measure. analyze. innovate.

The dream of clean flight

Kistler supports Switzerland's Cellsius team with measurement technology for alternative aircraft propulsion systems

CELLSIUS PROJECT H2

www.kistler.com

The objective of the second Cellsius project – the H2 – is to equip a Swiss Lightwing AC4 aircraft with a powertrain based on a fuel cell – again, with support from Kistler measurement technology.

Dedicated students at ETH Zurich are busy working on CO_2-free powertrains for small aircraft. In two projects, both a torque sensor and, for the upcoming fuel cell drive, the pressure and temperature transmitter 4080BT from Kistler are being used: emission-free aviation is already taking off!

Decarbonization presents a huge technical challenge for the aviation industry – especially for large aircraft and long-haul flights. On an average day, over 100,000 commercial flights take off worldwide – so air traffic is responsible for 2.5 percent of global CO2 emissions caused by humans. As well as sustainable aviation fuel (SAF) and potential alternative fuels for turbines such as hydrogen or liquid methane, development work is under way on electric drives powered by batteries or hydrogen fuel cells. But with longer flight durations and larger passenger capacities, it is becoming increasingly difficult to find adequate replacements for the high energy density of kerosene and aviation gasoline (AvGas).

> "The 4520A torque sensor from Kistler really helped us to make sure that the torque present on the front of the propeller also corresponds to the torque applied to the rear."
>
> Frederic Huwyler, Technical Team Leader at the ETH project team e-Sling

However, Cellsius – a Swiss team of young engineers – is providing impressive proof that this is already possible for small aircraft and short-haul flights. Founded in 2022 to focus on sustainable aviation, the Cellsius association offers students in their final year of studies for a Bachelor's degree the opportunity to test and expand their knowledge and skills on real aircraft. The Cellsius association's first project – named 'e-Sling' – ran from 2020 to 2022. Its objective: to equip a low-wing aircraft with an electric propulsion system. The successful outcome was the world's first licensed four-seater electric aircraft built by students! At an early stage of the project, a torque sensor from Kistler was obtained to assist with designing the motor and developing the power electronics. The sensor is an integral element of the test stand at the Dübendorf site of the Swiss Federal Institute of Technology Zurich (ETH), where the hangars, take-off and landing strips are located. This airfield, now part of the Swiss Innovation Park Zurich, is gradually being expanded to create space for laboratories, workshops, offices and classrooms.

Comfortable torque measurements on the test stand

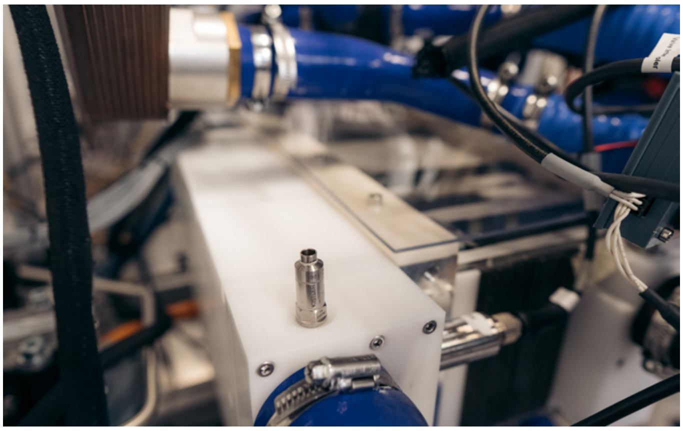
In the new H2 project, Frederic Huwyler is responsible for the electric motor in the fuel cell powertrain. He describes how the electric motor was adapted and integrated into the e-Sling aircraft. The rotor-stator assembly from project sponsor e+a Elektromaschinen und Antriebe AG was tested on the test stand to optimize the load spectra and validate the torque control. All the association's activities are financed and supported by various sponsors, including Kistler. "The 4520A torque sensor from Kistler really helped us to make sure that the torque present on the front of the propeller also corresponds to the torque applied to the rear. The e-Sling has a variable-pitch propeller that requires appropriate control," Huwyler explains.

The 4520A basic line torque sensor operates on the strain gauge principle. Outstanding features include an attractive price-performance ratio and excellent dynamics with contact-free signal transmission (analog output signal: 0 to 10 VDC) at up to 1,000 Nm and speeds of up to 10,000 rpm. Huwyler adds that the e-Sling's propeller required a maximum torque of 400 Nm. "In the cruise phase, this is around 340 Nm at about 2,300 rpm – and that's why our predecessors opted for a sensor with a measuring range of up to 500 Nm."

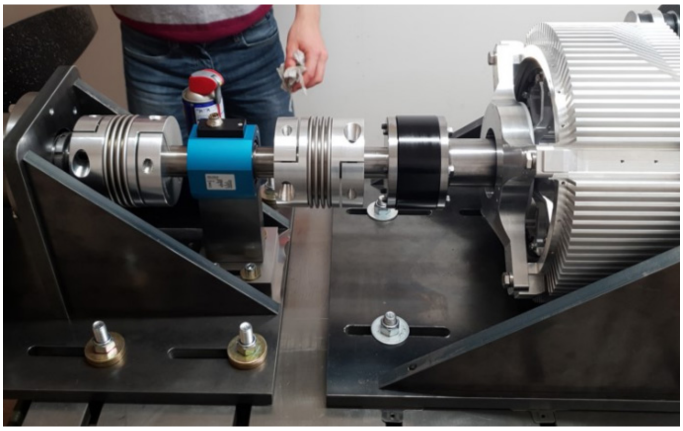
Kistler sensor proves its merits in continuous test operation

Michael Haslinger is a member of the power electronics team in the H2 project. His focus is on the inverter and DC/DC converter systems that control energy transmission from the batteries to the powertrain. He too was favorably impressed by the torque sensor from Kistler: "The excellent documentation makes it easy to set up and program, and it's very reliable during handling and use," Haslinger notes. Thanks to the sensor, he and his team were able to verify the inverter control. "It also has practical advantages such as integrated speed measurement and simple readout of the values. What's more, we didn't have any EMI problems with the 4520A – which was not the case with certain other sensors."

At long last, the all-electric e-Sling took off from the test site at Dübendorf airfield for its maiden flight on 19 September 2022 – a huge success that was followed by an intensive flight testing phase. However, the range and flight duration of this innovative four-seater electric plane are limited, so Cellsius immediately embarked on another initiative. The Cellsius association is headed by a six-member



The 4080BT pressure and temperature transmitter from Kistler is installed here in the first prototype of the Cellsius fuel cell system.



The first motor test stand for the Cellsius e-Sling, with the 4520A torque sensor from Kistler (blue)

Executive Board, with advisory support from professors at ETH Zurich. The objective for the H2 project: to equip a Swiss Light Wing AC4 with a fuel cell system that will allow a flight duration of more than two hours and a range of over 250 kilometers. Here too, Kistler technology is playing a key part with another special transmitter installed in addition to the torque sensor.

Miniature combi sensor helps to reduce weight

Cedric Mägli, the engineer working on the fuel cell system, explains: “A powertrain with a fuel cell is a complex system that requires a large number of individual components. We develop many of them ourselves.” The two hydrogen tanks are located under the wings of the AC4; then there is the fuel cell system with the fuel cell itself, plus the three circuits for the air and hydrogen supply and the cooling, buffer batteries, power electronics and, of course, the electric motor. All of these components add to the aircraft's weight. The temperature, pressure and humidity of the media also need constant monitoring, and that requires additional measurement technology. Mägli continues: “That's why we were keen to make the sensor technology as simple as possible, and accommodate it in one connection block with no additional fixtures. The Kistler sensor fits excellently into this concept.”

The 4080BT combined pressure and temperature transmitter is a miniature piezoresistive sensor with a diameter of 12.5 mm and a weight of less than 12 grams. The built-in PT1000 probe allows combined pressure and temperature measurements of up to 150°C (compensated) and a maximum of 20 bar. Mägli again: “Thanks to the very compact 4080BT, we were able to reduce the number and weight of the sensors we needed. And on top of that, this sensor effortlessly meets the requirements for the temperature and pressure ranges, and ensures the accuracy that is essential for the air supply.”

The emission-free Cellsius AC4 is fairly certain to take off sooner or later, although the exact date of its maiden flight is still ‘up in the air’. As the projects proceed, the students acquire a vast stock of valuable knowledge about handling alternative powertrains in practice – and with their proofs of concept, they also demonstrate what is already possible today. Martin Stierli, Business Development Manager Aviation at Kistler, has already visited the Cellsius site on many occasions. He says: “As an innovative measurement technology provider, we’re delighted to support young engineers with their research projects – especially when the aim is to improve sustainability in aviation. There are still quite a few measurement technology challenges to be overcome in the course of the H2 project, so we’re very happy to remain in close contact with the Cellsius team. Thrust measurements on the propeller, tensile tests on the wing, or a wide variety of vibration measurements: we're standing by to help overcome all these challenges and more, and we're able to find solutions thanks to our diverse portfolio.”

The Cellsius team for the 2022/23 academic year

961-816e-11.23

Find out more about our applications:
www.kistler.com/solutions

Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland
Tel. +41 52 224 11 11

Find your local contact at
www.kistler.com

measure. analyze. innovate.