Research on Brake System of Civil Aircraft

WANG Zijin¹,a, LI Zhenshui²,b, LI Wei³,c

¹AVIC THE FIRST AIRCRAFT INSTITUTE  710089 CHINA
²AVIC THE FIRST AIRCRAFT INSTITUTE  710089 CHINA
³AVIC THE FIRST AIRCRAFT INSTITUTE  710089 CHINA

a 78413571@qq.com,blizhenshui@163.com,dart1358@hotmail.com

Abstract. This paper briefly introduces the civil aircraft brake system’s composition and working principle. Otherwise, it shows some important accessories and their structure/principle of the brake system.

1. Introduction

The basic task of the BCS (Brake Control System) will be to control hydraulic pressure to the aircraft brakes as a function of brake pedal position (percent pedal displacement) and to provide anti-skid control to prevent deep tire skidding and minimize stopping distance. The BCU (Brake Control Unit) shall consist of two independent wheel boards (Inboard, Outboard). The BCS electronics (installed in the BCU) and control valves (which are part of the Dual Brake Control Module) shall operate from the system power supplies. The hydraulic shut off valves, shall operate through the BCU from the 28 volt aircraft right essential power bus for the inboard wheel pair and the 28 volt aircraft left essential power bus for the outboard wheel pair. Each brake pedal (left and right, pilot and copilot) shall have a transducer with dual coils which provide two pedal position signals. Four separate brake pedal signals shall be provided to each circuit board in the BCU for control purposes.

2. Brake System’s Composition and Working Principle

The Brake Control System (BCS) is partitioned into two separate channels: inboard (BCU channel 1) and outboard (BUC channel 2), as shown in figure 1. The system provides individual wheel control and full differential braking capability for steering the aircraft. Autobraking is included as part of the system.

Hydraulic system 1 provides pressure/liquid to the inboard wheels. Hydraulic system 2 provides pressure/liquid to the outboard brakes, as shown in figure 2. In the Park/Emergency braking mode, a Dual Park/Emergency Valve (DPEV) provides proportional braking to all four brakes simultaneously, without Antiskid protection. The inboard and outboard systems are fully isolated throughout the entire braking system.

Two accumulators are required to provide fluid for parking and to supplement the hydraulic system in case of a hydraulic system failure. A single Antiskid stop or multiple applications of the park/emergency system is possible using accumulators.

The brake control system uses four pedal position transducers (PPTs) each of which consists of dual channel Linear Variable Differential Transformers (LVDTS). One channel of each PPT is connected to the Inboard system and one channel to the Outboard system. The PPTs are monitored to detect inadvertent braking. This monitoring is performed in parallel with the brake control process.
Before the brake pedals are pressed, there will be no electrical power to either shutoff valve, and system pressure is not available to the brake control valves. When either pedal is pressed through approximately 8% displacement, electrical power is provided to open both 3-way shutoff valves allowing hydraulic pressure to reach the brake control valves. Pressure transducers are used to provide pressure feedback to the Brake Control System. Brake pressure feedback compensates for change in valve characteristics. The pressure signals are also used with Built In Test (BIT) to monitor the functioning of the control valves and the brake hydraulic lines. Four hydraulic fuses are also included in the braking system to preserve hydraulic fluid in case of hydraulic line rupture downstream of the fuse.

Wheel speed information is provided by four axle mounted, single channel AC wheel speed transducers.
Brake pressure is supplied to the brakes using 2 Dual Brake Control Modules (DBCMs). Each of these units incorporate two flapper-type brake control valves. Each DBCM supplies two wheel brakes, either the inboard or outboard pair from their respective hydraulic systems.

3. Important Accessories

3.1. Dual Brake Control Module (DBCM)
The DBCM consists of two identical flapper nozzle servo valves mounted on a fluid distribution manifold, as shown in figure 3. Each valve, being self-contained, is face mounted on the manifold as a discrete unit which allows for easy removal for servicing.

The function of each Dual Brake Control Module is to provide commanded brake pressure to the inboard (INBD) or outboard (OTBD) brakes. One servo valve in each Module (INBD/OTBD) controls the brake pressure to the right brake and the other servo valve controls pressure to the left.

Each servo valve has a separate first and second stage.

Fig.2 Brake Hydraulic System Block Diagram

1 Accumulator
2 Shutoff Valve
3 Dual Brake Control Valve Module
4 Dual Park/Emergency Valve
5 Hydraulic Fuse
6 Pressure Transducer
The first stage is a servo-control valve operating with a three-way flapper/nozzle configuration with inherent low leakage. An internal 25-micron absolute (10-micron nominal) filter protects the servo valve first stage from contaminants. In addition, a 25-micron absolute filter is installed in the inlet port. A 100-micron absolute filter is installed in the brake port. A check valve is installed in the return port to prevent pressure pulses from other outside sources from affecting the servo valve operation. A permanent magnet provides the working force against which a coil generates an opposing field to produce the valve action. When de-energized, the brake cavities have only return pressure.

The servo valve controls the pressure to one brake on the strut as a function of the applied control current. The 565 microcontroller outputs a digital control signal to digital to analog converter. The valve driver interface circuit receives this analog brake control signal from the digital to analog converter. This signal is buffered, filtered and processed by the valve driver circuit to produce a DC brake control signal. This signal is applied to the servo valve to control/modulate the brake pressure to the brakes.

The permanent magnet and coil that produces the valve action is referred to as the torque motor. When the Brake Control Unit channel applies a valve signal to the torque motor, force is applied to the flexure sleeve assembly and the resulting motion controls effective orificing of fixed nozzles to yield a control pressure.

The control pressure from the first stage, the inlet pressure, and the brake pressure feedback, function as three primary forces which operate in a force balance to allow proportional control of output pressure through controlled positioning of the second stage. In the event a skid is detected, the antiskid signal will subtract from the commanded brake signal to reduce the amount of brake pressure supplied by the servo valve.

![Hydraulic Schematic](image)

**Fig. 3 Dual Brake Control Module Principle**

### 3.2. Wheel Speed Transducer (WST)

The WST assembly is a single output, variable reluctance type signal generator, as shown in figure 4. A drive cap provides the motion transfer from the wheel to the WST.
The WST derives its energy from an internal permanent magnet and requires no external excitation for signal generation. The output signal consists of 100 AC cycles per revolution and has a frequency and voltage component. The BCU uses the wheel speed information to provide antiskid protection.

A self-aligning coupling subassembly is attached to the rotor shaft of the WST to turn the rotor/exciter subassembly.

The transducer shaft is rotated by the coupler subassembly, which engages the drive blade on the drive cap. The shaft turns the rotor. The rotor consists of a magnetic ironexciter ring with 100 external teeth located around the periphery. The stator consists of a toroidal magnetic circuit containing a coil, central pole/core and a permanent magnet at one end. The magnetic flux flows through the central core, a secondary air gap inside the rotor, across the rotor to a stator with 100 internal teeth in the housing and returns to the magnets through the case.

As the exciter rotates around the stator, the reluctance of the magnetic circuit will alternately be increased and decreased by the alternate alignment and nonalignment of the teeth of the exciter ring with the teeth of the stator. This change in reluctance causes a change in flux that causes a voltage to be developed in the coil. The voltage is sinusoidal having a frequency of 100 cycles per wheel revolution. The amplitude ranges from 2.5V to 6V through the speed range.

![Wheel Speed Transducer Principle](image)

**Fig.4 Wheel Speed Transducer Principle**

**Reference**

[1] Chen B, Jiao Z, Ge S S, et al. Robust Adaptive Neural Network Control of Aircraft Braking System[C]. Industrial Informatics (INDIN), International Conference on. IEEE, 2012: 740-745.

[2] Mitić D, Antic D, Perić S, et al. Fuzzy Sliding Mode Control for Anti-Lock Braking Systems[C]. Applied Computational Intelligence and Informatics (SACI), International Symposium on. IEEE, 2012: 217-222.

[3] Zuo J, Wu M. Research on Anti-Sliding Control of Railway Brake System Based on Adhesion-Creep Theory[C]. Mechatronics and Automation (ICMA), International Conference on. IEEE, 2010: 1690-1694.