Augsburg, Germany-based Renk Test Systems GmbH (RTS) developed a test rig for the world’s most powerful aircraft gearbox, which will be used in the new Rolls-Royce UltraFan™ engine for commercial aircraft. The result is an advanced system with a very high rigging capacity of 97.6 megawatts (MW). In this system, PC-based control with TwinCAT 3, as the real-time platform of the RDDS.NG test bench software, forms the basis for efficient gearbox testing and development.
RTS has been developing and manufacturing high-quality test systems for gearboxes, drive components and complete vehicles since 1960. In addition to the aviation industry, the company’s target industries include the automotive, commercial vehicle, railway, wind power and agricultural industries. One application example is Rolls-Royce’s Large Power Gearbox Test Stand (LPGTS) in Berlin, which went into operation in 2018. It is a torque test rig used in the development of gearboxes for the new UltraFan™ aircraft engine from Rolls-Royce, which is up to 25 percent more efficient than previous designs.

Michael Ruisinger, Product Manager, Retrofits and Automation Technology at RTS, explains the details: “The gearbox decouples the speeds of the driving turbine from the engine fan, enabling larger fan diameters and an even higher efficiency for future engine generations. The test rig for prototype development, which is 30 meters long and 10 meters wide and weighs approximately 400 tons, consists of a mechanical clamping circuit for generating the torque and a speed of up to 8,500 rpm, which corresponds to an output of 97.6 MW or around 135,000 horsepower. Secondly, a hydraulic load unit with six degrees of freedom provides the required tensile forces and bending moments. This extremely high performance is necessary, since the device under test is the world’s most powerful aircraft gearbox. The power is generated via the so-called load gearbox, the most powerful straight-toothed gearbox in the world, which was manufactured by our parent company, Renk AG.”

Complex test rig requires flexible automation

The modular test rig is a highly complex system, with approximately 600 sensors and actuators, six hydraulic cylinders, 13 hydraulic pumps and two medium-voltage motors, each with a drive power of 11 MW. In addition, there are six networked control systems:

– the Renk Dynamic Data System (RDDS.NG) for test rig control, data acquisition and visualization,
– a separate fast data acquisition system,
– a system for logging all measured values and maneuvers on the test rig,
– higher-level set value transfer for all systems,
– the oil supply for the gearbox under test, and
– the general building management system.

The advantages of RDDS.NG are particularly evident in such a highly complex development test rig, as Andreas Köhler, Senior Software Expert Automation at RTS, points out: “A prototype development test rig always has to offer plenty of scope for modifications and adaptations. The graphical editors for control...”
engineering and sequence control are ideal for implementing all these requirements flexibly and individually. Other factors include the database-organized test rig and test run configuration, the flexible system structure through the client-server architecture, and the user-defined visualization displays. RDDS.NG is based on the proven and open TwinCAT 3 automation software platform from Beckhoff, which ensures reliable performance for all real-time-relevant tasks. In this application, we also benefit from the openness and capabilities of PC- and EtherCAT-based technology from Beckhoff, in particular the high speed, large transmission distances and Hot Connect functionality offered by EtherCAT, as well as the connectivity options for numerous other bus systems."

The system openness of PC-based control is indispensable, and the large number of communication protocols required in the test rig provides just one example of its importance. In addition to high-speed EtherCAT as the primary fieldbus, the other protocols include PROFIBUS for drives, pumps and remote control, CAN for calibration tasks, SSI for speed logging, IEEE 1588 for time synchronization and DDS for communication between the controllers. According to Michael Rusinger, "This is an important aspect for the ability to set up customized inspection systems exactly according to the respective customer requirements, while still standardizing technology as much as possible to make developments more efficient. Another crucial factor is the option to integrate MATLAB®/Simulink®
models or to use C/C++ high-level programming languages via TcCOM (TwinCAT Component Object Model). For example, the complex controller model of the hydraulic load unit can be integrated, and the communication between TwinCAT and RDDS.NG can be implemented without great effort.”

**TwinCAT 3 as the real-time core of test rig software**

RDDS.NG is an automation software that was specially developed for test rigs and essentially consists of two components:

- TwinCAT 3 calculates the application created with RDDS.NG in real-time (TcCOM module and task).
- The RDDS.NG client serves as a user interface for operation, parameterization and application development.

Overall, RDDS.NG provides standardized test bench functions, including those for visualization, measured data logging, report generation, execution of automatic test sequences for the device under test (DUT) and test sequence management. Michael RUISINGER explains: “All tasks can be created intuitively with graphical editors, i.e. RDDS.NG consistently follows the philosophy of ‘parameterizing instead of programming.’ In this way, the software makes it easier for all operators of the Rolls-Royce test rig, who come from many countries around the globe, to familiarize themselves with the facility. It also increases its flexibility as a development test rig for different DUTs and test configurations and ensures the quality and traceability of the test results. The modularization of the hardware and software, which is optimally supported by PC-based control, is particularly important here, in order to master the complexity of the application.”

In addition to its functionality as an RDDS.NG real-time environment, TwinCAT 3 integrates the hydraulic load unit, which is mapped as a Simulink® model. It also connects the complete I/O level of the test rig, and executes smaller PLC programs that can, for example, implement various hardware interfaces. Andreas
TwinCAT 3 and the RDDS.NG real-time. The second IPC acts as a separate client PC, the third as a database PC for storing the complete configuration. Michael Ruisinger says: “We use three identical IPCs so that we can easily replace a computer, if necessary. The C5102 uses an Intel® Core™ i7 processor with four cores, since the complex application requires high computing power. Here we benefit greatly from the optimum multi-core support of the Beckhoff IPCs and TwinCAT 3 software. As a result, the tasks for the PLC functionality, the Simulink® controller model and the RDDS.NG application each run on separate processor cores, and the system performance is significantly increased as a result.”

Köhler describes the implementation: “The test rig functions implemented with the RDDS.NG client are transferred to TwinCAT at runtime without the need for complex compilation. The real-time part of RDDS.NG acts as a TcCOM module with an associated task in TwinCAT. The content of the TcCOM module and the task inputs and outputs can be easily defined through graphical parameterization in the RDDS.NG client. On the Beckhoff C5102 Industrial PC (IPC) used for control, the set and actual values required for visualization and operation are transferred between the modules via the ADS protocol. Within the higher-level client-server architecture, communication between the real-time program and clients takes place via the standard Windows Communication Framework (WCF) protocol, which can be processed via common network systems.”

Multi-core capabilities in hardware and software
RTS uses three 19-inch C5102 slide-in IPCs as the computer hardware for the Rolls-Royce test rig. One of them serves as the actual control computer running TwinCAT 3 and the RDDS.NG real-time. The second IPC acts as a separate client PC, the third as a database PC for storing the complete configuration. Michael Ruisinger says: “We use three identical IPCs so that we can easily replace a computer, if necessary. The C5102 uses an Intel® Core™ i7 processor with four cores, since the complex application requires high computing power. Here we benefit greatly from the optimum multi-core support of the Beckhoff IPCs and TwinCAT 3 software. As a result, the tasks for the PLC functionality, the Simulink® controller model and the RDDS.NG application each run on separate processor cores, and the system performance is significantly increased as a result.”

Further information:
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