

Good vibrations

Vibration-monitoring techniques for rotorcraft have become a vital diagnostic tool, reports Roger Alder.

VIBRATION detection is used to ensure rotorcraft stay healthy. A new breed of electronics is making this process even more sophisticated. A vibration spectrum analyser uses electrical signals transmitted from pickups or transducers mounted on specific locations on the airframe, to detect both the frequency and severity of vibrations in the airframe.

The severity or amplitude of vibration of the component or section of the structure to which the pickup is attached is measured in fractions of inches (of movement) per second, abbreviated as IPS. This information can be used to detect and resolve main rotor and tail rotor blade balance and track vibrations and to detect and analyse vibration levels of any rotating components.

The vibration spectrum analyser can provide a readout of vibration levels of the various rotating components, such as generators and gearboxes, as it is progressively tuned through various operating frequencies.

When a helicopter is scanned over a range from zero RPM to 10,000 RPM, a characteristic vibration "signature" is generated for each helicopter. The signature looks like a range of mountains, with valleys and peaks.

Helicopters of the same type and model typically have very similar vibration signatures. Any changes – often appearing as increases in sections of the vibration signature – are a clear indicator that something is wearing out.

Application One company taking advantage of this technology operates a fleet of Eurocopter SA 365 helicopters, and like other operators, uses a vibration spectrum analyser for an "in house" vibration trend analysis program, as part of its maintenance program.

The company runs a vibration signature scan during every 100-hourly assessment flight, or when the opportunity arises. Its maintenance program requires that the latest scan record be compared with previous

records to determine if there are any significant changes in the signature that may be caused by imbalance or wear in bearings or couplings.

Anomaly During one such routine scan, it was noticed that the subject helicopter had an uncharacteristic peak of 0.18 IPS in the 4,750-RPM range that had slowly been increasing over a period of 300 hours. A survey showed that this spike in the RPM region did not exist in any other rotorcraft of the same type in the operator's fleet.

Although the level of vibration was not noticeable to the pilots at this stage, precau-



An SA 365 tail rotor gearbox installation under maintenance.

tionary maintenance action included replacing all rotating components that operated in the 4700-RPM range. These included the tail rotor drive shafts, tail rotor gearbox and the tail rotor assembly.

Problem No fault was found in any of the components that had been removed, but the vibration persisted. Ultimately the tail rotor gearbox mount was removed for non-destructive inspection. No defects were found in the gearbox mount, and it was refitted to the helicopter. Because of the relatively low amplitude (0.18 IPS) and the fact that the source of the vibration could not be

clearly identified, it was decided to put the helicopter back into service and monitor this vibration peak at 50-hour intervals.

Approximately 300 hours later, while the helicopter was on a routine flight, the pilot reported that he felt a slight vibration through the rudder pedals. The rudder pedals are connected to the tail rotor gearbox and control the tail rotor pitch. A vibration spectrum analysis was again carried out on the helicopter airframe. This time the scan discovered that the vibration peak in the 4,700-RPM range had suddenly increased from below 0.2 IPS to 0.4 IPS amplitude during 40 hours of operation.

The tail rotor gearbox mounting area was again inspected and a crack was found on the forward mount plate. The crack seems to have originated from the weld, and had then progressed toward the edge of the mount plate.

Had the crack continued around the base of the support and caused separation, it is very likely that the loss of the tail rotor gearbox support would have caused the tail rotor blades to contact the duct in which they operate, causing the tail rotor to fail and result in loss of yaw control.

HUMS Health and Usage Monitoring Systems (HUMS) can be permanently installed in each helicopter, coupled to on-board computers designed to monitor critical aspects of the entire helicopter continuously, and notify the crew of any uncharacteristic vibrations.

Unusual vibrations can signal abnormal wear between gears, bearing wear and loss of structural integrity. Take this a step further, and it is not too hard to see that the fixed time between overhaul of a tail rotor gearbox bearing and gear set could be dropped, and the overhaul life could be based on HUMS evidence of wear – provided the HUMS equipment is maintained in a way that ensures its total reliability.

Roger Alder is a CASA airworthiness specialist.

Airworthiness Directives and Airworthiness Advisory Circulars

ADs AL 8/2003, 7 August 2003

Part 39-105 - Rotorcraft

Agusta A109 Series Helicopters

AD/A109/45 - Tail Rotor Hub and Blades Assembly

Eurocopter AS 350 (Ecureuil) Series Helicopters

AD/ECUREUIL/79 Amdt 1 - 'TRW-SAMM' Main Servocontrols

Robinson R22 Series Helicopters

AD/R22/31 Amdt 4 - Main Rotor Blades

Part 39-105 - Below 5700 kgs

Airtractor AT 300, 400 and 500 Series Aeroplanes

AD/AT/1 Amdt 1 - Wing Main Spar - Aluminium Spar Caps and Centre Section Splice Blocks - CANCELLED

Embraer 110 (Bandeirante) Series Aeroplanes

AD/EMB-110/16 Amdt 1 - Control Column P/N 4A-500-10-01-20 - Inspection

Pilatus Britten-Norman BN-2 Series Aeroplanes

AD/BN-2/71 Amdt 3 - Main Landing Gear Oleo Attachment Bracket

AD/BN-2/74 Amdt 1 - Engine Mounting Brackets

Pilatus Britten-Norman BN-2A Mk III (Trislander) Series Aeroplanes

AD/BNT/47 Amdt 3 - Main Landing Gear Oleo Attachment Bracket

AD/BNT/49 Amdt 1 - Engine Mounting Brackets

Pilatus PC-12 Series Aeroplanes

AD/PC-12/29 Amdt 1 - Engine Driven Fuel Pump

Piper PA-23 (Apache and Aztec) Series Aeroplanes

AD/PA-23/89 - Flap Control Torque Tube

Piper PA-34 (Seneca) Series Aeroplanes

AD/PA-34/51 - Combustion Heater Fuel Pumps

Piper PA-44 (Seminole) Series Aeroplanes

AD/PA-44/18 - Combustion Heater Fuel Pumps

Part 39-105 - Above 5700 kgs

Airbus Industrie A330 Series Aeroplanes

AD/A330/14 Amdt 1 - Windshield Central Retainer

AD/A330/17 - Type A Passenger/Crew Door Slide Rafts

AD/A330/18 - Forward Fuselage Frame 12A Stiffener

AD/A330/19 - Thrust Reverser - Directional Pilot Valve Pressure Test/Replacement

AD/A330/20 - Leading Edge Slat Rotary Actuator Type A - Inspection

Beechcraft 400 Series Aeroplanes

AD/BEECH 400/24 - Low Pressure Oxygen Tubing

Boeing 717 Series Aeroplanes

AD/B717/8 - Upper Centre Fuselage Longerons

AD/B717/9 - Wing Rear Spar

Boeing 727 Series Aeroplanes

AD/B727/184 - Autopilot Pitch Control Computer

Boeing 737 Series Aeroplanes

AD/B737/148 Amdt 1 - Uncommanded Rudder

Boeing 747 Series Aeroplanes

AD/B747/291 - Nose Wheel Well Panel Rivets

AD/B747/292 - BS 2360 Aft Pressure Bulkhead Outer Chord Bolts

Boeing 767 Series Aeroplanes

AD/B767/131 Amdt 1 - Canted Pressure Deck Drain System

British Aerospace BAe 146 Series Aeroplanes

AD/BAe146/106 - Elevator 'G' Weight Support Structure

British Aerospace BAe 3100 (Jetstream) Series Aeroplanes

AD/JETSTREAM/76 Amdt 1 - Windshield Wipers

SAAB SF340 Series Aeroplanes

AD/SF340/90 Amdt 1 - Main Landing Gear Assistor Spring and Bearing Replacement

Short SD3-30 Series Aeroplanes

AD/SD3-30/46 - Main Landing Gear Aft Pintle Pin Bushes

Short SD3-60 Series Aeroplanes

AD/SD3-60/65 - Main Landing Gear Aft Pintle Pin Bushes

Part 39-106 - Turbine Engines

Engines General

AD/ENG/5 Amdt 8 - Turbine Engine Continuing Airworthiness Requirements

General Electric Turbine Engines - CF 6 Series

AD/CF6/52 - Thrust Reverser - Inspection

Turbomeca Turbine Engines - Arrius Series

AD/ARRIUS/5 - Turbohaft Engine Unairworthy

General Electric Turbine Engines - CT 7 Series

AD/CT7/10 - Propeller Gearbox(PGB) - Inspection and Replacement of Gears or PGB

Pratt & Whitney Turbine Engines - JT8D Series

AD/JT8D/40 - Compressor Rotor - Removal from Service

Part 39-107 - Equipment

Instruments and Automatic Pilots

AD/INST/8 Amdt 4 - Instruments in VFR Aircraft

AD/INST/9 Amdt 6 - Instruments in IFR Aircraft - Test Requirements

Propellers - Variable Pitch - Hartzell

AD/PHZL/43 Amdt 10 - Single Shoulder Aluminium

Blades - CANCELLED

AD/PHZL/79 Amdt 1 - Propeller Vibration Placard

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Part 39-105 - Rotorcraft

Eurocopter AS 350 (Ecureuil) Series Helicopters

AD/ECUREUIL/89 - Battery Lug Connection

Eurocopter SA 360 and SA 365 (Dauphin) Series Helicopters

AD/DAUPHIN/46 Amdt 1 - Main Rotor Gearbox

Suspension Diagonal Cross-Member

AD/DAUPHIN/58 Amdt 1 - Main Gearbox Torque

Tightening

Robinson R22 Series Helicopters

AD/R22/31 Amdt 5 - Main Rotor Blades

Part 39-105 - Below 5700 kgs

Aerospaiale (Socata) TBM 700 Series Aeroplanes

AD/TBM700/27 Amdt 1 - Elevator Control System

AD/TBM700/28 - Fuselage Skin around the VHF1

Antenna

AD/TBM700/29 - Pitot Tube Supply Line/Aileron Control

Cable

AD/TBM700/30 - On-Board Servicing Power Receptacle

Diamond DA40 Series Aeroplanes

AD/DA40/2 - Modify Fuel Filter Assembly

Diamond HK-36 Series Aeroplanes

AD/DIMO/1 - Turbocharge Control Unit Software

Pilatus PC-12 Series Aeroplanes

AD/PC-12/37 - Fuel Boost Pump Wiring

Part 39-105 - Above 5700 kgs

Airbus Industrie A319, A320 and A321 Series Aeroplanes

AD/A320/149 - Inertial Reference Systems

Airbus Industrie A330 Series Aeroplanes

AD/A330/17 Amdt 1 - Type A Passenger/Crew Door Slide Rafts

Boeing 727 Series Aeroplanes

AD/B727/185 - Hydraulic Accumulator End Cap

Separation

Boeing 737 Series Aeroplanes

AD/B737/214 - Fuselage Skin Lap Joint - Fatigue

Cracking

AD/B737/215 - Hydraulic Accumulator End Cap

Separation

AD/B737/216 - Flightcrew Oxygen Masks

Boeing 747 Series Aeroplanes

AD/B747/277 Amdt 1 - Thrust Reverser Inspections and

Tests

Boeing 767 Series Aeroplanes

AD/B767/96 Amdt 2 - Trailing Edge Flaps - Hinge Fitting Assembly Bolts

AD/B767/159 Amdt 1 - Vertical Fin to Body Section 48 Attachment

AD/B767/179 Amdt 1 - Inboard Main Flap Support Bolts

AD/B767/185 - Flightcrew Oxygen Masks

AD/B767/186 - Passenger Address & Entertainment System Video Control Centre

Beechcraft 300 Series Aeroplanes

AD/BEECH 300/8 Amdt 1 - Wing Attach Fittings, Bolts and Nuts

British Aerospace BAe 3100 (Jetstream) Series Aeroplanes

AD/JETSTREAM/96 - Landing Gear Rod Spherical Bearing

British Aerospace (Hawker Siddeley) HS748 Series Aeroplanes

AD/HS748/33 - Battery Earth Posts

Fokker F100 (F28 Mk 100) Series Aeroplanes

AD/F100/57 - Low Pressure Fuel Line - Inspection - CANCELLED

SAAB SF340 Series Aeroplanes

AD/SF340/90 Amdt 2 - Main Landing Gear Assistor Spring and Bearing Replacement

Part 39-106 - Turbine Engines

Allison Turbine Engines - 250 Series

AD/AL250/82 - Hydromechanical Unit Power Lever Angle Potentiometer

General Electric Turbine Engines - CT 7 Series

AD/CT7/10 Amdt 1 - Propeller Gearbox(PGB) - Inspection and Replacement of Gears or PGB

Pratt & Whitney Turbine Engines - JT8D Series

AD/JT8D/29 Amdt 2 - High Pressure Compressor Disc Inspection

Pratt & Whitney Canada Turbine Engines - PT6A Series

AD/PT6A/33 - Compressor Rear Hub - Life Limit Review

Rolls Royce Turbine Engines - Tay Series

AD/TAY/3 Amdt 1 - Engine Controls - Emergency Fuel Shut

Off System

AD/TAY/8 - Engine LP Fuel Tube - Inspection/Replacement

Part 39-107 - Equipment

Parachute Equipment

AD/PARA/10 - PDF Techno 240 Emergency Parachute

Propellers - Fixed Pitch

AD/PFP/17 Amdt 3 - Hub Cracking

Propellers - Variable Pitch - Beechcraft

AD/PB/5 - Propeller Blade Retainer Ferrule

Propellers - Variable Pitch - Hartzell

AD/PHZL/77 Amdt 2 - Australian Air Props

Radio Communication and Navigation Equipment

AD/RAD/77 - Goodrich Avionics Systems TAWS8000

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Part 9 - AME Licensing and Examination

AAC 9-0 Issue 4 - General AME Licensing Information

AAC 9-1 Issue 10 - Aircraft Maintenance Engineer (AME)

Licensing Examinations

AAC 9-5 Issue 9 - AME Specific Type Training Courses and

Examinations Conducted by Approved Australian

Operators, Maintenance and Training Organisations.

AAC 9-91 Issue 10 - Administration and Procedure -

Aircraft Maintenance Engineer Licences - Category

Airframe.

AAC 9-93 Issue 6 - Administration and Procedure - Aircraft

Maintenance Engineer Licences - Category Radio.

AAC 9-95 Issue 8 - Administration and Procedure - Aircraft

Maintenance Engineer Licences - Category Instruments.