SERIOUS INCIDENT

Aircraft Type and Registration:	Avro RJ100, G-BZAW
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	1999
Date & Time (UTC):	5 February 2009 at 1333 hrs
Location:	London City Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 5 Passengers - 24
Injuries:	Crew - None Passengers - None
Nature of Damage:	Extensive damage to the left nosewheel and its axle
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	12,870 hours (of which 8,870 were on type) Last 90 days - 206 hours Last 28 days - 57 hours
Information Source:	AAIB Field Investigation

Synopsis

After landing, the flight crew felt a judder from the nosewheel during a 180° turn on the runway and the judder returned intermittently during the taxi-in. The aircraft was stopped to allow a visual inspection which identified that the left nosewheel was no longer properly attached. The passengers and crew were disembarked normally. Investigation of the damaged parts identified that the outer bearing of the left nosewheel had failed due to the roller cage becoming trapped. It is not possible to say which of the two potential causes led to the failure. Whilst no recommendations are made, this event is a reminder of the importance of following manufacturer's procedures to inspect and install all aircraft wheel bearings correctly.

History of the flight

The aircraft was operating a scheduled flight from Glasgow Airport to London City Airport, which was uneventful until after the landing on Runway 10. In order to vacate the runway, the aircraft executed a 180° turn to the left in the turning circle. During this turn, the flight crew felt the aircraft judder. They initially attributed this to the nosewheel skidding on the wet runway markings. As the aircraft back-tracked along the runway, the flight crew felt an intermittent judder which they now thought might be due to a deflating tyre. Shortly after turning onto Taxiway C the aircraft was stopped partly clear of the runway to allow the nose landing gear to be inspected. This revealed that the left nosewheel was no longer properly attached. The cabin crew and passengers were informed and they

disembarked from the aircraft normally. There were no injuries.

Recorded flight data

The aircraft was equipped with a flight data recorder (FDR) and a cockpit voice recorder (CVR), capable of recording a minimum duration of 25 hours of data and 120 minutes of audio respectively. Both were successfully replayed. The FDR record contained all 16 flights since the left nosewheel had been installed. The CVR record included the approach and landing at London City Airport.

The FDR record was analysed for unusual or abnormal aircraft operation that may have resulted in, or contributed to, failure of the nosewheel assembly. The incident landing at London City was analysed. Peak Normal acceleration at landing was 1.49g with the main landing gear contacting the runway surface about one second prior to the nose gear. Rate of descent at touchdown was less than 5 ft/sec, below the aircraft manufacturer's 'hard landing' descent rate limit of 10 ft/sec. Of the 15 preceding flights, one showed a similar level of Normal acceleration at landing, although well below that which would require a hard landing inspection. In addition to hard or unusual landing attitudes, rapid de-rotation during landing may result in higher than normal loads being placed on the nose gear and wheel assemblies. From the incident flight, the de-rotation rate was calculated to be about 3°/sec. This was higher, by about 1.5°/sec, than all but one of the preceding flights; the flight having a higher de-rotation occurred 11 flights prior to the incident flight.

The FDR record was also analysed by the operator's Flight Data Monitoring (FDM) system. If an anomaly in the operation of the aircraft were identified, the system would automatically produce a report. No reports were generated for either the incident or preceding flights.

Engineering examination

Both nosewheels were removed from the aircraft. The left wheel and its bearings were found to be severely damaged and parts of the bearings were recovered from the runway and Taxiway C. Subsequent inspection found damage to the nosewheel axle assembly and it was replaced. Both nosewheels and all the damaged parts were taken initially to the AAIB facilities.

A detailed examination of the damaged parts was conducted under AAIB supervision at the wheel manufacturer's overhaul premises by their technical support engineers and a technical representative of the bearing manufacturer. This examination identified that the outer bearing of the left nosewheel had failed first; the inner bearing, wheel and axle damage were as a result of this initial failure. A detailed examination of the outer bearing found that the damage had occurred rapidly, as most of the rollers still had their original surface finish intact and their ends were not deformed. Witness marks on the raceways indicated that the rollers had not skewed and the tips of the rollers were not burnt, indicating that there had been sufficient lubrication. This evidence led to the conclusion that the roller cage had become trapped and then severely damaged, which allowed the rollers to move and 'clump together' within the bearing. The bearing manufacturer stated that there are two possible reasons for the cage becoming trapped: wear in the cage pockets or, in their opinion more probably, insufficient pre-load on the bearings.

Nosewheel maintenance history

The wheel in this incident was manufactured in February 1998 and had completed 4,470 cycles since its previous overhaul. It had been returned to the manufacturer for a tyre replacement in December 2008. In order to replace the tyre, the two halves of the

wheel have to be separated. The wheel bearings are removed, cleaned and inspected and, if their condition is satisfactory for further service, they are greased and re-installed in the wheel. Because of this 'on condition' assessment of bearing serviceability, it is not possible to determine how long the bearing had been in service as there is no requirement to record its service life.

The fitters conducting the work receive regular continuation training to ensure their knowledge for the task is at a suitable level. The person inspecting the bearings completed continuation training, provided by the bearing manufacturer, in April 2008.

The wheel assembly was released from the manufacturer on 20 January 2009, in a certified 'fit for service' condition.

Aircraft maintenance history

The wheel assembly was fitted to the aircraft on 30 January 2009 in the left-hand position and the aircraft had operated for 16 cycles prior to the failure. It was installed by two licenced aircraft maintenance engineers (LAMEs) during a routine overnight inspection. The wheel was replaced in accordance with the Aircraft Maintenance Manual (AMM). Both LAMEs, who were familiar with the task and had changed nosewheels on this type of aircraft numerous times, reported that no problems were encountered during the task. Although it was night, adequate lighting was provided from their vehicle lights and portable halogen lights provided by the operator. The weather was cold and drizzly but neither LAME felt this affected the task. The only real distraction mentioned was a noisy diesel ground power unit supplying electrical power to the aircraft.

In order to correctly seat the wheel, the AMM requires that the axle wheel nut is first torqued to a relatively high figure to seat the wheel bearings, before the nut is undone and then re-torqued to the in-service value. Whilst the torque is being applied on each occasion, the wheel must be rotated to ensure the bearings take up their correct positions.

Both of the LAMEs involved were certain that this procedure was followed with one rotating the wheel whilst the other tightened the axle wheel nut to the specified torque value with a torque wrench.

The torque wrench used for the wheel installation was removed from service and was sent for calibration. The results of this testing showed that the torque wrench calibration was within satisfactory limits throughout its range.

The operator issued an Engineering Technical Requirement on 18 February 2009, to conduct a fleet-wide check of each nosewheel installation for correct axle nut torque. All the aircraft in the operator's fleet were checked, with no adverse findings.

In-service history

The aircraft manufacturer has only two recorded reports relating to failed nosewheel bearings since the start of their present database in 2000.

The most recent, in March 2008, was attributed to a lack of grease in the bearing which resulted in excessive heat, no corrosion protection, accelerated wear and ultimately failure of the bearing. It is thought by the aircraft manufacturer that the lack of grease was caused by the operator's washing procedures, rather than insufficient grease being applied during maintenance. The AMM is being updated to prohibit, more definitely, cleaning without wheel covers.

The other report, in November 2003, more closely resembles the event to G-BZAW on 5 February 2009, and was attributed to a trapped bearing cage. The likely cause was identified, in order of probability, as excessive bearing adjustment clearance due to inadequate or incorrectly applied axle nut torque, inadequate lubrication, or a bearing with an excessively worn cage refitted to the wheel.

Discussion

Although the incident landing could be considered as being 'firm', it was well below the aircraft manufacturer's hard landing inspection limits. The landing attitude was also normal. Of the preceding 15 flights, none were found to have an unusual landing attitude or to approach the aircraft manufacturer's hard landing inspection limits. Analysis indicated that the de-rotation rate was above average but was not excessive. It is thus unlikely that failure of the nosewheel bearing was a direct result of damage sustained during flight operations.

Analysis of the failed bearing indicated that the cause of failure was the roller cage becoming trapped. This was a rapid event and would have occurred during the incident landing. There are two potential reasons for the cage becoming trapped on this occasion: excessive wear in the roller pockets of the bearing cage, or insufficient bearing pre-load, caused by insufficient tightening of the axle wheel nut or failure to rotate the wheel sufficiently whilst the torque was applied.

During the last workshop visit, the wheel and bearings were inspected by the wheel manufacturer's staff and a suitably trained person undertook and certified the inspection activity. The wheel was fitted to the aircraft by two appropriately qualified LAMEs, following the Aircraft Maintenance Manual procedure and using a calibrated torque wrench. Both had completed nosewheel replacements on this type of aircraft on many previous occasions.

Conclusion

The failure mechanism of the bearing has been identified but it is not possible to say which of the two potential causes led to the failure. Whilst no safety recommendations are made, this event is a reminder of the importance of following manufacturers' procedures to inspect and install all aircraft wheel bearings correctly.