

VERTICAL TAKE -OFF AND LANDING ON THE BASIS OF LINEAR GAS TURBINE ENGINE

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Keywords: gas turbine engine, slot amplifier of thrust, flat stream of exhaust, brush seals from nanocarbon tube.

Abstract. The possibility used of the last achievements of fundamental science for creation of the engine for vertical take-off and landing flying platform (FP) are discussed. FP intended for transportation goods and passengers in speed range of 0 - 700 km/hour. It is offered to equip with engine creating flat stream of exhaust. At take-off, landing and patrol FP used the vertical direction nozzle working on the slot-hole ejector amplifier of thrust, on the cruiser mode - the pulling propeller variable pitch airplane type. The design of the engine allows redistributed power between a nozzle and the propeller.

ВЕРТИКАЛЬНЫЙ ВЗЛЕТ И ПОСАДКА НА ОСНОВЕ ЛИНЕЙНОГО ГАЗОТУРБИННОГО ДВИГАТЕЛЯ

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Ключевые слова: газотурбинный двигатель, щелевой усилитель тяги, плоская струя выхлопа, щеточное уплотнение из углеродных нанотрубок.

Аннотация. Рассмотрена возможность использования последних достижений фундаментальной науки для создания летающей платформы (ЛП), предназначенной для перевозки грузов и пассажиров в диапазоне скоростей 0 -700 км/ час. ЛП предлагается оснастить двигателем, создающим плоскую струю выхлопа. На взлете, посадке и патрулировании ЛП используется вертикально направленное сопло, работающее на щелевой эжекторный усилитель тяги (ЭУТ), на крейсерском режиме - тянущий тяжелонагруженный винт самолетного типа. Конструкция двигателя позволяет перераспределять мощность между соплом и винтом в зависимости от режима полета.

Introduction

There is a modern design trend to move away from the traditional reactive scheme to vertical take-off and landing (VTOL) scheme with rotor power unit. From the many schemes proved the Bell Helicopter are known to be the most promising scheme, which was developed for over 50 years. The scheme does not have any special lifting engines, That involves the rotation of axes of main rotor, which is located on the ends of the wing. During take-off and landing an axis is arranged vertically, and at the transitional mode that is rotate forward slow. In the case of cruise flight they is arranged horizontally, as for normal plane with two propeller (Fig. 1).

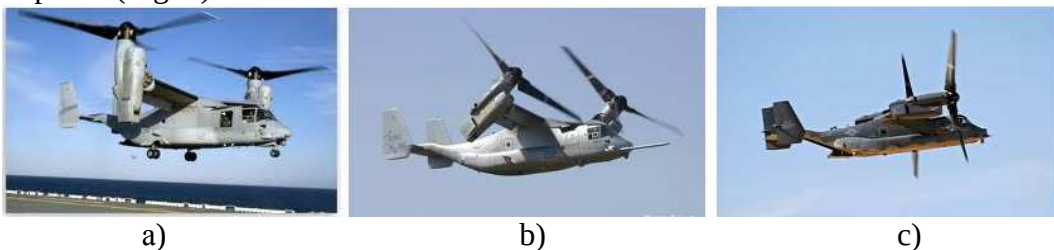


Fig. 1. Osprey V22 mode: a) take-off, b) – transition, c) cruiser

The characteristic feature of twin rotor transversal chart is a presence of dangerous sources of low frequency vibrations. That caused by the main rotors disposition on elasticity of flexure foundation.

There is impossible to select modes by means any theoretical and experimental investigations. In practice the modes that is improbable or in general is impossible may be existed. For example, flight along the edge of ravine lead to the different conditions under right and left rotor and sharp heel in the conditions of a limited height and time.

Another general lack of VTOL with main rotors is compromise parameters of propellers.

The condition of obtaining high efficiency main rotor is a small pitch, large diameter and small twist. In the case of propeller, vice versa, the conditions is big pitch, small diameter and large twist. Take-off with overload, including running, is limited to the possible angle of rotors slope.

There were attempts to make a rotor with changeable geometry by means of the deformed shell and changeable length of blade. It sharply reduces his durability and safety of flight [1]. Reduction of diameter of rotor allows to get high cruiser speed, and to carry full-loud take-off from a concrete surfaced airfield. However, under the vertical take-off with the large diameter of rotors, the losses have a large value on blowing of wing.

The exploitation of Osprey are know to be showed, that are highly sought, but expensive and unreliable. This lacks of similar chart are due the using of single type propulsive device for the substantially different modes of flight. In this case, nozzle creates insignificant part (~10%) of thrust and plays an auxiliary role. It is structurally simpler to use a nozzle for creation of vertical traction, and horizontal thrust creating by fixed variable pitch propeller.

2. GTE for generation flat stream of exhaust

The task is not simple to reach the nozzle efficiency as the level of main rotor, and will demand creation of the special engine [2]. At increasing of thrust of GTE the ordinary practice consists in the selection of the corresponding ejector amplifier. In the examined case vice versa - GTE, chart different from existing, offered for work on the well-known construction of slot linear ejector amplifier (coefficient of amplifier K_a 1,8 -2). First similar sequence is offers in article [3].

The key moment of similar chart is a receipt of flat stream of exhaust gas in engine. An engine must have a compressor, creating the flat stream of the compressed air, flat combustion chamber and flat nozzle, that is the engine must be executed in linear geometry.

The linear compressor will be make as a twin-rotor Ruts vacuum pump.

The pump can work in the mode of supercharger at changing entrance – exit. The main lack of similar noncontact pumps is subzero degree of pressure increase. The cause is reverse flow through gaps between rotors. As a rule, for these pumps the increase of pressure degree is arrived by means successive connection of a stages, and increase their number.

In [4] the design of a single-stage double-rotor supercharger is considered. The supercharger has an original trilobal shape the rotors, The axes of symmetry of the cross sections of each rotor are rotated relative to each other and around the axis of rotation of each rotor. The angles rotation of different rotors lying in the one plane are equal magnitude and opposite in sign. An air is transferred from suction area to the discharge region. The rotors 2,3 (Figure 2) rotation in step of relative to their axes in opposite directions. The shape of helical trilobal rotor provides increased overlap of phases of suck up, carried and injection. That improves the uniformity of flow and reduction of sound vibration load. In absence of seals, at presence of noticeable difference of pressure between an entrance and exit, there is a high level of circulation of energy. That lead to considerable warming-up of pump. Rotors dilation more than corps, that can bring to the friction a rotor - corps, rotor- rotor and to jamming of rotors.

A problem can be decided by preservation of axial clearance at used of brush seals from nanocarbon tube (Figure 3). They allow work at peripheral velocity up to 500 m/s, pressure differential up to 2 MPa and temperatures to 1000 C. Nanotubes have a phenomenally subzero coefficient of friction. If to suppose that force of normal pressure is 0.01 module, which for multi-layered tubes is equal ~ 25 GPa, then coefficient of friction $\sim 10^{-5}$. It on two orders less than for the best pairs of macroscopic solids [5]. The seals made from the vertical oriented tubes. For it production any method of stimulated diffusion can be used. The material of catalyst (on the basis of nickel alloy) executes of functions of holder tubes.

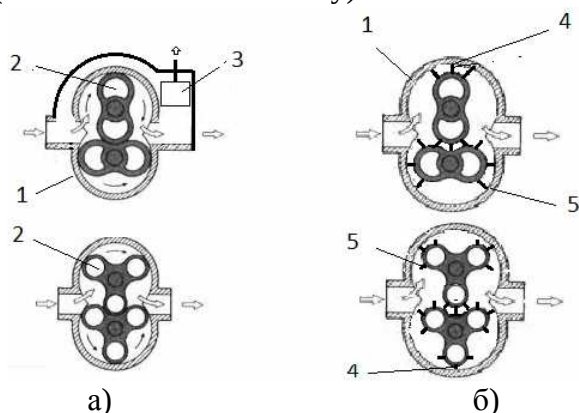


Fig. 2. Chart of a double-rotor vacuum pump of Ruts type: a) ordinary б) with elastic radial seals: 1- corps of pump; 2- rotor; 3- relief valve, 4- seal of rotor- rotor, 5- seal of rotor – corps

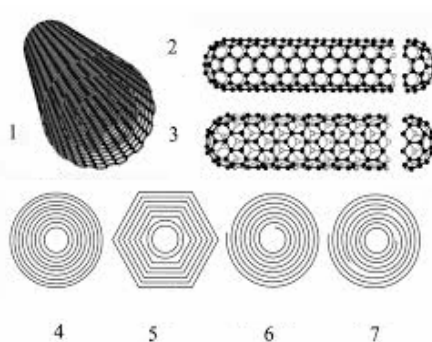
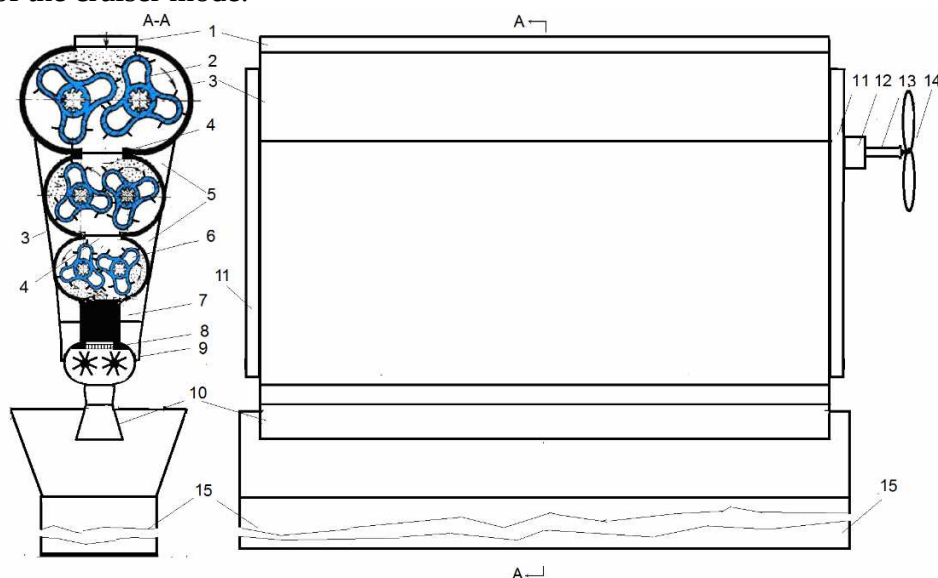


Fig. 3. Graphic image of multi-layered nanotubes; 1 - with an open end, 2,3 - with the closed end; 4-7 cross runner

On figure 4 the chart of turbo engine for generation a flat stream exhaust is presented. The engine has a rectangular air intake 1. Case 3 structurally unites all mechanisms of GTE. The number of the stages of compressor is determined by setting of engine and can be from 3 and more.

Every subsequent stage has a lesser cross-section because of air compression. Transmission 11, as gear transmission, united together with a reducing gear box 12.

It located on the edges of corps of engine. Combustion chamber 7 has a longitude flat form, and gas turbine of half-open type 9 has two shaft. They are located along the longitudinal axis of engine, symmetrically in relation to a combustion chamber. An engine has an output device made as a reactive nozzle 10. Propeller of changeable pitch 14 creates horizontal thrust from a zero at VTOL to the basic value of the cruiser mode.



1-air intake, 2,6- rotors, 3-case, 4 - shoulder-blades, 5- cavities for cooling of compressor, 7 - combustions chamber 8-directing shoulder-blades, 9 - gas turbine, 10 - nozzle, 11 - transmission, 12 reducing box gear, 13- shaft of power takeoff, 14 -propeller of changeable pitch, 15 – amplifier of thrust

Fig. 4. Chart of GTE with the flat stream of exhaust

The material of gas turbine blades can be made by the method of nonpiston low temperature extrusion [6]. Other most details of engine can be made by method of ordinary extrusion also.

The specific features of engine are the following:

- 1) work on the slot amplifier of thrust without hydrodynamic losses;
- 2) choice of optimal speed of rotation of rotors for every stage of compressor;
- 3) possibility cooling of compressive air and pin zone of brush seals;
- 4) enhanceable operating manufacturability and cheapness of production.

3. Use of GTE for the flying platform executed on a nozzle chart

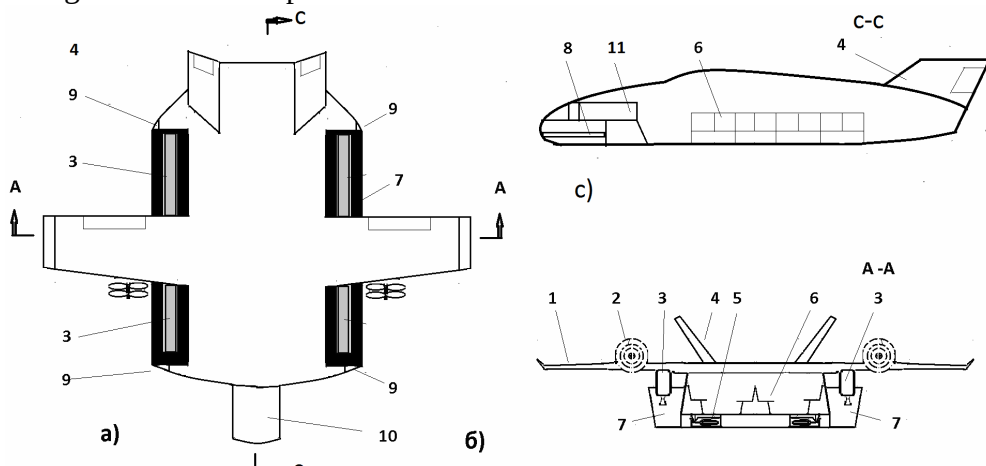
The attempts to replace a main rotor by a nozzle for flying platform were made in 60th in the USSR and France [7].

The power unit of flying platform consisted of four lifting GTE RB - 162 with the circular ducted amplifier of thrust (15,6 кN each). Similar platforms are simpler than helicopter in a production and exploitation, but does not possess sufficient fuel and economic efficiency. FP have considerable limitations on durability of flight pad soils and did not get further development.

The way of removing of the marked defects is obvious. This uniformly distribution of exhaust of GTE along the hull of platform, maximal reduce of his speed by means mixing with atmospheric air and increasing of fuel efficiency.

The engine allows distribute of combustion products in mixing chamber of amplifier 15 (fig.4) uniformly on all length. The presence of transmission, reducing box gear and output shaft allows to pass a twisting moment on a propeller 14 variable pitch for creation of horizontal thrust. GTE must be have surplus of power, that will provide gas-dynamic control traffic of platform on a height, course, heel and pitch [8].

On figure 5 the chart of FP is presented. It can be made in different variants, from FP of the ship basing to FP fire-prevention, intended for evacuation of people from pitch building. In last case it is necessary to have on some floors of building a receiving cone for a clamp barbell.



1 - short wing; 2 - propeller of changeable pitch; 3 - engine; 4 – tailplane;
5 -shassis; 6 –passenger cabin; 7 – slot linear amplifier of thrust; 8 – coupling rod in retract position; 9- nozzles of gas-dynamic control ; 10 – protective guard of conveyer of loading

Fig. 5. Chart of FP for evacuation of people from emergency objects: a) top view; b) cross section; c) longitudinal section

The construction of FP supposes three modes of motion :

- a) mode of take off, landing and patrolling, when vertical thrust of engines exceeds weight of platform;
- b) mode of aerodynamic maintenance due lift force on a wing
- c) the economical mode of screen flight, when under a bottom surplus pressure is created due to the reflection of exhaust from a screen.

The considered construction of flying platform is simple, technological and can be used as a transport vehicle substituting helicopters of middle and large carrying capacity. The slot longitude ejector provides sufficient fuel efficiency of power unit. The location of engines and device propulsion at two side of FP hull allow it direct docking with a pitch object through a sluice in nasal part, which may entered directly in a window aperture.

4. Achievement of high speeds for horizontal flight

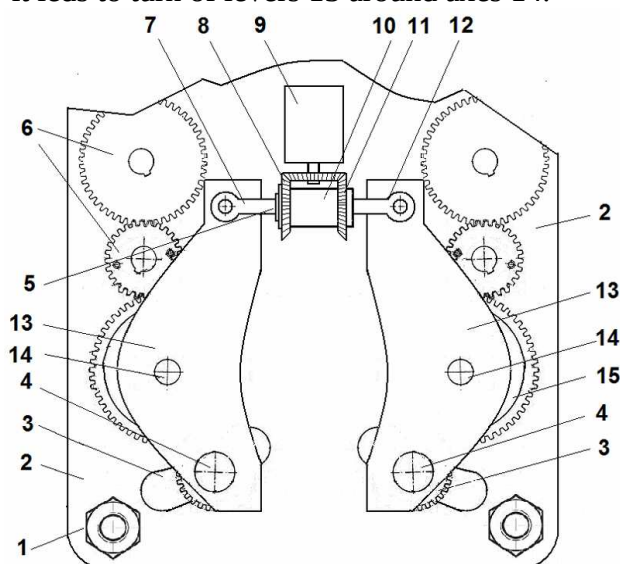
For the increase of efficiency of FP the motion are needed to be faster. That can caused by the bleed-off of the large value of energy on propeller.

In this case the reduction of vertical thrust can be compensated by an aerodynamic lift force arising on wing and hull. On take-off mode the power release on nozzle are needed to be enough for lifting. On transient mode the increasing of the power release are needed to be on propeller at conservation the power release on nozzle. That it can be reached by means off the change of propellers pitch.

In a difference from V – 22 aircraft this mode comes more reliably due to the fixed position of engines and propulsion device. After achieving of speed sufficient for aerodynamic maintenance of FP the decline of power release are needed to be on nozzle in use for propeller.

Fig. 4 shows chart of GTE that allows to redistribute the power between a nozzle and propeller depending on the mode of flight, i.e. to convert turbojet engine in turbo propeller. For the engine conversion the shafts of gas turbine 9 are needed to move its in step. At the conversation the large part of power is released on propeller at drawing together, and at moving away the power is released on nozzle. In any cases the part of engine power is released for the gas-dynamic control traffic of FP. This regulation must works in all modes.

On figure 6 it is presented one of possible mechanisms of the synchronous motion of both shafts of gas turbine. The mechanism is fixed on the cover of case 2. Motor-gear box 9 has kinematics connection with both right and left shafts of turbine. Twisting moment, created motor-gear box, through a gear 11 passed on a running around nut 10. Free rotate gear 8 is intended for prevention of the side loading on the shaft of motor 9. Rotation of nut 10 and motion of worms 7, 12 into it leads to turn of levers 13 around axes 14.



- 1 - fasteners of face cover of case,
- 2 - cover of case,
- 3 - directing slot,
- 4 - shaft of gas turbine,
- 5 - the radially-thrust bearing,
- 6 - gear of transmissions,
- 7 - left worm, 8 - free rotate gear,
- 9 - motor reducing gear, 10 - nut,
- 11 - gear of drive displacement shaft gas turbine,
- 12 - right worm, 13 - lever of displacement of shaft,
- 14 - axis turn lever,
- 15 - intermediate gear

Fig. 6. Mechanism of the synchronous moving of shaft gas turbine

Both shafts of turbine are displaced in slot of case 4. The hard kinematics connection of shaft with the transmission is saved. Slot 3 from the side of combustion chamber is closed by a movable shutter (on Figure 6 that is not shown).

The mechanism of displacement must be executed with the sufficient reserve of safety. Arising up on it the combined strengths will be about a few hundred kN.

The construction of air intake must have changeable geometry also. In this article that case is not examined. For creation of sufficient aerodynamic lift force at speed more than 150 km/h the hill of FP must have a corresponding form and wing of the small lengthening.

5. Conclusion

Development of VTOL aviation transport is possible only on the basis of the last achievements of fundamental science. The seals between two environments and moving details were always one of key moments of development of technique.

1. The creation of brush seals from carbon nanotubes is quite possible by means of modern nanotechnology. The seals may be used for the existing constructions of GTE also.

2. The method of non-piston low temperature extrusion [6] can be applied to the alloys on the basis of nickel. The method allows to simplify substantially one of the most difficult operation the production of shafts and radial blades of turbine of half-open type.

3. Further development of VTOL aviation transport is possible by means of preparation of fuel for detonation pulsating cycle [9,10]. It will be allow to obtain an additionally increase of the coefficient of strengthening of ejector amplifier and fuel efficiency of FP.

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