Pulling the plug: Novel MDD brings safety to high voltage aviation

Regional and short-haul are the most likely segments in aviation to take advantage of new hybrid-electric propulsion from the late 2020s onwards – with full electric propulsion to eventually follow, depending on advances in battery technology.

In parallel, larger passenger airplanes are shifting away from hydraulic and pneumatic systems towards increased deployment of electrical systems which are more environmentally friendly. Such systems will be used to cope with the power demands of passenger cabin air conditioning systems, cabin pressurisation as well as wing de-icing systems. This shift towards electrics will herald a new era in reduced-emission aviation with less noise, in line with ACARE and the EU's Green Deal aspirations.

However, these increased demands for management of electrical energy in this more-electrical chapter of aviation makes it important to devise new architectures that are capable of handling high-voltage electricity. And this, in turn, prompts the need for the design of a fail-safe device to disconnect the electricity from the embedded generator if a fault occurs, in order to prevent overheating or fire.

Clean Sky’s (now completed) Novel Mechanical Drive Disconnect (MDD) solution for embedded permanent magnet machines project is a prime candidate for this function. The project, coordinated by Denis Ferranti and Rolls-Royce, with the former as sole beneficiary and the latter as Topic Manager, set out to develop an MDD solution that could be developed and demonstrated as part of Clean Sky’s Large Passenger Aircraft initiative.

‘The MDD is a techno-brick and enabler for the upcoming Clean Aviation programme, where we will be moving more towards zero-emission type aircraft and we’ll most likely need to deploy MDD technology as more electrical and hybrid-electric engines are developed in the coming years,’ says Clean Sky Project Officer Pierre Durel.

The technical challenges and the imperatives to develop such a device are complex, because when electrical power is used as the propulsive force to fly, the electrical components and machines become much more safety-critical.

‘In this case, we are using a very power dense aerospace permanent magnet electrical machine,’ explains Ellis Chong, Global Technical Lead – Electrical Machines at Rolls-Royce Electrical.

The benefit of using a permanent magnet electrical machine is that it is very compact and light, which aligns with aeronautics. However, the challenge is that a permanent magnet electrical machine (a type of electric motor), is by definition, permanently magnetised – the magnet cannot be readily switched off.

‘So if there’s a fault in the system such as an electrical short circuit, we need a fail-safe way to disconnect our machines – or in some cases we can disconnect the failed machines, and allow the good machines to continue to operate, to enable the aircraft to stay airborne,’ says Chong.
‘This is where this Clean Sky project comes in,’ he elucidates. ‘This project is about developing a fail-safe mechanical disconnect to be integrated into permanent magnet machines, so that in the case of failure, a machine can intelligently detach itself, and make sure that we have a safe system. The biggest benefit is safety.’

For Rolls-Royce, the MDD project aligns with the company’s strategic trajectory towards developing electrical propulsion solutions, according to Chong.

‘The company sees electrification as one of the solutions, because when life becomes more normal again – the more electrical solutions will be at the heart of that. But everything we do in aerospace is very much driven by safety, therefore this trend towards electrification is step by step,’ he says.

**Longer term applicability**

Although the initial application of the MDD would be for hybrid-electric and eventually fully electric aircraft, Chong notes that longer term potential could extend to other propulsion technologies.

‘Currently we are mostly looking at hybrid-electric aircraft propulsion, and in terms of timeline, we are probably talking about the next five to 10 years for the hybrid. And then there will be some overlap – five to 15 years – before we move into full electric aviation, depending on battery technology,’ Chong says.

But what if, longer term, hydrogen became a fuel of choice for the 2030s and beyond? The MDD would still have applicability, as electrics will always feature prominently, regardless of the main propulsive fuel.

‘For this project in Clean Sky we’re producing a technology brick that we can use now, we can use it in the medium term, and we can use it in the future,’ Chong says. ‘One of our philosophies at Rolls-Royce is to ensure technologies can be reused and leveraged for future applications.’

**Outcomes and the broader exploitation path**

In January 2021 Denis Ferranti concluded testing of the novel integrated mechanical disconnect, with the testing process shared remotely via video feed. The coordinator reported that the ‘disconnect has been successfully tested repeatedly and works well.’

Beyond aeronautics, other transport modes can also benefit from the MDD – in defence and in marine applications in particular, says Chong. ‘The same technology could be applied to those areas as well to provide a fail-safe, fault-tolerant electrical machine – it’s all about leveraging technology bricks.’

Commenting on the conclusion of the project, Clean Sky’s Durel says that there have been positive outcomes from the MDD: ‘At component level, we have good results and good progress and the MDD is an enabler for the future of our programme.’