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EXAMINATION OF APPLICABILITY OF ENGINE CONDITION TREND MONITORING TO BELL 206B III HELICOPTER

ABSTRACT

Because of the advantages of turboshaft engine condition trend monitoring, it is in the interest of the Croatian Air Force to examine its applicability in Bell 206B III helicopter maintenance system.

The paper deals with the basic of turboshaft engine condition trend monitoring procedure; and describes also the procedure for Allison 250 C20J engine, which is installed in Bell 206B III. Results of parameter readings are presented and reasons of inapplicability of condition trend monitoring within pilot training process are explained. Alternative procedure is recommended.

KEY WORDS

engine condition trend monitoring, turboshaft engines

1. INTRODUCTION

In Croatian Air Force light utility helicopter Bell 206B III JetRanger is used for pilot training. It is powered by an Allison 250 C20J turboshaft engine.

Preventive maintenance of these helicopters is currently being performed on the basis of hard time intervals, which are established by helicopter and engine manufacturer. In case that engine performances drop below the required limits, corrective action must be taken in order to return them to the normal level.

Another type of preventive maintenance is "on-condition" maintenance. Engine condition trend monitoring is an integral part of maintenance on the basis of condition, and it is based on the fact that, during an extended period of time it is possible to tell the difference between normal and faster degradation of engine performances.

Croatian Air Force is interested in application of engine condition trend monitoring. It is an inexpensive and efficient procedure which, if conducted properly, enables reduction in maintenance costs, provides an easier insight into engine performance, helps in failure prevention, and shows if there is a need to schedule some maintenance actions which were previously unscheduled. These are the reasons why the possibility is studied of integrating the procedure into helicopter pilot training.

2. BASICS OF TURBOSHAFT ENGINE CONDITION TREND MONITORING

Basic parameters that enable pilot to control a turboshaft engine are (Fig.1):
- engine output torque (TQ);
- engine turbine(s) speed (N1, N2);
- turbine outlet temperature (TOT).

At the same time these parameters are also crucial for engine condition trend monitoring procedure, which is an integral part of "on-condition" maintenance. Degradation of engine performance can be ob-

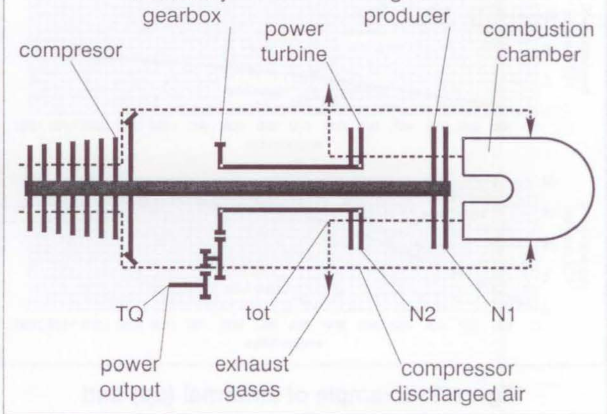

Figure 1 - Kinematic scheme of Allison 250 C20J turboshaft engine

served through changes of these parameters and that fact is the basis of engine condition trend monitoring.

The rule of normal and gradual degradation of performance is known, so in that case values of engine parameters are also predictable for practically the whole engine life. Actual values of engine parameters may be compared with the predicted normal values and in that way actual condition of an engine may be determined.

Engine condition trend monitoring includes long-term and almost daily in-flight engine recording of parameters, making corrections for ambient conditions and plotting on charts with accumulated engine hours used as the abscissa and a particular parameter as ordinate. On the basis of a large number of plotted data a trend line of the parameter is approximated (Fig.2).

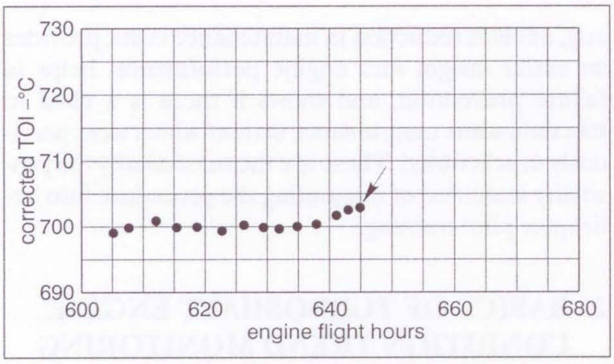

Figure 2 - Conected data plotted in an appropriate chart

Source: Operation and Maintenance Manual-Turboshaft Engine Models 250-Allison Engine Company, 1996, para 72-00-00, p.528

Quality of uncorrected data, which are recorded during flight, is of the greatest importance to the whole procedure. Therefore, aircraft instruments should be calibrated, and errors in interpretations of readings on the instruments should be minimized. Also, all bleed air operated components must be turned off during data recording. If not, data taken will not be accurate.

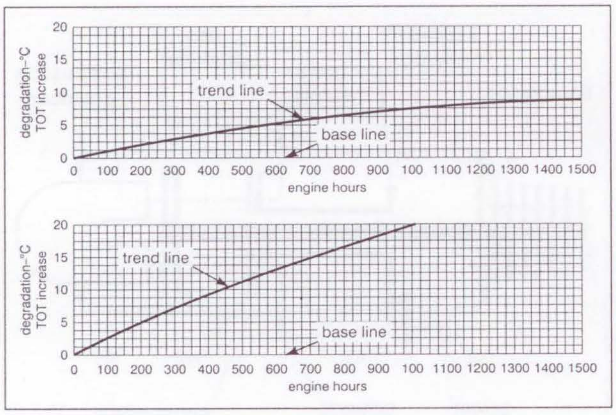

Figure 3 - Example of a normal (up) and an abnormal (down) trend line

Source: Operation and Maintenance Manual– Turboshaft Engine Models 250, Allison Engine Company, 1996. para 72-00-00. p. 523

Insight into each engine condition is established through quality and comprehensive analysis of data gained over an extended period of time, and it allows for some abnormal performance degradation to be discovered (Fig.3). Furthermore, determination of problem causes is made considerably easier by analysis and interpretation of parameter deviations and correlation. Thus, preventive or corrective actions can be easily undertaken.

Results of the analysis can be used to schedule some maintenance actions that were formerly unscheduled. For example, the need for engine wash may be indicated, which should return parameter values to the normal level (Fig.4), if not borescope check may be advisable.

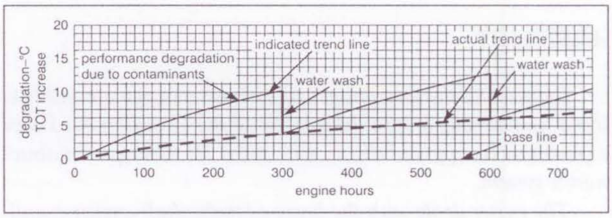

Figure 4 - Effect of engine wash on trend line

Source: Operation and Maintenance Manual– Turboshaft Engine Models 250, Allison Engine Company, 1996. para 72-00-00. p. 523

In some cases, as for Pratt&Whitney PT6 turboprop engine, it is possible, according to analysis results, to change (e.g. to extend) some maintenance intervals which were formerly scheduled on hard time basis. The engine condition trend monitoring procedure has to be diligently applied and commenced just after the engine has been installed or overhauled. It has to be carried out by experienced and qualified personnel. Benefits of the program are great and include maintenance cost reduction and improvement of safety because unnecessary disassembly of an engine is avoided.

3. ENGINE CONDITION TREND MONITORING - POSSIBILITY OF ITS INTEGRATION WITH PILOT TRAINING

The method called Engine Trend Check Analysis is described in Allison 250 C20J engine maintenance manual, and users are enforced to apply the procedure.

It does not enable the change of maintenance intervals, but there are other advantages that make interesting possibility of integration of the procedure with pilot training, without making additional flights for this purpose.

3.1. Allison 250 C20J engine trend check analysis

The procedure may be initiated at any point in an engine's life. Allison Company recommends calibrating instruments prior to initiating the procedure.

After take-off altimeter must be set to 1013 hPa. The parameters have to be red in level cruise flight at any convenient altitude from sea level up to 10,000 feet, at increments of 1,000 feet.

Without turning off the systems required for safe flight, it is necessary to turn off all bleed air operated components and to ensure that generator load is less than 20%. If anti-ice system is often required for safe flight, it should be turned on during each reading of parameters.

Power turbine speed (N2) must be set at normal cruise speed (100% for Bell 206) and this rpm must be repeated during each subsequent parameter reading.

Engine power must be set at baseline torque value that provides gas producer speed of 95% or more. This power should be kept for one minute at least in order to allow engine to stabilize. Then the following parameters should be recorded: pressure altitude (H_p), outside air temperature (OAT), gas producer rpm (N1), torque (TQ), and turbine outlet temperature (TOT).

After the flight, the recorded parameters are corrected according to the tables provided in the engine's maintenance manual. Corrected values are plotted on the appropriate charts.

Specified aircraft and engine limitations must not be exceeded during the flight.

In order to simplify the procedure, it is recommended to choose the basic pressure altitude and torque that will ensure that gas producer rpm is 95% or more. Each subsequent reading should be done at these values of pressure altitude and torque. If for any reason the selected pressure altitude cannot be established, new adequate altitude and torque can be found using the table given in the maintenance manual.

The importance of gas producer rpm being 95% or more, in order to ensure the bleed valve is closed, is especially emphasized. If not, the recorded parameters are questionable and as such they are useless.

3.2. Engine trend check analysis- examining of application with Bell 206B III

Three flights were performed, on three different helicopters, and test parameter recordings were made to determine whether it is possible to integrate the procedure within helicopter pilot training.

All three flights were performed with two-pilot crew, with 150-240 kg of fuel and with no other cargo carried. It is the usual helicopter gross weight for training purposes.

Readings were performed at each thousand feet, starting from 1,000 feet up to 10,000 feet, with altimeter having been set at 1013 hPa.

Table 1 – Data recorded during flights

Check number	1			2			3		
Date	27 Jan. 2000			31 Jan. 2000			11 Feb. 2000		
Gross weight	1218 kg			1308 kg			1304 kg		
NR, N2 [%]	100			100			100		
TQ [%]	85			85			85		
Hp [ft]	N1 [%]	OAT [°C]	v [kts]	N1 [%]	OAT [°C]	v [kts]	N1 [%]	OAT [°C]	v [kts]
1 000	90.5	2	105	91	12	108	91	8	107
2 000	90.5	0	115	91	10	105	91	4	106
3 000	91	-2	110	92	8	108	91.5	3	108
4 000	92	-1	105	92.5	6	110	92	3	105
5 000	92.5	0	102	93	4	106	93	2	105
6 000	92.5	-1	105	93	8	108	93	1	108
7 000	94	-2	105	94	7	106	93.5	1	100
8 000	94	-4	104	94.5	5	102	94	0	100
9 000	95	-4	101	95	4	99	95	-2	100
10 000	95.5	-6	100	96	3	99	95.5	-2	100

Flights were performed in accordance with Allison Company recommendations and each time similar data were recorded.

For 85 to 100% torque range the maximum allowed speed of flight is 80 knots and it appeared as the limiting factor during flights. Because each time speed was above 80 knots, the power increase was stopped just prior to 85% of torque.

The recorded parameters were analyzed and it was noticed that the required gas producer speed of 95% or more was achieved only at 9,000 and 10,000 feet (Table 1). It should be noted that the speed then was close to maximum allowed speed with respect to pressure altitude and helicopter gross weight (Table 2).

Table 2 – Speed limitation with respect to altitude and gross weight

Maximum speed [kts] for gross weight below 1360 kg						
Hp [ft]	OAT [°C]					
	46	40	20	0	-20	-40
0	128	130	130	130	130	130
2 000	121	122	130	130	130	130
4 000	112	114	122	129	130	130
6 000	103	106	113	122	130	130
8 000	96	97	105	113	122	130
10 000	87	89	96	104	113	122

Source: Bell JetRanger III Rotorcraft Flight Manual. Bell Helicopter Textron, 1995, pp. 1-19.

Flights for the purpose of pilot training are performed at altitudes up to 3,000 feet. Comparing this to the recorded parameters it can be concluded that the Engine Trend Check Analysis for 250 C20J engine described in engine maintenance manual is not suitable for everyday performance on Bell 206B III during pilot training, without changing the flight schedule significantly or without introducing additional flights only for that purpose.

3.3. Engine power check

The engine maintenance manual suggests that if aircraft or engine limitations are encountered during the procedure it could be a sign of possible aircraft or engine problem. For that reason, each time Power Check procedure was performed to determine if engine was capable of producing at least the minimum specified power.

In accordance with the procedure described in Rotorcraft Flight Manual, all necessary parameters were recorded in a stabilized 52 knots climb (Table 3).

Using chart shown in Figure 5, the torque value was found. Since the check was accomplished at 52 knots instead in hovering, 2% were added to the chart percent torque reading. Thus, minimum percent torque that must be developed by the engine was found.

Table 3 – Data recorded during power check

Check number	OAT [°C]	TOT [°C]	Hp [ft]	TQ [%]	N1 [%]
1	-1	745	6 000	100	96.5
2	8	740	6 000	100	96.5
3	1	730	6 000	100	96
1	-2	760	7 000	100	97.5
2	7	755	7 000	100	97
3	1	760	7 000	100	98

The engines developed torque values that were greater than the minimum in all three cases; the power checks were acceptable.

4. CONCLUSION

Although engine condition trend monitoring provides significant benefits to maintenance of turboshaft engines, performed readings of parameter showed that the procedure could not be integrated into Bell 206B III helicopter pilot training. Altitudes used for pilot training are up to 3,000 feet while gas producer speed which is required by the procedure was achieved only at 9,000 and 10,000 feet.

On the other hand, it is possible to perform engine Power Check procedure that is provided by the helicopter manufacturer. Helicopter Association International recommends frequent power checks as maintenance standard, as a possible way of detecting deterioration of turbine or compressor.

To conclude, Power Check procedure provided in Bell 206B III Rotorcraft Flight Manual should be regularly performed, at least after maintenance actions have been undertaken and before commencing some power demanding flights.

SAŽETAK

Zbog prednosti koje pruža monitoring stanja vratilo mlaznog motora (VMM) u interesu Hrvatskog ratnog zrakoplovstva je ispitivanje mogućnosti implementacije ovog postupka u sustav održavanja helikoptera Bell 206 B III.

U radu se objašnjavaju temeljne postavke monitoringa stanja VMM, te se opisuje postupak monitoringa za motor Allison 250 C10J, ugrađenog u helikopter Bell 206B III. Izlažu se rezultati probnih očitavanja parametara u letu, te objašnjava razloge nemogućnosti primjene monitoringa u sustavu obuke pilota. Preporučuje se alternativni postupak.

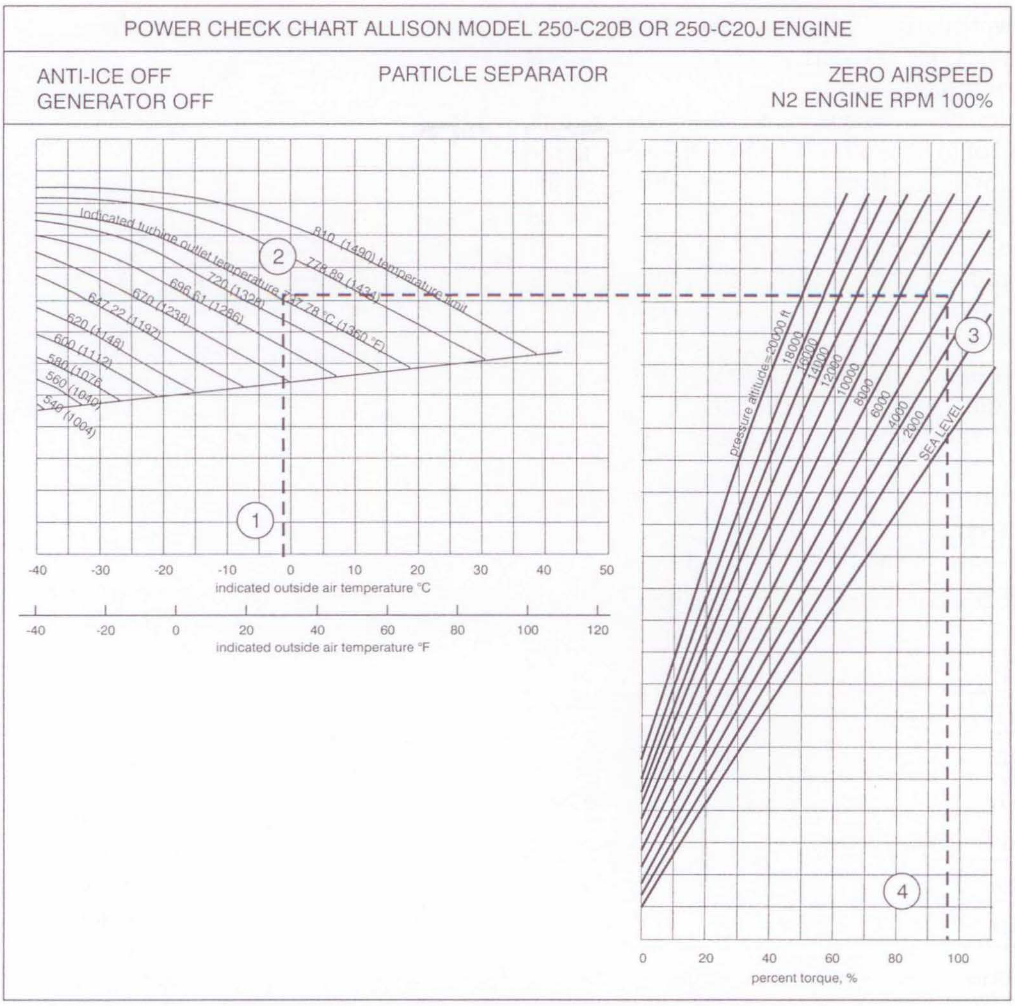

Figure 5 - Power Check Chart (with an example for the first reading at 6 000 feet)

Source: Bell JetRanger Rotorcraft Flight Manual Supplement: Particle Separator-Engine Air Induction System. Bell Helicopter Textron. 1994, p. 3.
Data from Table 3, row 1.

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