Hydroplane and touchdown protection engineering essay

To decelerate the Boeing B777 on the ground, the main landing gear wheels are equipped with hydraulic pressurized brakes. The nose landing gear is not provided with hydraulic pressurized brakes, but with an spin brake. The spin brake stops the rotation of the nose landing gear wheels during retraction. This is done duo the friction of the tires and the spin brake, which slows down the rotation of the wheel. The wheels of the nose gear must be stopped to prevent gyro effect. The nose wheel brakes will not be further discussed. The brakes of the main landing gear can be operated manual during normal braking (1. 4. 1). The brakes can also be automatically activated by the auto-brakes (1. 4. 2). In order to minimize the stop distance and to prevent skidding the Boeing B777 is provided with anti-skid (1. 4. 3). To prevent that the breaks will overheat, the Boeing B777 is provided/equipped with a brake temperature monitoring system (1. 4. 4).

Normal braking

To apply the brakes both pilots in the cockpit have braking pedals at their disposal to brake (1. 4. 1a). The Boeing B777 is provided/equipped with a multiple disk brakes of rotor-stator units (1. 4. 1. b). To provide the needed friction to convert the kinetic energy into heat. When the aircraft is parked, the parking brake is applied (1. 5. 1c). The brakes make use of hydraulic pressure, which can be supplied by different sources (1. 5. 1d).

1. 4. 1a Braking pedals

Manual wheel braking can be used for steering by applying only the left or right brake system. It can also be used during landing and taxi to slow down or stop. The brakes are activated by pushing the brake pedals (fig. x) with

your feet in the cockpit. The braking pedals are mounted on the rudder pedals, however they are differently operated. The braking pedals are operated by pushing onto the upper part of the rudder. Which will cause a rotation of the pedal and therefore a mechanical movement. This mechanical movement of the brake pedals is converted by the brake pedal bus mechanism to a movement of the brake cables. The brake cables are connected to the brake metering valve. There are two brake metering valves, one for right the main gear and one for the left main gear. The brake metering valve uses the cable movement from the brake cables to control the hydraulic pressure. which is used to operate the brakes. The brakes are controlled by two sets of brake pedals (1). The pedal movement is transported through the vertical control rods (2) to the lower bellcranks (3). The bellcranks are connected through the fore aft control rods (3), to the brake pedal bus crank assemblies (5) and cable quadrants (6). The brakes on the right MLG are controlled by the right cable quadrants through brake cables (7) and the brakes on the left MLG are controlled by the left cable quadrants.

Figuur x Brake pedals

Zo wil ik het doen maar ben niet zo handig met word: Pmoeten jullie me maandag wijzen

1. 4. 1. b Rotor-stator unit

To generate enough friction to slow down or stop the aircraft, rotor-stator brakes (fig xx) are mounted on each wheel in the brake unit of the main landing gear. The brakes consist of seven carbon discs, three stator discs

and four rotor discs. Rotor-stator brakes consist of multiple rotor disks (1) attached to the wheel. Between each rotor there is a stator disc (2). The stators are non moving discs attached to the wheel axels. To activate the pressure plate (3), six hydraulic pistons are used which automatically adjust for break wear. When the hydraulic pressure in the self adjusting pistons raises (4). The rotors and stators will be compressed between the pressure plate and the end plate assembly(5) which provide friction. Two indicator pins (6) on the inboard side of the brake housing show brake wear. Therefore it is easy to see when the brakes needed to be replaced.

fig xx Rotor-stator brake

1. 4. 1. c Parking break

The parking brake keeps the brakes applied when the aircraft is parked. To keep the brakes applied the parking brake uses any available pressure. The parking brake can be switched on by pulling the parking brake lever, when the brake pedals are pushed in. The latch system will keep the pedals in the brake applied position and sent a signal to close the parking brake valve. The parking brake valve is closed to prevent leakage of hydraulic pressure. When the parking brake is applied at 3000 psi, the brakes stay applied for at least eight hours. The parking brakes can be released by depressing the brake pedals until the parking brake lever releases.

1. 4. 1d Hydraulic resources

To provide the brakes from hydraulic power five sources can be used. Which source is used, is automatically controlled by two valves of the brake pressure source selection (fig xxxx). The five sources for the brakes are:

Normal brakes: Under normal conditions, when all the pressure sources are available, the

brakes uses the right hydraulic system to receive pressure.

Alternate brake: When the right hydraulic system pressure is low, the brakes receive pressure from the centre hydraulic system.

Reserve brakes: Reserve brakes use the isolated centre pressure to power the brake system.

Accumulator brakes: When all the pressure sources are low, the accumulator pressurizes the

brake system. The parking brake also uses the accumulator pressure when no other pressure

sources are available.

Gear retract brakes: When the MLG retracts, the wheels are stopped to resist the gyroscopic

effect. This is done by using the LG retract pressure to power the brakes.

Fig xxxx Brake sources

Auto-brakes

When the brake system control unit gets input from the auto-brake selector (fig xxxxx), it controls the brake pressure with the auto-brake valve module. When the brake system control unit gets the signal that the wheels touch the ground or the thrust levers are set to idle, it will monitor brake pressure to provide a constant deceleration set by the auto-brake selector. When the reverse trust is selected, the brake system control unit controls brake pressure to maintain the deceleration rate selected with the auto-brake selector. The auto-brake system ensures the brakes to be quickly and automatically activated with a constant metered brake pressure during landing or rejected take-off Braking with the auto-brake system is also experienced as more comfortable by the passengers, because of the constant braking pressure.

Fig xxxxx auto-brake selector

Anti-skid

In the main landing gear axle there are twelve anti-skid transducers installed. This is done because the anti-skid transducers can sense the speed of the wheel. The necessary information of the wheel speed can be sent to the brake system control unit, which will control the hydraulic brake pressure. This information is also used for auto-brake operations. When the Cf is too high the skid control valve is commanded to reduce brake pressure to a level just below the optimum friction. The Cf is the relation of friction between the surface of the runway and the tire. Brake pressure is then allowed to increase slowly until the wheel again decelerates above the reference level. With one inactive anti-skid transducer on each six wheel

truck the system can still be operated normally, but if two anti-skid transducers are deactivated on the same truck the system cannot function effectively anymore. The anti-skid card is a circuit card which controls the anti-skid valves to operate the anti-skid functions. There are four anti-skid cards each card controls a set of three wheels. The cards also supply wheel speed information to the auto-brake function. There are different functions the anti-skid cards supplies these are:

1. Skid control

2. Locked wheel protection

3. Hydroplane/touchdown protection

4. Gear retract inhibit

5. Taxi brake release

ad 1 Skid control

To control the brake force the skid control compares calculated wheel speed velocity with a velocity model. If a wheel speed is decreasing to fast the skid control releases brake pressure until the wheel speed increases and becomes equal to the other wheels. The skid control is available when the wheel speed is higher than eight knots. Skid control is available for each wheel, during normal anti-skid operation.

ad 2 Locked wheel protection

Locked wheel protection compares the wheel speed of the forward, the middle and the rear wheels. If the wheel speed of the slowest wheel is less

than 30% of the fastest wheel speed, the brake pressure to the slowest wheel will be released by the locked wheel protection system. These protections cause an increase of the wheel speed. The protection only operates on a speed above the 25 knots.

ad 3 Hydroplane/touchdown protection

The hydroplane/touchdown protection only operates on the rear wheels. This mode protects against hydroplaning and it prevents locked rear wheels during touchdown. If the gear lever is selected down and the wheel speed is 50 knots less than the ground speed, the protection releases the rear wheels. Indirectly the protection protects the forward and middle wheels through locked wheel protection.

ad 4 Gear retract inhibit

To brake the wheels during the retraction of the landing gear, the anti-skid system stops the alternate anti-skid for 12. 5 seconds after the gear lever is moved out of his down position. The gear retract braking is now permitted to stop the wheels without anti-skid brake release.

ad 5 Taxi brake release

The taxi brake release function releases on each truck two brakes during taxi-brake operation. The auto-brake/built in test/r-communication card supplies for both trucks the taxi brake release request. When the average wheel speed is less than 45 knots or the normal brake metered pressure is between 250 and 1800 psi, the requests are sent to the anti-skid cards. If the wheel speed is less than 45 knots the anti-skid card sends a full brake release signal to the normal anti-skid valves for the selected wheels. On one

axle of each truck the valves releases normal brake pressure. The selected axles may be different for the left and the right released brake pressure. With a pressure above the 1800 psi the taxi brake release is deactivated and permits al wheels to brake. When the pressure drops below the 150 psi, the selected axle changes for each brake application. The operation of the taxi brake release operates only in the normal anti-skid system.

Brake temperature monitoring system

To provide the pilots of information of the temperature of the twelve main brakes a brake temperature monitoring system is installed. The brake temperature monitoring system consists of twelve temperature sensors, two brake temperature compensation modules and a brake temperature monitor unit. The brake temperature sensor is a thermocouple, which is installed near the bottom of the brake in each main gear brake assemblies and sends the brake temperature signal trough the brake temperature monitoring system. The temperature sensor produces a voltage related to a temperature difference. The signals are changed to a value between 0. 0 and 9. 9, which is the brake temperature between approximately 38° Celsius and 1038° Celsius. The values less than 5. 0 (538°Celsius) is shown in white, if the brake temperature is 5. 0 or more the number will change to amber and will stay amber until the temperature of the brakes decreases to less than 4. 0 (430° Celsius). If the temperature is more than 5. 0 the thermal plugs may melt. This is to prevent heating of the tires, because the heat can cause expending of the nitrogen, what can result into a tire that will explode.

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http://boeing. com/commercial/aeromagazine/articles/qtr_03_09/article_05_1.html

Manual maintenance 777 wheels and brakes

http://www. smartcockpit. com/pdf/plane/boeing/B777/systems/0010/