FTD-ID(RS)T-1797-83

FOREIGN TECHNOLOGY DIVISION

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by

W. Ruifu and F. Jiechuan

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EDITED TRANSLATION

FTD-ID(RS)T-1797-83 1 February 1984

MICROFICHE NR: FTD-84-C-000124

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English pages: 8

Source: Guoji Hangkong, Nr. 8, 1983, pp. 6-7

Country of origin: China
Translated by: SCITRAN
F33657-81-D-0263
Requester: FTD/TQTA
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THE SUBSONIC-TRANSONIC WIND TUNNEL OF THE HARBIN INSTITUTE OF AERODYNAMICS

by Wang Ruifu and Fan Jiechuan

The Harbin Institute of Aerodynamics carried out technical modification of this institute's 0.52 meters x 0.64 meters subsonic-transonic wind tunnel. After this wind tunnel began to be used in July, 1982, it had already completed several thousand wind tunnel tests and the results were very good.

After technical modifications, the wind tunnel used for the first time single fulcrum semi-flexible wall nozzles and four wall variable open and close ratio oblique hole wall or low noise oblique hole plate test sections; using the DJS-622 computer as central, we realized wind tunnel operating program control and test data automatic-acquisition and real time processing; we tested the M number which could continually change from 0.3 to 1.5, we enlarged the low supersonic velocity testing range and in order to study the special features of the transonic wind tunnel wall we provided relatively advanced testing measures.

The Major Performances of the Wind Tunnel

This is a direct current continuous subsonic-transonic wind tunnel with atmospheric air intake driven by three turbojet 5 engines. See Figure 1 for the external contour of the wind tunnel.

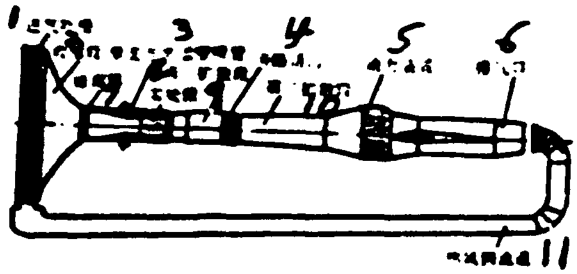

Fig. 1 Contour of the 0.52 meter x 0.64 meter subsonic-transonic tunnel.

Key: (1) Air intake cascade; (2) Contracting section; (3) Single fulcrum semi-flexible wall nozzle; (4) By-path valve; (5) Dynamic device; (6) Exhaust outlet; (7) Honeycomb apparatus; (8) First divergent section; (9) Test section; (10) Second divergent section; (11) Hot wind return path.

See Table 1 for the major dimensions and performances of the wind tunnel after technical modificatio..s.

1 [illegible]	30.5	8 [illegible]	600~4400
2 [illegible]	0.52×0.64	Re×10⁻⁶ *	0.5~1.0
3 [illegible]	1.75	9 [illegible]	11 三台[illegible] 11560[illegible] [illegible]1.72
4 [illegible]	6 [illegible] ±15°, ±6° 7 [illegible] ±180°		
5 M [illegible]	0.3~1.5	10 [illegible]	12 [illegible]

13 * [illegible]0.1√A, A[illegible]

Table 1 Major dimensions and performances of the wind tunnel.

Key: (1) Total length of wind tunnel (meters); (2) Section of test section (meters x meters); (3) Length of test section (meters): (4) Model angle range; (5) M number range; (6) Whole model; (7) Half model; (8) Dynamic pressure; (9) Wind tunnel's power; (10) Wind tunnel's operating time; (11) Three turbojet 5 engines with the highest rotating speed of 11,560 rotations/minute provides the wind tunnel's maximum power supercharging ratio 1.72; (12) Continuous; (13) The characte-istic length of the R_e number is taken as 0.1 $\sqrt{A}$, A is the test section's cross-sectional area.

The single fulcrum semi-flexible wall nozzle controls the stepping motor by computer which changes the height of the nozzle and can cause the nozzle profile to change from a contracting sonic nozzle to a contracting-expanding Laval nozzle. The oblique hole wall with a variable four wall open-close ratio or the open-close ratio of the low noise oblique hole wall can be controlled by computer. The four walls can synchronously or asynchronously continuously change in the 0.9% range and the precision is controlled at ±1 millimeter. The test M numbers are regulated by the computer controlling the nozzle's throat height, the engine's rotating speed and the degree of openness of the by-path valve. The M number controlled precision is 0.004. The computer control of the stepping motor is used to change the model attitude angle and the precision is ±1'.

The wind tunnel is equipped with a common light source and laser light source Schlieren instrument which can take color Schlieren photographs. The wind tunnel is also equipped with fluorescent oil flow flow state observation and photographic equipment.

After the wind tunnel was technically modified, we completed flow field check tests, GBM-01 and GBM-03 model dynameter tests and conical pressure measuring tests under different open-close ratio situations. Results showed that the quality of the wind tunnel's flow field was raised, it satisfied the requirements of the domestically stipulated "high speed wind tunnel's flow field performance targets" and this wind tunnel possesses very good wave elimination properties (see Figure 2). The maximum M number of the empty wind tunnel reached 1.58. The model dynamometer test precision satisfied the domestically stipulated "dynamometer test precision targets" and the test curve coincided relatively well with foreign materials and the domestic "standard curve."

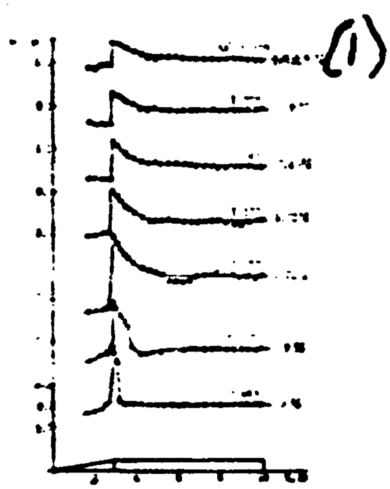

Fig. 2 Conical model's pressure distribution (degree of blockage 1.02%)

Key: (1) Open-close ratio.

The Test Data Acquisition Processing and Control Systems

The wind tunnel was fitted with the wind tunnel test data acquisition taking the DJS-622 computer as central processing and control systems. Its composition is shown in Figure 3.

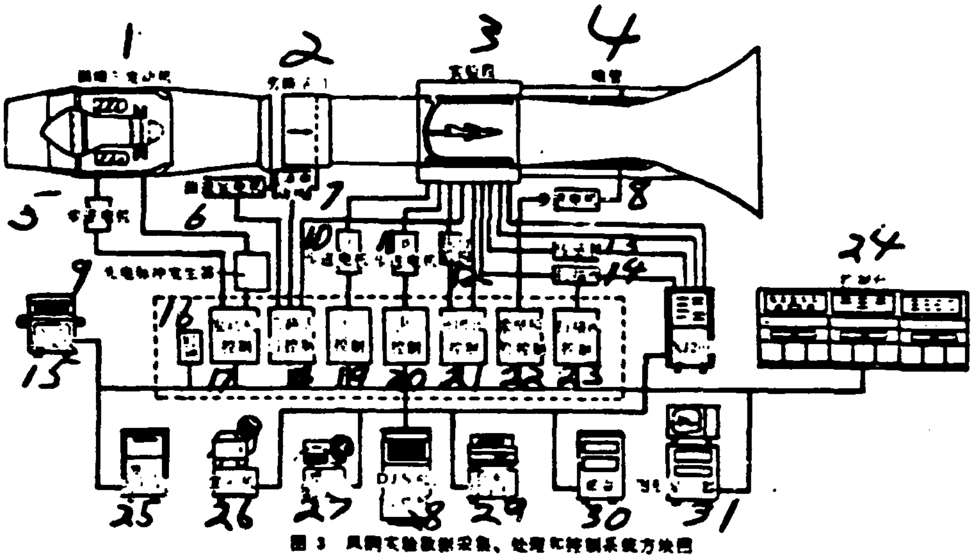

Fig. 3 Block diagram of wind tunnel test data acquisition processing and control systems.

Key: (1) Turbojet 5 engine; (2) By-path valve; (3) Test section; (4) Nozzle; (5) Stepping motor; (6) Velocity measuring generator; (7) Direct current generator; (8) Stepping motor; (9) Photo-electric pulse generator; (10) Stepping motor; (11) Stepping motor; (12) Executive structure; (13) Sensor; (14) Scanning valve; (15) Recorder; (16) Clock; (17) Engine control; (18) By-path valve control; (19) Control; (20) Control; (21) Open-close ratio control; (22) Flexible wall nozzle control; (23) Scanning valve control; (24) Console; (25) Wide line printer; (26) Boring machine; (27) Paper tape input device; (28) Computer; (29) Control typewriter; (30) Disk; (31) Graphic display.

This system, under the control of the wind tunnel operating control program drawn up with "Basic-II wind tunnel test language" and the test data acquisition processing program, realized program control of the wind tunnel operations and the test data automatic acquisition and real time processing. The wind tunnel's operating parameters can be digitally displayed on the console. The resulting real time of the test data processing is put out by the line printer and the curves are drawn by the X-Y function recorder. The total precision of the test data processing is 0.5%.

The wind tunnel test data acquisition system includes a formed series, strain scales with different forms, different components and levels, a pressure measuring system with a pressure scanning valve (the 192 point group made up of the 48D8-1099H7M48 point single valve and 48D-8GM I and II type type four single valves) and corresponding pressure sensor (PDCR-22PSI), the XJ-200 cruise inspector, CYD-801A line printer, LZ7-304 function recorder and self made and self-developed graphics display. During test data acquisition, based on the base frequency properties of the interfering signals, we can select the acquisition period and number of acquisitions, carry out mean smoothing and raise the precision of the test data processing.

The wind tunnel control system includes flexible wall nozzle control, model attitude (α, β) control, wall plate open-close ratio control, steady M number control, engine rotating speed control etc., subsystems and the safety warning system. Each subsystem has "machine connected" and "independent" work functions. During the wind tunnel's operating process, each subsystem coordinates at separate times and automatically operates under the supervision of the control program.

The wind tunnel test standard program and the sensor and strain scale static check data processing program have also been drawn up for the entire system. Therefore, we have raised the control precision of the model attitude angle, the control precision of the M numbers and the test data processing precision causing the wind tunnel's test efficiency to be 50% higher than before technical modifications and shortening the period of providing test results.

Test Items Which Present Wind Tunnels Can Undertake

1. Vertical and horizontal aircraft whole model dynamometer tests.
2. Half model dynamometer tests.
3. Whole model and half model hinge moment tests.
4. Externally hung object and airframe interference tests.
5. Pressure measuring tests.
6. Free air diffuser tests.
7. Vibration tests.
8. Sensor performance demarcation and other special tests.
9. Flow state observation tests.

This wind tunnel is still further developing new testing devices and testing techniques.

The X-29A Forward Swept Wing Proving Aircraft Will Carry Out Flight Tests

The Grummond Company of the United States estimates that the X-29A forward swept wing proving aircraft will carry out flight tests next April. After they first carry out four test flights in the factory, they will be sent to the NASA Dryden

Center to complete flight testing and verification plans. The Grummond Company estimates that the use of carbon fiber compound materials will lighten the total weight of the aircraft by 10-15% but not the originally estimated 25%. However, wind tunnel tests show that transonic resistance was reduced by 20%. The prototype of the X-29A used 57% ready-made parts including the F404 turbofan engine (the thrust is about 16,000 pounds), the front fuselage of the F-5A and the landing gear of the F-16 produced by the General Dynamics Company. The aircraft also used the digital telecontrol system with three degrees of redundancy, the wing's forward sweep is 30° and the span length is 8.2 meters.