



Control Systems for Strength Test Stands

The activities of the research department for the static, fatigue and thermal strength of aviation structures at the Siberian Research Institute of Aviation named after A.S. Chaplygin (SibNIA) located in the city of Novosibirsk are aimed at organizing and conducting static and endurance tests to determine the strength of full-scale aviation structures. During the institute's existence, the department has tested 166 airplanes with 42 various types of modifications (57 for static strength, 109 for endurance) and over 170 aircraft units at separate stands (wing panels, stabilizers, wing extendable devices, landing gear, etc.). Over 100 structures, units and items of aviation, rocket and space technology have been tested for thermal strength.

At present, the department laboratories are testing 11 full-scale aircraft samples: 8 aircraft from the Sukhoi Design Bureau (DB), 1 aircraft from the Tupolev DB, 1 aircraft from the Myasishchev DB, 1 aircraft from the Scientific Commercial Firm TECHNO-AVIA and 5 large-scale aviation units. The experimental base of the department consists of three buildings for full-scale testing of aviation struc-

tures with a total floor area of 15,400 square meters making it possible to simultaneously test the strength of more than 20 full-scale aviation structures with a takeoff weight from 2000 N to 6000 kN. The thermal strength testing laboratory of the department has separate stands for thermal strength testing of supersonic aircraft canopies. Testing is performed using electro-hydraulic force loaders to ap-

ply the required loads. Loading on the aviation units is distributed in accordance with preprogrammed curves. To satisfy the requirements for load reproduction accuracy, each object uses from 4 to 200 loading channels, each of which represent a program-controlled servo-hydraulic drive. The control rules are chosen to take into account the interrelations between the loading channels. The process of

loading during endurance testing has a continuous, periodic character. The control process is governed by force. The frequency at which loads are applied to the aircraft units ranges from 0.2 to 3 Hz. To satisfy the requirements for control accuracy during loading, a very high update rate for controlling the regulators is required (approx. 200-400 μ s for all system channels).

The tests require a state-of-the-art control system both for the process of creating the working liquid pressure in the hydraulic system and for the loading process itself. The control system should meet the most rigid requirements.

It should ensure the following in the automatic mode:

- sequential and shockless switching on of channel groups.
- synchronous loading of all active channels according to the program;
- shaping of the loading cyclogram and issue of control actions for the execution thereof by the actuators of the test stand with the given accuracy of reproduction of forces.
- shutdown of the program and loading process in all channels at any moment of the test or at the extremes of the cyclogram.
- analysis of emergency situations and drilling of response to the emergency situations in accordance with the test stand protection circuits.
- Real-time representation (on the



SSJ 100 - Russian Regional Jet Sukhoi Superjet 100 in the 75- to 95-seat category

monitor) of the levels of realized and programmable loads, the regulation parameters of the current loading channel, the pressure of the working liquid and air in the system as well as emergency situations.

- Logging and recording test reports on the hard disk
- Registering all operator actions.
- Switching to manual control mode from any test stand state (in shutdown mode, etc).

These requirements are fully met by control systems based on hardware and the Automation Studio software

from B&R. For nearly 15 years, SibNIA has been working with B&R through its official partner in Novosibirsk, CJSC «Research Institute of Electrical Communication» (NIIES). The systems are developed jointly by the specialists at SibNIA and NIIES (НИИ-ЭС).

At present, practically all endurance test stands from SibNIA operate with B&R control systems: SYSTEM 2005, SYSTEM 2010, X20 totaling over 400 control channels. The most modern endurance test stand is the test stand for testing a new Russian regional SUPERJET aircraft. While developing this test stand, a number of new requirements have been incorporated: creation of a structure for information exchange and a linguistic interface between the loading automatic control system and the independent control system for reproducible loads, an operational analysis system, presentation and interpretation of the results of endurance and static testing of aviation technology, monitoring integrity systems and a stressed-deformed structure and stabilization system.

The range of loading is a large combination of nearly 140 various loading segments, which make up laboratory flights that are in turn grouped in blocks. A periodically repeatable laboratory block consists of 5000 laboratory flights.



SUPERJET endurance test stand control station

The loading system on the test stand for testing the new Russian regional SUPERJET aircraft in SibNIA consists of:

- oil pumping station with control on the basis of B&R SYSTEM 2005 and the APC620 computer with the AP920 panel.
- An oil pumping station with a control system based on the B&R SYSTEM 2005 and the APC620 computer with AP920 panel.
- A system of hydraulic servo drives;
- loading automatic control system (ACS) on the basis of B&R APC620 and B&R SYSTEM X20 for 80 channels.
- A control system for reproducible loads based on the B&R X20 system with 80 channels.

The 80-channel ACS processor RRJ is built around an APC620 industrial computer (Pentium M 1800) with AR106 operating system. Quick-acting X20AI4632 and X20AO4632 analog modules are connected via the SUPERJET endurance test stand control station Ethernet POWERLINK network.

They are distributed over 5 stations using EPL controllers on the BC0083 bus. For the first time, the loading ACS is integrated with the reproducible load control system via Ethernet POWERLINK as a single two-processor unit. The APC620 ACS controller in this network is the master. The X20CP1486 control system controller



Full-scale samples in the endurance and static testing hall

is the Intellectual Controlled Node and has a direct access to the input modules for the unit connected to the APC620 in listening in mode. It compares the values obtained from the APC620 input modules and the X20AI4632 modules connected via the X2X bus. In case of an excessive discrepancy of the values, emergency signals are generated to protect the system. The EPL cycle in the system is synchronized with the X2X cycle and coincides with the update cycle of the 80 PID controllers resulting in 400 μ s. The control system is highly automated and continues to poll the modules over the X2X bus even when the master is fully out of action. Visualization is handled on a 19" AP920 touchpad using Visual Components. All of the software is developed using Automation Studio version 3.071. The software is developed jointly by SibNIA and B&R's official partner in Novosibirsk - CJSC «Research Institute of Electrical Communication». At the moment, metrological certification has been performed on the test stand and certification tests of the aircraft are being performed with very high reproduction quality and independent recording of loads.



SibNIA

Founded: 1941

Employees: about 700

Location: Novosibirsk, Russia

Products and services: Research, Development and Testing for Aeronautics and Space: Full-scale static, fatigue and thermal testing, aerodynamic and flight dynamic research, dynamic strength research, material and specimen testing, flight testing

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