



**ASSEMBLY — 41ST SESSION**

**TECHNICAL COMMISSION**

**Agenda Item 33: Other issues to be considered by the Technical Commission**

**THE NECESSITY OF IMPLEMENTING ENGINE CONDITION TREND MONITORING  
(ECTM) IN AIRLINES TO INCREASE FLIGHT SAFETY**

(Presented Iran (Islamic Republic of))

**EXECUTIVE SUMMARY**

Engine condition trend monitoring (ECTM) is an effective method to maintain engine health, which can increase flight safety and reduce maintenance costs. The existence of regulations and requirements to do this in airlines can be very useful, and taking appropriate corrective actions in a short period of time can achieve these two goals. The purpose of this paper is to present two case studies of timely diagnosis of engine failure and emphasize the importance of the requirement to perform ECTM in airlines.

<i>Strategic Objectives:</i>	This working paper relates to Strategic Objectives on Safety.
<i>Financial implications:</i>	Reduce maintenance costs.
<i>References:</i>	Doc 9760, <i>Airworthiness Manual</i> , AMC and GM for Part-M

**1. INTRODUCTION**

1.1 ECTM is a method of continuous monitoring and performance assessment using flight data and non-destructive tests. It improves engine performance, reduces maintenance costs and increases flight safety. This can be done in two ways: using data recorded by the pilots or using data recorded on the FDR or QAR.

1.2 By using the data recorded by the pilots in the cruise phase, it is possible to obtain the trend of the engine parameters and monitor the health of the engine. But the most important parameter in ECTM is the EGT Margin. Based on this parameter, the lifetime of the engine and the maximum permissible flight temperature for the engine are estimated, and controlling its value will reduce engine maintenance costs, increase safety and reduce fuel consumption. The value of EGT Margin is possible only from the data obtained from the take-off phase and considering that the data of this phase is not available to the pilots (Pilots have not enough time at take-off to record engine parameters), it is inevitable to implement FDM to complete ECTM.

- 1.3 An ECTM team should be able to perform the following activities:
- a) extracting engine data such as EGT, EPR, N1, N2, and FF during the flight;
  - b) calculating EGT Margin and estimating engine life using it;
  - c) estimating the maximum allowable flight temperature using the EGT Margin calculation;
  - d) analyzing the ECTM parameters trend and the relationship between them;
  - e) providing ECTM reports;
  - f) keeping the history of the process and checking them repeatedly in order to analyze trends; and
  - g) providing corrective actions.

## 2. ENGINE FAULT DIAGNOSIS USING ECTM

2.1 Engine fault detection can be done from take-off and cruise phase information. If the trends of ECTM parameters is abnormal in a certain period of time, the ECTM expert must analyse it and identify the probable causes and suggest the necessary corrective actions.

2.2 The engine fault can be detected both from the EGT Margin parameter (which is obtained from the take-off phase information) and from the delta EGT, delta FF, delta N1 and delta N2 parameters (which are obtained from the cruise phase information). Any changes that these parameters have, has a different interpretation and different probable causes. The task of the engine technical department is to analyse and take appropriate corrective actions to prevent the engine failure.

## 3. SUCCESSFUL EXPERIENCES OF TIMELY DIAGNOSIS OF ENGINE FAILURE

3.1 **Case study 1:** In this case, the fault was diagnosed based on delta parameters. As seen in figures 1 to 4, the changes of table 1 can be considered for these parameters:

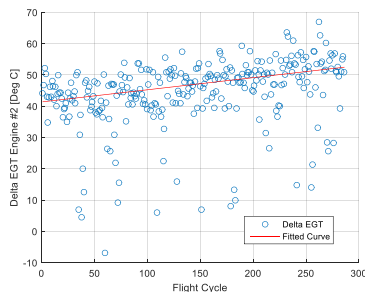


Figure 1: Delta EGT of the engine (Case study 1)

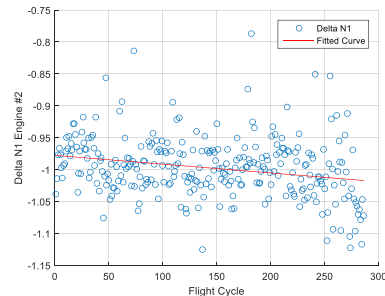


Figure 2: Delta N1 of the engine (Case study 1)

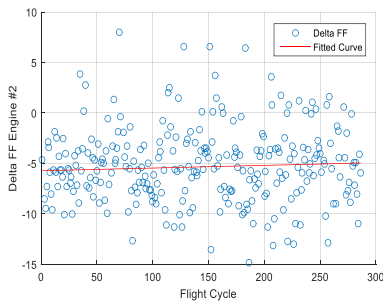


Figure 3: Delta FF of the engine (Case study 1)

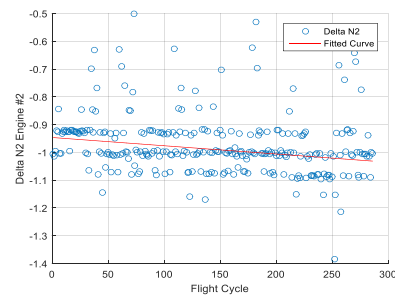


Figure 4: Delta N2 of the engine (Case study 1)

Table 1: Trend of ECTM parameters (Case study 1)

Delta EGT	Delta FF	Delta N2
/	/	\
/	/	—

3.2 Probable causes for the above changes can be the following:

- a) normal hot section deterioration taking place over years;
- b) CT blade tip clearance increase;
- c) CT blade distress/deterioration; and
- d) combination of a compressor section problem and hot section problem happening at the same time on the engine.

3.3 According to the existing history of the above engine, ECTM experts of Airsa Chakad Kish<sup>1</sup> have diagnosed the hot section problem and suggested borescope inspection to the airline. After the investigation carried out by the technical department and performing BSI, the engine fault "Bulkhead segment and bulkhead deflector burn, has been diagnosed and therefore the following statement was announced by technical experts:

“In accordance with reference AMM, subtask 72-00-00-220-134-A-Q-(4-b) and subtask 72-00-00-220-117A-S(5-c), Remove the engine in less than 30 cycles.”

3.4 Obviously, if ECTM was not performed, the problem would not be detected in time and would lead to engine failure.

3.5 **Case study 2:** This case refers to fault detection based on the EGT Margin parameter. Figures 5 to 8 show the changes in EGT Margin and Delta parameters. As can be seen, in the flights of two consecutive days, the EGT Margin of the engine experiences a great decrease (more than 50 degrees) and at the same time, the delta parameters also increase abnormally. Monitoring and investigation by ECTM experts of Airsa Chakad Kish company on the same day has led to the diagnosis of these changes. The available changes are in the form of table 2.

<sup>1</sup> An FDM and ECTM company in Iran.

Table 2: Trend of ECTM parameters (Case study 2)

EGT Margin	Delta EGT	Delta FF	Delta N2

3.6 Probable cause for the above changes can be "Check Compressor Bleed Valve". After performing this corrective action by the technical department, the following report was received as the reason of the engine's behavior:

“Bleed Valve open and did not close completely”.

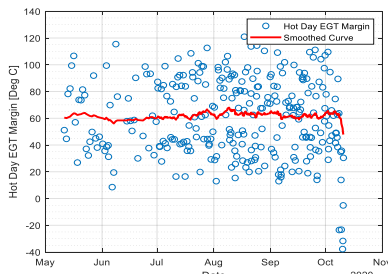


Figure 5: EGT Margin of the engine (Case study 2)

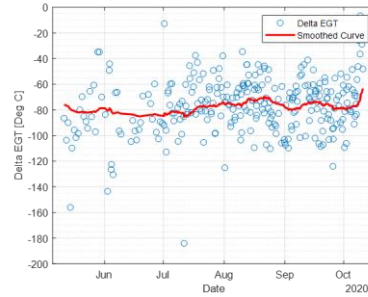


Figure 6: Delta EGT of the engine (Case study 2)

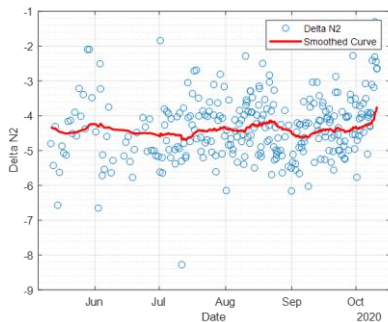


Figure 7: Delta N2 of the engine (Case study 2)

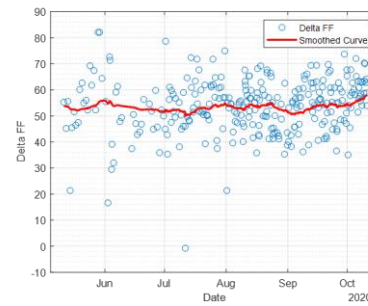


Figure 8: Delta FF of the engine (Case study 2)

3.7 Therefore, the defect was fixed in time and serious damage to the engine was prevented. The result of the corrective action can be seen in figure 9 to 11 that the parameters have returned to the normal state before the event.

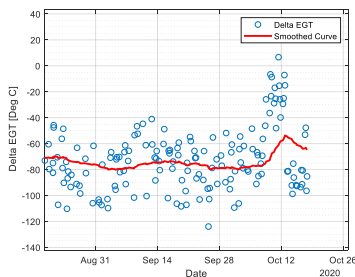


Figure 9: Delta EGT after performing corrective action (Case study 2)

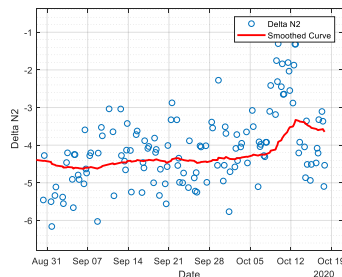


Figure 10: Delta N2 after performing corrective action (Case study 2)

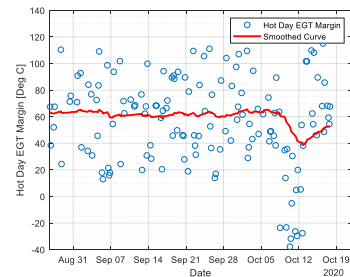


Figure 11: EGT Margin after performing corrective action (Case study 2)

#### 4. CONCLUSION

4.1 Considering the high cost of engine maintenance and the importance of its health in flight safety, the existence of an “Engine Condition Trend Monitoring” system seems very necessary. There is no requirement or clause in any of the existing regulations regarding to the way of conducting ECTM. In this paper, we have tried to mention some examples of the benefits of doing ECTM and its effects in increasing safety and reducing costs. Therefore, it is suggested that the legal clause should fully present how to do it correctly, such as how to set up ECTM, responsibilities, how to collect data, how to analyse data, how to interpret data, provide corrective actions, etc. The benefits of such an action will be felt by the safety, technical and commercial departments in less than a year.

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