology and application in aviation industry, strategic collaborative research is needed. There is no single party able to deliver superconducting power network on its own. There are many HTS demonstration projects in land-based grid applications. The effect and lessons learned from these application on the aviation application was also discussed.

At the end of the seminar, there was an interesting social and networking opportunity. Delegates from industrial companies and research institutes expressed great interest to work together to accelerate the development of superconducting technology for aviation applications.

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