Fokker F27 Mark 500, G-BNCY

AAIB Bulletin No: 7/98 Ref: EW/C97/12/7 Category: 1.1

Aircraft Type and Registration:	Fokker F27 Mark 500, G-BNCY
No & Type of Engines:	2 Roll-Royce Dart 532-7 turboprop engines
Year of Manufacture:	1977
Date & Time (UTC):	3 December 1997 at 1900 hrs
Location:	Guernsey Airport, Channel Islands
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 - Passengers - 28
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Burst tyres, failed engine control rod, failure of impeller steady bearing in No 2 engine and metal contamination of associated propeller pitch change system
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	32 years
Commander's Flying Experience:	4,500 hours (of which 380 were on type) Last 90 days - 90 hours Last 28 days - 50 hours
Information Source:	AAIB Field Investigation

Circumstances

The commander reported that the aircraft was in the climb passing FL45 for FL90, about 20 miles from Guernsey. Without any actions on the part of the crew, the right engine power output reduced. The torque indication decreased from a figure in the region of 300 lb/sq in to a figure of approximately 190 lb/sq in. At the same time, the engine speed reduced from 14,200 RPM to approximately 12,500 RPM. The commander stated that he then levelled the aircraft and reduced power to stop the aircraft from accelerating. At this point it was noted that the indicated power and shaft speeds of the two engines were almost identical. All temperatures and pressures of the right engine were normal and it appeared to be stable. The crew informed ATC that they were returning to Guernsey, they then advised the cabin crew to that effect and asked them to secure the cabin.

Radar vectors were received for a visual circuit, backed up with the ILS for Runway 09. The aircraft established on finals at about 10 miles, with a speed of approximately 140 kt, for a full-flap landing. As power was reduced at about 3 to 4 miles from the threshold, the commander noticed that the right engine was producing slightly more power than the left engine. He considered, nonetheless, that the situation remained fully controllable.

Full flap was selected and the speed started to reduce back towards the touchdown speed. Some slight right rudder was needed at this point. On touchdown, the aircraft swung to the left. More rudder was applied to keep straight. It became clear that the right engine was still producing power, so the commander instructed the first officer to feather it. The commander then selected ground-fine pitch and the aircraft came to a halt on the centreline, about half way along the runway.

It became evident to the crew that both tyres had burst on the right side, so they elected to remain on the runway, checking for any fire or damage. They shut down the left engine. The cabin crew and passengers were then advised that evacuation would not be necessary and they remained in the aircraft until the handling agents arrived with steps. An orderly disembarkation then occurred. The crew continued to monitor the fire crew radio frequency until the passengers were clear of the aircraft but because no transport was available, the passengers were required to walk to the terminal building.

Previous events

During initial investigation it was noted that on the 29 November, about 4 days before this incident, the aircraft had also experienced a sudden and large loss of power on the right engine whilst in the climb. On that occasion, an in-flight shut-down was carried out, followed by a largely uneventful landing at Southampton. On investigation it was established that a power lever push-pull rod, situated within the nacelle, had fractured close to an eye-end, adjacent to the junction with the Rolls-Royce control box. This had denied the crew power control on the right engine, by isolating both the fuel control unit and the propeller control unit from the power lever.

Detailed examination of the push-pull rod (an airframe part) had shown evidence that it had failed in bending fatigue and that the eye-end bearing was seized. The engine was therefore carefully inspected for other damage, but none was found. The main oil filter was found to be uncontaminated. The possibility of high frequency vibration having been present was considered but none had been reported. It was therefore concluded, after extensive discussions amongst the operator's technical personnel, and after consultation with the engine manufacturers' specialists, that seizure of the bearing had probably caused cyclic bending loads to be applied to the rod, leading to a bending fatigue failure. The fractured push-pull rod was replaced and, after appropriate ground running and checks, the aircraft was returned to service.

Technical investigation

On examination of the aircraft after the second incident, this replacement push-pull rod was also found to be fractured, hence again eliminating power control on the right engine. More detailed examination revealed cracking of the engine turbine heat-shield, a symptom normally associated with high frequency vibration. Again, however, no reports of such vibration occurring in this aircraft were on record.

A decision was taken to change the engine along with the propeller; some contamination of the main engine oil filters was noted after this second event and it was therefore not considered advisable to re-use the propeller until it had been flushed out and checked. Another replacement for the fractured control-rod was fitted. The engine mounting 'W' struts were also replaced, as a precaution, in case undetected cracking was present. The aircraft was again returned to service and the suspect engine forwarded to the operator's maintenance base and thereafter to its manufacturer.

Detailed examination

During subsequent strip examination of the engine at the manufacturers' facility, it was noted that a roller journal, acting as a steady bearing for the forward overhang of the first stage impeller, had suffered partial failure; the cage had crushing and plastic deformation of inter-roller bars and some pitting of rollers was present. Damage to the running surface extended over a large part of the circumference of the outer race. The bearing in question is defined by the manufacturers as "Bearing Assembly Roller Journal First Stage Impeller Shaft Front". It consists of an outer race, enclosing rollers and a roller cage, running on a journal formed on the forward part of the shaft carrying the first stage of the 2 stage centrifugal compressor. No other significant defects were found in the engine.

Technical background

The Dart engine has a very lengthy record of service use (over 45 years) in many different versions. The engines on G-BNCY were of the RDa 7 series with overhaul lives of 6,800 hours when operated in the modification state of these units. At the time of the incident, the No 2 engine had completed 3,895 hours since overhaul and 48,103 hours since new.

RDa 7 series engines are known to have occasionally suffered in-service problems, in the past, at this bearing position. The manufacturer's records show that, so far as these series engines are concerned, one such bearing failure occurred in 1967 and a total of 21 failures have occurred since 1981 (including the failure to the unit in G-BNCY). The majority of these engines were rejected from service as a result of metal debris being found during routine filter inspections. One was rejected as a result of excessive vibration being noted and one as a result of an unusual noise. The amount and severity of damage found on the bearing components during subsequent engine strip inspections varied, but was all of a broadly similar nature to that noted on the failed bearing of the engine from G-BNCY.

The cause of the damage found on previous occasions has not been determined but it is thought to be the effect of roller skidding. Since this is most likely to occur when little or no side-load is being carried, it has been suggested that a small degree of imbalance in parts of the engine may be beneficial in preventing it, and hence a perfectly balanced engine is more likely to suffer the problem. Attempts to reproduce the effect during test-bed operation have not been successful. A number of early failures were reportedly traced to a batch quality problem, the source of which was rapidly eliminated. It has been noted by the manufacturer that the frequency of failure of this bearing has decreased during the last 10 years at a higher rate than the reduction in total engine operating hours during the period.

The RDa 10 series of engines suffered a number of failures of the corresponding bearing some years ago. It was found that errors in machining an adjacent shaft within the engine were occurring occasionally during overhauls. These errors resulted in distortion of the assembled bearing. Further investigation showed that ambiguities in overhaul instructions were responsible for the errors. Once the instructions were re-drafted, the failures ceased to occur. There is no evidence that any defect of this nature was present in the engine from G-BNCY.

None of the previous bearing failures described above were reported to have lead to breakage of any of the engine control rods and in most instances on RDa 7 engines no form of in-flight problem was encountered. It is understood, however, that a rod of modified design, occupying the position and function of the failed rod, is available and widely used on F27 aircraft as an alternative to the earlier rod design. The modified type of rod is to a more robust design than the earlier type of rod which was in use on G-BNCY. It has not been established why two alternative designs of rod remain available.

It is pertinent to note that the version of the engine involved in this incident incorporates the latest standard of compressor, having modified impeller wheels. This design was introduced to reduce fuel burn and achieves this by carrying out a higher rate of work than previous versions of the compressor. To achieve this improved performance, it incorporates a different number of vanes of modified shape on each impeller wheel. Although this design of compressor unit is extensively used on Dart engines now in service, operational experience with the unit forms only a small proportion of total Dart experience. The incidents involving G-BNCY are understood to constitute the only known case of a failure occurring to the roller journal in question with post-modification impeller wheels in use. It is assumed, however, that the altered characteristics of these impeller wheels produce frequencies of vibration different from those excited by earlier designs of impeller in conditions of bearing failure. Fracture of the control rod may thus have occurred on this occasion, when the bearing became damaged, since the new impeller may have produced vibrations at frequencies closer to the natural frequency of the rod design than would the earlier type of impeller under similar circumstances.

Although, as stated earlier, there is reason to believe that a defective batch of roller cages may have lead to some early failures in RDa 7 bearings, the reason for the onset of bearing failure on this occasion has not been established.

The aircraft, G-BNCY, having been returned to service with a replacement engine and propeller in the No 2 position, was damaged in an over-run accident at Guernsey a few days later. The decision was taken not to repair and return the aircraft to service, largely on cost grounds. It was therefore dismantled locally. There is no evidence that this final accident was connected with the earlier incidents.

The manufacturers of the engine are continuing laboratory examination of the failed bearing components from G-BNCY.