Gas Turbine Plant On The Basis Of The Converted Aero Engines

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Abstract **– The aim of this work is to study the possibility of using a converted gas-turbine engine for the mobile power stations.**

Keywords – gas turbine engines; power plant; thermodynamic; gas dynamic; performance; electricity.

I. INTRODUCTION

Gas turbine engines which has spent flight service life can be used for terrestrial objectives in the energetics. Turboprop (turboshaft) aircraft (helicopter) engine is the simplest to use as gas-turbine power plant, because in this engine, mechanical energy is transmitted on the outer shaft and can be used directly.

Such gas turbine power plant is indispensable for using in these cases, when:

– it is necessary to solve the problem of electrical and thermal energy, supply to a town or production plant - the modularity of the blocks allows to create any variants depending on the needs of its consumers;

– economic efficiency is important; modern gas turbines have efficiency up to 40% in simple cycle, high efficiency of plant provides the possibility of producing cheaper electricity and heat generation and short payback period;

– it is industrial development of new areas of people's lives and the natural features of these territories have great importance; operation of the plant is ensured in the range of ambient temperatures from -50 to +50 ºC when the adverse weather conditions like humidity, rain, snow effect (the level of stress and thermal condition of the aviation engine parts almost has no analogues among the products of mechanical engineering);

– it is necessary the automation of control plants; gas turbine stations on aircraft engines is very maneuverable, and require a small time to start from cold condition to full load, can be automated and controlled remotely.

II. JUSTIFICATION OF THE CHOICE OF ENGINE

As a power drive for the mobile power plant the turboshaft engine PT6T-3D (PT6 family), fig.1, fig.2, which consists of two PT6A power sections coupled to a combining gearbox with a novel clutch system enabling both twin and single engine operation, was chosen. Its

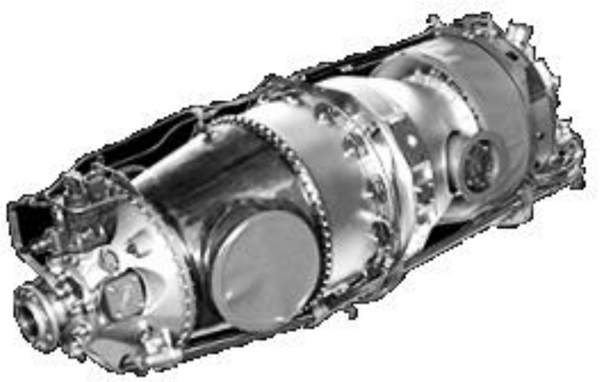

Fig.1. Turboshaft engine PT6

compact size, weight, modular design, high efficiency and the presence of outer shaft (for the mechanical energy transmission) make this turboshaft engine as a good choice to use for terrestrial purposes.

The engine consists of two sections that can be easily separated for maintenance: a gas generator supplies hot gas to a free power turbine. A two-shaft configuration consisting of a multi-stage compressor driven by a single-stage compressor turbine and an independent shaft coupling the power turbine to the output shaft. The starter has to accelerate only the gas generator, making the engine easy to start, particularly in cold weather. Air enters the gas-generator through an inlet screen into the low-pressure axial compressor. The air then flows into a single-stage centrifugal compressor, through a reverse flow combustor, and finally through a single-stage turbine that powers the compressors. Hot gas from the gas generator flows into the power turbine, the gas generator speed is around 36,000 rpm. For turboprop use, this powers a two-stage planetary output reduction gearbox, which turns the propeller at a speed of 1,900 to 2,200 rpm. The exhaust gas then escapes through two side-mounted ducts in the power turbine housing. The turbines are mounted inside the combustion chamber, reducing overall length.

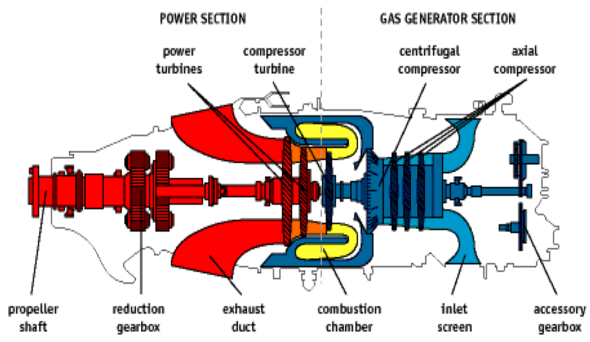

Fig.2. PT6A cross section

III. CHARACTERISTICS OF GAS TURBINE PLANT ON THE BASIS OF THE CONVERTED ONE POWER SECTION OF PT6T-3D TURBOSHAFT ENGINE(PT6A)

The turboshaft engine PT6T-3D which consists of two PT6A power sections is the engine for which studies and calculations of the main characteristics were performed.

The engine main components are a compressor which consists of 3-stage axial and 1-stage centrifugal flow compressor, combustors which has Annular reverse-flow with 14 Simplex burners and turbine that has 1-stage gas generator power turbine with 1-stage free power turbine (independent 'free' power turbine with shrouded blades Forward facing output for fast hot section refurbishment).

By performing thermodynamic and gas dynamic calculations we have recalculated the performance details of this engine as a gas turbine plant which are the followings:

- Maximum power output is around 670921 kW;
- Overall pressure ratio is 6.3;
- Air mass flow is approximately 2.5 kg/s;
- Specific fuel consumption is around 0.44 kg/kW/h;

CONCLUSION

As a result, the rotational speed of the gas generator rotor is around 36000 rpm which is far less than the limited value of this engine and also other parameters as total gas temperature before turbine compressor (1363 K), on the other word this engine is proper to be used as gas turbine plant.

It should be noted that in addition to electricity, electricity generating plant produces heat. According to experts at transporting heat long distances the loss is up to 40...50%. Therefore, the location of power plants close to the consumer is important; considerably smaller losses of energy will be when high power capacity plants are replaced by small, placed close to the consumer. This makes gas turbines of small and average power perspective.

The article proposes to use a spent flight resource engine as a mobile power station in remote areas and areas recovering from natural disasters. The use of mobile plants is the best solution for the electricity supply for people living in areas prone to natural disasters. It is very important to make a mobile power station more portable and easy to use in emergency situations.

At the end the estimation of the ability to provide electricity for residential usage of this engine is approximately around 1550 families per month.

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Comparative analysis of modern turboprop engines of two well-known firms

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INTRODUCTION

The Canadian engine manufacturer Pratt Wittney (P & WC) is the leading engine in regional passenger aircraft with a long history and significant achievements. Today, the family of P & WC turboprop engines has more than fifty modifications of engines and their operating time in flight is more than 120,000 hours, which is an exceptional achievement given its work on flights, usually less than one hour. Imagine ... three out of every four modern regional aircraft equipped with turboprop engines are powered by PW100 of this company all over the world. Therefore, in this report, we decided to analyze the design features of the engines of this company and compare them with our domestic engine TV3-117 firm "Ivchenko-Progress" for the same regional aircraft. Engine PW150A firm P & WC is a three-shaft engine with two centrifugal compressors, with a free turbine providing propeller drive.

Main technical data of the engine: Power: 5071 Shaft power (SHP), specific fuel consumption – 1350 l/h for each horsepower. Rotation speed of the screw: 1,020 rpm (RPM). Used fuel: kerosene: Jet A (primary), A-1 and JP8. Wide cut: Jet B JP4 or High Flash JP5 and JP1. Used oil type: synthetic, which corresponds to PWA 521 Type II, in service manual PW150A number 3043522. Oil capacity: 6.58 US gallons or 24.9 liters (total). The engine was Certified on June 24, 1998 by Transport Canada, the Federal Aviation Administration (FAA). Pratt & Whitney Canada applied for certification from the FAA on October 25, 1995. Reverse flow combustion chamber, advanced cooling, high efficiency and durability, low emissions and low noise level, PW150A FADEC (digital engine management with full control) with redundancy with two channels.

If we compare the latest development of Pratt & Whitney with turboprop engine TB3-117BMA-SBM1. The TB3-117BMA-SBM1 is an advanced, economical and low-noise turboprop engine. It is designed for use as a cruise engine for aircraft with short range. The engine is derived from the helicopter engine TB3-117, successfully operated in 40 countries in different climatic zones and received a type certificate. If we compare these two engines, which are approximately close in traction, then we can note the following differences:

1. In the engines of Pratt & Whitney, the combustion chamber is of the reverse flow, and the domestic manufacturer of the ring type. The annular chamber is the most perfect in terms of the uniformity of the temperature field. In addition, it has the minimum length and total surface area and therefore the lightest (about 6-8% of the engine mass), has minimal pressure loss and requires less air for cooling. However, such a chamber is complicated in the development, ensuring stable combustion and strength, especially with large dimensions and high gas flow pressures. In addition, the possibility of repairing it is quite small and, in general, requires disassembly of the engine. In contrast, the direction of movement of the gas in the combustion chamber does not coincide with its direction of motion along the engine path. Because of this in the loop chambers, the pressure loss is much higher than in the loop chambers. But the axial dimensions in them are noticeably smaller.

2. The engine of the Canadian firm has a combined (5 axial and one centrifugal stage) compressor, and TB3-117BMA-SBM1 axial. The need to use the last centrifugal stage in the Pratt & Whitney engine is due to the desire to prevent a reduction in the efficiency of the compressor at low blade heights of the last stages. However, in the transition from the axial direction of the air flow to the radial direction in the centrifugal stage, still leads to some loss of energy. In TB3-117BMA-SBM1 all stages are axial, which provides a higher efficiency.

3. The diametrical dimensions of the axial compressor are smaller than the centrifugal, which means that the front resistance of such an engine is less than that of a motor with a centrifugal compressor, which is its significant advantage. Axial and centrifugal compressors differ in the direction of the main flow in the impeller. In the axial compressor, the flow direction coincides with the axis of rotation of the impeller, in the centrifugal compressor the flow moves in the radial direction. Both schemes have their advantages and disadvantages, but there are differences as in that and in this engine.

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Application of vacuum arc coatings for the restoration of aviation equipment

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Annotation – the work is devoted to the consideration of the problem of increasing the wear resistance of the elements of the aircraft. In the paper, the use of the vacuum-arc method is proposed.

Erosion - the destruction of metal or metal products, due to the action of mechanical factors or electrical discharges.

I. INTRODUCTION

The most affordable reserve for saving energy, materials and other types of resources is an increase in the life of products and process equipment. This is achieved by providing the working surface of products with high strength characteristics, corrosion and other operational properties appropriate physical and chemical treatment and coating. By changing the traditional methods of surface treatment and applying coatings on it become vacuum, ion-plasma technology.

II. FORMULATION OF THE PROBLEM

Unlike traditional methods of cleaning, treatment and deposition of coatings, vacuum ion-plasma technologies, primarily based on vacuum arc discharge, are more cost effective, efficient and environmentally friendly. The influence of a vacuum arc discharge on the surface of a metal product, a cathode, is carried out in the region of cathode spots, formed on its surface and creates an environment for the existence of a vacuum arc discharge.

III. MAIN PART

A cathode spot is characterized by a small time of existence (10^{-4} s), a high current density (10^{-9}-10^{-10}) A/m^2, and a temperature of ~ (3-4) 103 K at a cathode spot size of ~ 10-6 m. The process of formation of new cathode spots instead of the ceased existence is represented by their chaotic displacement on the surface of the cathode at a speed up to several hundred meters per second, depending on the state of the surface. High concentration of energy in a rapidly moving cathode spot causes a short-term, local heating of the surface in the zone of its influence, followed by its rapid cooling, which contributes to increasing the mechanical strength of the parts, improving their corrosive-resistive properties and other properties of the product, and also provides cleaning of the surface from various contaminants. Performing the cleaning and processing of the surface of the product, applying coatings on the basis of vacuum arc discharge allows combining these processes in one technological cipher and thereby implement an integrated approach to modifying the surface of metal products, which ensures high economic efficiency of the vacuum arc method.

IV. CONCLUSIONS

Consequently, the vacuum arc used in the technological systems of film spraying and massive coatings is characterized by a low burning discharge level, a high current density in the cathode bonding region, a high plasma concentration in the cathode region, and the generation of high-speed plasma jets from a cathode spot.

Vacuum technology allows to make the process of coating the "closed" and completely eliminate contact with the environment. From this point of view it can be considered ecologically pure. This is the great advantage of vacuum technology before the "open" methods of coating (metal spraying, electrolytic deposition, etc.).

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The Concept of Propfan Engine

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Abstract **– This report is about advantages and disadvantages of propfan engine. It describes the difference between propfan engines and other modern aircraft engines.**

Keywords—propfan; propeller; increased thrust; efficiency.

The propfan engine is considered very promising, but in actual operation in the world there is only one type of it – the D-27, installed on the only one type of aircraft – An-70[1].

It significantly reduced the gap in the parameters between turboprop (TPE) and turbojet engines (TJE). TJE with a large degree of bypass ratio, or turbofan engines (TFE), having a sufficiently high thrust with significantly better fuel efficiency than TJE, allowed to make economical cruising flights at high subsonic speeds of 750-900 km/h.

Nevertheless, in terms of fuel consumption, they still could not compete with the TPE in the range of speeds in the field of their application (as well as in terms of thrust efficiency in this area). Therefore, for a long time there was a certain temptation for engineers, which was to "teach" the turboprop engine to fly faster and to add speed efficiency to its fuel efficiency, that is, maximally bring it closer to the TFE.

The used type of propeller is called the propfan (PF). This unit differs from the conventional TPE propeller in that it works with a sufficiently high efficiency to a flight Mach number of at least 0.8-0.85. This is achieved in two ways. Firstly, the circumferential velocity decreases, which has a beneficial effect on the flow around the tips of the blades. Secondly, the aerodynamic characteristics of the blades as a whole are changing in terms of improving their flow around with relatively high flight M numbers (it is meant the relative speed for the blades).

The circumferential speed is reduced by increasing the number of blades. There can be 8-12 blades and even more (against 3-5 in conventional TPEs). The same method allows significant reduction of the diameter of the prop, and hence it's mass – up to 40-50%. At the same time, the specific power taken from 1m^2 of area swept by the screw can be increased by 2.5-3 times in comparison with the ordinary prop of TPE, that is, the propfan turns into a heavily loaded effective unit.

To improve aerodynamic characteristics in terms of effective operation at high speeds for blades, thin (relative thickness of about 0.02) supercritical or specially designed profiles are used. This makes it possible to delay the wave crisis by large Mach numbers of streams.

Thus, the newly formed concept of PFE can be considered a further development of TPE and TFE versions of the gas turbine engine. For example, the turboprop engine, turbofan and propfan can be compared by their thrust efficiency (fig.1). The thrust efficiency is the ratio of the useful thrust power expended directly on the movement to the available engine power. In propfan engines, it directly depends on the efficiency of the propeller.

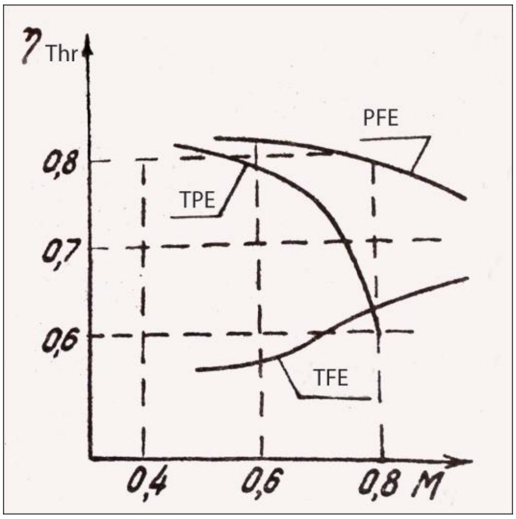

Fig.1 Probable fields of application of engines, depending on the thrust efficiency.

It can be seen that for TPE high values of thrust efficiency are achieved at low flight M numbers, and at M>0.65 their value drops sharply. In TFE thrust efficiency increases with the increase of the M number, but its maximum value remains about 15% lower than that of the TPE. In PFE, for M = 0.8, the same efficiency can be obtained as for TPEs at M = 0.6 and to provide at M = 0.8 the efficiency is 15% higher than for TFE. Propfan engine is a compromise between turboprop engine and turbofan engine.

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Stig Role In Increment Of Gtp Efficiency Cycle And Reduction In Emissions

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***Abstract* – This article is based on formation of steam injected gas turbine cycle, defining its role as an additional parameter in simple turbine cycle and its outcome efficiency performance in comparison to simple cycle, where decline in emissions are also concerned.**

Keywords* – *Aircraft; Passenger Cabin; Passenger Seat Design; Head Injury Criterion; Comfort.

INTRODUCTION

STIG (Steam injected gas turbine) is based on an idea that the high temperature exhaust gas can be used to convert water in steam which when combines with air-fuel mixture in combustor improves the efficiency of GTP. Through studies and research we have come to know that this steam injected can amount from 10-20% of air mass flow acting as an additional mass flow and helps to increase the air flow through turbine which efficiently boosts the network of turbine.A schematic diagram can be seen in figure 1[1].

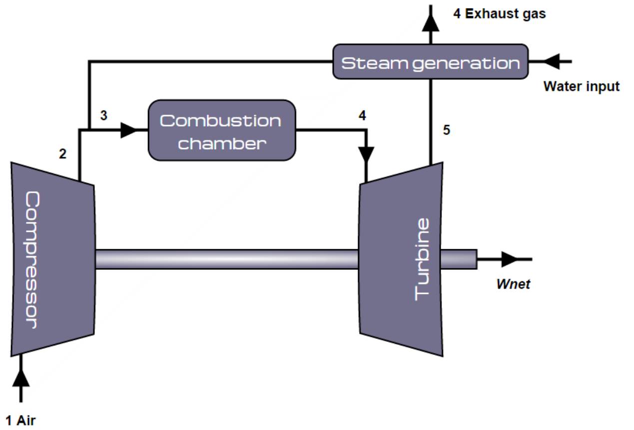

Figure 1. Schematic overview of STIG setup

ANALYZING GAS TURBINE PERFOMANCE WITH STEAM INJECTION

By comparing simple gas turbine and STIG cycle performance on practical bases, injecting steam increases the turbine power when ambient condition exceeds ISO (International system of standardization) condition. Point to be noted that here the pressure required for injecting steam is obtained from a pump.In creation of steam the part where it is super heated prior to injection ,the two important boundries are needed tobe considered, the temperature of steam in saturated vapour form and the turbine outlet temperature because this is the gas used for heating. Also during the process it should be noted that the net power output has been kept constant by injecting water independent with the variation of ambient temperature. [2].Similar observations have been considerd for the thermal efficiency deviation. This is due the additional vapor mass injected which in result stabilizes the net power output and thermal efficiency (figures 2, 3).

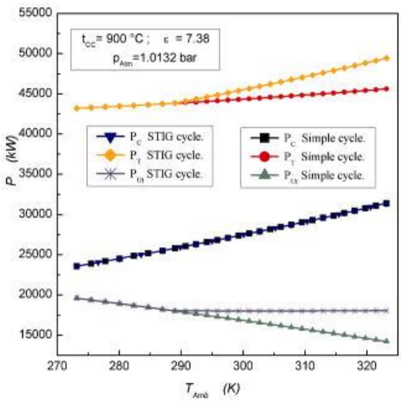

Figure 2. Power with and without steam injection

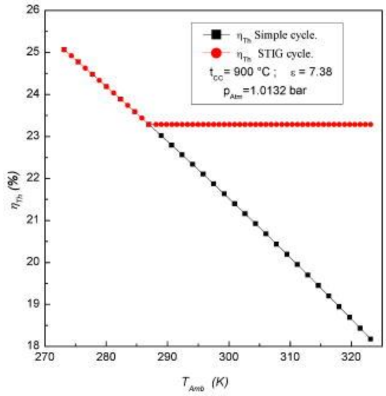

Figure 3. Efficiency without and with steam injection

The tests performed on a single shaft gas turbine engine (GE MS5002).Examples shown in figure 2 and 3 shows the comparison between simple gas turbine plant performance and STIG cycle performance. From figure 2 it can be noticed that injecting steam increases the turbine power, when ambient conditions exceeds the ISO condition. [2].

STIG operates at the highest efficiency. While plotting STIG the SF (steam factor) requires to be taken into consideration, three important regions can be distinguished (figure 4). Region I, where the SF is so low the steam can be brought up to a maximum temperature, region II, where the steam can be heated to a certain temperature, but lower than maximum, and region III, which consists of SFs which cannot be generated by using the turbine outlet gases [1].

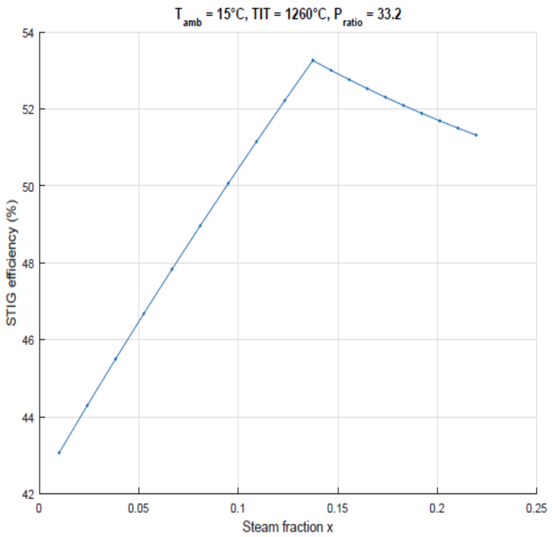

Figure 4. STIG efficiency for certain amount of injected steam x

If one would look at the efficiency as shown in figure 1.4, where region I and II meet the most efficient point can be found. Here lays the SF which utilizes the most transfer heat while still reaching the maximum temperature, hence having the highest enthalpy. On both sides the efficiency drops rapidly. The reason for lower SFs being twofold: lowering the steam mass-flow goes at the expense of the gained work reduction in the compressor. Additionally the turbine outlet temperature decreases, likewise does the enthalpy of the injected steam which is accompanied by an increase of fuel flow. The reason for higher SFs being that despite the efficiency increase because of more steam, the lower temperature/enthalpy of the injected steam decreases the efficiency at a faster rate [1].

Major precautions are to be taken while conducting the procedure, specifically in creation of steam the water used has to be of high quality. This makes the process a bit complex but helps in prevention of corrosion on internal parts like turbine blades at higher temperature. This is especially important for aero-derivative engines, which need higher quality water compared to ”heavy-duty” machines. In order to prevent excessive high-quality water consumption, the injected steam can be condensed and recovered from the exhaust gas in order to recycle it for steam generation.

Where steam injection plays an important role in complete fuel combustion on the other hand GTP’s have undesirable combustion products like NOx and CO formed due to high primary zone temperatures in the combustion chamber.Steam has a higher heat capacity than air and therefore functions as a heat sink when injected, which reduces the overall primary temperature. In order to prevent local high temperature spots which could still produce these undesirable emissions the steam should be injecting far up-stream of the CC in order to allow for proper mixing. Although the steam injection will increase the total exergy loss, the exergy loss per MW output is much smaller than that of simple cycle. It also reveals that the degree energy wasting thermal pollution can be reduced after retrofitting.[3]

CONCLUSION

Overall we can conclude and give the perspective about STIG cycle that plays an important role in improving the GTP performances. For this purpose detailed researches have been made to improvise the real cycle of GTP with and without Steam injection. Similarly to overcome different challenges under hard climatic conditions. Most probably the objective of present study is to improve the performances of GTP used under Sahara conditions where injecting suitable quantities of steam in the upstream of combustion chamber. The suggested method has been studied and compared with a simple cycle. Efficiency, however, is held constant when the ambient temperature increases from ISO conditions to 50°C.

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Modern Aircraft Passengers Seats

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***Abstract*—The article is devoted to the modern view on the passenger seats of aircraft, the development prospects according to the trends, the influence of design on safety and on the solution of the issue of technology development.**

Keywords – Aircraft; Passenger Cabin; Passenger Seat Design; Head Injury Criterion; Comfort.

INTRODUCTION

The design of modern passenger seats must meet safety requirements, be comfortable, understandable for use, light in weight, not too expensive and possible for production. To satisfy all demands to the cabin seating systems, a team of design experts has to understand all given requirements and deliver the ideal customized solution for the best passenger seat design. Designers group has to provide advanced construction implementation, to use lightweight materials, to provide clear and functional seat usage for good experienced and comfortable flight.

Over time, the interior design of the passenger cabin becomes more practical, convenient and safe. The main safety requirements to the passenger cabin are survivability at fire, as well as the quick and safe evacuation, safe evacuation during ditching, safe evacuation during emergency landing. According to these, the design of passenger seat directly affects on survivability of occupants. Survivability in a fire is ensured by the use of modern refractory materials, the presence of fire extinguishers, smoke detectors, and fire extinguishing systems. An important aspect of survival is the correct arrangement of passenger seats that will not impede evacuation and conform to all necessary standards.

Also, the designers have to think about strength requirements to the passenger seats to provide the certification or so called crash tests. The supporting frames and seats attachment joints are the weak points of the system, and they don’t have to reduce the total strength of the system and for other hand they have to give the possibility to change seat pitch for the necessary cabin layout. The certification tests include the static and dynamic tests of a new type of seat, and crash tests with anthropomorphic test device for the measurement of Head Injury Criterion (HIC).

The passenger seat is designed and calculated in such a way as to protect the passenger from head injuries. Federal Aviation Administration [1] regulates standards that provide the necessary design conditions to protect passengers from a head injury. In the first half of the 20th century, a passenger seat could withstand overload in 6g. Over time, in the second half of the 20th century this number increased to 9g. Cabin seating systems are designed to withstand all operational loads. The maximum of these loads are applied to the joints of seat attachments, and to the attachments of the safety belts. During the certification/crash tests the all loads to the system are multiplied by the 9g force acceleration. And the main task of the tests is the measurement of crash impact to the head and impact to the articulations of anthropomorphic test device. Head injury criterion (HIC) must be analyzed and measured by the next formula [2]:

$$HIC = (t_2 - t_1)\left\{\frac{1}{t_2 - t_1}\int_{t_1}^{t} a(t)dt\right\}^{2,5} \leq 1000,$$

where the head impact is described by *a(t)*: a(t) – resultant acceleration of the head center of gravity in g’s; t_1 – initial integration time, expressed in seconds; t_2 – final integration time, expressed in seconds. Unfortunately, the increases of loads are associated with disasters and there is no possibility to model all loads during the tests.

To provide maximum comfort during flight the design of the seat has to provide efficient means of operation by replacing manual seat control leavers and buttons with a touch screen control panel. To improve passenger flight experience, electrical assist and full power configurations are available to use. Features of the given seat series can include: electric assist track and swivel and floor tracking release. Optional features can include full electric recline, leg rest and lumbar.

In conclusion, it should be noted that the design and development of passenger seats of the aircraft is very responsible and difficult task even for a team of experienced specialists. Compliance with standards and safety requirements, providing comfort and accessibility for passengers as well as following modern trends in the passenger seats deign are necessary elements of the modern passenger seats design process.

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Static Characteristics Of Pressure Regulating Valve From Hydrodynamic Point Of View

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***Abstract*— this work is dedicated to investigation and consideration of static characteristics of pressure regulating valve from hydrodynamic point of view. This work has proposed better variant of formula of resulting superficial force in valves in particular in the relief valves.**

***Keywords*— relief valve, flow rate, pressure, superficial force, valve shutter, spring stiffness, tension.**

I. Introduction

In hydraulic systems are used different valves. Safety valve is a valve of episodic action that limits fluid pressure increasing over the preset (10 - 20%).

Safety valves serve to automatically limit the pressure in the system "in front of you". The main elements of the safety valve are a shutter, a body with a seat and a spring. The principle of operation of the safety valve is based on balancing the force of the fluid pressure on the spring. When the force of the fluid pressure overcomes the force of the spring tightening, the valve opens, limiting the increase in pressure “before itself” by relieving the flow of liquid into the reserve tank.

II. Ease of Use

Nowadays is known standard formula for calculation of spring pretension force. But the minus of this formula consists in taking into account just hydrostatic forces without influencing of hydrodynamic forces. After experimental determining we will get a formula which includes all forces in the hydraulic relief valve.

III. Main Part

There are two modes of operation of the pressure-regulating valve. The first mode is when the valve is closed. In this mode, equation of forces acting on the valve shutter is:

$$R_{\text{spr}} - F\Delta p - R_{\text{seat}} = 0,$$

where $\Delta p = p_{\text{pump}} - p_{\text{discharge}}$; R_{seat} is the seat reaction; F is the valve shutter working area.

For the second mode:

$$R_{\text{spr}} - \int_F \Delta p \, dF = 0 . \text{ (a)}$$

Taking into account the friction force:

$$R_{\text{spr}} - \int_F \Delta p \, dF \pm R_{\text{fr}} = 0 . \text{ (b)}$$

In equation (a), (b) the integral can be expressed as follows:

$$\int_F p_{\text{pump}} dF = p_{\text{pump}} F - \int_{F_1}^{F_2} p_{\text{pump}} dF ,$$

where $\int_F pdF = R_{\text{hd}}$ is a hydrodynamic force.

Then for the second mode of valve operation, the expression will look like:

$$R_{\text{spr}} - \Delta pF + R_{\text{hd}} \pm R_{\text{fr}} = 0; \; R_{\text{spr}} = C(l_0 + h),$$

where l_0 is preliminary spring tension; C is spring stiffness.

Formula for the hydrodynamic force has the form:

$$R_{hd} = \rho Q(u_1 - u_2 \cos\frac{\alpha}{2}),$$

where u_1 is the fluid speed in the enter channel; u_2 is the fluid speed in throttling orifice.

Because the speed $u_2 >> u_1$, than the following expression for the hydrodynamic force may be :

$$R_{hd} = \rho Q u_2 \cos\frac{\alpha}{2} = \rho\mu\pi dh \sin\frac{\alpha}{2}\sqrt{\frac{2}{\rho}\Delta p}\varphi\sqrt{\frac{2}{\rho}\Delta p}\cos\frac{\alpha}{2} =$$

$$= \mu\varphi\pi dh\Delta p \sin\alpha .$$

Due to the bulky appearance of the expression, let us take the notation $A = \mu\varphi\pi d \sin\alpha$.

Then

$$R_{\text{hd}} = A\Delta ph,$$

where $h = f(\Delta p)$.

The equation of forces without considering the friction force will be:

$$C(l_0 + h) - \Delta pF + A\Delta ph = 0 .$$

Conclusion

The valve characteristic p = f (Q) has been obtained on the basis of Euler's theorem about changing quantity of the flow written for the control loop.

The characteristic of the safety valve can be profiled by means of using of low rigidity springs and compensation of hydrodynamic forces.

The valve shutter is profiled to unload shutter from the effort of hydrodynamic forces with an additional cone deflecting the streamline in the opposite direction.

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Modernization Of The Gas Turbine Engine By Application Of Advanced Working Cycle With Isothermal Expansion In Turbine Section

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***Abstract* — this work is dedicated to research of alternative ways to increase efficiency of gas turbine engine by the improvement of thermodynamic cycle (using the isothermal expansion in turbine section). Also, in this article possible problems of advanced gas turbine engines redesigning are indicated.**

***Keywords* — gas turbine engine, Bryton`s cycle, turbine, isothermal expansion, efficiency, compression ratio, fuel consumption.**

I. INTRODUCTION

Nowadays due to wide exploitation of gas turbine engines (GTE) in modern aviation numerous configurations of GTE are created (for example turbofan engine) with the aim to increase efficiency (and consequently decrease fuel consumination) by increasing of compression ratio.

II. PROBLEM PLACEMENT

All of gas turbine engine types have the same operational principle based on Bryton`s cycle : alternation of isoenthropic compression in the compressor section, isobaric temperature increase and isothermal expansion of the working body in combustion chamber with isobaric temperature decrease in turbine section. Considering the fact that in spite of possibility of increasing of compression ratio in wide range the temperature rise is naturally limited by air-fuel mixture combustion temperature. To avoid this limitation it is theoretically possible to use fuel with higher adiabatical combustion temperature or to create ameliorated working cycle from the thermodynamic point of view. Application of different fuel type is unprofitable in view of investigation complexity, changes in fuel storage technology, row of economical factors like costliness of fuel production etc. That is why it is worth to discover the issue of application of principally new thermodynamic cycles as the base of gas turbine engine`s operation. In this article will be considered the problem of improvement of gas turbine engine by use of isothermal expansion in turbine section.

III. MAIN PART

In comparison with GTE with traditional cycle the gas turbine engine with isothermal expansion in turbine section will have higher efficiency (despite lower thermal efficiency at higher velocities of flow) at the same operational conditions [1]. As result the fuel consumination will probably be reduced. Furthermore it will be profitable to use more wide range of compression ratio with aim to increase efficiency even more. Advanced gas turbine engine will correctly operate at the supersonic speeds. That is why the further analysis of the new cycle has sense.

In spite of these facts the application of isothermal expansion in gas turbine working cycle has several disadvantages. The isothermal expansion in turbine section involve direct fuel combustion in interblade channel. Consequently the problem of advancing of turbine blades heat resistivity occurs. Moreover it is necessary to redevelop principal design of gas turbine engine in consideration of peculiarities of the real working cycle and to alter numerous changes in the gas turbine engine control system. Also, it is obligatory to specify the cross-sectional dimensions of modernized engine to ensure its influence on the form drag and construction weight.

All above mentioned possible changes development and test need the high amount scientific research and economical investments.

CONCLUSIONS

In this article main aspects of gas turbine engine modernization by using isothermal expansion in turbine was figured out. On the initial stage of investigation it is important to prove expediency of applying isothermal expansion in the turbine section especially in real gas turbine engine working cycle.

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Rotary-piston Wankel engine (part I)

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***Annotation* – the work is devoted to the consideration of modern piston engines, directly to Wankel engines. The original construction of the Wankel engine, the principle of operation and its work is proposed in the work. Also, the cycle of this engine is considered in the paper, and its comparison with the Otto cycle, which also corresponds to the four-stroke process.**

Keywords* – *Wankel engine, rotor, Wankel cycle, four-stroke cycle of the engine, shaft, epithrooidal body, rotor-piston engine, injection, suction, exhaust, compression.

I. introduction

Wankel engine – an internal combustion engine running on gasoline, which uses a triangular rotor or a rotating part to obtain mechanical energy. In traditional internal combustion engines, instead of the rotor, pistons are used (solid cylinders move inside a tight-fitting body). Wankel engine has a weight, vibrates much less than reciprocating engines, has several moving parts and can operate relatively quietly and smoothly on different types of fuel. The engine is named after the German engineer Felix Wankel for his contribution to the development of the engine in the 1950s.

II. Main part

Wankel engine produces a rotational motion, directly driving the main propeller shaft, instead of feeding the pistons, which are indirectly driven by the main propeller shaft. The rotor of the Wankel engine is enclosed in an oval body. Although all three points of the triangular rotor remain in close contact with the shell wall, the space remains between the sides of the rotor and the wall of the housing. When the rotor rotates, gasoline is drawn into the housing through the inlet and is caught between one side of the rotor and the wall of the housing. It contracts when the rotor continues to rotate. The captured gas is then transferred through the spark plug and ignited, releasing the energy that moves the rotor. The rotor moves the exhaust gas and air into the discharge channel, quickly unloading it from the housing. Each of the three sides of the Wankel engine rotor constantly controls the shaft. When the rotor moves one third of the distance around its center, the main drive shaft rotates one complete revolution.

In addition to cars, Wankel's engine has been successfully used in trucks, boats, electric generators, golf carts, lawn mowers, snowmobiles and motorcycles. The aviation industry also showed interest in the engine, because it is small and more easily serviced than piston engines. However, the usage of the Wankel engine was limited by the relatively high fuel consumption and exhaust emissions of the engine.After many years of research, Wankel found a solution for a new type of engine. Unlike the simple piston engine, when the piston performs linear motion, the Wankel engine uses a so-called piston rotating in the combustion chamber.

In 1954, an engine with a rotating piston was built. The first "Wankelmotor" type DKM 54 was launched in 1958.Traditional piston Wankel engines have many parts that quickly accelerate and slow down. The applied acceleration forces must not exceed a certain value and, therefore, set the engine speed limit (rpm). The new idea was to replace the linear reciprocating motion with rotational motions. This concept is implemented in the so-called rotary piston engine DKM (Drehkolbenmotor). This design has the following advantages over piston engines: improved silent running, compact design, no valve drive mechanism, smoother flow of energy, lower weight. The rotating piston performs a double movement: it rotates around its center, and the center rotates around the center of the body. Three vertices of the rotating piston move along the wall of the body. A later design of the KKM type (Kreiskolbenmotor) is a kinematic change of the DKM type. In a KKM type engine, a convex triangular rotor rotates inside a static epitrochoidal body. Inlets and outlets are provided in the housing wall. In the cells between the rotor and the wall, a four-stroke cycle (inlet - compression - expansion - exhaust) is performed. The size of the camera depends on the motion of the rotor.

The Japanese manufacturer of cars Toyo Kogyo Mazda was the unique company which was engaged in development of the engine.

In 1982, Wankel developed a new rotary piston engine, using a new two-stroke cycle.

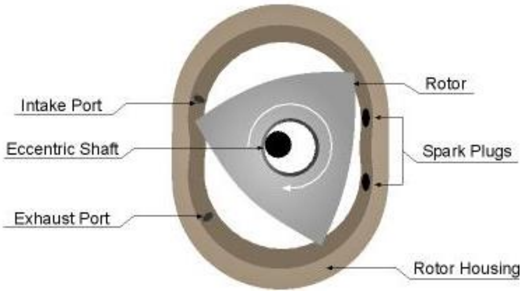

Fig.1 Construction of Wankel engine

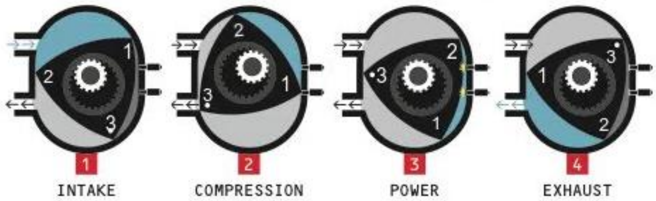

Fig.2 Wankel engine in detail

III. conclusion

In this article the Rotary-piston Wankel engine is proposed. The engine is commonly referred to as a rotary engine, although this name also applies to other completely different designs, primarily aircraft engines with their cylinders arranged in a circular fashion around the crankshaft. All parts rotate consistently in one direction, as opposed to the common reciprocating piston engine, which has pistons violently changing direction. The four-stage cycle of intake, compression, ignition, and exhaust occur each revolution at each of the three rotor tips moving inside the oval-like epitrochoid-shaped housing, enabling the three power pulses per rotor revolution. The rotor is similar in shape to a Reuleaux triangle with sides that are somewhat flatter.

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THE INFLUANCE OF CARRIEERS REQUIREMENTS ON THE SIZE OF BAGGAGE

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***Abstract* – This article is about preferences that are given for carry-on bags sizes in the most popular low-cost airlines from Africa, Asia, Europe, the Middle East, North and South America, Oceania from one side and recommendations of Federal Aviation Administration and International Air Transport Association from other side.**

Keywords – aircraft, baggage, low-cost airlines, overhead bin

I. INTRODUCTION

Overhead bean for passenger luggage is one of the significant part of the aircraft passenger cabin, which can define the satisfaction of passenger with the flight. Also, there are safety requirements and necessity to foresee mutual arrangement of overhead bean with another aircraft items, so sufficient attention should be devote to its designing.

Many factors influence on the overhead bean design and size. One of them is defined by its function – store the hand baggage of passenger, so the size of bean should be enough to do this. From the other hand, too large overhead bean will decrease the cabin space, which will lead to discomfort of passenger. The next factor that has an effect on the overhead bin size is possibility of items to fall out of overhead stowage bins and the risk of passenger's injury [1]. Due to this, the stowage bin door should not be used to compress or stabilize the baggage when closing because there is a higher risk that articles may become dislodged when the stowage bin door is opened.

According to the airworthiness requirements [2] the areas above the overhead bins must be designed to prevent objects (weapons, explosives, or other objects) from being hidden from view in a simple search from the aisle.

Also size and shape of the overhead bins must be taken in account for estimation of influence on airflows in an aircraft cabin [3].

As result, the main task for designers is to provide airworthiness requirements, reduce the number of baggage-retention-related injuries, and satisfy operators' requests for maximum stowage bin volumes and passenger comfort [4].

II. ANALYSIS OF RESEARCHES AND PUBLICATIONS

Nowadays we could see passenger traffic increases in segment of low-cost airlines. In general, low-cost operators have a fleet of single aircraft with a single economy class cabin. To provide high cost efficiency low-cost airlines apply the stringent requirements for carry-on baggage. Usually, this recommendations are coincidence with Federal Aviation Administration (FAA) recommendations for passengers the maximum size carry-on bag that is 45 linear inches. In 2015 the International Air Transport Association (IATA), proposed a new "Cabin OK" initiative to optimize the accommodation of carry-on bags [5, 6]. The optimum size for bags from IATA point of view is 55×35×20 cm (or 21.5×13.5×7.5 inches). This regulation of carry-on bags will theoretically allow everyone to store their carry-on bags on board aircraft of 120 seats or larger. Recently Boeing offers new Space Bins for the 737 that could hold more bags [7]. As example, the number of bags on overhead bins in B737-800 could be increased from 118 up to 178.

III. PROBLEM STATEMENT

To carry on an analysis of possible factors which influence on baggage size there were chosen 100 popular low-cost airlines in the world from the list [10]:

- 10 airlines in Africa;
- 35 airlines in Asia;
- 27 airlines in Europe;
- 8 in the Middle East;
- 13 in North America;
- 2 in Oceania;
- 5 in South America.

It is possible to say that most preferable types of aircraft for low-cost operators are narrow body 150-200 passenger seats airplanes of Airbus A320 and Boeing B737 families. The one of the important parameter for operator is the length L of passengers' bags. The preferences of operators are shown in fig.1.

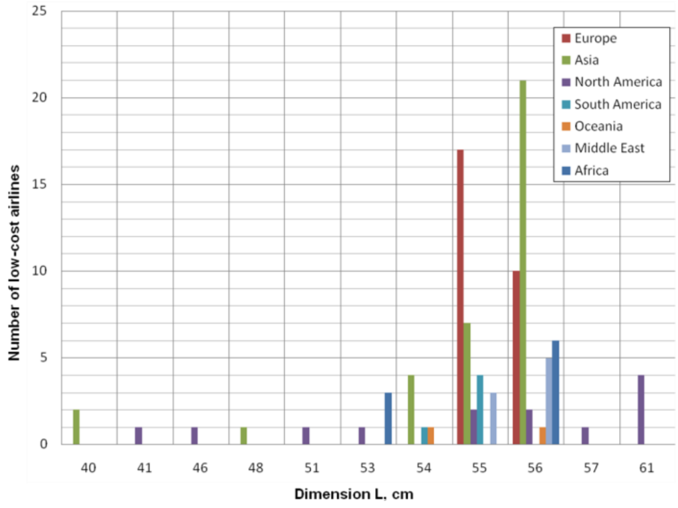

Fig. 1. Number of low-cost airlines vs. preferable length of carry-on bags

It’s clear that most popular in low-cost airlines length for luggage are 55 cm (more preferable in Europe) and 56 cm (in Asia). Also it is necessary to notice that there is no preference for luggage length in North America. Four airlines choose length of 61 cm. From the point of view of world statistic 36% of operators prefer length of bag equal to 55 cm and 45% prefer 56 cm.

Next do comparison with volume of luggage L×W×D (cm3). Analyzing the data on fig.2 we could recognize that Asian's operators prefer 46368 cm3 instead of European's operators use 44000 cm3, and 56000 cm3 volumes.

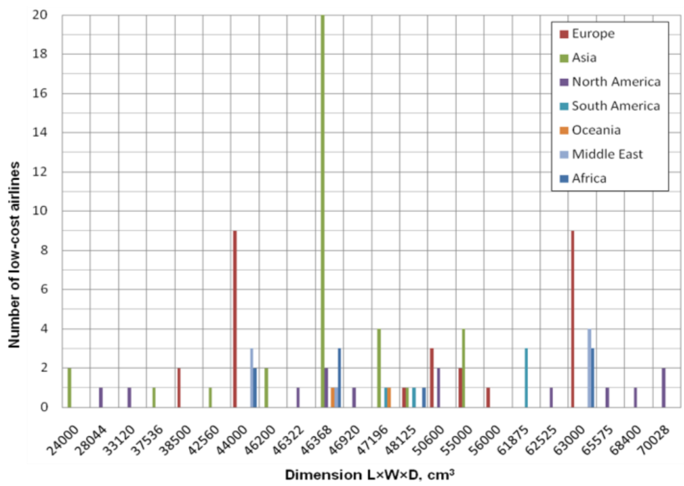

Fig. 2. Number of low-cost airlines vs. preferable volume of carry-on bags

Africa and the Middle East prefer to use bags with 44000 cm3, 46380 cm3 and 56000 cm3.

In the world it will be next distribution for recommended by operators' volume of the bags: 14% for 44000 cm3, 27% for 46380 cm3 and 16% for 56000 cm3.

IV. CONCLUSIONS

There were discussed recommendations of FAA and IATA for carry-on bag size. These recommendations have “regulatory approach” and are aimed on necessary level of onboard baggage load for already existing overhead bins dimensions providing.

Analysis of low-cost carriers’ preferences for bags' length, total length and volume shown some semblance and distinction in requirement for carry-on bags size. Operators from some regions have typical recommendation for bags size. Due to that these carriers provide a standard requirement for luggage. This standards awareness will be useful for aircraft and aircraft equipment designers. Such “adaptive approach” for overhead bins could give flexibility for passenger cabin layout designing

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Substantiation Of The Aircraft Overhead And Floor Cargo Systems Components

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***Abstract* – Criteria for the selection of the aircraft cargo systems components are considered. It is shown that the cargo medium range airplane requires usage of telpher as a overhead cargo equipment and winch as a floor cargo equipment. It is shown, that the cargo systems must be integrated into the primary structure.**

Keywords – cargo aircraft; overhead loading equipment; floor loadinf equipment.

I. Introduction

Purpose of this work is substantiation of the aircraft overhead and floor cargo system components on the base of airworthiness requirements and Pros and Cons comparison [1]. This list is based on experience of design and operation of cargo airplanes, with taking into account requirements for loading and unloading systems, requirements for integration of equipment with elements of aircraft primary structure.

As a typical object for analysis and synthesis of the recommended list of equipment, the airplane with 10 tons payload has been considered. This airplane, as many of modern cargo planes, represents high-wing monoplane with cargo ramp in aft part of the fuselage. As the plane refers to the cargo category, the possibility to use it for civil and military purposes must be taken into account as well.

II. Criteria for selection of the aircraft overhead and floor cargo systems

Selection of the aircraft cargo overhead and floor cargo equipment first of all is based on the analysis of similar planes, being in operation. Among the most close analogues the Ukrainian transport An-26 [2] and well-known Il-76 are choosen. The first plane features winch with possibility to increase capacity by application of block and tackles. The second one has a set of telfers. Both machines are demanded in the processes of loading, thus combining these machines the opportunities to load wheeled and unwheeled object becomes realistic.

At the same time, while selecting cargo equipment, the structural aspects require analysis. It is important because the loads from the cargo transmits to the cables, from the cables to cargo machine, and finally, from the cargo equipment to the primary structure. The loads usually are exerted to the frames of the cabin and then are distributed throw the aircraft structural components. Thus the structural components require special reinforced design.

One more aspect is adequate selection of the loading machines parameters, for example the weight of the motor depends on the winch or telpher required power, thus the excessive power leads to the undesirable increase of the system weight.

Demand of using of both type of equipment may be substantiation by next reasons: a) give possibility load most types of cargo faster than winch, b) improve possibility to load monolithic cargo with not standard geometrical dimension. But winch is more effective in case of loading wheeled objects. All this measures give possibility increase economic efficiency of airplane by way of decreasing time for loading of cargo. Additionally it may decrease required sizes of equipment by effective spread of cargo between telpher and winch.

Disadvantages of this scheme is: a) increasing of equipment which required of maintenance, b) increasing of total price of airplane.

III. Conclusions

It can be stated that selection of the cargo overhead and floor equipment requires multi problems analysis. This analysis comprises: a) analysis of the current successful cargo planes design and experience of operations; b) needs of civil and military transportations; c) functional analysis; d) stress-strain analysis and proof of strength for primary aircraft structure.

Acknowledgment

The author thanks lectures of the Aircraft Design Department for the advices, recommendations and valuable information.

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Method for the investigation of the rolling texture influence on metal fatigue.

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Abstract – The paper deals with the development of the experimental method for the study the effect of rolling direction on fatigue properties of D16AT alloy. The results of the study, carried out according to the discussed below method can be used for the improvement of the aircraft skin repair procedure when the structure is damaged by corrosion, fatigue cracks, dents, and even shooting. Thus, expected results are valuable for civil and military aviation.

Keywords – Aircraft; damage; patch; anisotropy; deformation relief.

I. Introduction

As a result of different external factors the aircraft structure deteriorates as a whole or partly, in most trouble zones. Some defects, for instance corrosion and fatigue are accumulated gradually with time, while some of them, like damage by shooting are not predictable in certain moment. One of the commonly used practice intended to keep bearing capacity of the damaged component is an installation of patches. This method is widely used for repair of aircraft skin. Two factors need to be analyzed for correct performing of the repair: 1 – stress-strain state of the component in the trouble zone; 2 – data concerning anisotropy of the repair patch. The first task can be solved by conventional nowadays Finite Elements method. To solve second task the method being under the development and presented in this paper will be recommended.

II. Rolling anisotropy and its influence on metal fatigue requires exploring

Rolling anisotropy is the property of metal being directionally dependent, which implies different mechanical properties in different directions. The quantitative relations of fatigue strength and rolling direction require special attention because components of aircraft made of rolled materials need high level of durability. The problem is exacerbated by the multiaxial mode of mechanical loading.

Aircraft repair practice includes procedure of recovering by installation of patches on the spot with different kinds of damage. The skin patch component participates in the reaction on applied operational loads and transition of the loads throw the structure. The stress-strain state of the aircraft skin is complex. This complexity is resulted from the action of wide spectrum of loads of different nature: bending of the fuselage, twist of the structure, pressurization. At the same time the complexity exacerbates by the anisotropy of skin metal sheets and anisotropy of patches.

Thus, the correct installation of the patches on damaged aircraft skin requires knowledge regarding the influence of rolling anisotropy on metal fatigue under the different mode of loading.

It proposed to use computer aided method for the metal surface inspection and quantitative assessment of the fatigue damage by the parameters of surface deformation relief.

As a material for test the widely used aluminum alloy D16AT has been selected. The specimens were cut from the 1.0 mm thickness sheet along the rolling direction, at 45^o to rolling direction and at 90^o to rolling direction.

The cyclical loading is carried out by special test machine for bending of compact specimens.

The level of stresses chosen to be close to the operational stresses in aircraft fuselage skin, namely 120.0 MPa.

The computer aided method for surface relief monitoring and correspondent fatigue damage assessment is described in details in works [1-3].

III. Preliminary test results

As the experimental part of the work has been just began the preliminary results are limited by the data related to the fatigue life of specimens cut along the rolling direction, perpendicular to rolling direction, and with angle 45^o to the rolling direction. The first results reveal the strong relation between the rolling direction and number of cycles to failure.

Thus, the specimen cut along the rolling has failed after the 540 000 cycles of loading, the specimen cut perpendicular to the rolling direction has failed after the 320 000 cycles of loading, and specimen cut with 45^o angle to rolling has failed after 380 cycles.

These preliminary results confirm the value of further investigation with more detailed analysis. The surface relief expected to be excellent tool for the exploring the process of fatigue damage for different rolling conditions.

IV. Conclusions

It is shown by preliminary tests of D16AT specimens under the cyclical loading the rolling texture influences fatigue damage of this alloy sheets. Further experiments should include monitoring of surface deformation relief to inspect details of the fatigue process at the stage of fatigue crack nucleation.

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For Development of Simulation Program of Passengers Enplaning on Narrowbody Aircraft

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***Abstract* – This article deals with the problems of simulation program development for passengers boarding narrow body (single aisle fuselage) aircraft. There were described different parameters that could effect on the rate of passengers enplaning and aircraft time on the ground.**

***Keywords* – aircraft; behaviour; boarding; enplaning; passengers; turnaround time.**

I. Introduction

The International Air Transport Association (IATA) expects doubling of passengers to travel in 2035 by comparison
with 2016 and number of air travelers will be near of the 3.8 billion [1]. Some existing airports will be redesigned and ground operation of others should be adopted to such significant increasing of travelers. As result, the turnaround time for airplanes will be reduced.

The full turnaround time includes:
- disembarkation and boarding of passengers,
- replacement of the crew,
- servicing the galleys,
- cabin servicing,
- unloading and loading compartments,
- refuelling the airplane,
- servicing toilets,
- servicing potable water.

A short turnaround is usually reduced to passengers and compartment replacement. Sometimes it also involves refuelling with the assistance of a fire brigade and servicing of the cabin.

The theoretical duration of a full turnaround for a B737-900 is 45 minutes, while in case of a short turnaround, it is only 23 minutes [2]. According to Rayanair requirements a turnaround should be not more than 30 minutes.

Therefore prediction of turnaround time could help to organize maintenance procedures and reduce air company's costs.

II. Problem statement

Nowadays there are a lot of simulation programs for passenger aircraft evacuation in emergency situation. Some of them have option that allows to carry out aircraft enplaning. This is high cost certified products that can afford to pay only aircraft design organization with high budgets.

There were analyzed open access references that allows us to develop basic algorithm for simulation program for boarding passengers [2-6].

III. Main part

Estimation of minimum size of grid cell that will be covered by passenger during simulation is the key problem for any model. It is possible to see that mean size for grid that is filled up by passenger is equal in more cases to 400×400 mm [3].

On Fig.1 the grid cell model for a narrow body airplane is shown. Grey cells are main aisle route and magenta cells are simplified routs to seats.

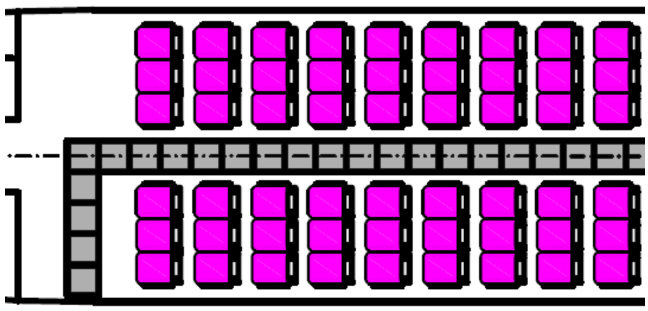

Fig.1. Simplified passenger cabin model

"Passenger" sliding from cell to cell in main aisle is performed by the program time delay that is formed by movement rate - 1,0...1,5 m/sec [2].

This difference could be explained by the passenger's age and some other limitations in movement that will be explained below.

According to CS-25 requirements [7] a representative passenger load of persons in normal health must be used as follows gender/age groups:

1) At least 40% of the passenger load must be females.

2) At least 35% of the passenger load must be over 50 years of age.

3) At least 15% of the passenger load must be female and over 50 years of age.

This is typical representative passenger load for evacuation test that should be carried out in 90 seconds through half of all existed doors.

But change in this representative load has an influence on the time. As example the evacuation from Boeing 737 Flight LS117 took an estimated 3 minutes and 38 seconds (approximately in 2,5 times slowly than required). The analyses shows that there were 42% passengers over 60 years.

Then, analyses of evacuations through Type-III exits [8] give us information about rate of movement through passageway between rows of seats. In our cases it will be movement by magnet color cells with purpose of seat occupation. For 40 years and older passengers movement rate is twice slower than for 20-40 years passengers group.

So, the age of passengers is one of the most important parameter that should be taken into account as factor that affects rate of boarding because it vary in 1.5...2 times.

This information could be monitor by the operator during pre-flight check-in of the passengers.

The next factor is height of passengers. There were carried out test in Tupolev Tu-154 airplane that shows that the tall passenger could put his typical carry-on 55×35×20 cm luggage on 20-30 % faster than a small one.

Unfortunately operators haven't such data. This problem could be solved by using the statistical data of person's height from region to region in the World [9]. Or, as long term project this data could be collected by different operators with the agreement of passengers during registration or ticket booking.

Some other significant factor that must be taken in account is weather that cause wear by passenger additional clothes. Taking of the jacket or coat will take up to 5 seconds, while taking of the jacket of sweater will take up to 10 seconds. Than passenger need time to place this things in compartment. The high occupancy of an aircraft limits the possibility for finding a place for storing their outerwear during the flight.

Next, some operators could use instead of random passengers boarding back-to-front, block by block or other sequences [2].

Summarization of main factors are represented on fig.2.

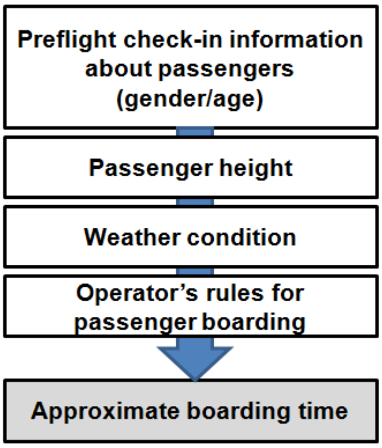

Fig. 2. Key factors for boarding time estimation

Acknowledgment

There were analyzed different factors, that determine boarding time. The more predictable parameters are gender and age data that could be obtained during boarding. Also the weather condition and type of carry-on luggage should be taken into account.

Such data inputting in simulation programs allows to predict the airplane turnaround time. This time is one of the important from point of view of operator's efficiency factor.

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Rotary-piston engine of Wankel (part II)

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***Annotation* – the work is devoted to the consideration of modern piston engines, directly to Wankel engines. The original construction of the Wankel engine, the principle of operation and its work is proposed in the work. Also, the cycle of this engine is considered in the paper, and its comparison with the Otto cycle, which also corresponds to the four-stroke process.**

Keywords - Wankel engine, rotor, Wankel cycle, four-stroke cycle of the engine, shaft, epithrooidal body, rotor-piston engine, injection, suction, exhaust, compression.

I. introduction

\Wankel engine is an advanced internal combustion engine which was developed by Felix Wankel. in 1956

Wankel's engine is very different from common engines. It preserves the regular cycle of suction, compression, power and exhaust, but instead it uses a triangular rotor that rotates around the eccentric. The crankshaft-is the only driving part. It`s important to note that The Wankel engine has fewer parts. The three apexes, or tips, of this rotor remain in constant, snug contact with the combustion-chamber walls. The only other moving part is the crankshaft.

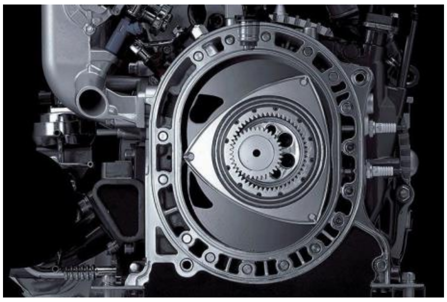

Fig.1 The Wankel engine

II. Main part

It`s vital to note that the engines are able to operate at extremely high speeds during long periods of time.

Moreover, the engine shows a high power-to-weight ratio and an unusually good torque curve at all engine speeds.

Theory, design and principles of work:

Internal combustion engine: a mixture of fuel air ignites, and the explosion directly drives the engine.

• Four-phase cycle motor: consumption, compression, power, exhaust.

• Three main moving parts in most RC motors: 2 rotors and an eccentric shaft. They rotate continuously in one direction. They do not come off back and forth.

• They are surrounded by a peripheral body, where the tip of the rotor makes an epitrochoid curve.

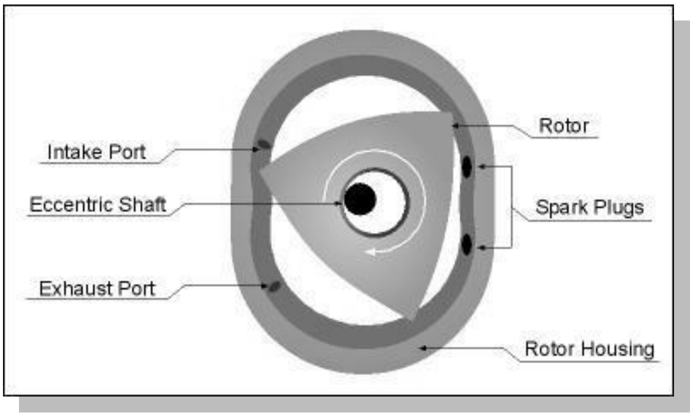

Fig.2 The main construction of the engine

The Wankel engine uses a four-stroke cycle, thus this engine operates on the Otto cycle:

stroke A: The fuel-air mixture enters the engine chamber through the intake port

stroke B: The rotor rotates and compresses the mixture, the mixture is ignited by an electric spark

stroke C: Combustion products pressurize the surface of the rotor, transferring forces to the cylindrical eccentric

stroke D: The rotating rotor displaces the exhaust gases into the exhaust port.

The famous Mazda engineers solved the main problems of these engines

1)exhaust

2)toxicity

3) inefficiency.

A. There are two types of RCE

- **KKM** *Kreiskolbenmotor* or planetary rotation motor (PLM), distinguished by one stationary peripheral housing. The rotor moves in an orbit and propels an eccentric shaft. This is easier to manufacture, cool, and maintain than DKM. Intake and exhaust passages are better. Better cooling is achievable. It is more compact. **Modern rotaries are KKM types.**

- **DKM** *Drehkolben Maschine* or single-rotation engine (SIM), the first RCE, has the distinctive feature of an inner rotating housing and rotor moving in circular motion around a fixed central shaft. This requires disassembling the motor to change spark plugs (three), perhaps the main reason it was discarded. However, DKM is the smoothest of the two, and high rates beyond 25,000 rpm are possible. Bearing loads are lighter.

In the car world, Mazda has had a great success with two-rotor, three-rotor, and four-rotor cars. Private racers have also had success with stock and Mazda Wankel-engine cars.

In principle, Wankel engines must be perfect and suitable for light aircraft, being light, compact in shape, less vibrationless, and with a high power-to-weight ratio.

Due to the compact size and the high power to weight ratio of a Wankel engine, it has been proposed for electric vehicles as range extenders to supplies supplementary power when electric battery levels are low. Small Wankel engines are being found increasingly in other applications, such as go-karts, personal water craft, and auxiliary power units for aircraft.

III. conclusion

In conclusion it`s necessary to emphasize that the Wankel rotary engine is a very interesting and well-known.

There is a great history of an engine and also some very interesting facts about it. Wankel engine has many advantages as well as many disadvantages. These engines surely have their place in this world.

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