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Above the clouds

How KiBox is supporting Continental Aerospace Technologies with aircraft engine development

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A view of the aircraft's engine bay showing the Continental Aerospace Technologies engine instrumented with KiBox for combustion analysis

Until now, the "natural habitats" for KiBox were vehicle interiors and development centers in the automotive industry. But at Continental Aerospace Technologies, the combustion analysis system from Kistler is now taking to the skies! As part of development work on a new generation of engines, test pilots and engineers from the engine manufacturer soared high above the clouds where the air is thin – and extremely cold. KiBox was on board to help optimize engine performance while the flight was in progress.

More power and less fuel consumption – aircraft engines are expected to meet the same requirements as those in automobiles. But different physical conditions prevail high above the clouds, making it much more complex to develop new engines for aircraft than for road vehicles. Continental Aerospace Technologies GmbH, which is a part of globally operating group Continental Aerospace Technologies Ltd., operates facilities in the US and in Germany. This company ranks as one of the world's leading manufacturers of engines for small aircraft. Starting in the first decade of this century, the company developed its kerosene piston aircraft engine based on a diesel engine for passenger cars, with a redundant electronic control. This engine uses about 40 percent less fuel, so the range of the aircraft is extended by as much as 30 percent. This success was a quantum leap in innovation for Continental Aerospace Technologies, setting a new benchmark in the industry.

„As we continue to develop our engines, we literally want to soar to new heights!" The speaker is Dr. David Dörner, Application engineer for Test and Application at Continental Aerospace Technologies GmbH. Some background information: as density decreases with altitude, air resistance becomes less – so fuel consumption can be reduced. However, there are limits on the possibilities for flying high: as aircraft gain height, their engines must also increase their altitude performance to ensure that planes always have sufficient lift. Unlike large jets, engines in small aircraft have no turbocharging or only single-stage charging, so they have a much lower service ceiling. This is why optimizing altitude performance is such a key aspect of development.

To guarantee that the engine will also run smoothly while the plane is descending from a high altitude when power output from the engine is low, there must be sufficient compression energy for combustion to take place. Otherwise, the result can be flameout, which is similar to loss of flame in jet engines. Another requirement is the ability to actively turn the engine off at altitudes above 10,000 feet and then restart it reliably – functions that are even more difficult at temperatures in the two-digit minus range. A reliable and constant combustion process is essential in these circumstances.

Knowledge gained in real time

Development work on the latest generation of engines showed promising potential: for example, the cruising altitude where 100 percent of maximum continuous output is still available could be increased from the previous height of 2,500 meters to over 3,900 meters. „Thanks to this improvement alone, fuel savings of several percent could be achieved – and the new engine is also more efficient in other respects," Dörner explains. A comparison with competitors indicates that a new benchmark was set here.

To arrive at a reliable determination of the flameout limit, the engineers depend on data that it collects during test flights. „With our previous solution, we had to return to land every time so we could read the data and use it to reset the engine. Then we had to take off again for another flight," the engineer continues.

The result was that test phases often became long, drawn-out affairs, especially when changeable weather conditions made it even more difficult to take off again. „In order not to endanger our projects and the ones of our customers, we can't afford any delays."

These problems prompted Dörner to search for a solution that would allow analysis of the data immediately after a measurement – an approach that is standard in automobile development. „Since this is a familiar problem in the automotive industry, my colleagues recommended me to contact Kistler. And that's how I became aware of the KiBox," he recalls.

KiBox breaks new ground

The inquiry from Continental Aerospace Technologies meant that the engineers at Kistler really had to break new ground: never before had a KiBox operated at such altitudes, with ambient pressure of only 375 mbar. The small aircraft were not equipped with pressurized cabins, so the pressure would act directly on the instrument. „Until then, we'd only used the KiBox in the automotive sector. As the basis for our altitude specification, we took journeys in mountainous areas where the pressure more or less corresponds to 750 mbar," according to Jörg Ruwe, Sales Engineer at Kistler.

To collect their own empirical values, the Swiss sensor experts initially loaned a KiBox to the customer. „We're used to sounding out the limits from our experience with motor racing, and we saw that this would be an opportunity to gain new knowledge," Ruwe continues.

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> Dr. David Dörner, Application Engineer Test and Application at Continental Aerospace Technologies GmbH

The first experiments were performed in a cooling chamber, and then came the acid test: to carry out the test flights, the engineers took a winter trip to Sweden – where temperatures were still below zero while the first spring flowers were already blooming in Germany. „We simulated the worst-case scenario here: temperatures at altitude of below –40 degrees Celsius, poor fuel with low cetane ratings, and altitudes of over 7,000 meters. 85,000 meters was the total altitude covered by the team on two days of testing," David Dörner continues.

The KiBox completed the experiments with no complications and proved its merits across the board. The crew (one test pilot and an engineer) were able to read the data in real time, and they performed various settings on the engine software while they were still airborne. By eliminating take-offs and landings, the engineers saved many hours of flying time as well as the landing charges and parking fees that would otherwise be incurred.

With its compact dimensions and easy handling, the KiBox also made work much more efficient back on the ground. The developers only needed a few minutes to relocate the instrument between its measuring points in the aircraft and on the stationary test stand. This gave them added flexibility with planning their tests, because they could decide where to operate the KiBox according to the weather at the time. And thanks to a 28-volt connection, the KiBox could also operate easily from the onboard power supply with no need for an additional unit.

Boost for new developments

As well as appreciating the practical advantages of the KiBox, Continental Aerospace Technologies was convinced by its technical equipment. With eight measuring channels, it has twice as many inputs as the instrument they were using previously. This pays off for the aircraft engine manufacturers in two ways. First, they obtain extra data that was previously unknown to them, or could only be captured at the cost of other measurands: „As well as the pressures in the four cylinders, we're now able to measure current signals and injection pressures. We can apply this knowledge to other models, and that saves us several test cycles," Dörner points out. And second, the KiBox is a genuine all-round solution for Continental Aerospace Technologies: it is suitable for the company's entire portfolio of engines, including the six-cylinder models.

The KiBox performed so well that the engineers at Continental Aerospace Technologies were utterly convinced – prompting them to purchase the loaned system as soon as the first tests were completed. „Our working relationship with Kistler was smooth. Even though the conditions were unknown, they took on the risk involved in the tests and they provided excellent support for us throughout this phase," Dörner sums up. This places Continental Aerospace Technologies in an excellent position: as well as deploying its modern engines in newly-built aircraft, the company can also supply engine replacement kits to many plane owners all over the world, who will thus have the opportunity to install cutting-edge technology.

How do engine performance and flight characteristics change with altitude? A look at the instrument panel and the values measured by KiBox provides the answers.

Measuring station in the cockpit; on the left, the KiBox from Kistler for engine indication

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

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