PROPOSAL MODIFICATIONS TURBOSHAFT ENGINE TV3-117 ON ENERGY USE

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Summary. This work is dedicated to the treatment of aviation turboshaft engine TV3-117 for energy purposes. The paper provides an analysis of engine construction, design modifications analysis of main components for energy use, as well as analysis of major engine systems. There are mentioned various parts of the engine. Thermal cycle engine is calculated for 1. cruise mode. And also it discusses the legislative formalities associated with aircraft engine modifications for energy purposes. The paper processed requirements for such equipment. It is the establishment of framework proposal facilities for electricity production based on the use of engine TV3-117 and describes the different elements of the proposal. The work is also devoted to analyzing the actual state of the engine and its inspection. It is a procedure for checking the actual condition of the air turboshaft engine. The analysis of the actual state of the engine is to identify motor error. In the end, it evaluates the use of motor TV3-117 for power generation purposes and proposes the possibilities for solving problems of implementation of aircraft engines for energy purposes.

Keywords: Turboshaft engine, gas turbine, energy, analysis of actual state, thermal cycle.

1. INTRODUCTION

Nowadays, Slovak Army helicopters Mi-17 are getting to end of their life cycle. After that, lof of parts will be sold as spare parts or junk. So this theme is very actual. It is important to find another opportunity for another purposes for main parts as engines, to preserve their rest value. It seems that there is lot of options but after deeper analysis, it is obvious there is very narrow space for use of engine with specifications similar to TV3-117.

2. TV3-117

TV3-117 is turboshaft engine, developed in the years 1965-1972 in the research design office VJ Klimov led by SP and SV Izotova Ľuneviča. It is produced since 1972 in the company "Motostrojiteľ" at present "Motor sich" in Zaporozhye, Ukraine. From its inception until now were produced more than 25,000 engines TV3-117 various modifications. TV3-117 was installed on 95% of all helicopters designed by Mil and Kamov Engineering Centre. The total number of hours worked is over 16 million. It is one of the most reliable aircraft engines in the world.

Figure 1 TV3-117

3. TV3-117 CONSTRUCTION

TV3-117 is turboshaft engine with a twelve-stage axial compressor, annular combustion chamber, two-stage cooled gas turbine of axial compressor, and two-stage axial free turbine and gas outlet system. Two engines TV3-117 are an power unit of helicopter arranged side by side. They are interchangeable, if you change the output devices. Motor TV3-117 is one shaft engine with free turbine, which is not kinematically coupled to the rotor of the compressor. Power exerted by the free turbine rotor is transmitted to the main gearbox VR-24.

Single rotor construction with free turbine has lot of advantages for energy purposes:

- allows you to set the desired speed of the rotor independently of the free turbine rotor speed turbocharger engine;
- makes it easier to start up turbocharger rotor when starting the engine;
- allows optimization of fuel consumption engine in its various operating modes;
- eliminates the need to use the friction clutch in the drive assembly of the helicopter.

4. MAIN SYSTEM OF TV3-117

On engine are placed all necessary systems for operation. On engine are placed:

- fuel system;
- fuel-engine regulation system;
- lubrication system;
- deicing system;
- starting system;
- fire protection system.

5. BASIC TECHNICAL SPECIFICATIONS OF THE ENGINE TV3-117

Engine power at take-off	$P_e=1632_{-32}$kW
The maximum air flow at take-of	$Q_v=8,1$ kgs^{-1}
The maximum degree of compression of the compressor	$\pi_{kc,max}=9,55$
Specific fuel consumption at take-off	$c_m=0,313$ kgkW^{-1}h^{-1}
The maximum temperature before the gas turbine	$T_{3c}=975$°C
The maximum speed of the turbocompressorr	$n_{TK,max}=19500$ min^{-1}
The maximum speed of the free turbine	$n_{VT,max}=15000$ min^{-1}
Total length of engine with aggregates and an outlet pipe	$L_{max}=2055$ mm
The maximum width of the engine	$W_{max}=650$ mm
The maximum height of engine	$V_{max}=728$ mm
The maximum dry weight of the engine	$G_{max}=285^{+5,7}$ kg

6. LEGISLATION OF CONSTRUCTION AND OPERATION OF GAS TURBINES FOR ENERGY

Stationary power source must before putting into operation, to meet a number of legislative requirements concerning construction and ecology. Also manufacturer, supplier and the operator must demonstrate their competence to work in the energy sector and knowledge of the energy law, "The professional competence to conduct business in the energy sector". On the Slovak territory are valid regulations for environmental protection and standards of technical compliance. The main parameter for control of such devices is the amount of emissions that are released into the atmosphere. Then there are rules to protect against noise, explosive environment, working environment and ISO standards in terms of design.

Overview of standards and regulations:

- ISO 3977 is an international standard related to the design and procurement of gas turbine system applications.
- ISO/DIS 19859.2 - Gas turbine applications - Requirements for power generation
- ISO 21789:2009 – Standard for safety of gas turbine operation
- no. 272/1994 ; no. 40/2002 - Slovak republik regulation for noise.
- no. 355/2007 – regulation of Slovak republik- „on protection, support and development of public health and amending some laws ".
- 393/2006 - The minimum requirements for occupational health and safety at work in explosive atmospheres
- no. 410/2012 – Slovak republik regulation for emisions. In Slovakia emision limits are about 20% more strict than EU. There are no emission limits for emergency or back up source of energy.

7. ANALYSIS OF ACTUAL STATE

Every machine by time or by work loses its original characteristics. We are talking about depreciation and for aircraft engines is no different. At present engineering as well as aviation is time to follow the trend of individual components work and maintenance plans before an damage and thus prevent work incapacity entire machine, or even damaged. It saves time and costs. But this method does not tell us about how it was straining engines, and in what environment worked. The engine can operate under minimum load, for example when doing routine military exercise, or high-performance when the transporting load oh hoist. Environment is also reflected in the condition of the engine. If the engine is operated in dusty environment, it should sanded compressor blades. In coastal areas,is high the risk of corrosion caused by moisture from the aggressive sea. It must not be forgotten that the level of maintenance is not the same everywhere and the ability of maintance personal is reflected in the condition of the engine. All this has a significant impact not only on performance but mainly on the residual life of the entire engine. Therefore, when selecting or estimating the life of the engine it is necessary to do an analysis of the actual state of the engine.

By analyzing the actual state we should be able to tell what state is the engine and an appraisal life. Also based on the results of the analysis can further determine whether the motor used or not, or replace some modules or modify the operating mode.

Process analysis of the actual state of the motor is convenient to divide into specific number of steps to introduce systemicity and eliminate the possible oversights relevant facts or deficiencies, which could have ultimately nedozery consequences, especially financial. The process of analysis of the actual state of the engine should be performed by a person who has experience with a particular engine. Analysis procedure should be divided into the following sections:

• analysis of the documentation of motors;

• check the main parts of the engine;

• check engine systems;

• engine test;

• the final report.

In the final report is clearly described actual state of the engine. In conclusion is defined what else is wrong and what is necessary to replace or send to overhaul. Is there a general estimate outlined further engine operation and related activities. Such as the number of hours to the next inspection or replacement of the unit or module.

8. ANALYSIS OF THE ENGINE TV3-117 FOR ENERGY USE

When designing the engine TV3-117 for energy use, it is necessary to take into account all the characteristics resulting from the construction of the engine helicopter turboshaft engine. The engine itself TV3-117 is designed so that it can be almost without affecting the construction of the main elements be used for energy use.

By adjusting for the energy use can be understood any modification of the engine, which is used to produce electricity, the compressor drive source or mechanical work.

For gas compressor station TV3-117 has low power. Nowadays are in gas industry used 30MW aeroderivate engines and stronger.

For emergency use TV3-117 has long starting procedure as almost every gas turbine engine. For these purposes are used diesel generators.

Use as short-term energy source is the principle area where the modified engine TV3-117 has greatest ambitions. Back-up source of energy can be counted in the factories in order to avoid interruption of an important process, stadiums and computer centers, etc. A perspective area for the deployment of an engine could be backup source in the time of maximum electricity consumption. Then it is also the highest price of energy which would ensure the profitability of the project.

While the gas turbines excels in certain parameters, in practice, piston engines are prefered for the source of energy as mobile so static version. This is due to easier operation and reduced sensitivity to errors in operation. The price of new combustion turbine is extremely high. If it is already applied for such purposes combustion turbine is mostly adapted old aircraft engine.

9. FRAMEWORK DESIGN OF BACK-UP SOURCE BASED ON ENGINE TV3-117

According to the analysis, engine TV3-117 is suitable as a backup source of electric energy. It was suggest whole power unit for mobile, backup source of elektric energy, Figure 3Figure 3 View on mobile, backup unit.. There are demonstrate all important parts. Motor TV3-117 after its removal from the helicopter does not require any major modifications of main parts of the engine. It can be used such as. Design consist of suggestion of generator, gearbox, placement, couplings, container and steel frame. For conversion from mechanical work of engine to electric energy is used 2-pole alternator. It needs planetary gearbox which provide reduction of operating speeds and coaxial placement of all parts. Then next part which have to be designed is engine mounts. It has to be strong and tough to prevent resonance. Whole unit would be stored in classic 12m long container for easy work with whole device. In the coat of container would be placed doors for easy manipulating with all parts. Free turbine is fixed with gearbox by sphere conection used from helicopter Mi-17. It provides freedom in setting position of engine by adjustible bars. Planetary gearbox is connected with alternator by flexible coupling. Recomended is flexible copling Steelflex. Container is diveded in 3 rooms, engine room, control room and fire protection room. All rooms are separetad by safety walls.

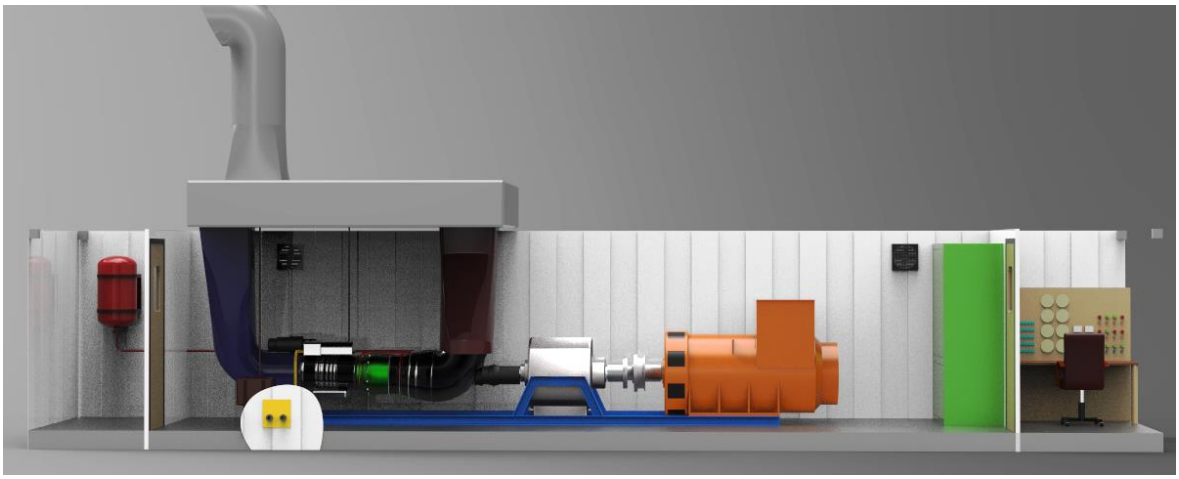

Figure 2 Side view for mobile, backup unit.

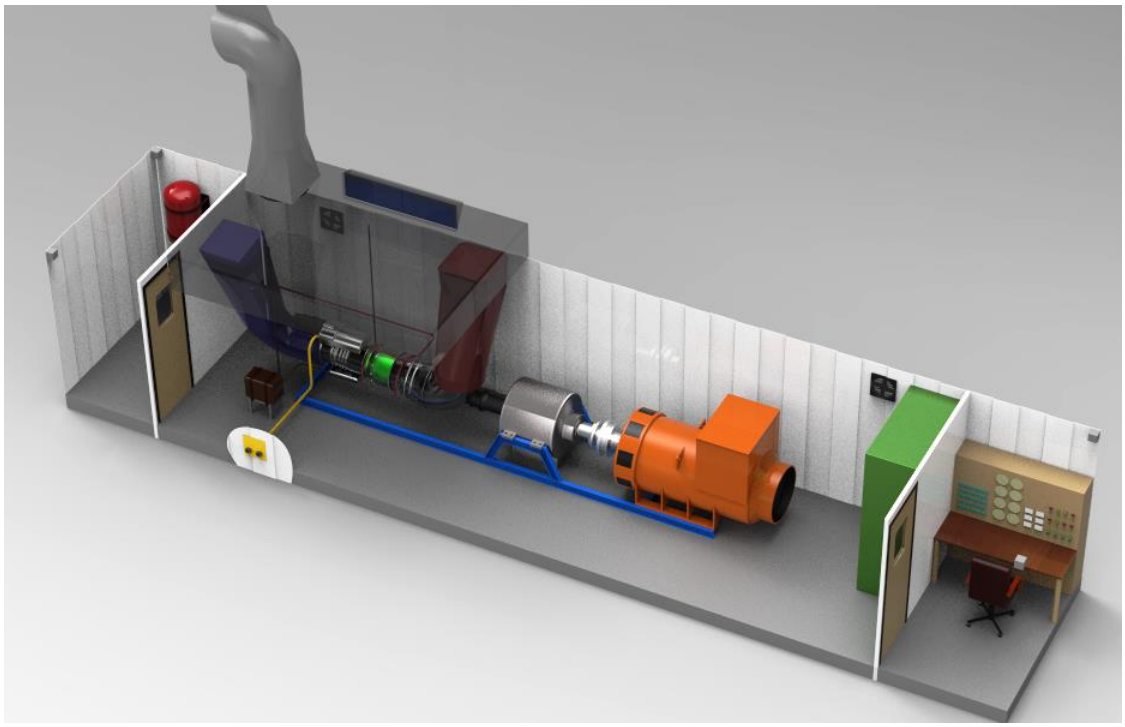

Figure 3 View on mobile, backup unit.

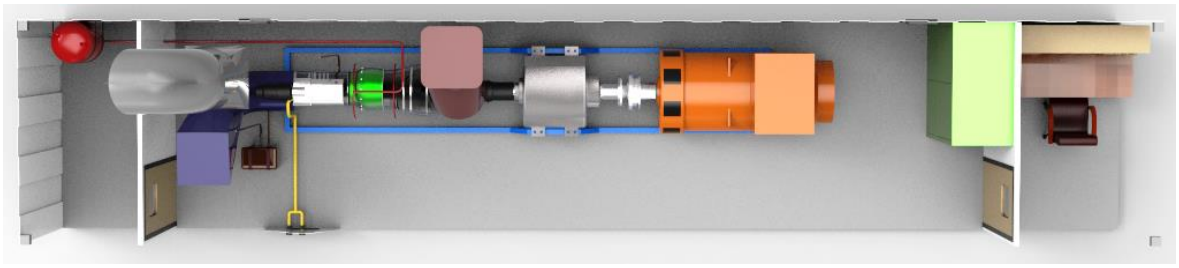

Figure 4 View from above on mobile, backup unit.

10. MODIFICATION OF MAIN SYSTEMS OF TV3-117

When designing the engine modifications TV3-117 for energy use it is necessary to adjust the engine systems. It is necessary to modify the fuel system, oil system, starting system. On the engine is installed low-pressure fuel system, the basic fuel circuit, the limit system for the engine operation modes, the limit system for the temperature of the gas turbine compressor, protection system of free turbine, drainage systems and piping.
When modifying is only necessary to connect the fuel line from the tank to a delivery centrifugal fuel pump DCN-70 low-pressure system, which is placed on the engine drive reck, Figure 5.

Figure 5 DCN-70

For safety reasons it is best to separate the tank from the engine compartment. It is proposed the use of 15000 l Benkalor. The tank should provide engine running for 30 hours. By the tank is placed delivery pump with filter, flow meter and shut-off valve. Tank itself is equipped with the air vent valve and drain valves. Fuel hose connects the tank to the engine via connections to a static fuel tanks and containers with energy unit.
In the container of the power unit is between the external connector and the pump 70 DCN placed fire valve, controlled either automatically by fire protection system or manually.

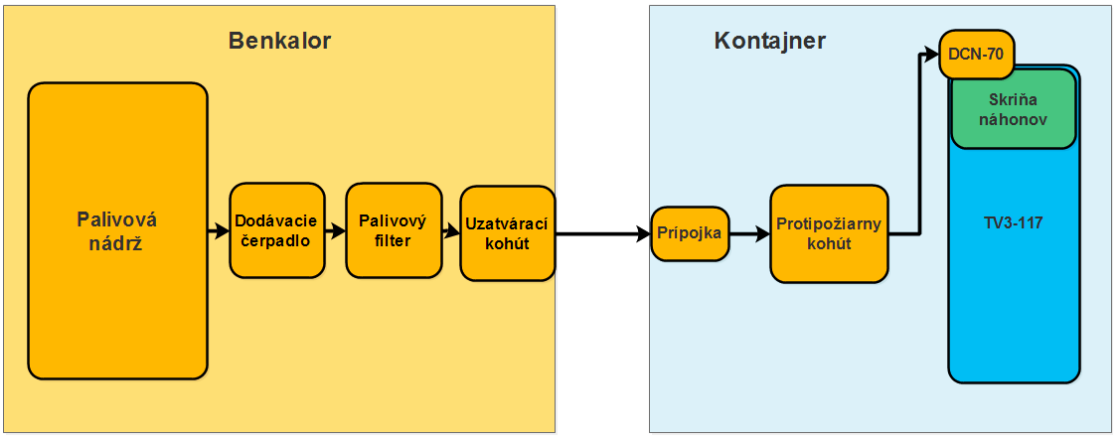

Figure 6 Scheme for fuel connection to engine.

Proposal lubrication system for energy use can also seek a modification. The entire lubrication system except cooler is installed on the motor. Cooler would be placed in entry of the engine.
For starting the engine TV3-117 is used air starter SV-78B and as a generator of air is used AI-9V. Using this system would complicate the whole device. So, it is designed to start the engine for energy use by TV2-117 starting system, which was triggered by dynamo GS-

18MO. That would be mounted on the front gear box reck. In the design would be used wiring diagrams of starter-generator of TV2-117 engine.

Figure 7 Starter-generator GS-18MO.

On the the safety and reliability of the engine has a significant impact frost, which occurs under specific atmospheric conditions. The greatest risk of icing is at a temperature from 0 ° C to 4 ° C at high humidity. Icing may significantly affect the operation of the engine, or in the worst case, cause damage. It is therefore essential to ensure the optimum temperature of the intake air to the compressor (5 ° C). Active anti-icing system reduces engine efficiency. Therefore, in the framework design of the energy use is used heat exchanger, which ensures the heated air is at the inlet to the compressor at optimal temperature. To heat the air used off-gas heat. System is triggered only in specific weather conditions.

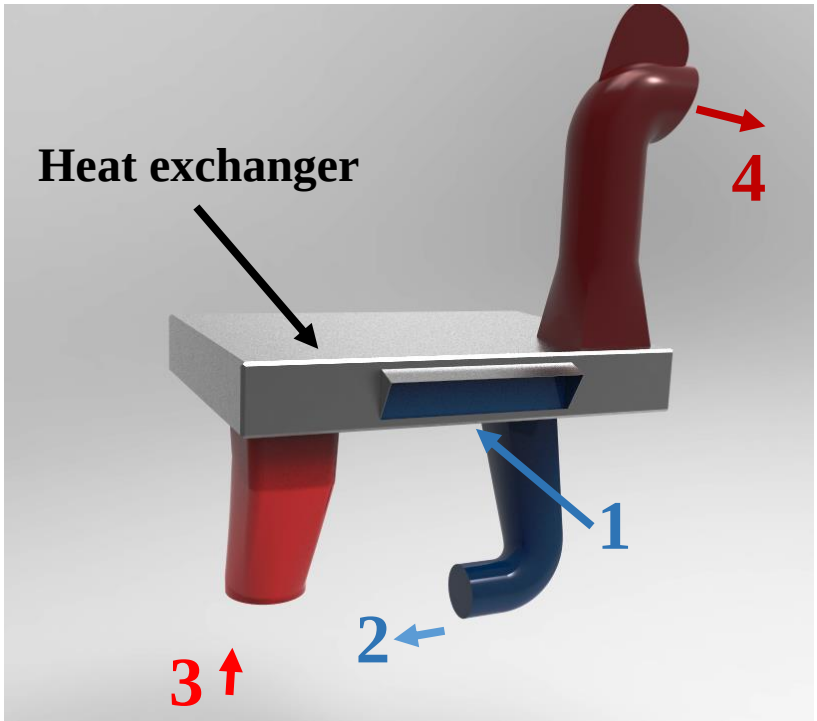

Figure 8 Suggested framework heat exchanger

1-Air inlet, 2 – heated air at entry to the engine, 3 – hot exhausted gasses, 4 – cooled exhaust;

11. CONCLUSION

The current situation in the world is full of military conflicts and natural disasters. It requires to have strong and mobile backup power source.

Analysis of the possibilities of the engine TV3-117 for energy use concluded that the motor is suitable as a backup power source, either static or mobile. Aircraft engines have a high ratio of performance to weight, and that's the main parameter for mobile version. While in industry in power category to 2MW diesel generators become established,but compared with transformed retired aircraft engines operation is more expensive and harder.

When designing the engine modifications TV3-117 for energy purposes must comply with the regulations applicable to such facilities, so the work has produced legislation requires modifications to the land use of aircraft engines. There are mentioned and described rules concerning gas turbines for energy use.

Using appropriate helicopter engines available after its service life, reduce the price of device for the production of electricity. However, before using engine, it is necessary to carry out an analysis of the actual state of the engine. Thus avoiding unnecessary waste of financial resources to destroyed engine or prevent engine damage due to easily removable problems, but the lack of an unknown motor. Analysis of the actual state is an important process that must be made responsible and experienced person.

Changes connected with grounding motor TV3-117 are not demanding and are feasible even without the participation of the manufacturer. Framework proposal describes the adjustment of the engine parts and adjust the fuel, lubricating, release and defrosting system. Part of the de-icing system is a heat exchanger, a draft of which must be disposed of discussions. To better understand the processes in the engine TV3-117 was processed to calculate the thermal circulation for the first Cruise mode. However, for a deeper understanding of the work and the conditions the engine is necessary to obtain all the characteristics of the engine.

Use of redundant and decommissioned military equipment is not only an economic and ecological point of view effectively, but also will benefit in the future. It is therefore necessary to continue developing the issue of conversion of aircraft engines for energy use.

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