AERODYNAMIC RESEARCH CONNECTED with BLADE SELECTION for KAMOV 115 HELICOPTER

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Summary

The investigations of coaxial rotor blade tip for the light Kamov 115 helicopter (Fig. 1) are considered in the report.

The results of aerodynamic tests of the blade tip model at different angles of attack and different wing tip angles with respect to the cord plane are given.

Tests have been carried in wind tunnels available at Moscow Aviation Institute:

- In the subsonic wind tunnel the blade tip aerodynamic characteristics at different angles of attack **(α)** have been defined, including the stalled flow over region in comparison with those for blade tips of other geometry. different deflection angles **(γ)** with respect to the chord plane (i.c. different blade tip anhedral angles **(γ)**).
- In the supersonic wind tunnel the blade tip characteristics of the model have been investigated in the transonic flow past region.

The quantitative values of the blade tip aerodynamic parameters and the surface streamlining pattern visualisation have been obtained. The analysis of the obtained results has been made.

- try area).

Fig. 1 Kamov 115 helicopter

The Problem Statement of Aerodynamic Investigations

The modern technology of aircraft composite structures production presents wide possibilities of the main rotor development, in particular the blade tip aerodynamic configuration and optimisation of its tips.

In the present work the directivity vector of the blade tips optimisation has been aimed at solving the problem of the main rotor better performance, namely:

- improvement of dynamic characteristics;
- reduction of parasitic resistance;
- increase of lifting ability;
- decrease of loads in the control system.

These characteristics are of priority for light single-engine helicopter, since they carry a considerable consumer component of the principle “Design in terms of prescribed cost”.

The Blade Section Model

The model is a blade section geometrically similar to the helicopter blade Ka 115 with a hyperbolic blade tip constituting **5.3%** of the blade radius.

The blade profile is asymmetric to the relative thickness $\mathbf{C_{л}=11\%}$. The hyperbolic blade tip had a sweepback χ of leading edge only, and the profile-modified with the transfer into a symmetric one with a relative thickness of $\mathbf{C_{3}=9.05\%}$.

The blade section was fixed on the boom installed on the strain-gauge balance, which were mounted in the wind tunnel by means of a special device (Fig. 2).

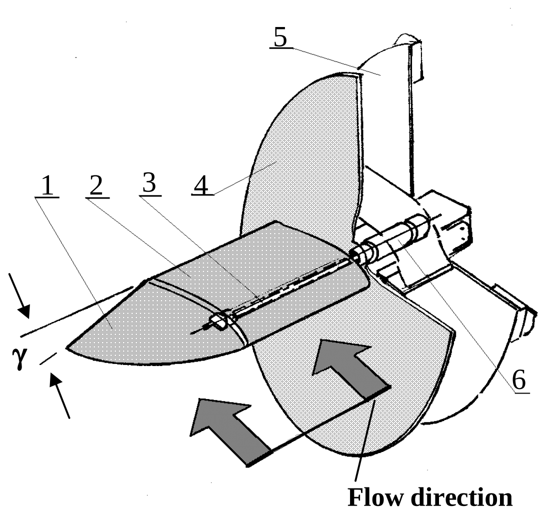

Fig. 2. Model installation in the wind tunnel

1. Hyperbolic blade tip
2. Blade section
3. Blade section boom
4. Shield
5. Model installation fixing in the wind tunnel
6. Strain-gauge balance

In order that the walls of the wind tunnel do not impact on the blade tip buttoned a shield was installed.

The model has been tested in the wind tunnels of Moscow Aviation Institute:

- The tested in the subsonic aerodynamic tunnel HK-1 (Fig. 3) were limited by the air flow maximum speed of **30 m/s** (the flow factor was $\mathbf{R_e=0.03\cdot10^6}$). In parallel with the aerodynamic loads and moments determination at different values of angles α and γ the streamlining visualisation of the model surface has been done by the oil spectral techniques.
- The tests in the supersonic wind tunnel T-2 (Fig. 4) have been carried in the range of Mach numbers **0.5...1.1**. The aerodynamic loads have been measured as a whole both in the whole section of the model and separately on the hyperbolic blade tip.
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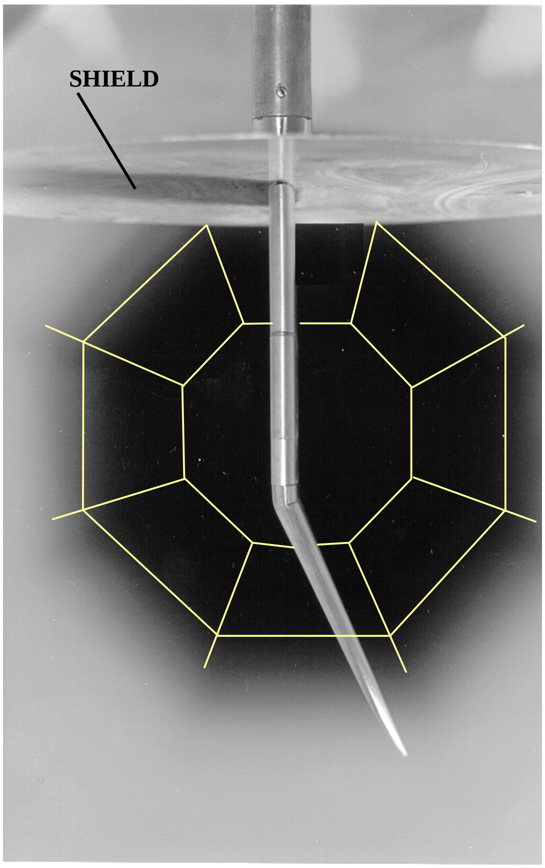

Fig. 3. Scavenging of the model in the subsonic wind tunnel HK-1

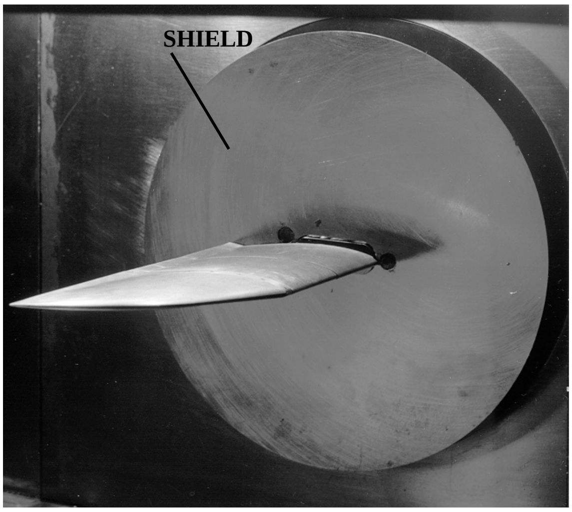

Fig. 4. Scavenging of the model in the transonic wind tunnel T-2

Results of Investigations

The results of model scavenging in the subsonic tunnel are illustrated in Fig. 5 and Fig. 6. Diagram in Fig. 5 show the dependence is given for drag coefficients $\mathbf{C_{xa}}$ of the model having blade tip anhedral angles $\boldsymbol{\gamma}$ at different lift coefficients $\mathbf{C_{ya}}$.

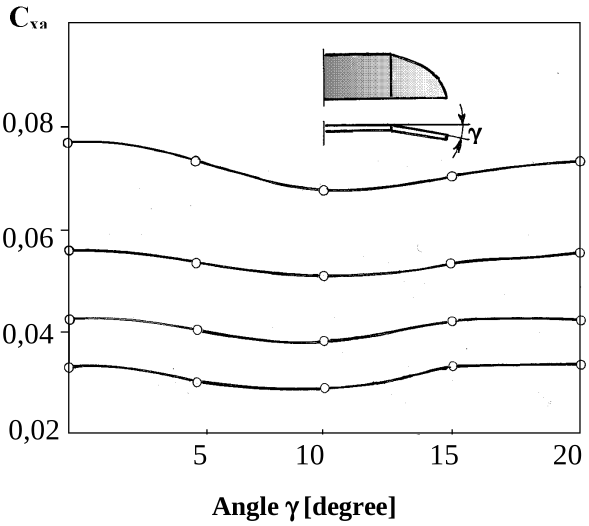

Fig. 5. The dependence C_{xa}=f(γ) at different values C_{ya}

The analysis of dependencies $\mathbf{C_{xa}=f(\gamma)}$ shows that in the area of angles $\boldsymbol{\gamma}$ close to **10°** there is stable reduction of the tip vortices with the resulting reduction of the model resistance.

This effect is effectual detected on the visualization patterns of spectral streamlining of the model surface (Fig. 6), showing the angle $\boldsymbol{\gamma}$ influence on the flow stall on the upper surface of the model up to the angles of attack $\boldsymbol{\alpha}$**=16°** at the cost of tip vortex dissipation.

ce of the model (γ=10°)

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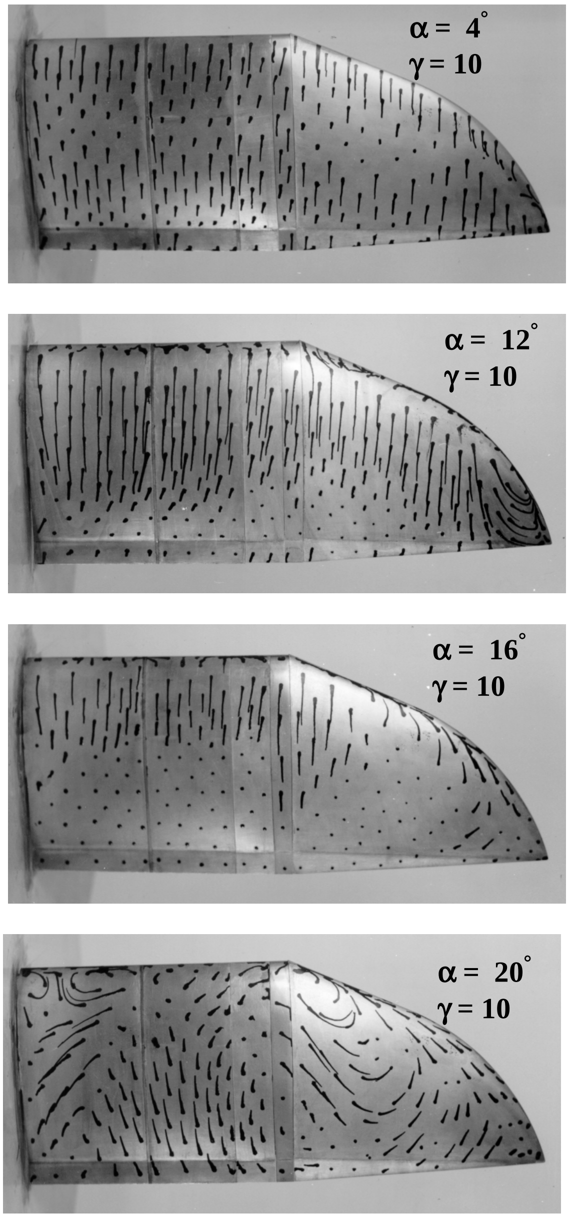

Fig. 6. Spectral visualization of the upper model surface streamlining at the angle of γ=10°

On the bottom surface of the model there is a full attached flow at all angles of attack investigated α (Fig. 7).

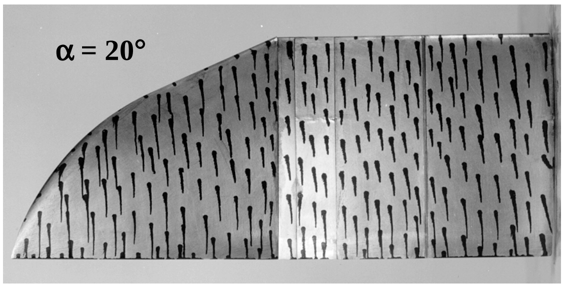

Fig. 7. Visualization of spectral streamlining of the bottom surface of the model (γ=10°)

In addition to the results of scavenging the calculations followed from a nonlinear vortex of the main rotor model have been made based on which a conclusion can be made on stable influence of the cant angle **γ** of blade tip on the reduction of blade load gradients and that of hinge moment.

The effect is observed of the characteristic increase of the relative efficiency of the main rotor **$\Delta\eta_0$**, the numerical values of which for tips lay within the limits of **3%**.

This result was proved by a model experiment on the screw instrument at the hover models with rotor's parameters close to Ka 115 helicopter rotor (Fig. 8).

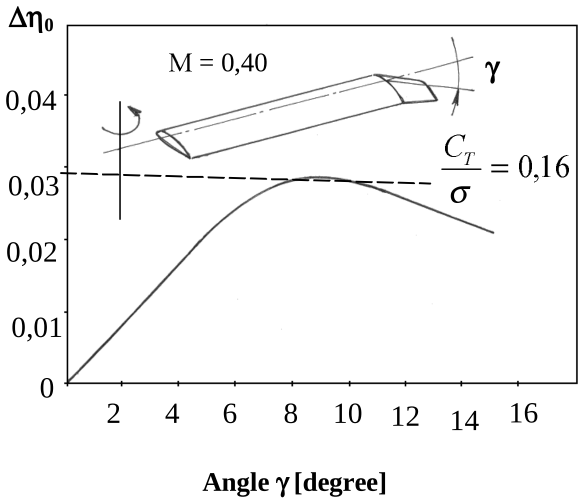

Fig. 8. Rotor relative efficiency increment $\Delta\eta_0$ at the blade tip anhedral angles γ

Fig. 9 depicts the dependence **C_{xa}=f(M)** at **C_{ya}=0** of the model under investigation in the transonic tunnel compared to two other models with the blade tips of rectangular and hyperbolic form with the sweepback of leading edge and that of trailing edge. An observable reduction of resistance on the model under investigation takes place already at M>0.75 as well as the increase of critical number M to ≈0.8, that diminishing the shock stall on the blades in flight speed.

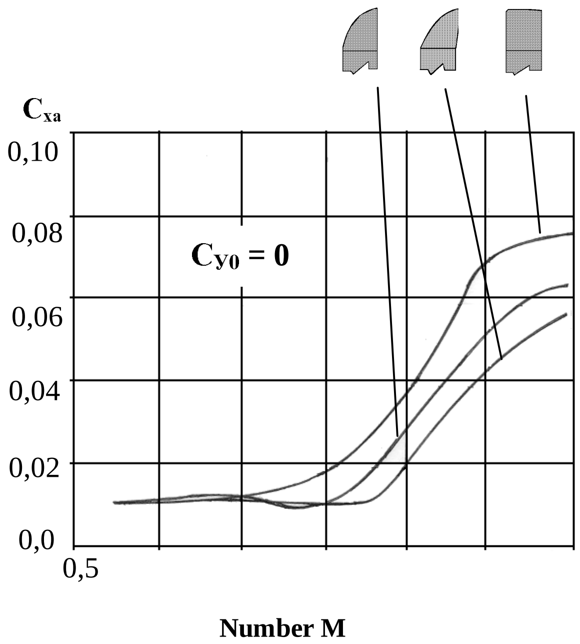

Fig. 9. Dependence C_{Xa}=f(M) for different blade tips

Conclusions

The combined analysis characteristics for the three blade-tip models by the results of scavenging and theoretical studies has shown that the closest to the achievable optimization vector mentioned above is the blade-tip model under investigation with a hyperbolic sweepback blade tip of rear edge χ**=0** and blade tip cant angle γ**=10°**.

This conclusion is based on the results obtained:

- Of lower resistance of the model in the whole range of high-speed mode;
- Of better dynamic stability in a wide spectrum of angles of attack α;
- Of higher lifting ability of the blade tip at relatively low hinge moment.

Introduction of a technically new aerodynamic configuration of the coaxial main rotor Ka 115 helicopter will allow:

- To gain higher helicopter flight characteristics;
- To guarantee safety of helicopter handling by one pilot in conditions of more strict regulations JAR 27;
- To improve the helicopter fuel consumption parameters (smaller fuel consumption due a complex technique to the development of the main rotor and glider);
- To correspond property ICAO ecological standards (by noise level on the country area).