

Improved Braking Performance

for the Lancair 360 with the 'Outback Gear'

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Figure 1, New Brakes Installed

When Lancair introduced the Outback Gear, the tire diameter was increased with 5.00-5 tires while the brakes remained the same. This had the effect of reducing maximum deceleration during braking when compared to the original smaller 11-400x5 tires. For a given brake pressure, brake calipers apply a torque to the wheel. The braking force the aircraft experiences is then a function of the wheel diameter. As the diameter goes up, the force goes down.

The original brakes supplied in Lancair kits were manufactured by Matco. They consisted of a single 1.500" piston (Figure 2) and 66-106 brake pads. Nominal maximum operation pressure

the system was 450 psi. I had previously measured my maximum brake pressure and I was able to achieve 525 psi. Operationally, braking performance was adequate but certainly not impressive. At mid to low speeds I could apply full brake pressure without fear of locking up the wheels.



Figure 2, Original Matco Caliper, one 1.5" piston

There were some alternative brake systems on the market that provided an incremental improvement. Grove provides a popular replacement with 38% more piston area, two 1.25" pistons (Figure 3), and 20% more pad area using a 66-110 brake pad.



Figure 3, Grove Caliper Body, two 1.25" Pistons

Space constraints prevented the use of larger and more powerful commercially available systems. Obtaining a substantial improvement was going to require a custom design.

Design

The intent was to use as much of the existing hardware as possible and to make the modification a drop-in replacement. Analysis showed that there was no need to increase the disc size. From Matco energy specifications one can derive the bulk temperature limits to which the original discs were designed. Given the speed and weight of the Lancair 360, the original disc was more than adequate. The worst case scenarios only utilized 2/3 of their energy absorption capacity.

The resulting design has three 1.25" pistons (Figure 4) and four 66-105 (or alternatively 66-106) brake pads per caliper. This slightly more than doubles the piston area and doubles the pad area. The fit in the aircraft is actually a bit improved. The smaller diameter pistons reduced the total outer diameter of the caliper body. The overall height is also slightly reduced. Basically the caliper body is tucked in closer to the wheel and disc.



Figure 4, Three-piston Caliper Body, three 1.25" pistons



Figure 5, Compact Three Piston Brake Caliper

Testing

The brakes were instrumented to capture disc temperatures, caliper temperature, brake pressure. Deceleration was recorded using a 20 Hz Doppler GPS. For several weeks, landings were done with maximum braking effort to stress the parts and record actual performance. Maximum effort was limited by the friction coefficient on the given runway. An attempt was made to keep the wheels just short of locking up to achieve the shortest roll-out.

Brake disc temperatures were recorded with IR sensors using and an Arduino. The IR sensors were looking at the portion of the disc engaged by the pads. The IR sensors were calibrated with actual discs heated in an oven as the emissivity was unknown. This approach would also take into account any changes in emissivity as a function of temperature.

Braking performance was greatly improved. Peak deceleration recorded was 0.4 G's, with 0.35G's being a typical value (Figure 6). This results in being able to go from 45 kts to a full stop in 250-300 ft. During these event the highest brake pressure ever recorded was only 260 psi. This is nearly half the prior peak operating pressure. It indicates a substantial gain in effectiveness of the pads by lowering the contact pressure at the disc. i.e. twice the area and with half the pressure yields far greater brake torque.

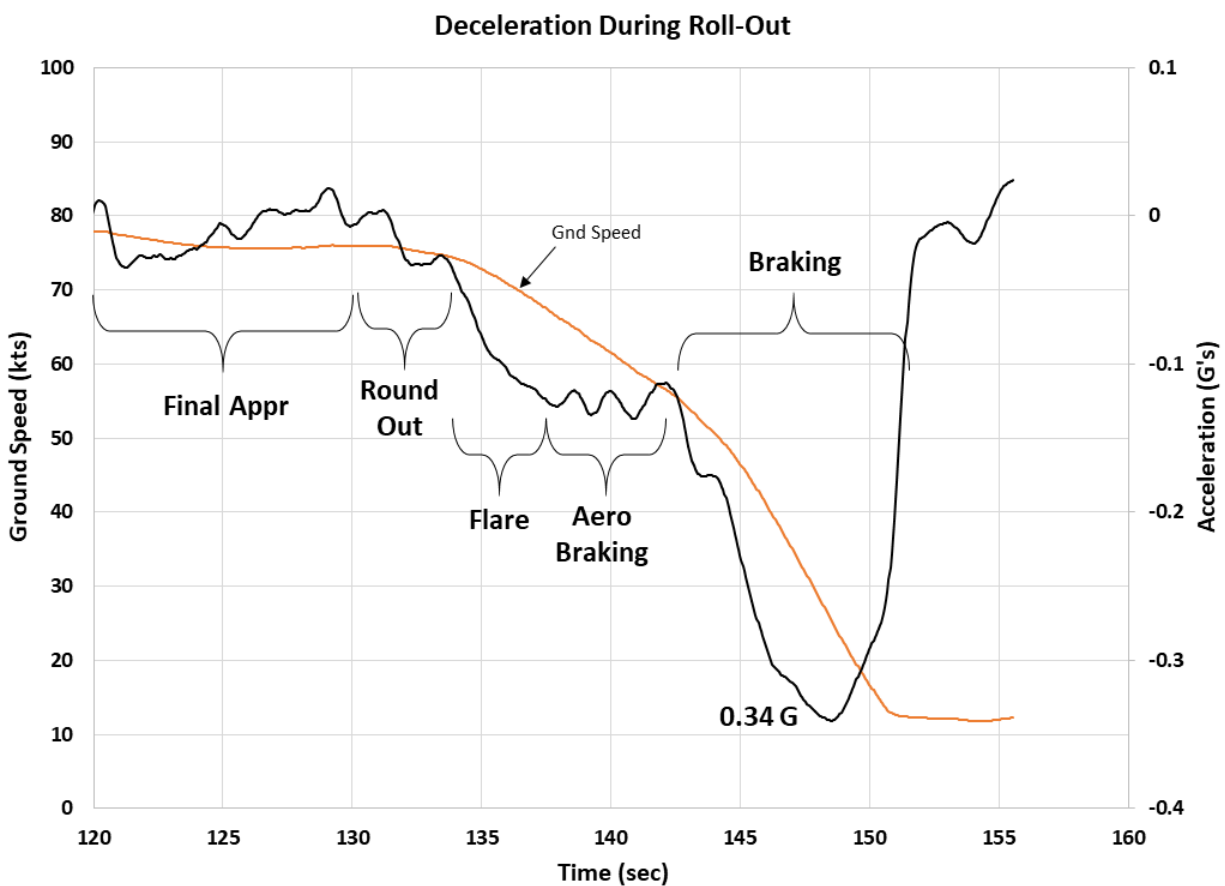


Figure 6, Landing Deceleration

The new calipers were tested in various configurations for tens of thousands of brake cycles. A pneumatic actuator was used to drive the master cylinder. While the maximum recorded operational brake pressure was 260 psi, most cycle testing was at 450 psi. Pressure as high as 1,000 psi was applied to the calipers.

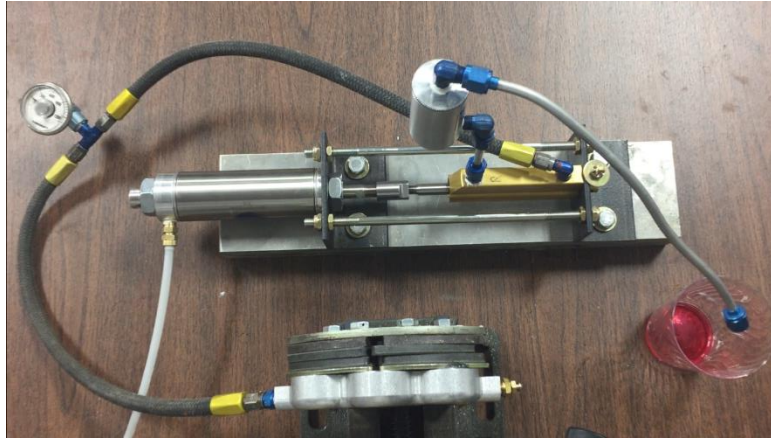


Figure 7, Pneumatic Cycle Testing Rig

Thermal Measurements

Since the Lancair uses a castoring nose wheel, the brakes are used for steering. This adds to the total heat load. Sample data can be seen in Figure 8 through 10. Figure 8 shows an overview of a short, once around the pattern, flight. Figure 9 zooms in to the landing phase. Peak disc temperatures reach 800 deg F. Once the heat diffuses into the entire disc, the temperature settles at about 400 deg F.

Noteworthy is how low the brake pressures are. Now only half the pressure range is needed to achieve maximum braking. 260 psi is the highest pressure recorded to date.

Another interesting observation is that it takes roughly 20 seconds for the heat generated in the disc under the brake pads to completely diffuse into the entire disc. The initial peak temperature drops quickly as this happens. Cooling of the entire disc takes quite some when sitting stationary on the ground. When coming to stop and parking, the lack of airflow slows brake cooling. It takes on the order of 30 minutes for the brakes to reach ambient temperature. If another take-off and landing are performed followed immediately following a landing, the disc will have cooled back down to ambient conditions prior to the next braking event. This allowed continuous testing cycles of landing, taxi back, and takeoff.

Operational Results

Brake performance is now much better matched to the aircraft. Maximum brake effort is solely a function of runway surface condition. Brake torque can be modulated up to the maximum friction coefficient point throughout the entire landing roll-out resulting in some impressive deceleration rates.

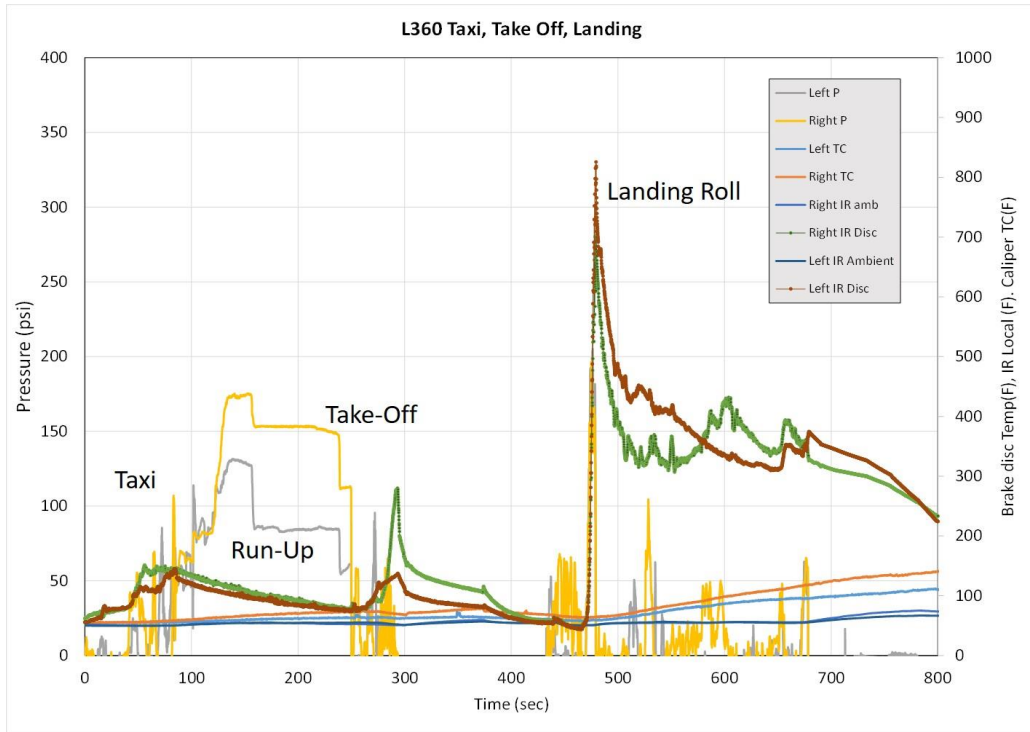


Figure 8, Thermal Response – Taxi through Landing

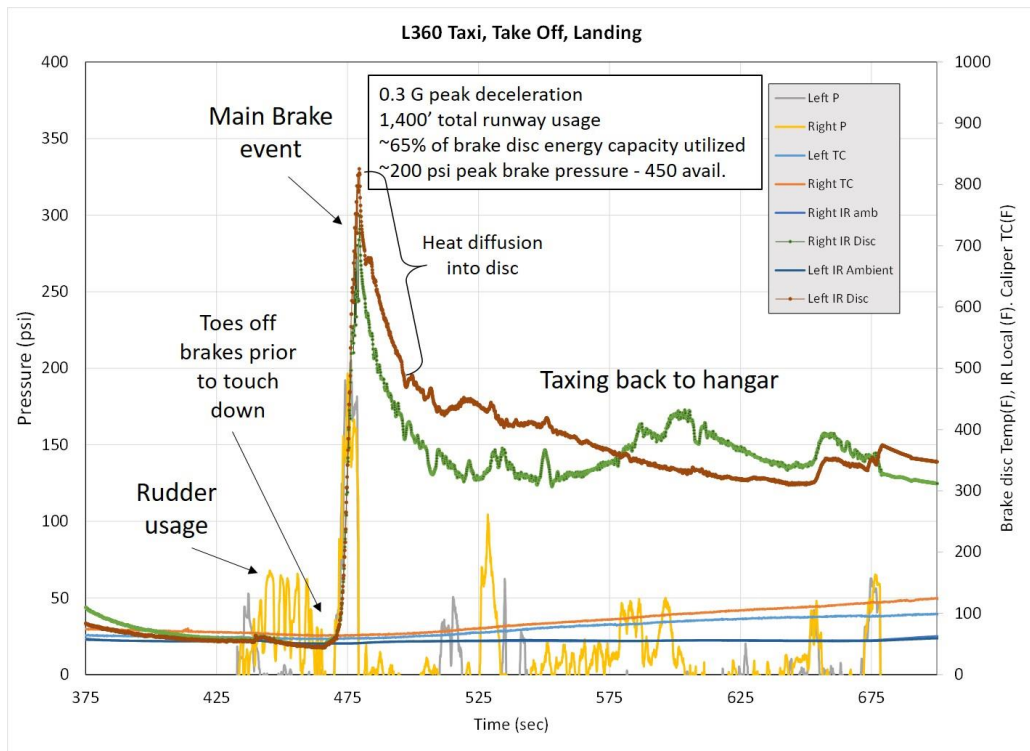


Figure 9, Thermal Response, Landing

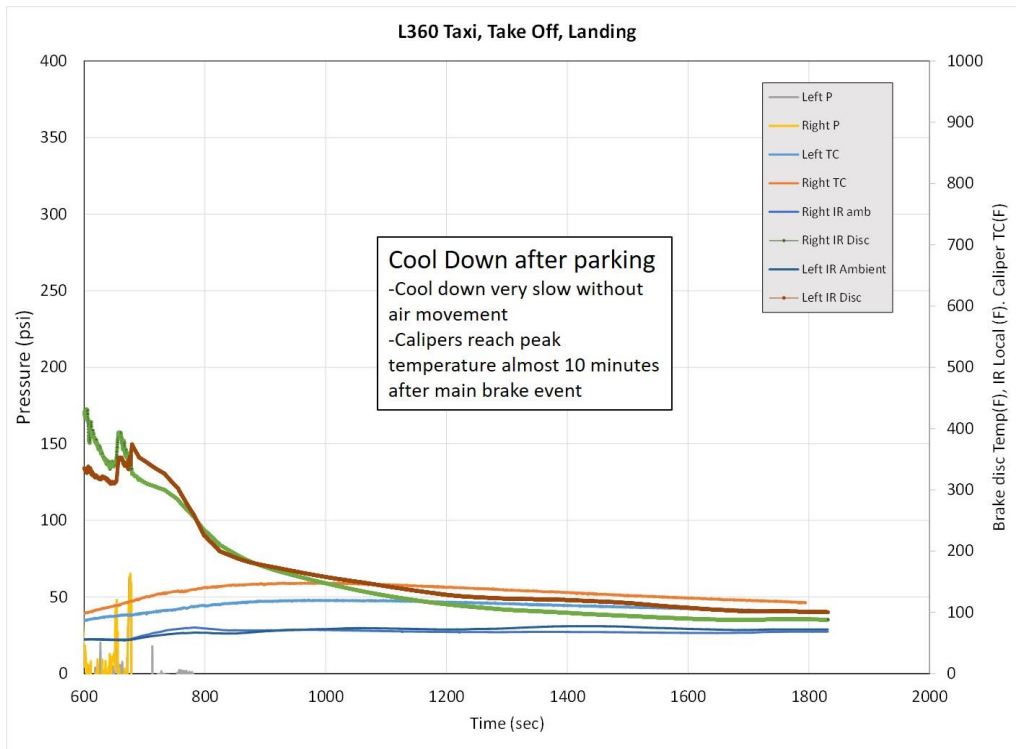


Figure 10, Thermal Response, Post-parking Cool-down