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PROJECT OF VERY LIGHT HELICOPTER "SHMEL"

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Abstract

An effectiveness of helicopters has been proved in many aviation operations. The helicopters are widely used for transport and observation operations, crane works, emergency service and plant spraying tasks. However, the rotorcraft of ultralight and very light class with takeoff mass less than 1 ton, are very seldom involved in performing professional operations. Usually very light helicopters are used for training and entertainment purposes. The main problem of using them for other kinds of works is the insufficient payload. The low weight effectiveness is typical for all helicopters of small dimension. Introducing the small helicopters with improved characteristics can significantly reduce the cost of some types of aerial works. The paper presents the development of the new light helicopter "Shmel" applying the coaxial rotors.
Keywords: coaxial rotors, very light helicopters, prototype.

Currently a significant quantity of little helicopters are produced in the world (Fig. 1) [3]. Considering the disadvantages of the existing helicopters, initiative group from Russia and Belarus started the development and manufacturing of a new little helicopter. It could be used successfully in a wide range of aerial works. The main advantage of the developed helicopter should be high load ratio. It was the main aim of designing the rotorcraft. As a result, it was decided to use a double rotor coaxial carrying system. Such system allows to receive big load capacity and some other advantages.

During design process it was determined that the optimal takeoff weight for many aviation works is 750 kg. In this settlement the dry weight of the helicopter should reach 325 kg, which will provide a load ratio of 50%. According to calculations the helicopter needs 120 hp of engine power for hover on sea level in standard conditions ISA. Developed modular mounting system of power plant allows to make replacement of the engine in an easy manner. System of engine mounts, pulley belt drive and engine supply systems change with the replacement of power plant. Consequently, several engines are considered as the power plant for the helicopter. One of them is a new light specialized aviation engine GR140 (Fig. 2). Maximum power of it is 140 hp. Using this engine allows to decrease weight of aircraft but now there is practically no statistics of its application. Therefore, it is not considered as the only option. In some helicopters, such as AK1-3, H-2S, CH-12 are used conversion engine Subaru EJ-25. Some measurements were performed on a specially assembled motor stand, which

showed that the same engine has acceptable performance. It will enable the helicopter not only to take off in hover conditions with a full load but also to reach the speed of 160 km/h (Fig. 3) [2, 4]. In addition, another embodiment of the conversion of the diesel engine Subaru EE-22 is being considered. The advantage of this engine is low fuel consumption.

Fig. 1. Several ultralight and very light helicopters which are manufactured in the world

Fig. 2. GR140 engine [Authors photo, 2015]

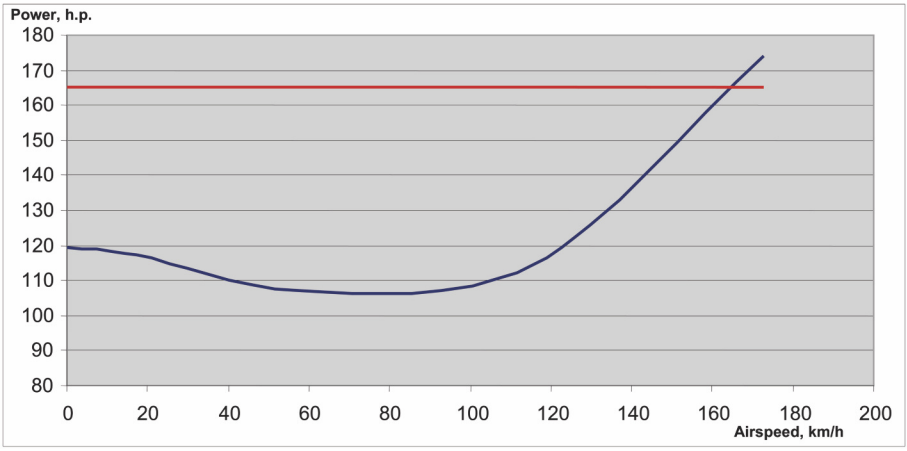

Fig. 3. Required and the available power of the helicopter with engine EJ-25 at H = 0 ISA [Authors picture, 2014]

Analysis of tip rotor speed showed that the optimal for Shmel helicopter is the speed of 160 m/s. Maximum thrust of the main rotors was obtained at this tip speed with supporting cone angle of 3 degrees at given mass parameters of the blade (Fig. 4). Polar curve at hovering (Fig. 5) shows a decrease in the efficiency of the bottom rotor. Absent of the tail rotor and heavy tail boom which use single-rotor helicopters allow to speak about greater efficiency coaxial helicopters. Small rotor tip speed complicates the flight mode at considerable speed, but allows you to get a large load capacity on the power (Fig. 6).

Safety of blades intersection was tested theoretically for horizontal flight. The analysis showed that the accepted distance between the rotors – 9% corresponds to the statistics of coaxial helicopters (Fig. 7).

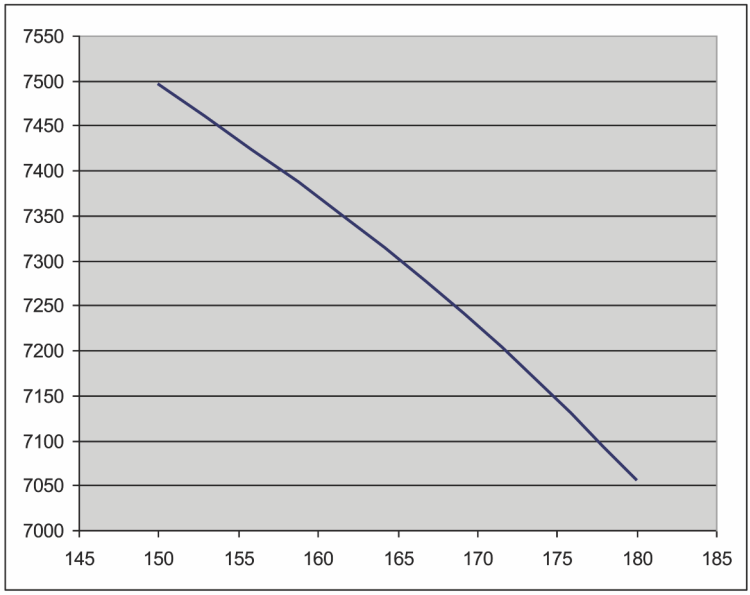

Fig. 4. Influence of rotor tip speed for rotor thrust [Authors pictures, 2014]

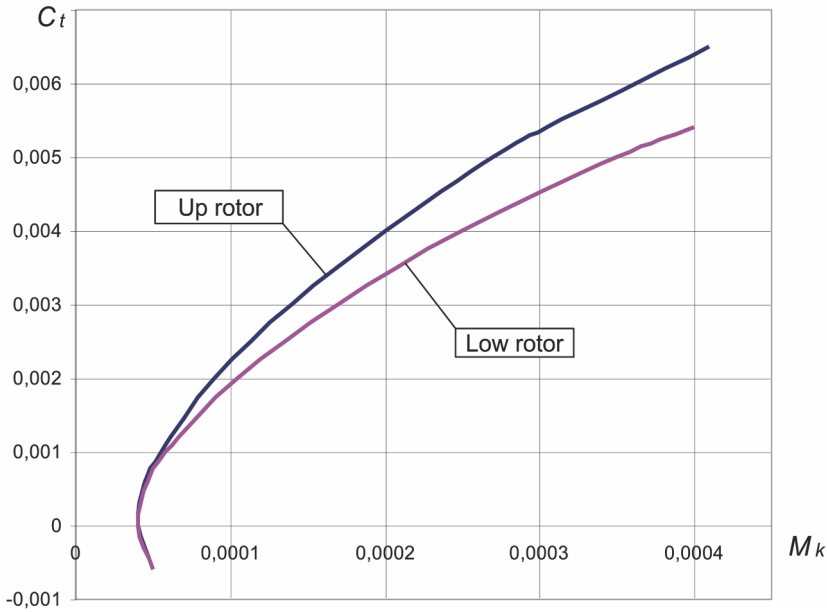

Fig. 5. Polar curve of rotors [Authors pictures, 2014]

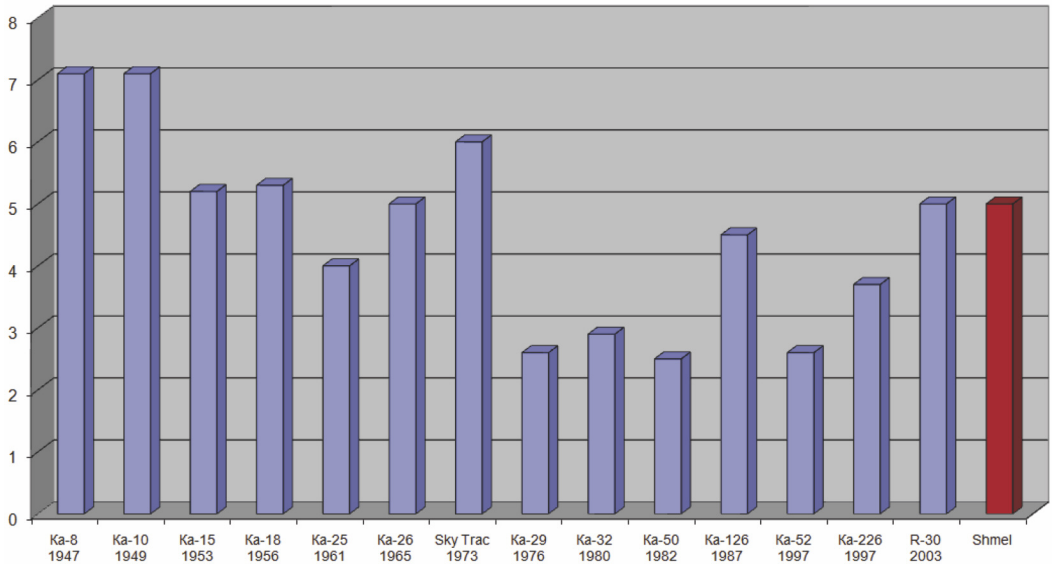

Fig. 6. Load capacity on power of coaxial helicopters [Authors picture, 2014]

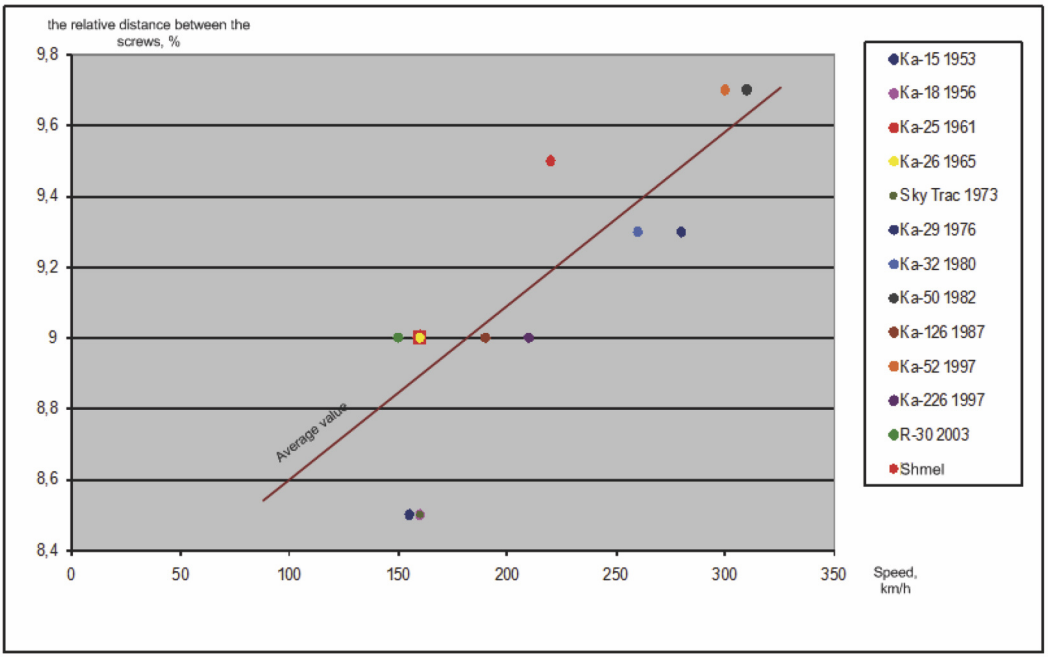

Fig. 7. The relative distance between the rotors of coaxial helicopters
[Authors picture, 2014]

Certain general parameters allow to determine the shape of the helicopter. Its general view is shown in Fig. 8. The basis of the fuselage consists of welded steel tubes. Two-bladed main rotors are connected to the hubs by teeter hinges. The blades with foil NACA 230 series are made of composite materials which provide acceptable strength characteristics. The control system includes four channels connected to the rotors. The specific realization of the directional control channel involves the upper rotor and connection with rotating part of fin. Rotor head has a classic scheme with axial torsion hinge (Fig. 9). The unusual modification of rotor comprises the centrifugal restrictor limiting the angle of blade dangling overhang. Fig. 10 shows the view of restrictor.

Fig. 8. General view of "Shmel" helicopter
[Authors pictures, 2014]

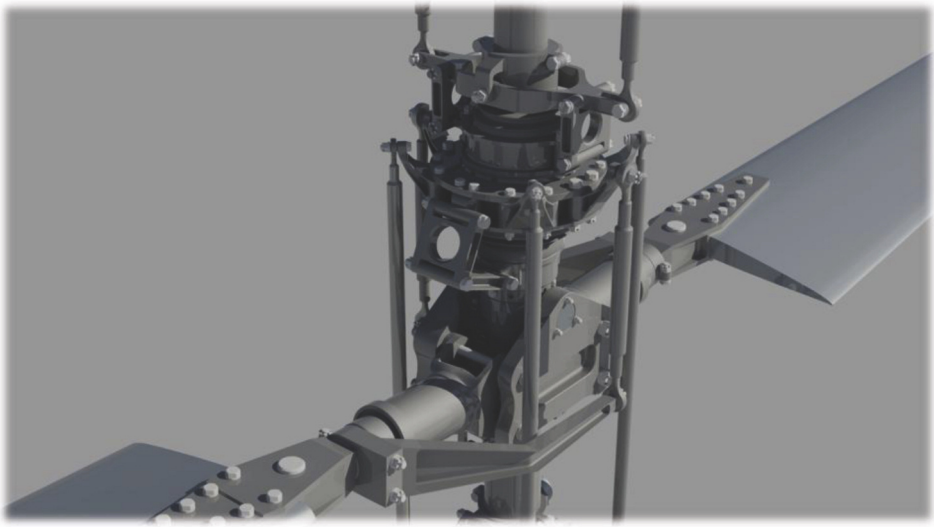

Fig. 9. Lower rotor hub [Authors picture, 2014]

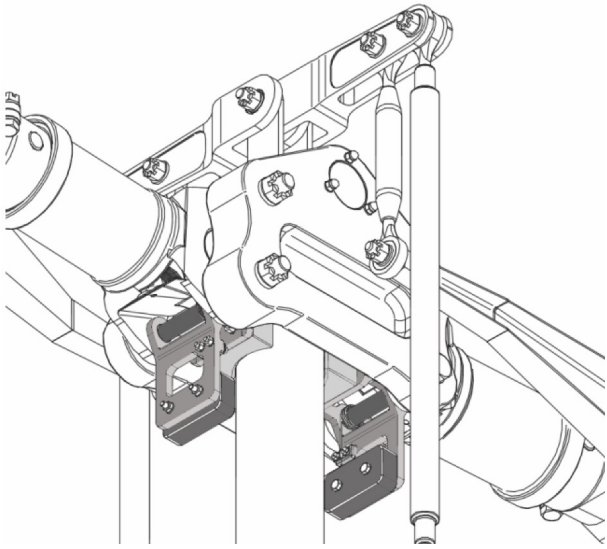

Fig. 10. View of centrifugal rotor restrictor and it calculated characteristic according with rotation speed of the rotor [Authors pictures, 2015]

Two-seats cabin with large area of glass is similar to helicopter cockpit AK1-3, but has smaller dimensions [1]. Its volume is sufficient for convenient pilot operation.

The cockpit arrangement with side by side pilots' seats minimizes influence of changes in mass of pilots for the location of the helicopter gravity center.

For the "Shmel" helicopter is being developed the special version of complex device of PDP series with LCD monitor which will aid pilot as the flight director including the engine control function.

Helicopter landing gear consists of elastic struts and large diameter skids. Technological wheels can be installed in front of the helicopter as well as in rear part for easy transportation on the airfield.

The tail unit consists of a fixed stabilizer and fins with rudders. The transverse angle of the fins equal 6 degrees provides enough directional moment even in the case when one of fins is shaded by cabin.

Currently the project is at the stage of manufacturing the helicopter prototype. Several produced elements are shown in Fig. 11. Fig. 11a – cockpit, 11b – instrument panel, 11c – transmission with engine, 11d – fuel tank.

a) b) c) d)

Fig. 11. Several produced elements of "Shmel" helicopter [Authors photos, 2015]

It is expected that successful realization of project will provide development the helicopter of high performance which enable to perform aerial works efficiently.

LITERATURE

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PROJEKT BARDZO LEKKIEGO ŚMIGŁOWCA „SZMIEL"

Streszczenie

Efektywność helikopterów została udowodniona w wielu operacjach lotniczych. Helikoptery są powszechnie używane w transporcie i operacjach obserwacyjnych, pracach dźwigowych, akcjach ratunkowych oraz oprysku roślin. Jakkolwiek, wiropłaty klasy ultralekkiej i bardzo lekkiej o masie startowej poniżej 1 tony są bardzo rzadko używane do wykonywania operacji profesjonalnych. Zwykle bardzo lekkie helikoptery SA używane do treningów i celów rekreacyjnych. Głównym problemem wykorzystania ich do prac innego rodzaju jest niewystarczający ciężar ładunkowy. Niska efektywność załadunkowa jest typowa dla wszystkich helikopterów o małych wymiarach. Wprowadzenie małych helikopterów z udoskonalonymi parametrami może znacznie obniżyć koszt niektórych prac wykonywanych w powietrzu. Artykuł ten prezentuje rozwój nowego typu lekkiego helikoptera „Szmiel" w układzie wirników współosiowych.
Słowa kluczowe: wirniki współosiowe, bardzo lekki śmigłowiec, prototyp.