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DESIGN AND IMPLEMENTATION OF AN ALTERNATIVE ROTAX 915IS ENGINE MANAGEMENT SYSTEM

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Abstract

The content of this article is design and implementation of an alternative Rotax 915is engine management system. In my research, I worked with a wide-spectrum control unit ECU MASTER designed for the optimization of the injection time of spark-ignition engines and also the control of the ignition advance taking into account several sensors of engine input parameters. The article was created as part of research into the issue of optimal control of piston engines. Current methods of controlling engines and their systems, in principle, allow very precise control of important systems of modern piston engines, especially with regard to the ignition and fuel system. The inclusion of microprocessor units with multiple options for input parameters allow the control unit to take into account even less important parameters, which, however, help the control unit to keep the engine running smoothly while maintaining high combustion efficiency. The elaborated design of a possible alternative engine control system is subsequently connected with the practical realization of this control system. The result of the research is the design of the control system of the Rotax 915is engine and the subsequent practical production and adjustment of the control unit under the name ECU MASTER, which verifies the universal applicability of such a unit for various combustion engines.

Keywords

engine management, piston engine, ignition system, fuel system, ECU MASTER

7. INTRODUCTION

The aviation industry is an ever-evolving industry that emphasizes new technologies and improvements to increase the efficiency of various components. In my work, I therefore focus on an alternative way of controlling the Rotax915is engine. It is a four-cylinder piston engine, mainly used in ultralight aircraft, sport aircraft or home-made aircraft. The main goal is to "revive" the exhibition piece. One of the tasks in carrying out the research was to ensure the lowest possible costs with the limitation of purchasing original system parts. This involved making the best use of the parts and components we had physically in the workshop. I worked with a classmate on starting the engine. In my part of the work, I mainly focused on designing the fuel, oil and cooling system. In my research, it is also important to mention the ECU master Ignition control unit, which we used to set the parameters when starting the engine. We did not have to buy the control unit and thus eliminated the expenses associated with the control member of the drive unit.

8. INTRODUCTION TO THE ISSUE

A piston engine is a very complex system that consists of many interconnected parts. For optimal engine performance, all components must work in balance and harmony.

Engine control is a process that controls the operating behavior as well as the engine itself. The main goal is to maximize the efficiency and performance of the drive unit. For the desired behavior of the engine, the correct timing of the fuel injection, the timing of the ignition and the correct moment of opening and closing of the opening and exhaust valves are important.

The air-fuel mixture is also a very important aspect of improving performance and engine response. The controls also check engine parameters such as engine temperature, oil pressure and, last but not least, exhaust emissions. By optimization control of piston engine we can reduce fuel consumption, in connection with the reduction fuel consumption, reduce exhaust gas emissions and ultimately increase performance engine.

9. CURRENT STATE OF THE SOLVED PROBLEM

In the past, piston engine control was much simpler and less sophisticated like today. Early engines used a carburetor to mix air and fuel and relied on for manual choke and throttle adjustments to regulate engine power. They were later introduced electronic ignition systems that allowed for more precise control ignition timing. However, these systems still relied on simple mechanical components and lacked the advanced sensors and computing power of modern ones engine control systems. [1,2]

9.1. FADEC

"Full authority digital engine control" (FADEC) is a computer controlled system aircraft engine ignition and control. It consists of a digital computer, called "Engine Electronic Control Unit" (EEC) or "Engine Control Unit" (ECU) and other accessories. The FADEC system can be used with both types engines, both jet and piston. It will find its use in modern commercial aircraft but also military aircraft, for digital control of all aspects of the engine instead of technical or analog electrical controls. [2]

FADEC systems respond to pilot inputs, using data from sensors such as for example, engine temperature, engine pressure, fuel flow, air density and others automatic adjustment of engine settings, which ensures performance optimization. There are inputs analyzed up to 70 times per second. The systems are self-monitoring, while including system redundancy aimed at preventing failures. The system has 2 channels, the first is active and the other is in the so-called in "standby" mode with activation in case of failure. [2]

9.1.1. Applicability in piston engines

The FADEC for reciprocating engines works by using a digital computer continuously monitors and controls engine operation. The system adjusts fuel injection, timing ignitions and other variables based on data from various sensors such as sensor throttle position, air flow sensor and oxygen sensor. [2,3]

With the FADEC system, engine performance can be optimized for a wider range operating conditions, including changes in altitude and temperature. The system too it can detect and repair engine faults, improving safety and reliability. [2,3]

10. THEORETICAL KNOWLEDGE

A piston engine is a type of internal combustion engine that converts fuel into mechanical energy by using the force of the expanding gas. Basic principle of operation of a piston engine is the compression of the mixture of air and fuel in the cylinder. It will then be pressed and expands rapidly after ignition. The induced pressure on the piston converts thermal energy combustion to mechanical. [1,4]

In the case of combustion engines, we start from the second theorem of thermodynamics. It follows that the conversion of thermal energy into mechanical work cannot take place voluntarily. Heat machines operating in circulation are used for such a change of work. [1,4]

10.1. Otto Cycle

He is considered to be the first creator of an internal combustion engine working in a four-stroke cycle the German Otto Nikolaus, after whom the Otto cycle is named. At present ho we know in connection with the ideal analysis of the spark-ignition combustion cycle. When analyzing we considers an instantaneous constant volume combustion process. Analysis provides an overview of the engine's efficiency under changed conditions, whether of construction or appearance for operation. [4]

10.1.1. Otto cycle diagram

The diagram defines the phases depending on pressure and volume. By displaying all phases in one diagram, the space was bounded by two adiabats and the same number of isochores. [4]

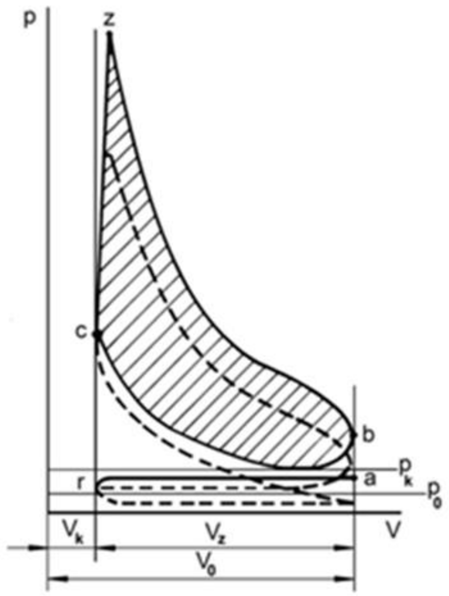

Figure 1 - Engine indicator diagram with and without turbocharging

10.1.2. Work cycles

With a four-stroke gasoline engine, we are talking about four cycles during which it changes the composition and condition of the working substance with which the engine works. They take place in a very short time physical and chemical processes that repeat for two revolutions of the crank shaft. [5]

- Suction
- Compression
- Expansion
- Exhaust

10.2. Piston combustion engines

For the drive of various means of transport, devices or construction or others mechanisms, combustion, electric, steam or solar engines are mostly used. Most often, however, we find combustion engines that convert thermal energy into mechanical work. A suitable type of fuel-air is burned in the designated space mixtures. The mixture ratio is adjusted with regard to the requirement of rapid ignition and burning without the rest if possible. In piston engines, the transfer of thermal energy takes place in the four work cycles mentioned above. The released energy from the fuel is transferred to the piston in the form of gas pressure, which causes the movement of the piston in the engine cylinder. Sliding the movement of the piston is transformed into a rotating movement with the help of the crankshaft. [6]

10.3. Ignition system

In gasoline engines, one of the most important systems is the ignition. Ignition system in a piston engine is responsible for providing the spark that ignites the fuel mixture and air in the combustion chamber of the engine. Modern ignition systems use computer controlled sensors for optimization spark timing and ensure that it occurs at the right moment for optimum combustion. Some systems also use multiple spark plugs to ensuring complete fuel combustion. [5]

10.4. Fuel system

The fuel system of the piston engine is responsible for supplying fuel to the combustion chamber chambers. Fuel is usually stored in the fuel tank and distributed by the fuel pump pipe pumped from the tank by the fuel pump. When the fuel is fed to the engine, it mixes with air in the carburetor or fuel injection system to form flammable mixture. A carburetor is a mechanical device that mixes fuel and air in the correct ratio, while the fuel injection system uses electronic sensors and fuel supply control injectors. When fuel is mixed with air, it is ignited by the spark from the spark plug, creating the power that drives the engine. Fuel system is a critical part of the engine and proper maintenance is essential for optimum performance and fuel economy. [5,7]

10.4.1. Injection

Injection of volatile fuels is not just a modern trend. Its primal it was used in aircraft engines, where it performed not only the function of good atomization mixture but also met important conditions. The main task of injection is to create a precisely determined ratio of fuel and air. The injected fuel must be in a certain proportion to the amount of air taken in. [6]

10.5. Lubrication system

The piston engine oil system is responsible for lubricating the moving parts of the engine, reducing friction and wear and heat dissipation. The oil is usually stored in an oil tank in the tub under the engine and is sucked into the engine by a pump. The oil then circulates through the block engine and cylinder head, where it lubricates components such as the crankshaft, connecting rods and cam shaft. As the oil circulates, it takes the heat generated by the engine and conducts it to the radiator oil, where it cools before returning to the engine. The oil also helps clean the engine by captures and suspends dirt and metal particles that can cause damage. Over time, the oil can become contaminated and break down, resulting in reduced lubrication and increased wear and tear. It is important to regularly check and change the oil so that ensured proper lubrication and engine performance. [6]

10.6. Cooling system

The piston engine cooling system is designed to maintain optimum operating temperature of the engine by removing the heat generated during combustion process. This is typically accomplished by circulating coolant through the engine block and head a cylinder that absorbs heat and sends it to the radiator to dissipate it. There is coolant usually a mixture of water and antifreeze and is circulated by a water pump. In addition to the liquid cooling system, some engines are also air-cooled components such as cylinder fins that help dissipate heat. [6]

10.6.1. Air cooling

The basis of this type of cooling is the flow of air flowing around the engine parts. It is a system of direct heat removal into the air. To ensure sufficient cooling, it is necessary that the components and the motor have the largest possible contact surface with a flowing medium, which is ensured by the cooling ribs. This heat removal process is increased by the speed and nature of the air flow, the material of the structure orcombinations. [6]

10.6.2. Liquid cooling

For more efficient cooling, a liquid with a higher specific heat is used, which it has resulting in more intense transmission. The heat-carrying medium is mostly distilled water mixed with antifreeze. The entire system works under pressure and is therefore pro the liquid more difficult to reach the boiling point. Excess pressure is released by the radiator cap, so as not to damage the integrity of the cooling system. Accumulated thermal energy in the medium it is supplied to the heat exchanger through the casing, the double wall of the head and the cylinder blocks. In exchanger, the heated liquid is cooled by air, which ensures heat removal to atmosphere. The liquid cooled in this way returns to the engine and cycle ensures a constant supply of cooling medium. The thermal energy of the liquid is also used for heating in the medium. [6]

11. WORK METHODOLOGY

All Internet sources and book publications were searched using the literature search method. By comparison, all available resources were compared. By subsequent choice and selection resources suitable for the work have been allocated. The main content of the information is contained from book publications, but it is appropriately supplemented with professional, electronic sources. Work and obtaining information is carried out by the method of processing when it is obtained necessary information on individual areas of the issue. The analysis obtained a detailed view of the individual drive unit systems. Information we have received so far were used in other parts of the work. Suitable alternatives were selected using the method of analogy components of specific systems to ensure functionality and propulsion requirements units. Using the experiment method, they were constructed on the basis of the obtained information drive unit systems. During testing, individual systems were tested separately and leaks and design issues were eliminated. Subsequently, it was examined by observation functionality of the system after successful implementation. Testing resulted in results at starting the drive unit as a whole.

12. WORK RESULTS

The practical part of this work presents the design and implementation of an alternative method steering for the Rotax 915is engine. It focuses on the construction of fuel, oil and the cooling system to start the malfunctioning engine that is in the workshop.

We designed the new systems based on the requirements of the given drive unit. They took advantage we use as many original parts as possible, which we supplemented with the necessary components. At in the alternative parts, we worked with the parts that were provided to us in the workshop or which we had. We bought some parts. We replaced the fuel system main fuel and sump tank, pump and all wiring related connections these components. In the lubrication system, we replaced the oil tank with parts for connecting a new oil tank. We preserved the cooling system as much as possible and just added a cooler. I only removed the collecting tank and I went to the pressure tank built in an outlet in the form of a hose for the excess amount of coolant.

12.1. Fuel system

For the implementation of the alternative, we chose the central tank, considering the original request acrobatic system. During aerobatic flying, the position of the fuel changes, caused by gravitational force in a vertical downward direction. Therefore, we ensured the position of the pump so that met the requirements. Fuel intake takes place in the center of the spherical fuel tank, which ensures fuel supply at any position of the tank. However, we had to take into account requirements for material that would ensure strength and resistance to internal pressure.

That's why we chose a spherical tank. However, we had to modify the cap for ours needs. The fuel system at work consists of the main fuel tank, from which it flows down gasoline and flows through a filter located under the tank. The filtered fuel enters the collection tank, from which it is subsequently pumped out by a pressure pump and fed to inlet of the injector ramp. The injector ramp distributes fuel to the injectors on both sides of the motor unit. The return control valve is used for draining excess fuel from the system to maintain the required value fuel pressure in the fuel rail. Excess fuel is diverted back to the collection tank. The check valve also includes a pressure regulator that reduces the pressure in the fuel system to optimal.

After connecting all parts of the proposed fuel system, we first checked all connections. First, we tested the functionality of the injectors, and after success tested, we started the fuel system without ignition. The fuel flows nicely through the reverse the valve supplied back to the collection tank.

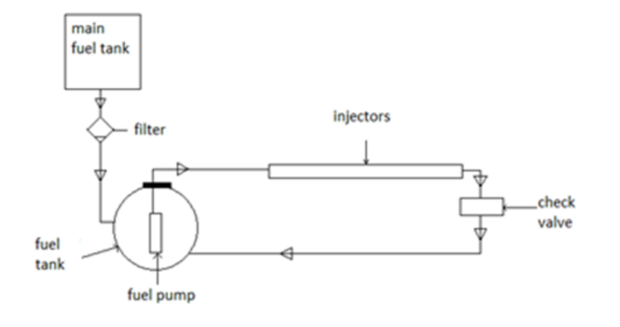

Figure 2 - Fuel system diagram

12.2. Lubrication system

At work, we replaced the oil tank with a round one. Material requirement was strength against internal pressures. However, we had to have an oil tank adjust with an oil drain hole. When connecting the oil system, we were limited by some requirements from the manual. According to the installation manual from the manufacturer, we had to place the oil tank by 360 mm lower than the engine axis. To comply with this requirement, we had to put a fuel tank to a higher stand, which we ultimately had to modify with an intermediate piece. We chose a spherical oil tank. We had to fit it properly to connect the tank modify for our needs. The modification included drilling a suitable hole for the connection return branch and the creation of a suitable mounting system on the stand. We were pacing with aluminum, in which we drilled suitable holes for attachment.

We used 10W-40 four-stroke engine oil. We chose it because of its viscosity for proper lubrication of the drive unit. Suitable temperature is from -25°C to 40°C.

To seal the opening, we used two-component epoxy glue, for fulfillment requirements for strength and sealing potential.

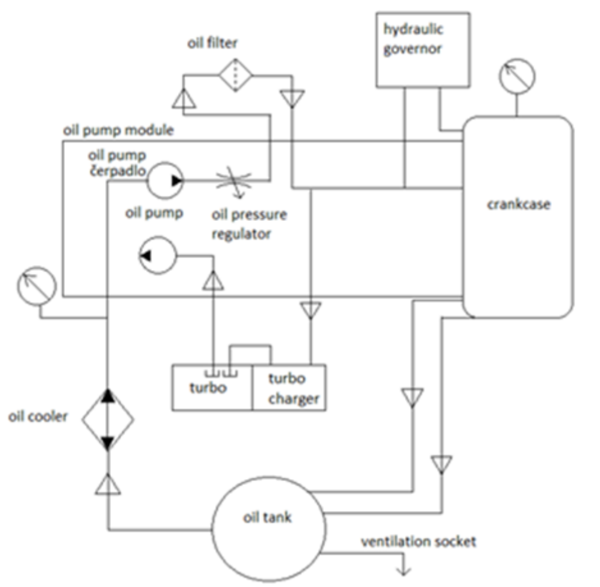

Figure 3 - Oil system diagram

To ensure optimal pressure in the oil system, we have introduced a sump into the collection tank venting valve, through which it will be removed in the event of overpressurization of the system excess amount of gases and air from the oil.

12.3. Cooling system

In our work, we focused on modifying the system in the form of removing the collection tank. For cooling, a cooler is built into the system, in which the liquid is cooled and further enters the engine through the cooling branch. Drainage of excess cooling medium provided through the outlet directly from the overpressure tank. For our alternative cooling system, we used distilled as a coolant water, which we finally poured into the pressure tank. Given that the engine is placed in the workshop on a stand, there was no need to use antifreeze.

The cooling system consists of an overpressure tank in which the coolant is located medium. In case of excess pressure, a hose outlet is made from the overpressure tank, which will remove the excess amount of coolant from the system if necessary. The coolant enters the cooler from the overpressure tank, from which it is pumped out using a pump. It is distributed to the engine, specifically to the cylinder heads, which are cooled precisely by liquid. When modifying the system, we installed a cooler in system and we connected the entire system to the cooler with suitable hoses.

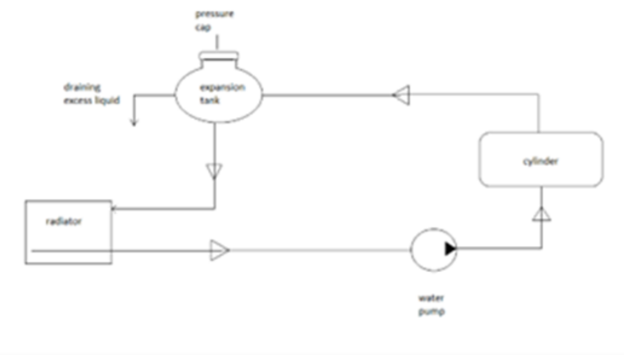

Figure 4 - Cooling system diagram

12.4. ECU MASTER CDI-TCI V8.41

The ECU MASTER control unit is a wide-spectrum unit for contactless controls ignition timing and injection timing for spark-ignition combustion engines with one up to twelve cylinders. Redundant sensing enables integration into all types engines from motorcycles, cars to aircraft engines or generator stations. It has working speeds in the range of 0 to 65,000 rpm and a working temperature from -40 to 80°C. It offers the sensing of parameters such as vacuum, temperature, output to tachometers, but also offers fuel pump switching control, exhaust valve servo, electronic pedal, PID speed controller and many others. The support of 5D maps is also a positive benefit advance and injection. We used this unit in our work for its graphic display and a good user interface. We also had it at the department, which eliminated costs associated with the purchase of the control unit.

12.4.1. Connection of systems to the control unit

We used inputs to the control unit to connect all components. In my work I mainly focused on connecting the injectors. In the above scheme, we are for our needs had to adjust the connection of the injectors, where we connected to one input two injectors. We used inputs 10B and 10D.

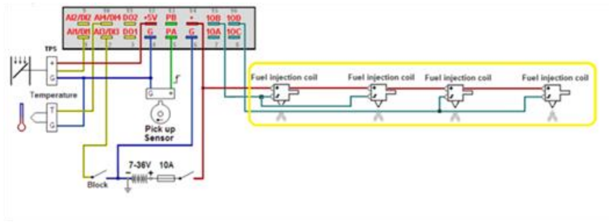

Figure 5 - Connection to ECU Master

12.5. First engine start

After connecting and testing all systems, correctly setting the parameters in the control room unit, we finally started our engine. We tested the correctness of our proposal and confirmed success. The engine has not yet been completely smooth as it needs to be adjusted injection timing and advance curves to optimal values, but this activity can be considerably time-consuming, therefore its implementation will be beyond the scope of this final paper work.

Figure 6 - First test

13. CONCLUSION

In this job, I worked on starting the Rotax 915is power unit. In the theoretical I worked partly with book publications, professional articles and internet publications resources. By choosing the right materials, I secured a good base for practical, constructive part of the work. Subsequently, I put them all good use in the practical part acquired information and knowledge to successfully connect all the missing parts to system and thus ensured the functionality of the systems. We tried all the parts that were missing replace with the best possible efficiency and the least possible cost.

The assignment of the final work was fulfilled and fully verified by the functional start of the engine. During the development, we encountered several problems, but we successfully solved them they solved. We worked towards the main goal with sub-goals, and thus verified it the correctness of the solution. The output is a prototype engine that can be used on University of Žilina as a teaching aid or can also be a basis for others investigation.

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