INVESTIGATION OF OPTIMAL ENGINE MONITORING SYSTEM FOR ULTRALIGHT AIR VEHICLE

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Abstract. Ultralight aviation is active developing now. Main part of ultralight air vehicles in the world uses piston engines by Rotax firm. During the flight piston power plant needs to check few data, among them operating time, temperature of cylinder head and exhaust gas from every cylinders, temperature and pressure of oil, RPM of shaft and torque. It can be done by collection of devices or universal digital monitoring system. Authors investigated optimal engine monitoring system (EMS) for ultralight power plant. Ground experiments with different piston engines show high convenient of this system.

Offering EMS includes sensors, communication lines and devices for analyzing of measured data. Engine condition data, received from sensors, send into preliminary processing units where are transformed to digital type. Then deviations of engine parameters are determined and showed to the pilot. The micro-controller also calculates indirect parameters, such as engine operating time and wear rate. System allows to remember data from 3 engines and set new data in the case of engine changing. EMS send out data to by CAN-bus. This data can be used another memory or visual devices.

This system can be used not only for ultralight air vehicles and also for another mechanical complexes.

Keywords. UAV, EMS

1 Introduction

Ultralight aircrafts (ULA) is very active developing in the world now. Simple engine checking systems are often mounted on ULA. There are separate system as a “Flydat” by Austria or combined device like “Stratomaster” or “Dynon”. Weaknesses of existing systems are high cost, absence possibility of system upgrade and adaptation to new algorithms of engine diagnostics.

2 Main problem

The Engine Monitoring System must be autonomous and not demand additional actions with it. It has to track operating time, temperature of cylinder head and exhaust, temperature and pressure of oil, and RPM. In future it’s expediency to add in system measuring of torque, vibration acceleration, depression in carburetor and other parameters. Cycles and exceeding of possible rates has to be traced.

It data can use for defining of forecast of technical condition of engine parts. This permits to estimate possible time of safe engine running with defects and malfunctions that showed up on early stage of its evolution.

The engine monitoring system must contain sensors, data lines, devices of processing and analysis of measured rates and monitoring parameters (see Fig. 1).

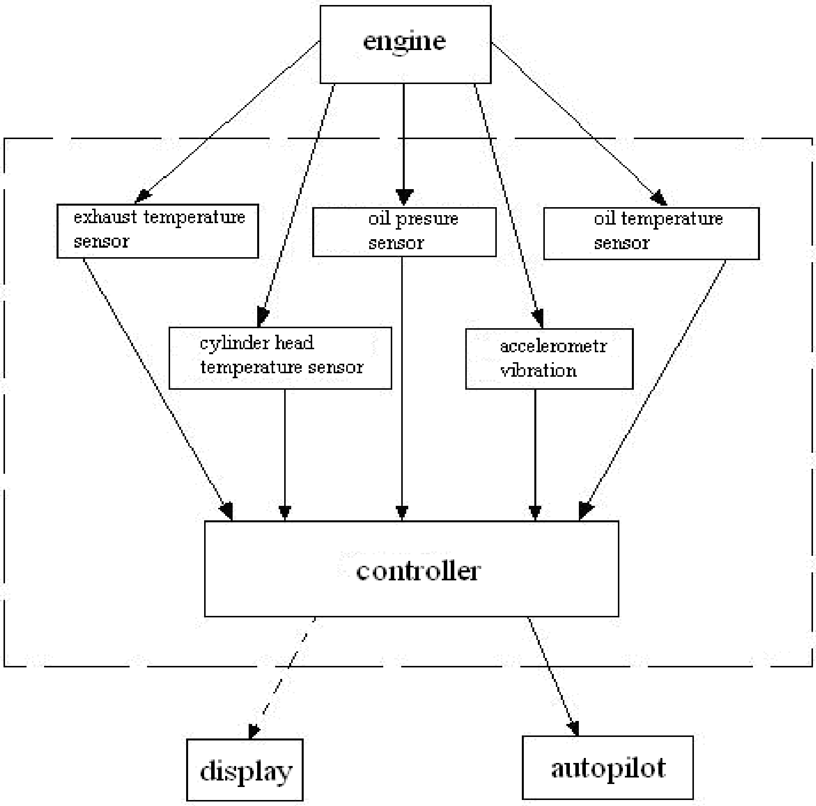


Fig. 1: Structure schematic of engine monitor system for ULA

The engine condition data are transferred from engine sensors to devices of preliminary data processing where they are transformed into digital form.

The controller calculates engine parameters, transforms them from electric signal to digital form, calculates indirect parameters like operating time or degree of wearing and sends them via CAN-bus to display, autopilot or data saver. Vibration information about power plant with Fourier analysis would be given out (see Fig. 2). Fourier analysis use addition processor which send results also through CAN-bus.

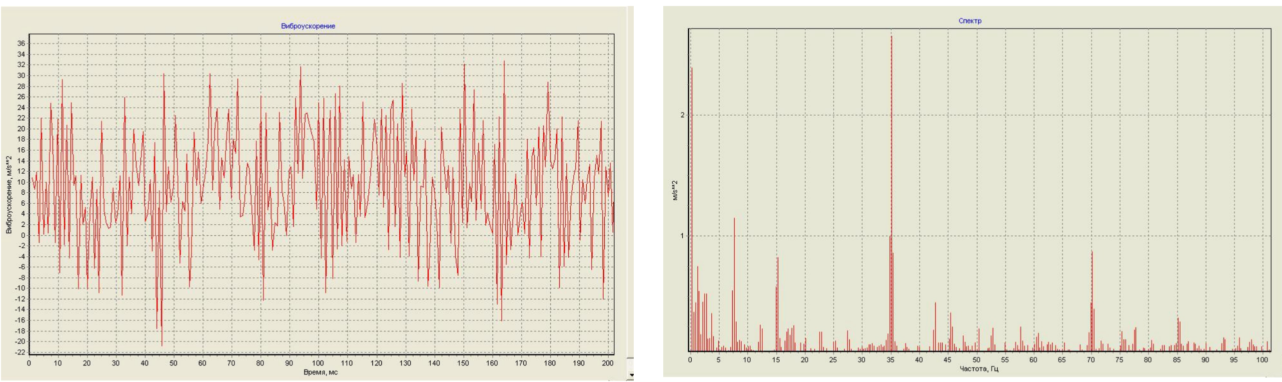
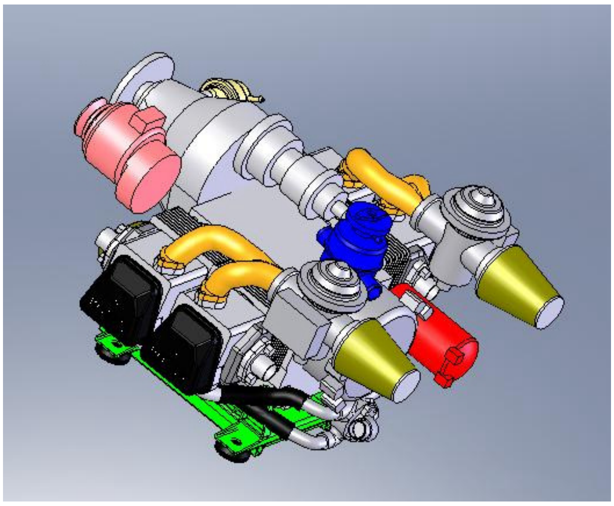


Fig. 2:Saving of vibration accelerates and amplitude-frequency performance of engine

Micro controller can give out information on the LCD (Fig. 3,b) that allows to display text and graphical data. Information about critical parameter are showed on the display if any data of engine (temperature, RPM, operating time etc.) are exceeding bounds.

Exceeding of admissible range of RPM can bring to break the engine work, failure and destruction of composite part that inadmissible in flying. If engine works on very low RPM reduce traction and falling down is possible. So engine work in adjusted limits is necessary for normal and safe flying. Violation of temperature mode can bring to unstable working and reducing of engine power that very dangerous in flying. Failure and stop of engine always arise if oil pressure in engine casing is very dropped down. Other parameters pilot can control by increasing or reducing traction, speed or altitude but oil pressure falling is conditioned of engine malfunction.

The most part of engines for ultra light vehicles are piston engines produced by Rotax firm. Optimal set of sensors for Rotax 912 (Fig. 3,a) was selected according with customers' requirements. This engine is most distributed among the ULA now. Examples of Russian ULA with Rotax 912 are showed in Fig. 4. The engine has oil pressure sensor which mounted on body of oil pump. Tachometer is a pulse counter that counts the same as a sensor of ignition system. Exhaust temperature is measured by thermocouple. They get out constant voltage depending of temperature difference between cold and working seams. The inner voltage for ADC must vary from null to several volts therefore thermocouple signals must be amplified. The amplifier coefficient has such value that maximal voltage from sensor correspond to maximal available voltage that can be proffered to ADC, i.e. voltage that correspond to maximal digital code. The reference voltage is generated by high precision power stabilizer. Operating amplifier works in differential mode in case of measuring of exhaust temperature, i.e. it amplifies difference between inverted and not inverted inputs. Temperature of cylinder head, temperature of oil and oil pressure is measured similarly to measuring exhaust temperature but amplifier is working in not inverted mode, i.e. input signals from sensors connected to not inverted input of amplifiers.



(a)

(b)

Fig. 3: interface of experimental module of engine monitoring system for engine Rotax 912 (a) that is adapted for LQ057Q3DC12 by Sharp (b).

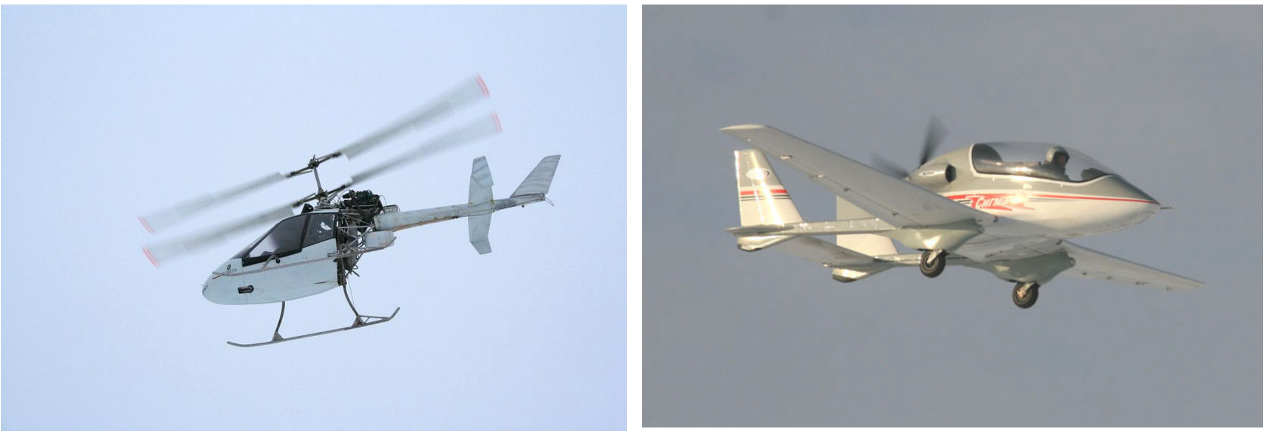


Fig. 4: Russian ULA with Rotax 912 engine.

The problem of torque measuring of vehicles in flights is very complicated but very important. The toque is defined by deformation of shaft and resistance tensometer can be used for that. It is expedient to use for torque strength measurement the bridge scheme with 4 sensors that is glued with angle of 45 degrees to axis.

Utilizing of bridge scheme increases sensitivity and improves linearity of data. It allows to reduce temperature influence on output signal value, alteration elasticity module that is caused by temperature alteration and also advantage of this scheme is measuring change of resistance and not general resistance.

The main disadvantage of tensometric converters for torque measurement is necessarity of collector for signal transferring from sensors to measurement device. Measurement device must be fixed on vehicle.

Solving of this problem is transferring signal by digital radio channel. Modern element base allows designing very small transceiver that is mounted on shaft. Counterbalance is necessary on other side of shaft. The transferring block consists of 2 parts – transmitter and receiver. The micro controller uses for radio module controlling. Control is realized on Serial Peripheral Interface (SPI). SPI is synchronous interface in which all transaction is synchronized with general clock that generated by processor.

3 Conclusion

At present special controller is created and experiments of Rotax 912 regular parameters measurement are executed. Torque sensor adding experiment are carried on.

The experiments show that utilizing of multifunctional simply engine monitoring system may increase period of engine work and to use it more effective. Moreover it is confirmed that system can be adapted for other land vehicles.