Disk Wing of a Vertical Takeoff and Landing Aircraft as a Solution of Basic Problems of Aviation

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This paper discusses the research of the rotating disk wing proposed by the authors. Blades are extended from the wing during takeoff and landing [1, 2, 3] thus creating a convertiplane, an aircraft that combines features of both airplane and helicopter (Fig. 1). These vehicles exist separately, perform different tasks, and almost do not replace each other, although there is such a need when there are no concrete runways, and goods cannot be shipped by air directly to their destination, and instead in large airports the goods are moved from airplanes to helicopters with small payload, range, and speed. A limited range often requires refueling and makes it impossible to reach remote areas of Siberia, the Arctic, the Antarctica, and Oceania. For an airplane, refueling is an insurmountable obstacle, while for the VTOL aircraft landing without an airfield is a nominal operation.

Fig. 1. VTOL "Diskolet"

The increase in range and payload is especially important when it is necessary to deliver the assembled turbine, gas compressor station, or reactor to sites where there is no runway. As a rule, the weight of such deliveries is around 100-200 tons, and the helicopter maximum lift capacity is less than 30 tons.

In this situation, designers of spacecraft landing systems do not even dream of landing of heavy rocket stages or aerospace planes with blades. Our team won the Robert A. Heinlein Flight into the Future Project Contest with the module based on the wing disk for the landing of rocket stages up to 60 tons.

Helicopter operating limitation by relative airflow (wind) velocity is considered insurmountable during the propeller spin up and down when before stop or early in the rotation inertial forces of the blades are small and the blades are curved by gravity, i.e., they have a large "parking overhang". The effective bending stiffness of the blades drops, and large deflections and twisting result in their destruction by the relative flow. For shipboard helicopters, this flow is formed by the rate of sailing of the ship, wind speed, and rough water effect. The disk wing spins up before takeoff, when the blades are not yet extended, and during landing they already have high tensile inertia forces and therefore more effective flexural rigidity, which makes it possible to overcome any air flow during the extension of the blades.

This feature of the convertiplane with the disk wing, which does not depend on weather conditions, will allow for building vertical takeoff and landing (VTOL) aircraft carriers, while airplanes generally require fine weather conditions for flying.

Low aspect ratio disc wing with a lenticular or hexagonal profile can be a good supersonic wing.

The development of remotely piloted aircraft for military use, takeoff and landing of which in the field is impossible, is a very promising direction in modern aviation. In order to takeoff, special starters are used that should be transported in war zones, and there is almost no possibility of landing. In this area, as nowhere else, the VTOL aircraft is required.

One of the most important stages of the development of new aviation equipment is the mathematical modeling of its flight capabilities. In order to estimate it, the balancing problem should be solved. Until recently there have been no models of balancing of disc-shaped aircraft. Therefore, the question arose about the choice of the prototype. Since the disk-shaped aircraft is equipped with a rotor, like a helicopter, helicopter models for the solution of the problem of the calculation of the balance of forces and moments have been chosen.

Existing models of balancing the helicopter have been considered, but a common shortcoming of these studies is that they are focused on helicopters equipped with a hinged rotor. Such models have proven good for the helicopters, which are characterized by little variation in the coefficient of resistance of the fuselage with angle of attack, small size of the wing, and flapping hinge interval of less than 5%.

For the proposed aircraft, this method of balancing problem solution is unacceptable, since in this case both conditions are violated. Therefore, our attention has been drawn to a mathematical model of the spatial balance of hingeless rotor helicopter, developed in Kazan [4]. In this model, these constraints are not incorporated. In addition, it was tested in the design and flight trials of the Ansat helicopter, produced by the JSC Kazan Helicopter Plant. Taking the solution algorithm proposed in this paper as a basis the authors have developed a comprehensive mathematical model of spatial balancing of the disk shaped aircraft [5] based on several methods of flight, i.e., on the rotor wing together with the disk wing, on the disk wing, and on the disk with extended aerodynamic wing panels.

Balance calculations have been carried out for several variants of the setting angle of wing panels φ_w with respect to the disk plane (see table).

№	φ_w	Notation
1	0	●
2	2	□
3	5	◇
4	10	■

The symbol ○ indicates the results obtained for the disk without panels.

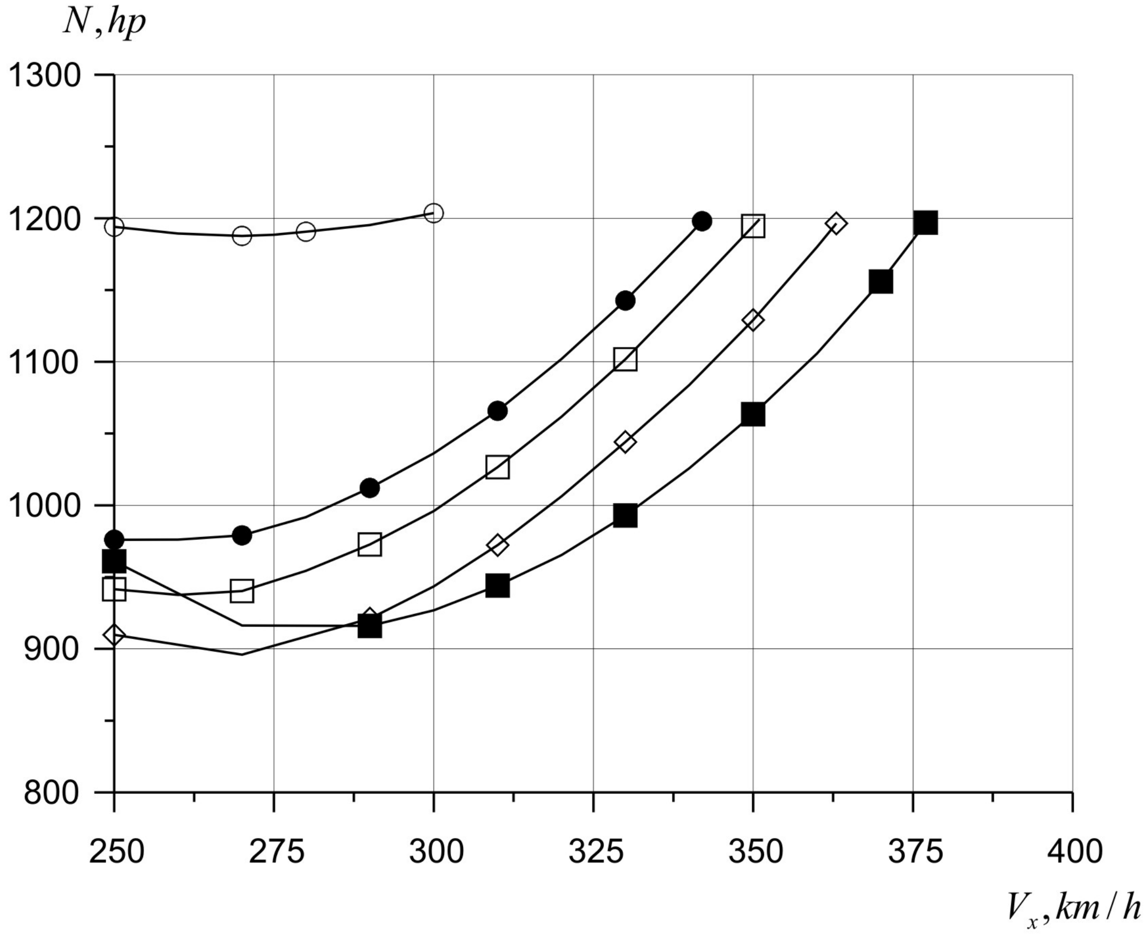

Fig. 2. Power requirements in relation to flight velocity.

The results of numerical studies of flight opportunities of the disk shaped aircraft have confirmed the expected performance characteristics, i.e., the top speed is 376 km/h, which is significantly higher than figures for helicopters with the power limit 1200 hp (Fig. 2).

REFERENCES

1. Pavlov, V.A. and Pavlov, V.V., RF Patent 2101215, 1998.
2. Pavlov, V.A. and Pavlov, V.V., RF Patent 2192986, 2002.
3. Pavlov, V.V., RF Patent 2385267, 2010.

4. Girfanov, A.M., Aeroelastic Calculation and Balancing of Single-Rotor Helicopter with a Hingeless Rotor, *Cand. Sci. (Eng.) Dissertation*, Kazan: Kazan State Technical University, 2000.
5. Girfanov, A.M. and Pavlov, V.V., Mathematical Model of Balancing of Vertical Takeoff and Landing Disk-Shaped Aircraft, *Izv. Vyssh. Uchebn. Zaved., Aviats. Tekh.,* 2010, no. 1.