Research of Zlin Z42 engine´s operation by EDM-800 monitoring system

Maria MRAZOVA*

*Corresponding author
University of Zilina, The Faculty of Operation and Economics of Transport,
Air Transport Department
Univerzitna 1, 010 26 Zilina, Slovak Republic
mraz.marie@gmail.com

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Abstract: *The purpose of this paper is based on the analysis of the M137 engine performance by the EDM- 800 monitoring system that is also mounted on Zlin Z42 aircraft in operation of Air Training and Education Centre of the University of Zilina. This research consists of measurements based on the comparison and analysis of the engine parameters where its performance was simulated under various temperature conditions. Measured parameters are monitored during these flight regimes – take off, climb, cruise and approach. Briefly, these measurements are able to detect the existing problems during the engine operation and consequently they will be helpful to prevent potential engine malfunctions in the future operations.*

Key Words: *piston engine M137, EDM-800, EGT, CHT, engine efficiency*

1. INTRODUCTION

The measurement of selected engine parameters was conducted at Air Training and Education centre (ATEC) which is located at the international Airport Zilina – Dolny Hricov in Slovak Republic. Air Training and Education Centre uses both, single and twin engine aircraft for professional pilot training.

This paper deals with a specific type of aircraft – Zlin Z42 (with M137 engine) where EDM-800 monitoring system is installed for the purpose of monitoring the critical engine parameters, focusing on EGT (Exhaust Gas Temperature) and CHT (Cylinder Head Temperature) analysis. J. P. Instruments, Inc. is a company which made EDM-800 monitoring system.

This company is also one of the leading instruments producers in this field. The monitoring system has been installed on the selected aircraft of the ATEC (Zlin Z43, Zlin Z42 and Zlin Z142) in order to measure selected parameters of the engine and consequently increase safety and efficiency of the pilot training.

This monitoring was chosen due to the possibility of monitoring engine operations without any effect of other flight instruments [1].

Data was obtained from the monitoring system using an easy to install special utility program called EzTrends, which transfers compressed data from the EDM system to the computer and after that it decompresses them.

In common, EDM stores the data for 20 hours, but the length depends on the options that are chosen and installed. Furthermore, EDM's data is downloaded to the PC through the serial port and by the EzTrends software decompresses the data file and it also divides it into separate flights. Zlin Z42 is a single – engine two seat Czechoslovakian trainer aircraft that is powered by M137 AZ engine. Firstly, the Avia M337 (originally Walter M337) is an inverted 6 cylinder air – cooled inline engine.

It was produced as a six-cylinder derivative of the four-cylinder M332. An unsupercharged version of the M 337 is designated M137 [2], [3].

In addition, M137 / M337 engines are used for training aircraft for flight school or for commercial small, light-weight aircraft. The advantage of these engines is that they are characterised by a small frontal area, low weight, their economic efficiency and simple maintenance.

Figure 1. Zlin Z42 OM-DLS [4]

Note 1: For the purpose of our research we used only data obtained from EDM-800 system installed on Zlin Z42 aircraft – OM-DLS, OM-ALR and OM-ILR.

Note 2: Also, for the purpose of this paper we evaluate only data related to Z42 – OM-DLS aircraft (Figure 1).

2. MEASURED PARAMETERS AND RESEARCH METHODOLOGY

This research was based on the analysis of selected measured parameters related to M137 engine. The analysis of EGT and CHT was provided and short description of mentioned parameters is introduced in the next paragraphs.

EGT – Exhaust Gas Temperature: is a parameter that describes the temperature of the exhaust gases that exit the cylinder. It depends on the power setting, altitude, and ambient air temperature and cylinder compression. On the other hand it is also influenced by engine mechanical conditions, such as cylinder leakage [5], [6].

CHT – Cylinder Head Temperature: is the residual heat from combustion and therefore ought to be able to provide much of the same diagnostic information than EGT. The main difference between CHT and EGT is the response time where EGT is much quicker to change and then the changes are larger in magnitude. Therefore, EGT is a much more valuable tool for detecting irregularities in the whole combustion process [7], [8].

Furthermore, CHT is important from the cylinder head thermal load point of view. EGT is important because of thermal load on the combustion area materials. These two parameters tell us how the piston engine is working, what is the fuel mixture, but at the same time they indicate any abnormality of combustion process.

2.1 Measurement procedures

All measurements could be conduct after obtaining data from the EDM-800 monitoring system installed on selected type of aircraft; in this particular case - Zlin Z42 aircraft. Data were downloaded by the above mentioned EzTrends program and also, due to big amount of data, it was necessary to disregard the data that lasted longer than 0.30 hours.

Database of flights related to Zlin Z42 OM-DLS aircraft is illustrated in Table 1 as can be seen in the next chapter.

Selected parameters were investigated during three flight regimes: take-off, climb and cruise in order to the fact that these regimes are standardized in terms of engine speed and manifold pressure and investigation of single power output would be insufficient because the engine power setting change also changes the thermal load.

Note 3: Due to the fact that more measurements were performed in one of the days, we counted the values related to the same date. Consequently, mean and deviation values for all flight regimes were calculated in order to compare and evaluate them.

Note 4: For the purpose of finding the change in OAT – Outside Air Temperature, we analysed two selected flights that were performed with the same aircraft under different weather conditions in order to see the effect of the engine performance.

3. RESEARCH OUTCOMES

The data obtained from the EDM-800 monitoring system are illustrated in Table 1 below.. The measurement was performed both in winter and summer season in order to obtain different temperature conditions for the engine monitoring.

For the purpose of this research we will use just these two flights where EDM flight number 172 was measured on 31.7.2013 with duration of 1.13 hours, and second flight number 189 was measured on 18.10.2013 with duration of 0.83 hours.

Table 1. Data obtained from EDM-800 for Zlin 42 OM-DLS [author]

	Zlin 42 OM-DLS		
Flight Number	**Date**	**Measurement Time**	**Duration (the longest)**
7	9.2.2013	14:10:08	0.58 h
9, **10**, 11, 12	24.2.2013	10:29:26	0.87 h
14, 15, 16, **17**	25.2.2013	11:56:10	1.08 h
21, 22	18.7.2013	8:39:10	1.19 h
25, 26	19.7.2013	9:09:42	1,71 h
28	20.7.2013	8:36:42	0.30 h
123, **124**, 127	9.7.2014	12:27:06	1.19 h
130, 131, 132,**133,** 134	10.7.2014	12:43:40	1.20 h
137, 138, **139**, 140	11.7.2014	10:52:02	1.22 h
142, 143	12.7.2014	8:32:54	2.22 h
157, **158**	20.7.2014	11:25:16	1.19 h
160, 161, 162	23.7.2014	8:04:08	2.09 h

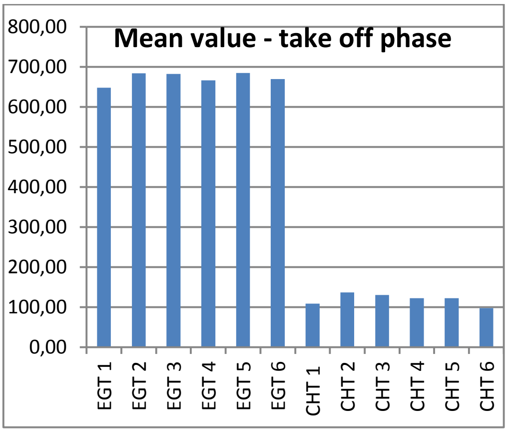
164, 165, **166**	24.7.2014	12:21:22	1.54 h
172	31.7.2014	12:12:20	1.13 h
174	6.8.2014	11:15:02	1.02 h
178, 179	24.9.2014	9:08:06	0.95 h
186, 187	11.10.2014	10:30:42	1.23 h
189, 190, 191, 192	18.10.2014	8:55:59	0.83 h
197, 198, **199**, 200	22.10.2014	12:58:28	1.18 h
203, **204**	14.11.2014	11:25:14	1.65 h
217, **218,** 219	26.3.2015	10:20:20	1.04 h
221, 222, 223, 224, 225, 226, 227	28.3.2015	9:20:04	0.80 h
230, 231	18.4.2015	12:49:06	1.14 h
233, 234, **235**, 236	23.4.2015	11:35:00	1.10 h
241, **242**	25.4.2015	11:53	1.23 h

Note 5: All measurements were done during time period of February 2013 until April 2015. Another measurement did not continue due to the termination of technical aircraft airworthiness.

3.1 Analysis of the performance related to EDM flight number 189

For the purpose of this research we calculated the mean value and also the deviation for all flight regimes: take-off, climb, cruise and approach.

Moreover, the engine average values (EGT, CHT parameters) and their deviation (Take-off flight regime) are illustrated in Figure 2.



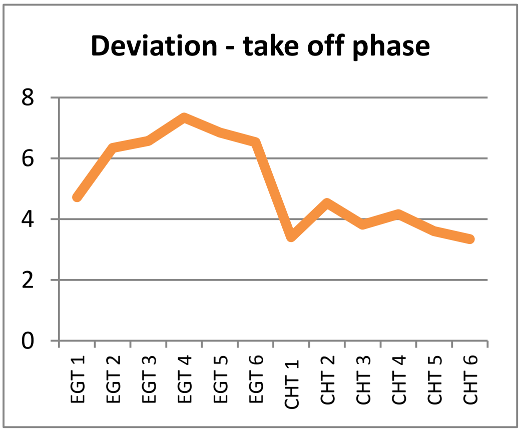


Figure 2. Mean value for the take-off phase (left) and deviation value (right) [author]

According to Figure 2, we can notice that CHT 1 and CHT 6 are lower than the rest of CHTs.

The values related to the climb phase are shown in Figure 3.

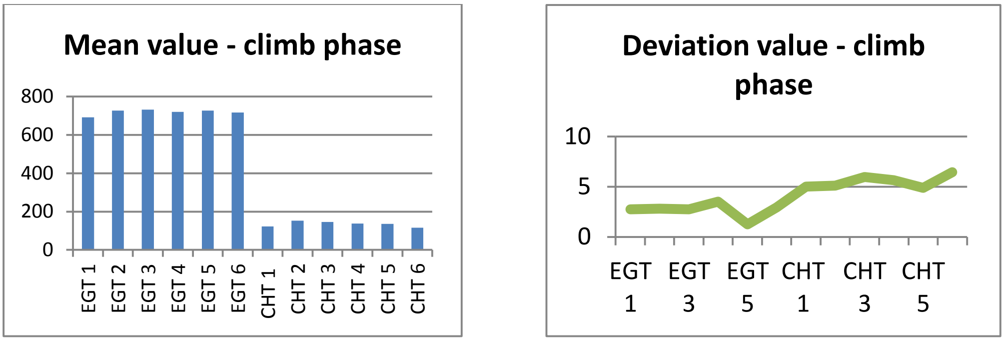


Figure 3. Mean value for the climb phase (left) and deviation value (right) [author]

According to Figure 3 we can see the following: CHT 1 and CHT 6 are lower than the rest of CHTs. So the results are the same like in the previous case during the take-off phase. But on the other hand, we can observe that EGT 1 is lower than 700 while on other cylinders it is higher. Also, the deviation during the take-off phase is higher than during the climb phase in the case of the EGT parameters, and consequently, in the case of CHT parameters, the deviation value is reverse – higher during the climb flight phase and lower during the take-off phase. According to Figure 4 we can notice the following values related to the cruise flight phase.

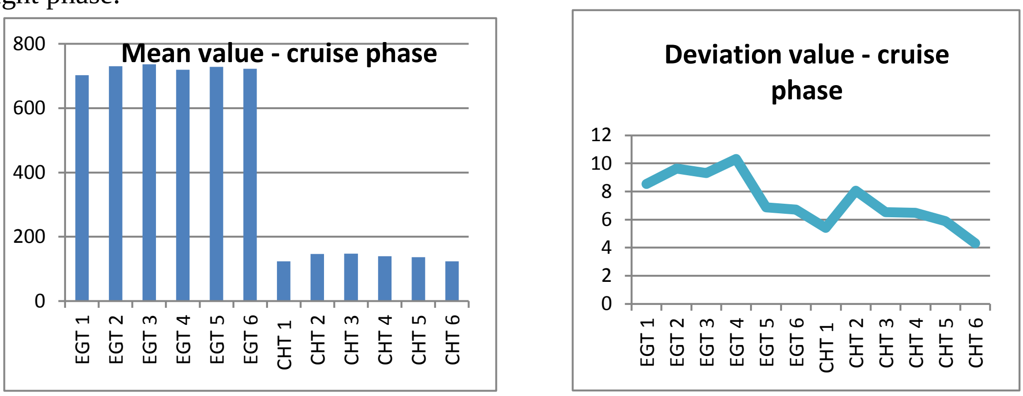


Figure 4. Mean value for the cruise phase (left) and deviation value (right) [author]

According to Figure 4 we remark the following: CHT 1 and CHT 6 are again lower than in previous cylinders. Figure 5 represents the data related to the approach flight phase.

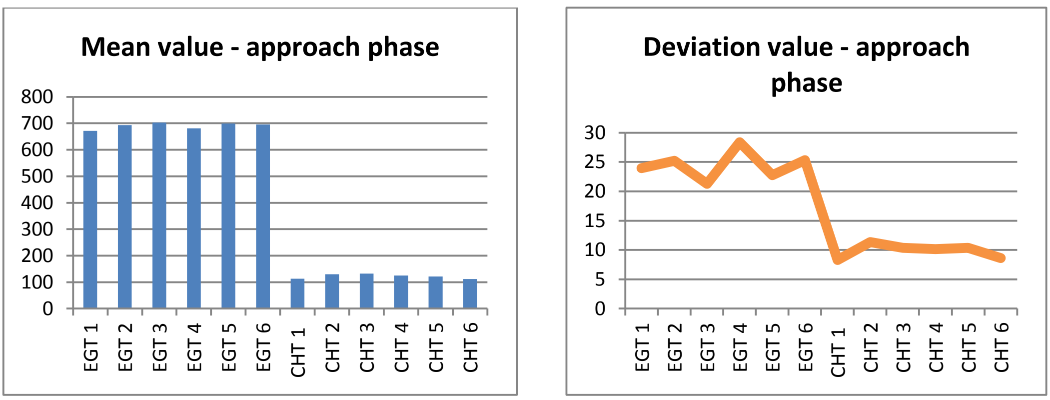


Figure 5. Mean value for the approach phase (left), deviation value (right) [author]

As IT can be seen in Figure 5 above, the mean value of EGTs is a little bit less than 700°C like that during the take-off phase, while the values of CHTs were above 100°C in the case of all flight regimes. The deviation was the highest during the approach phase and the lowest during the climb flight regime.

3.2 Analysis of the performance related to EDM flight number 172

Following the results obtained from the EDM-800 monitoring system, all measurements are described in the next paragraphs.

Also, all measurements were done for all flight regimes as in the previous case. Also, the calculation of mean and deviation values was done.

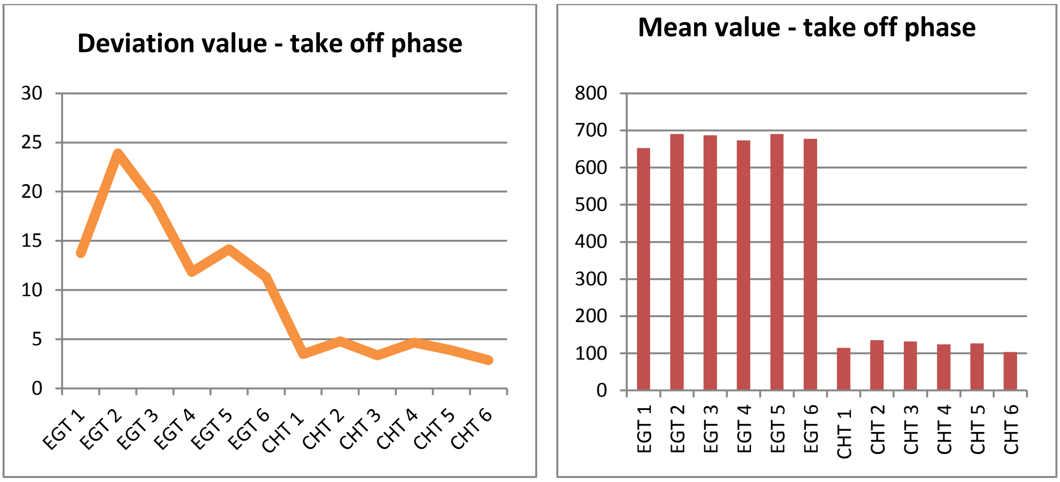


Figure 6. Mean value for the take-off phase (left), deviation value (right) [author]

Following Figure 6 we remark that EGT 1 is lower than other EGTs and CHT 6 is lower than the temperature on other cylinders.

Also, the biggest deviation is visible on EGT 2.

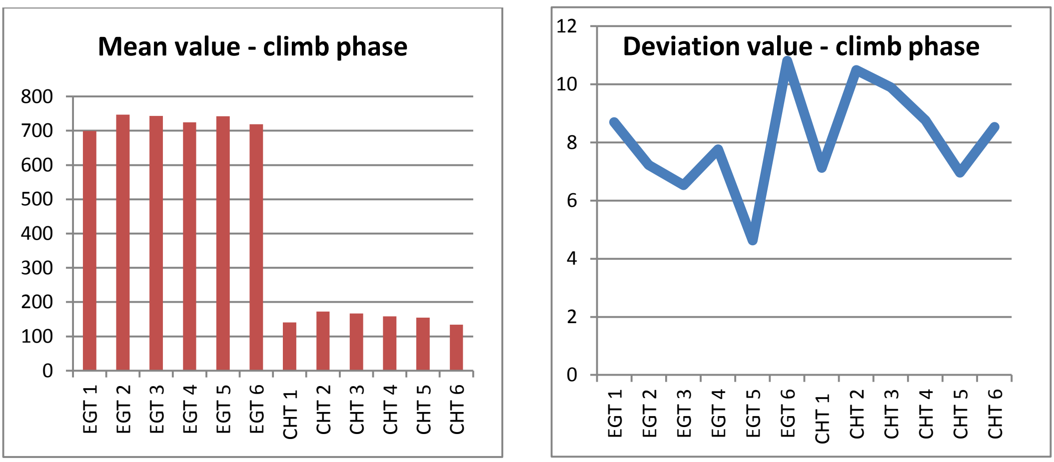


Figure 7. Mean value for the climb phase (left), deviation value (right) [author]

Following Figure 7 we can remark that EGT 1 is less than 700 °C while EGTs is higher than 700 on other cylinders. Also, CHT 1 and CHT 6 are lower than the temperature on other cylinders.

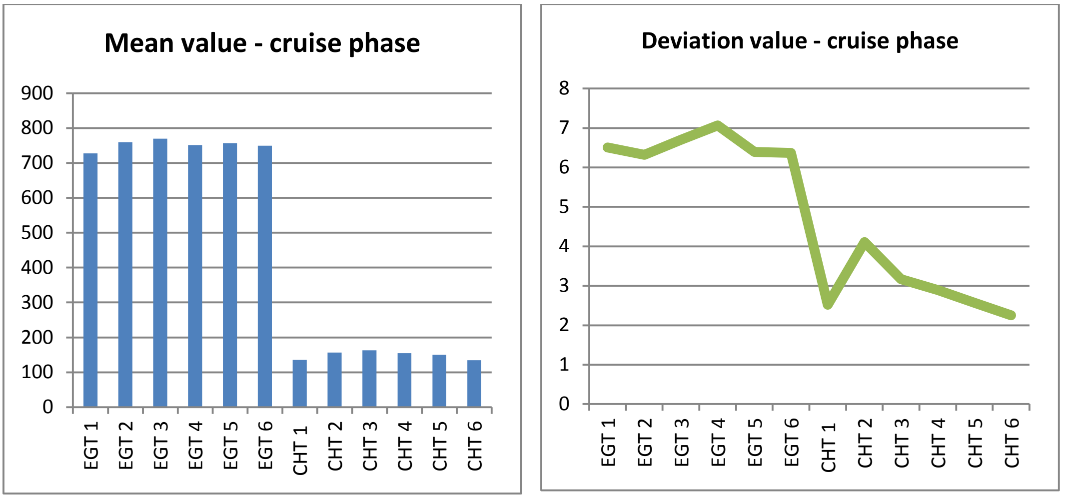


Figure 8. Mean value for the cruise phase (left) and deviation value (right) [author]

Following Figure 8 we can see that the value of EGT 1 is lower than the rest of EGTs and CHT 1 and CHT 6 are also lower than the rest of CHTs.

In the case of deviation value, we can see that the highest deviation is reached in EGT 6 and CHT 2.

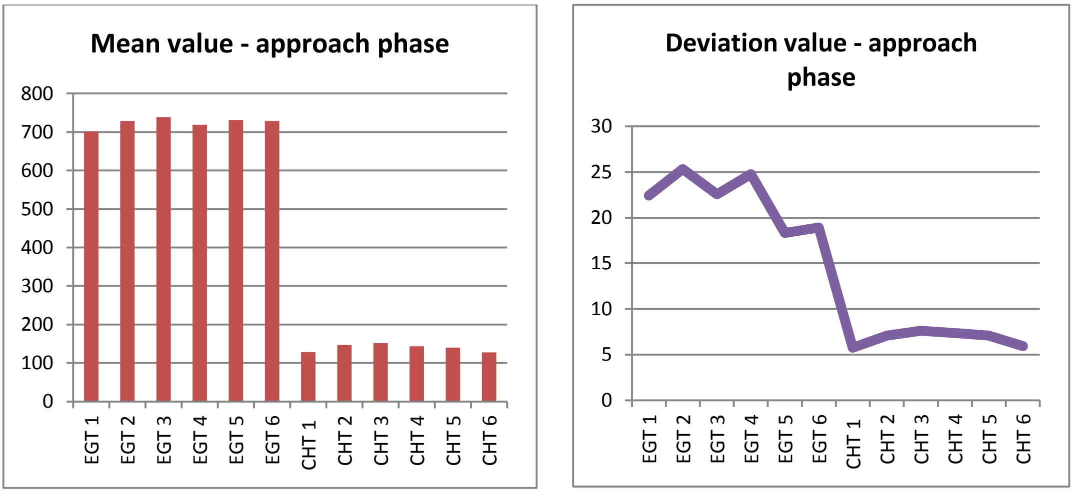


Figure 9. Mean value for the approach phase (left), deviation value (right) [author]

Following Figure 9 we can see that EGT 1 is lower than other EGTs. On the other hand, CHT 2 and CHT 6 are lower than the rest of CHTs. The deviation value was the highest in EGT 2 and CHT 3.

4. CONCLUSIONS

EDM flight number 189 observations:

- The Mean value of EGTs parameter reached the highest value during the cruise flight regime (EGT 3) and the highest average value of the CHTs parameter was reached during the climb regime (CHT 2). The lowest mean value of EGTs parameter was reached during the take-off flight regime (EGT 1) and in the case of CHT parameter it was also during the take-off flight regime (CHT 6).

- The highest value of the deviation was reached during the approach flight regime (EGT 6) and the lowest value of the deviation was reached during the climb phase (EGT 2). In the case of CHT parameter, the highest deviation was reached during the approach phase (CHT 3) and the lowest deviation was reached during the take-off flight phase (CHT 6).

EDM flight number 172 observations:

- The Mean value of EGT parameter reached the highest value during the cruise flight (EGT3), the same as in the case of Flight number 189. The highest value of CHT parameter was achieved during the climb regime (CHT 2). The highest deviation was achieved during the approach phase (EGT 2) and in the case of CHT parameter during the climb phase (CHT 2). The highest deviation was reached during the approach phase (EGT 2) and in the case of CHT parameter it was during the climb phase (CHT 2).

Comparison of Flight number 172 and 189:

- The Values of EGTs and CHTs were lower during the EDM flight 189. Also, Figure 10 illustrates the average values related to EGT and CHT parameters for each flight.

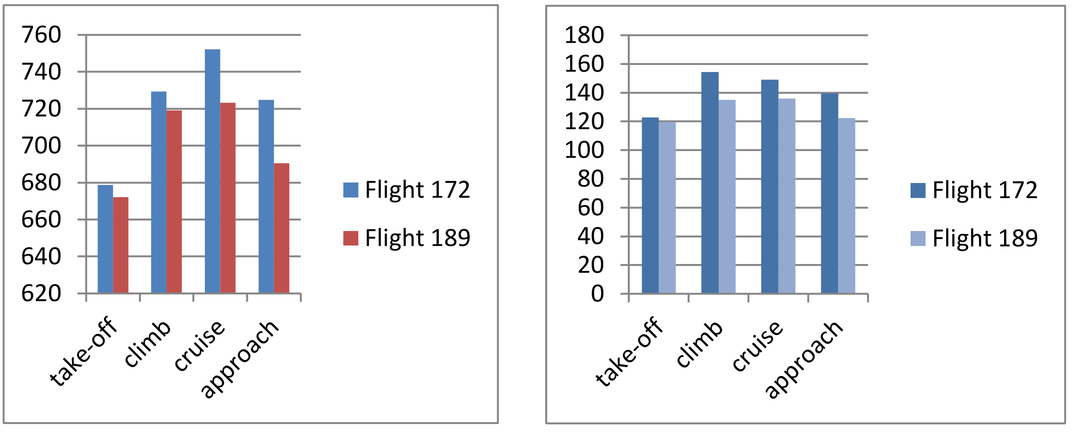


Figure 10. EGT parameter (left), CHT parameter (right) [author]

Briefly, we can also summarise that in cruise regime the engine runs at the highest EGT and CHT at the same time.

These values result from the leanest mixture and in cruise flight regime the mixture is richer because of engine cooling and regular operation and because of this CHT and EGT values are also the lowest.

Finally, we can also note, that possible problems could be caused by these options:

- CHT parameter was higher on some cylinders. It could be caused by broken ring or with some damage on cooling system and therefore cold air doesn't get properly to the cylinders.
- On the other hand, there is a big difference between the highest and the lowest EGT values. It could be caused by injection nozzles that are dirty or by a problem with the induction system.

Briefly, these measurements were performed in order to detect damaged or improperly maintained components of the M137 piston engines.

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