WARWICKMOTO
ELECTRIC RACING

MIVOLT®
IMMERSION COOLING LIQUIDS

A NEW FRONTIER FOR IMMERSION COOLING

Designing an immersion-cooled battery pack for an electric TT superbike.
A first for the motorcycle industry!

WARWICK MOTO

Developing firsts in the electric automotive market

The Warwick Moto team is a multi-departmental project at WMG, The University of Warwick, consisting of students, researchers, and academics. In just seven months, the team has developed and built an electric racing motorcycle named 'Frontier', using a high-performance sports model as a platform. This cross-functional team has already developed a first in the electric automotive market, by producing an immersion-cooled battery pack – the first of its kind for application on an electric motorcycle.

The team's long-term objective is to compete with a podium qualifying time at the Isle of Man TT (IOM TT) 2022. The IOM TT has a global audience of 26 million people and since 2010 the race has seen the introduction of an electric class – TT Zero, which sees some of the most technically advanced motorcycle builders and engineering companies from around the world pitted against student-based University teams who operate with a fraction of the budget. The TT Zero is one of the only competitions in the world where students can compete against professional teams on a level field. Riding Frontier for Warwick Moto will be road racer Tom Weeden, who has been working closely with the team alongside other industry partners, including Norton Motorcycles and M&I Materials Development Ltd.

"The jump between riding a normal bike to jumping on an electric bike was easy and I just got straight into it. The bike was so easy to ride, it's controllable and not too dissimilar from what I'm used to. I do like not having to change gears especially as the power of the bike just keeps coming."

Tom Weeden
Road Racer

PUSHING BOUNDARIES

Exploiting synergies with industry partners

The research team, supported by WMG Centre High Value Manufacturing Catapult, have developed an electric motorcycle powertrain, using a high-performance sports chassis from Norton Motorcycles. It is rated with a power output of 160kW or 201bhp, delivering 400Nm of torque from a standing start. The acceleration and speed characteristics of the electric bike in motion roughly translate into an internal combustion-engine equivalent of around 900cc to 1,000cc.

The electric motor draws power from a battery pack that has been designed and tested by the students. With a capacity of 16kWh, the battery is designed to last longer by being cooled with MIVOLT®, which also allows for larger short term power peaks required by a racing motorbike. In addition, the cooling system will enable the team to operate at a more efficient temperature range by optimising the starting temperature of the MIVOLT liquid prior to a race or testing, based on the requirements of the track.

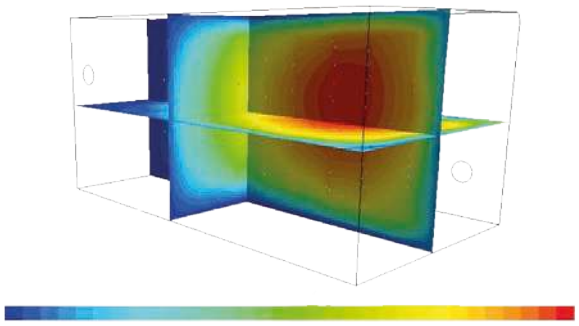


Figure 1 – Thermal Computational Fluid Dynamics (CFD) results displaying the distribution of temperature within a battery module.

Various prototypes of the battery design have been put under mechanical vibration tests in accordance to ECE-R100, which is equivalent to a 100,000 miles, to replicate the vibration load that a pack might see under motorsport conditions. Moreover, prototypes were also thermally and electrically stressed under various standard and non-standard loads to verify the validity of the thermal management strategy under normal and extreme operations.

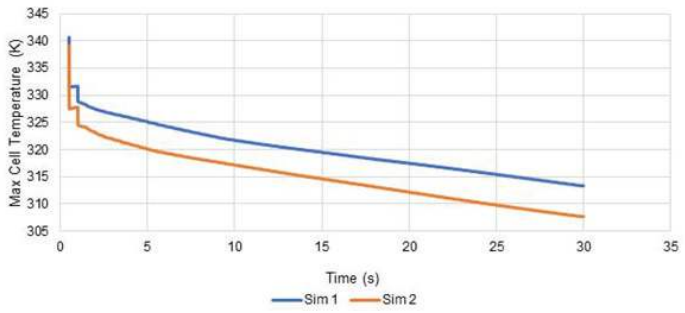


Figure 2 – Maximum cell temperature over 30 seconds when doubling the MIVOLT® flow velocity of the cooling liquid. This enabled students to make informed decisions to optimise cell cooling and operating temperatures.

The battery can be recharged with the common RS CHAdeMO connector, facilitating fast charging where available and allowing for a full charge of the battery in around an hour (up to 80% from empty in just 32 minutes).

THERMAL MANAGEMENT STRATEGY

Value achieved through immersion cooling

Although immersion cooled batteries are not new from a racing perspective, e.g. Formula E vehicles utilise this method of thermal management - Warwick Moto is the first to introduce the system to a motorbike.

From an engineering point of view, using an immersion cooled battery presents many benefits. Firstly, it paves the way for more dense battery pack configurations. For motorcycles, where mass is a performance constraint and overall space is limited, immersion cooling will reduce the number of cells necessary. From a racing perspective, this will lower the bike's weight and increase its performance. From a cost perspective, battery modules will become cheaper as less cells will be required for the same power output.

Secondly, liquid immersion cooling reduces the likelihood of hotspots. Battery cells are more efficient at certain operating temperatures, so this method of thermal management will ensure that optimal temperatures are maintained at all times. This level of efficiency will increase performance and maximise Frontier's range.

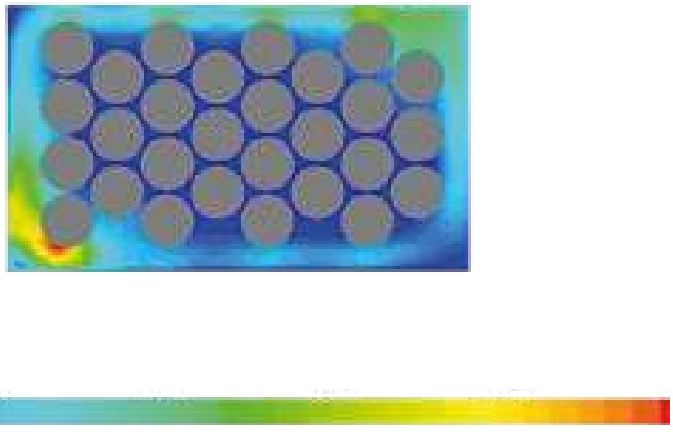
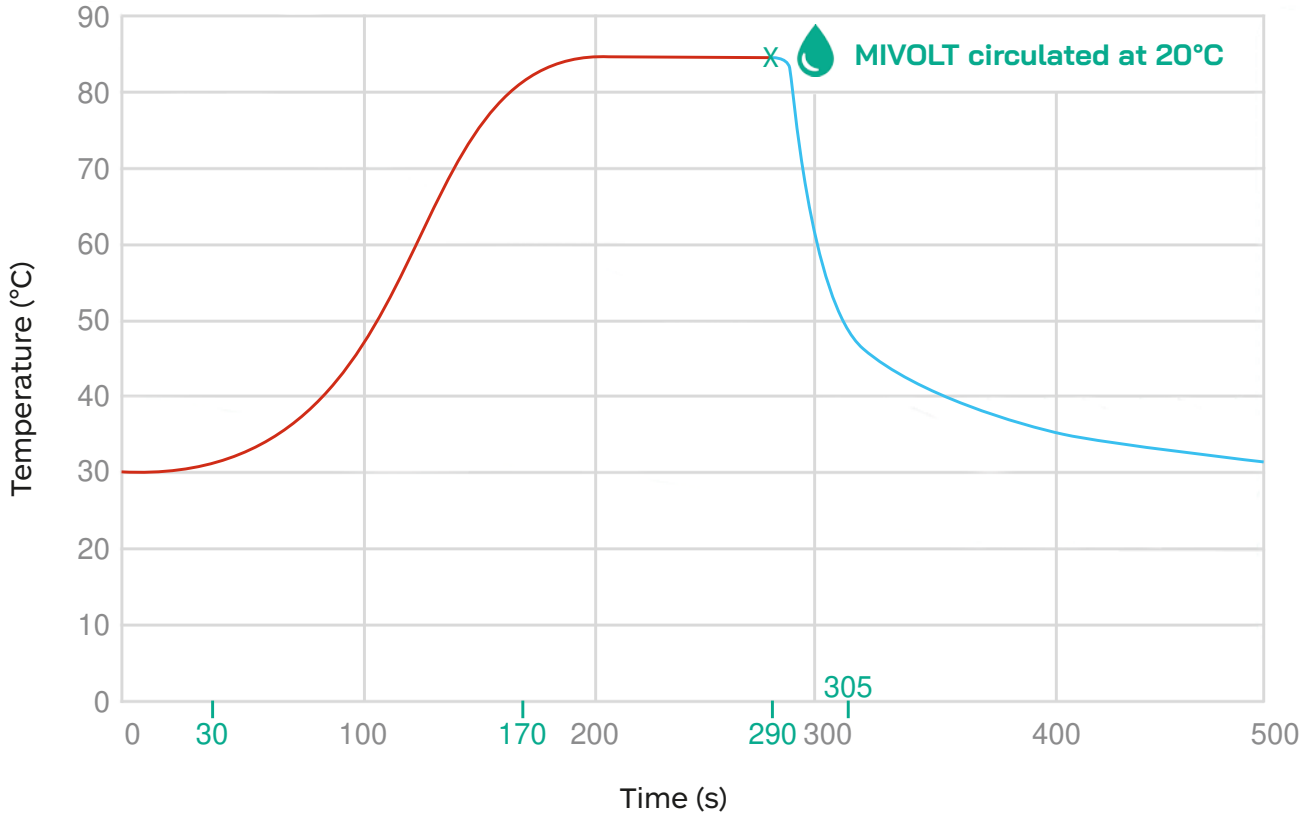


Figure 3 – Computational Fluid Dynamics (CFD) model of a module pre-physical testing to validate the packaging of the cells within the module. This simplified 2D figure displays a flow velocity plan profile through the cells.

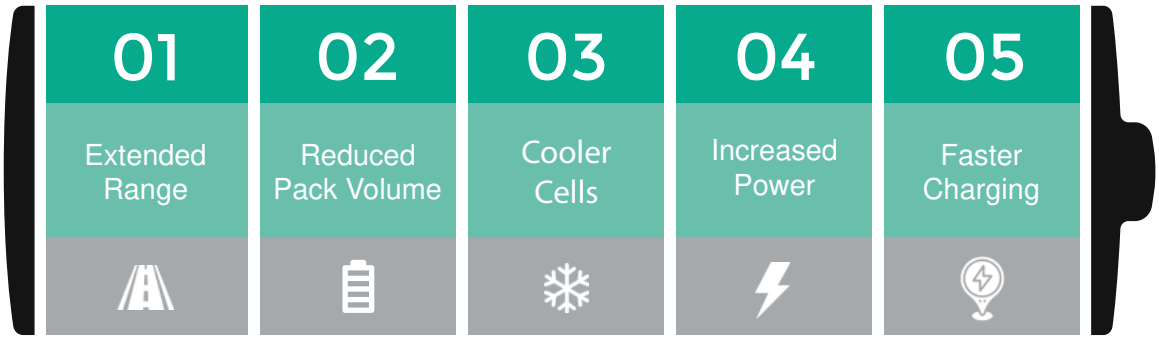
FLUID PERFORMANCE

Rapid cooling of cell surfaces

It takes just over 3 minutes for MIVOLT® to cool the battery cell surface temperatures from 85°C to 30°C. This has significant implications for Frontier's performance - it allows the batteries to be charged at faster rates and reduces thermal strain on batteries, increasing the lifespan of battery packs.



BENEFITS



GOING THE ESTER MILE

The natural engineering choice for immersion cooling

There are a number of advantages to using an ester-based dielectric liquid as a direct submerged coolant as opposed to other battery cooling methods and technologies.

The biggest advantage of MIVOLT liquids are their low electrical conductivity. This allows MIVOLT® to come into direct contact with all electrically conductive parts of the system without the risk of short-circuiting the battery.

These dielectric strengths are what allows all components to be fully submerged - taking heat away from the battery cell and other conductive surfaces, such as busbars and electronics boards.

Benefits of MIVOLT liquids

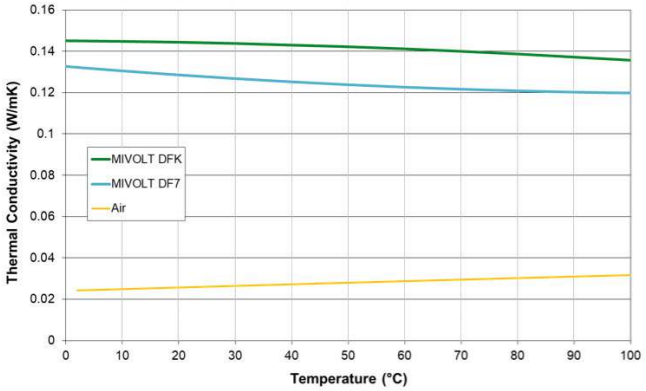
- High fire point, but low viscosity
- Low electrical conductivity
- No risk of short circuiting upon liquid contact

HIGH FIRE POINT, LOW VISCOSITY

One of the key features of MIVOLT liquids are their high fire point - the temperature at which the bulk fluid would set alight when exposed to a naked flame. Low kinematic viscosity also allows the fluid to circulate around the cooling system. MIVOLT DF7 is superior to other materials in terms of viscosity and fire point. Going significantly further is MIVOLT DFK, which has a fire point of over 300°C thanks to its K-class thermal rating.

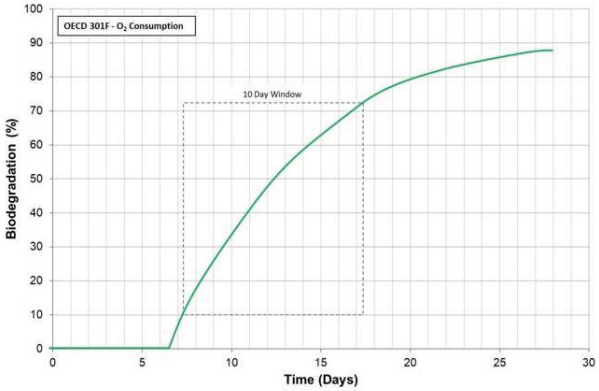
SUPERIOR THERMAL CONDUCTIVITY

Despite their low electrical conductivity, MIVOLT liquids possess high thermal conductivity an order of magnitude higher than air. With its high heat capacity, MIVOLT® quickly draws heat away directly from the battery cell to cooling surfaces.



THE GREENER, SAFER CHOICE

MIVOLT liquids are biodegradable, meaning if they spill or leak, they pose a low threat to the environment. MIVOLT easily surpasses the 10-day window requirement of 60% degradation under the OECD 301 test regime.



MIVOLT AS A TECHNOLOGY PARTNER

Heritage in material innovation

MIDEL & MIVOLT Fluids Ltd is committed to developing specialised materials for challenging applications, and whose roots can be traced back to 1901.

Having started out manufacturing products for electrical insulation, the company has reinvested in its capabilities throughout its history, having engineered its first dielectric fluid range over 40 years ago.

Product development is undertaken within the company's own laboratories, as well as with some of the leading research institutes around the world, including the Schering Institute in Germany, CESI in Italy and TJ|H2b in the UK.

Globally, MIDEL & MIVOLT Fluids Ltd supplies to a wide range of sectors, from power utilities and renewable energy to transport, mining and manufacturing.

From its Trafford Park headquarters in the UK, MIDEL & MIVOLT Fluids Ltd exports its specialist products to 60+ countries around the globe. This is made possible by the company's growing network of production facilities and commercial premises across the Americas, Africa, Europe and Asia Pacific.

"Our partnership with MIVOLT® has enabled us to develop a high-performance battery pack tailored specifically to the intense demands of the Isle of Man TT Zero. The immersion cooling fluid allows us to package the cells more closely, culminating in a 16 kWh pack which perfectly fits our Norton chassis. Moreover, by using MIVOLT® we have been able to extract higher discharge rates, enabling 210 kW of power delivery."

Aneesh Jois
Engineering Director, Warwick Moto

"We have been thrilled to be involved in this project as an industrial partner. We supplied MIVOLT DF7, which is a dielectric fluid suitable for the direct cooling of EV batteries. We have been able to use the work we completed with WMG on the I-CoBat Project to support and inform the students on some of the design aspects, particularly in regards to MIVOLT's ability to help supress thermal runaway and propagation."

Eleanor Jones
Product Engineer, MIVOLT®

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