TRANSACTIONS OF THE INSTITUTE OF AVIATION ISSN 0509-6669
No. 1(242), pp. 94-100, Warsaw 2016 eISSN 2300-5408
DOI: 10.5604/05096669.1202205

PISTON ENGINE MONITORING SYSTEM – EFFICIENT OPTION IN AIR TRAINING AND EDUCATION CENTRE

Mária Mrázová, Paulína Jirků
University of Zilina, Air Transport Department, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic,
maria.mrazova@fpedas.uniza.sk, paulina.jirku@fpedas.uniza.sk

Abstract

This paper describes the process of Walter M337 AK engine monitoring in operation of Air Training and Education Centre. We accomplished measurements of selected aircraft engines by EDM-800 monitoring system which uses the most advanced microprocessor technology for monitoring critical engine parameters, such as cylinder head temperature and exhaust gas temperature. These measurements will help us to increase economy of the aircraft and its operation's reliability. The EDM-800 monitoring system improves the aircraft maintenance at Air Training and Education Centre of the University of Zilina allowing to determine and localise malfunctioning components of M337 piston engines.
Keywords: piston engine, Exhaust Gas Temperature, Cylinder Head Temperature.

1. INTRODUCTION

For the purpose of our paper, we achieved all measurements at Air Training and Education Centre (ATEC) which is located at the international Airport Zilina – Dolny Hricov, in the north-western part of Slovakia. ATEC provides flight training up to ATPL (Air Transport Pilot Licence) and it also offers specialised courses, such as different courses for Slovak Air Force, security courses for airports and also courses for Air Traffic Controllers.

ATEC uses for the pilot training single and twin engine aircraft-from which we selected types of aircraft with M337 engine in order to installation of the EDM-800 system for the purpose of its monitoring. The Avia M337 originally Walter M337 engine is an inverted six-cylinder air-cooled inline piston engine which was developed by the Czechoslovak company and went to the production in 1960. ATEC operates three types of aircraft powered by this engine: Zlin 43, Zlin 142 and L-200D Morava. For the purpose of this research we analysed aircraft Z142 OM-PNU (Figure 1).

Figure 1. Illustration of Zlin 142 OM-PNU [Source: Official website of ATEC]

1.1. EDM-800 Monitoring System

The EDM-800 system (Figure 2) is the most advanced and accurate piston engine-monitoring instrument on the market which is able to monitor up to twenty four critical parameters in the engine, four times a second. This system has been installed into selected aircraft in ATEC in order to measure critical engine parameters to increase safety and efficiency of pilot training. The main reason for installation of this system was based on the fact that it is able to work in the background without affecting of the other primary instruments in the cockpit.

Figure 2. EDM-800's emplacement on the instrument panel in Zlin 43 [2]

This system is able to monitor 29 functions every 6 seconds for up to 25 hours or even every minute for 550 hours. The parameters can be recorded in a set time interval from 6 - 500 seconds. Immediately, if monitored parameters exceed the limits, the pilot is warned by special signal, including potentially damaging shock cooling and it also allows setting the warning criteria for each gauge. Also, it is possible to show a percent power or horsepower indicator, which shows the actual power output of the engine in the existing air-density conditions.

All data are recorded and stored to the computer and subsequently they are used for monitoring and evaluation. For evaluation of data we use a special utility program ***EzTrends*** which transfers compressed data from EDM system to the PC and after that it decompresses it. Consequently, the data are plotted and shown in the graphical form (the user can choose the way of displaying options). Moreover, EDM stores the data for 20 hours but the length depends on the options that are chosen during the installation [2].

2. MONITORING OF SELECTED ENGINE PARAMETERS

The state of the art for piston-engine monitoring has advanced quickly in recent years, both for experimental market and for certified airplanes. Engine instruments play key role for the pilot information about the health of the engine and how it will perform during the flight. The accurate engine monitoring is very important to keep the engine running within its limits so as to ensure a safe flight. Also, engine data monitoring creates a history of data in which problems can be detected and it can lead towards preventive maintenance and keeping the engine running as long as possible.

The **Eztrends software** is able to monitor different parameters, such as RPM, MAP, Fuel Flow, EGT, CHT, etc. Description of selected engine parameters is explained in further paragraph.

A) Manifold Pressure (MAP) and Tachometer (RPM)

Instrumenting MAP and RPM in addition to FF allows checking what the pilot was doing with all three primary engine controls (throttle prop and mixture) throughout the flight being analysed. It also allows the analyst to determine whether the prop governor is adjusted and working properly.

B) Fuel Flow (FF)

This information is necessary to diagnostic mixture distribution problems, incorrect fuel system adjustments, dirty fuel nozzles, stuck carburettor floats, etc.

C) Cylinder Head Temperature (CHT)

CHT is important from the cylinder head thermal load point of view and it is the residual heat from combustion and therefore ought to be able to provide much of the same diagnostic information than EGT can. It is a thermocouple probe fitted in the cylinder head. Each cylinder should have one, but it is usually installed on the hottest cylinder. It is made from iron or copper constantan (consisting of 55% copper and 45% nickel) and it is able to measure up to 400°C.

D) Exhaust Gas Temperature (EGT)

It is a parameter that describes the temperature of the exhaust gases that exit the cylinder. This temperature depends on the power setting, altitude and ambient air temperature and cylinder compression. It is fitted on the hottest cylinder exhaust pipe of some carburettor engines and used for leaning the engine. Fuel authority digital engine control (FADEC) is a system consisting of a digital computer and ancillary components that control an aircraft's engine and propeller. This system eliminates the need for magnetos, carburettor heat, mixture controls and engine priming. Its goal is to allow the engine to perform at maximum efficiency for a given conditions. It regulates the amount of fuel per cylinder in combination with RPM and MAP to obtain the best mixture for the power requirement without causing detonation in the cylinders [3].

Briefly, CHT is important from the cylinder head thermal load point of view, while EGT is important due to the thermal load on the combustion area materials. These two parameters describe how the piston engine is working, what is the fuel mixture, but at the same time it also indicates any abnormality of combustion process.

2.1. EDM-800 data analysis

In 2013 we made measurement of selected temperature indicators related to piston engine monitoring as was mentioned in previous chapters.

It is important to say that optimal mixture of fuel play key role in order to ensure efficient flight. A slightly richer mixture increases engine performance and an excess fuel can deliver cooling of the combustion process, while leaner mixture will cause a decrease in performance (because not all oxygen is burned), but the increased temperature can lead to damage of engine itself.

In February 2013 we made just one test flight where following Figure 3 we can see that the values of CHT were the highest in C1 while the lowest one was in C5. In addition, mixture was richer in E6 while leaner was in E2.

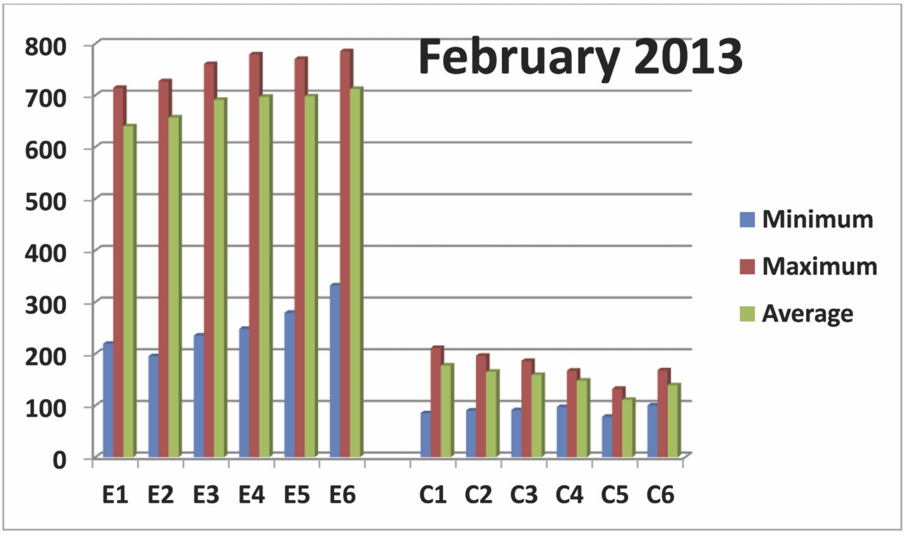

Figure 3. Illustration of EGT and CHT in February 2013 [Authors]

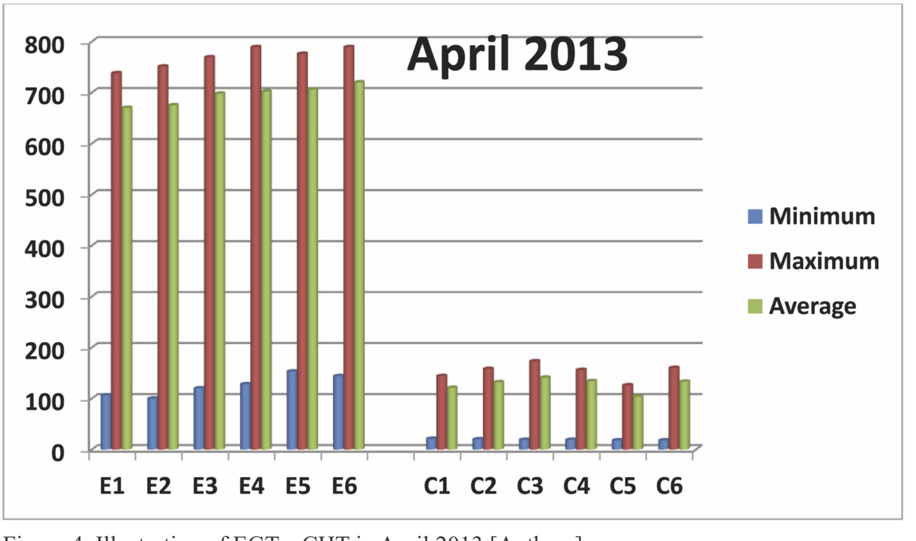

Figure 4. Illustration of EGT a CHT in April 2013 [Authors]

In April 2013 were executed 11 flights, where following Figure 4, the highest value of CHT was achieved in C3 while the lowest was achieved in C5. Moreover, the highest value of EGT was in E4 and the lowest one in E2.

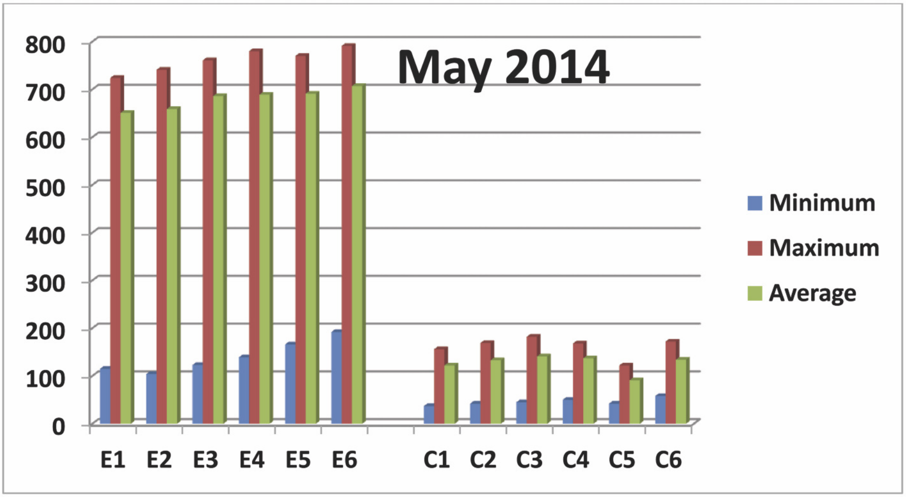

Figure 5. Illustration of EGT and CHT in May 2014 [Authors]

In May 2014 were executed 13 flights where according to Figure 5 we can see that the highest value of CHT was obtained in C3 while the lowest one was obtained in C1. In order to EGT values, the highest value was in E6 while the lowest one was in E2.

For comparison during April and May measurements we can see that the highest value of CHT was obtained in both cases in C3 while the value of EGT was higher in E4 and later in E6.

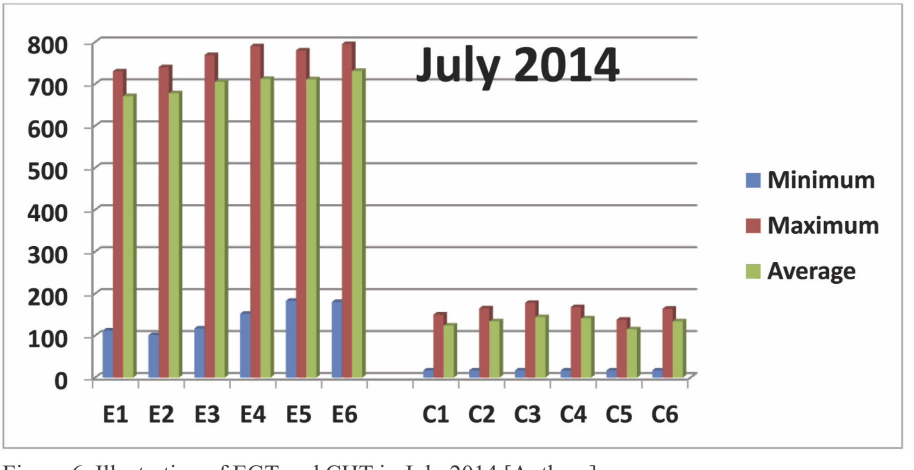

Figure 6. Illustration of EGT and CHT in July 2014 [Authors]

In July 2014, following Figure 6, were also executed 13 flights where we measured these values: the highest value of CHT was obtained in C3 and C4 while the lowest one in C5. Moreover, the highest value of EGT was obtained in E4 while the lowest one in E2.

For comparison with previous monitored time periods (April and May) we can summarise that the highest values of CHT were obtained in C3 while during last measurement (July) was also obtained in C3and C4. EGT measurement showed the highest values in E5 while in July in E2.

3. CONCLUSIONS

While analysing the data of engine monitoring, some deviations were noticed. As can be seen in Figure 7 below, in the case of Cylinder Head Temperature we can summarise that the highest temperature was during all flights in Cylinder 3 and the lowest temperature was in Cylinder 5. In the case of Exhaust Gas Temperature we had richer mixture in E6 and leaner was in E2 during all flights.

Time period	CHT		EGT	
	Highest	Lowest	Richer	Leaner
February 2013	C3	C5	E6	E2
April 2013	C3	C5	E4	E2
May 2014	C3	C1	E6	E2
July 2014	C3	C5	E4	E2

Figure 7. Summary of data obtained from EDM-800 [Authors]

The most common problems were: CHT on some cylinders was higher than on the other ones. Possible cause: the ring can be broken or there's something wrong with the cooling system and cold air doesn't get to some cylinders. There is also a difference between the highest and the lowest EGT. Possible cause – injection nozzles are dirty or there's a problem with the induction system.

Briefly, EDM-800 system also helps the aircraft maintenance at the Air training and education centre of the University of Zilina to determine and localize malfunctioning components of M337 piston engines. All research was done in order to avoid cylinder head temperature overheating that caused 3 aircraft incidents in Air Training and Education Centre. EDM system was installed just on 4th cylinder by fabric, but later research showed that problems were not caused by the wrong fabric settings of the 4th cylinder. Consequently the procedures consist of the system installation on all cylinders in order to find out the reaction of the engine while the cylinder head temperatures will be changed. These measured were done in order to avoid any engine problems caused by cracked cylinder head in previous aircraft incidents.

REFERENCES

[1] Kříž, et al., 2010, "Implementation of the EDM-800 Monitoring System in Air Training and Education Centre," *New Trends in Civil Aviation*, Zilina.

[2] Romanova, 2014, "Monitoring of M137 Aircraft Engine," Bachelor thesis, University of Zilina.

[3] FAA, 2008, *Pilot's Handbook of Aeronautical Knowledge*, http://www.faa.gov/regulations_policies/handbooks_manuals/aviation/pilot_handbook/, Chap. 6.

MONITOROWANIE SILNIKA TŁOKOWEGO W INSTYTUCJI SZKOLENIOWEJ DLA PILOTÓW NA LOTNISKU HORNÝ HRIČOV

Streszczenie

Artykuł opisuje proces monitorowania silnika Walter M337 AK w instytucji szkoleniowej dla pilotów na lotnisku Horný Hričov. Wykonaliśmy pomiary wybranych silników lotniczych przez EDM-800 system monitoringu, który wykorzystuje najbardziej zaawansowaną technologię mikroprocesorową do monitorowania krytycznych parametrów silnika, takich jak temperatura głowicy i temperatury spalin. Osiągnięte wyniki pomogą nam zwiększyć ekonomiczność samolotu i jego niezawodność. System monitorowania EDM-800 poprawia obsługę techniczną statku powietrznego w Instytucji Lotnictwa Uniwersytetu w Żylinie pozwalając na określenie i zlokalizowanie uszkodzonych elementów silników M337.
Słowa kluczowe: silnik tłokowy samolotu, temperatura gazów spalinowych, temperatura głowy cylindrów.

This paper is published as one of the scientific outputs of the project: **Implementation of scientific research knowledge to the Air Transport ITMS 26220220010**.

We support research activities in Slovakia/Project is co-financed by EU