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INFLUENCE OF THE BALLISTIC PROTECTION ON AERODYNAMIC HELICOPTER CHARACTERISTICS

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Abstract

This paper contains results of experimental tests of the influence of passive ballistic protection on aerodynamic coefficients of the model fuselage of the Sokol helicopter. The research was carried out in the Institute of Aviation low speed wind tunnel T3 of 5 m diameter on the helicopter test stand. Measurements of aerodynamic coefficients acting on the fuselage with and without passive ballistic protection were taken using six–component internal strain gauge balance placed inside the model of the fuselage for the angles of attack α = –90-90° with step 10° and for sideslip angles β = –10°, 0°, 10°. Several aerodynamics coefficients: drag (Cx), force (Cy), lift (Cz) and moment: bank (Cmx), pitch (Cmy) and yaw (Cmz) were analysed. The results of the wind tunnel tests were presented in figures as non-dimensional mean values of the above aerodynamic coefficients. Different measurements of aerodynamic characteristics were made like: the influence of Reynolds number on the Cx of the helicopter fuselage with and without protection and the comparison of aerodynamic characteristics of the helicopter fuselage Cx, Cy, Cz, Cmx, Cmy, Cmz as the function of α, without stabiliser, with and without protection. Moreover, a comparison Cx, Cy, Cz, Cmx, Cmy, Cmz as the function of α, with a stabiliser, with and without protection was made and a comparison of the influence of a stabiliser and protection on the above aerodynamic characteristics for the range of useful angles of attack were analysed. A comparison of the influence of a stabiliser and protection on aerodynamic characteristics of the helicopter fuselage Cx, C_y, Cz, Cmx, Cmy, Cmz for the range of α angles of attack was also described.

Keywords: *passive ballistic protection, aerodynamic coefficients, stabiliser, helicopter fuselage*

1. Introduction

Since 2004 "The Program of Work for Defence Against Terrorism", implemented by NATO has still existed. One of the goals of the program is creating new and improved technologies for self-protection of helicopters from firing with small-arms projectiles [1] and rocket-propelled grenades [2-4].

The need arose due to the fact that major cases of casualties during resent conflicts (II Gulf War) have been attacks on helicopters using 7.62-12.7 mm API (*Armour Piercing Inflammable*) ammunition and rocket-propelled grenades launcher of RPG-7 type. Examining how passive armour technologies can be incorporated into the existing and future rotary-wings aircraft, ranging from fuselage-resistant to certain RPG-resistant coatings and materials that were originally designed for armoured personnel carriers is necessary.

Due to the use of API ammunition, which after perforation of the target (armour) causes burning of inflammable materials, protection against it should be emplaced outside the helicopter fuselage (Fig. 1).

In the view of very large limitations of additional loading of the helicopter (200-300 kg) the protection of other vital places, such as the engine, cylinders of the compressed gas, hydraulic systems, etc. and the floor of the helicopter, is taken into account to a lesser degree. Thereby, the external armouring, in the form of steel armours, titanic and composite armours with the ceramics, is mostly used.

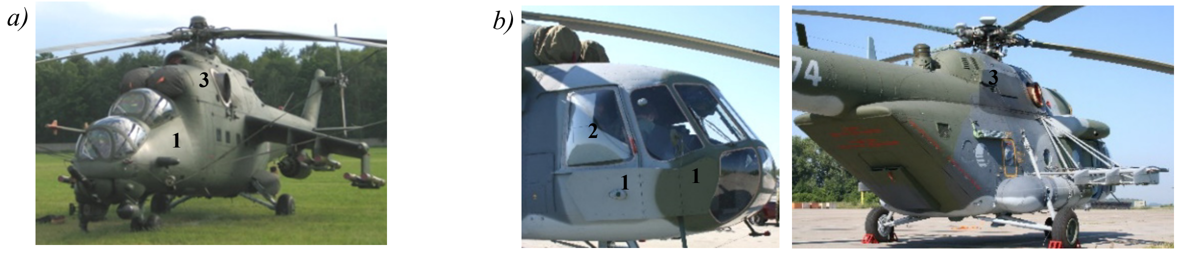

Fig. 1. The Polish Mi-24W (a) and the Czech Mi-171Š (b) gunship helicopter with the additional protection of cockpit (1), windows (2) and the engine (3) against the perforation with API projectiles 7.62 mm (a) and 7.62-12.7 mm (b)

The example of such protected helicopters is Polish Mi-24W (Fig. 1) with titanic metal sheets protecting the cockpit and the engine.

2. Tested object

For the aerodynamic tests, the fuselage model of *Sokol* helicopter with one-layer passive protection was used (Fig. 2).

Fig. 2. The fuselage of the Sokol helicopter model with protection

Data of the fuselage of the *Sokol* helicopter model were the fuselage model scale: 1:6.49; the fuselage length $L = 2.055$ m.

Main rotor model (for radius R and main rotor area S aerodynamic coefficients of fuselage were calculated): the main rotor model scale 1:6.49; the diameter of the main rotor model $D = 2.42$ m; the area of main rotor model $S = 4.5996$ m².

Data of the protection model were the following: the protection model scale 1:6.49; the length of protection $L = 0.775$ m; the perimeter of protection $O = 0.87$ m.

The range of tests included:

1. measurements of aerodynamic characteristics of the helicopter fuselage with and without protection were carried out in T-3 wind tunnel.
2. *Cx* as the function of Reynolds Number.
3. *Cx*, *Cy*, *Cz*, *Cmx*, *Cmy*, *Cmz* as the function of α: –90 – 90° with step of 10°.
4. for $\beta = -10°$, 0° and 10°.

3. Testing methodology of passive protection of fuselage

Performing tests of the *Sokol* model of the helicopter with the additional armour in the aerodynamic tunnel consists of testing the loads affecting the helicopter's hull protecting shield and the influence of the shield into the hull aerodynamic characteristics (Fig. 3).

Another important element was the calibration of the weighing machine, determination of the angle of incidence and sideslip caused by the aerodynamic forces linked with the distortions of fixing and weighing machine. Weigh measurements (Fig. 4) of the helicopter hull model aerodynamic characteristics were made for different incidence and sideslip angles for the model with and without the shield in order to evaluate the influence of the shield on aerodynamic forces acting against the hull and the static stability of the hull.

Visualisation of the air stream lines passing through the helicopter hull model for different incidence and sideslip angles with and without the presence of the shield in order to find out the areas of stream separations and the influence of the shield into the air currents passing the hull and control wings of the helicopter was very important for the tests.

Fig. 3. The Sokol helicopter model with the passive armour model in the wind tunnel

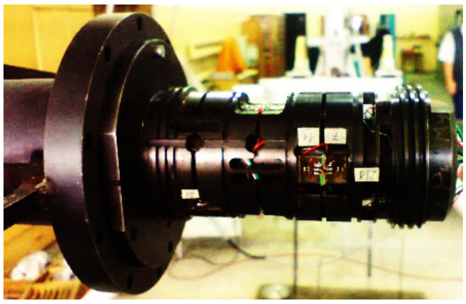

Fig. 4. HWG-6 six-components internal strain gauge balance used for the helicopter fuselage model tests

The measurement range of HWG-6 (static accuracy from calibration) were: drag force (150 N) $P_x < 0.17\%$, side force (300 N) $P_y < 0.2\%$, lift force (200 N) $P_z < 0.2\%$; rolling moment (50 Nm) $M_x < 0.15\%$, pitching moment (50 Nm) $M_y < 0.15\%$, yawing moment (50 Nm) $M_z < 0.2\%$.

The process of balance and pressure transducers calibration and measurements of aerodynamic loads were executed in accordance with Quality Procedures and in compliance with Quality Assurance System in BA-A1 and procedure: JPB.03/LA "Carrying out balance measurements of aerodynamic loads in T-3 wind tunnel".

4. Tests results

The results of wind tunnel tests are presented in Figs. 5-8 as non-dimensional mean values of *Cx*, *Cy*, *Cz*, *Cmx*, *Cmy*, *Cmz* aerodynamic coefficients model of the fuselage in function of the α attack angles and sideslip angles ($\beta = -10°, 0°, 10°$).

5. Conclusions

On the basis of the presented test results of the influence of the one-layer passive protection model placed on the fuselage of the *Sokol* helicopter model on their aerodynamic characteristics it can be stated that:

1. For the fuselage model of the *Sokol* helicopter with, without the protection model, with, and without a stabilizer for the range of attack angles: $\alpha = -100\text{-}100$ deg and for sideslip angles $\beta = -10, 0, 10$ degrees the maximum ranges of the coefficients are very small.

Forces' coefficients:			Moments' coefficients:		
Drag, *Cx*	Side, *Cy*	Lift, *Cz*	Rolling, *Cmx*	Pitching, *Cmy*	Yawing, *Cmz*
0-0.01	–0.035-0.021	–0.045-0.045	–0.0052-0.0052	–0.022-0.014	–0.0057-0.0059

2. The installation of the protection makes the helicopter fuselage model become statically unstable for the entire range of α angles of attack. It can cause an increase of a vertical stabilizer area in order to make a flight possible.
   It was estimated that aerodynamic drag of the *Sokol* helicopter model after the installation of the protection increased by about 25%. It will be possible to evaluate of the influence of modernized one-layer passive armour (based on the *Sokol* or another type of helicopter model) on helicopter airworthiness as a result of: the maximum diminution of value of the helicopter

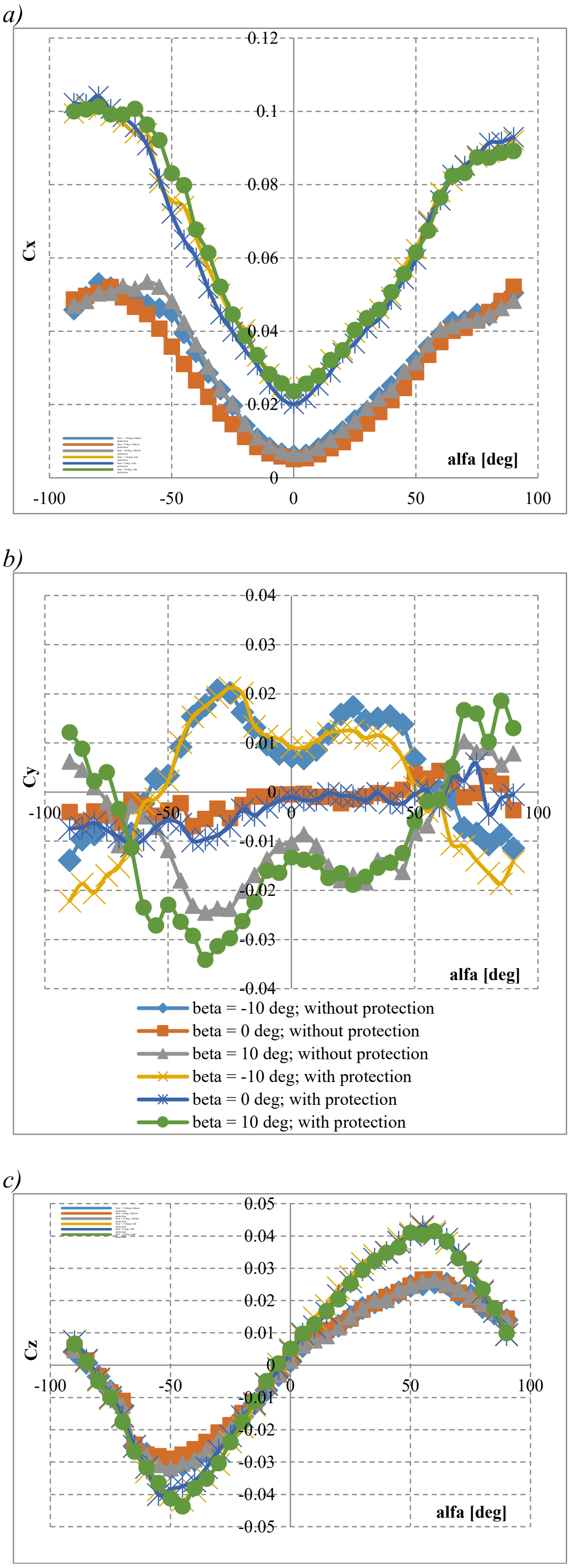

Fig. 5. *The influence of the passive protection and lack of protection on: a) Cx drag force coefficient, b) Cy side force coefficient, c) Cz lift force coefficient, of the helicopter fuselage model for various angles of attack and the sideslip angles β = –10, 0, 10 deg*

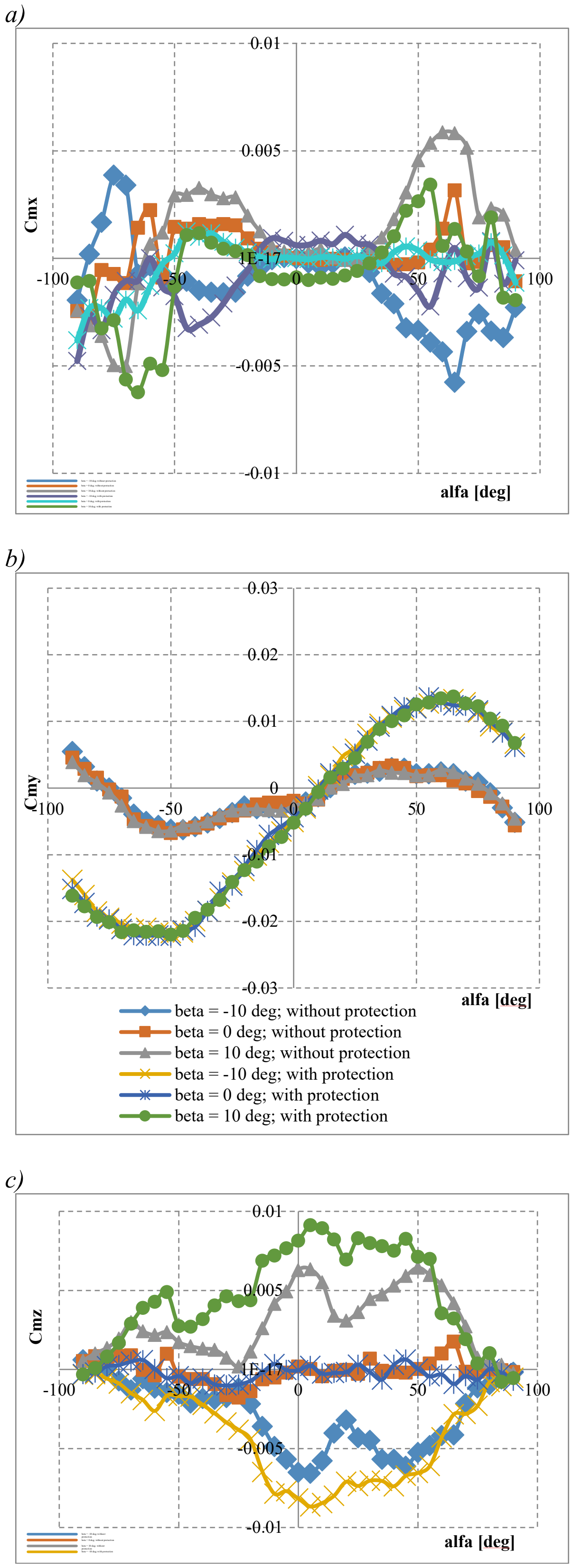

Fig. 6. *The influence of the passive protection and lack of protection on: a) Cmx rolling moment coefficient, b) Cmy pitching moment coefficient, c) Cmz yawing moment coefficient, of the helicopter fuselage model for various angles of attack and the sideslip angles β = –10, 0, 10 deg*

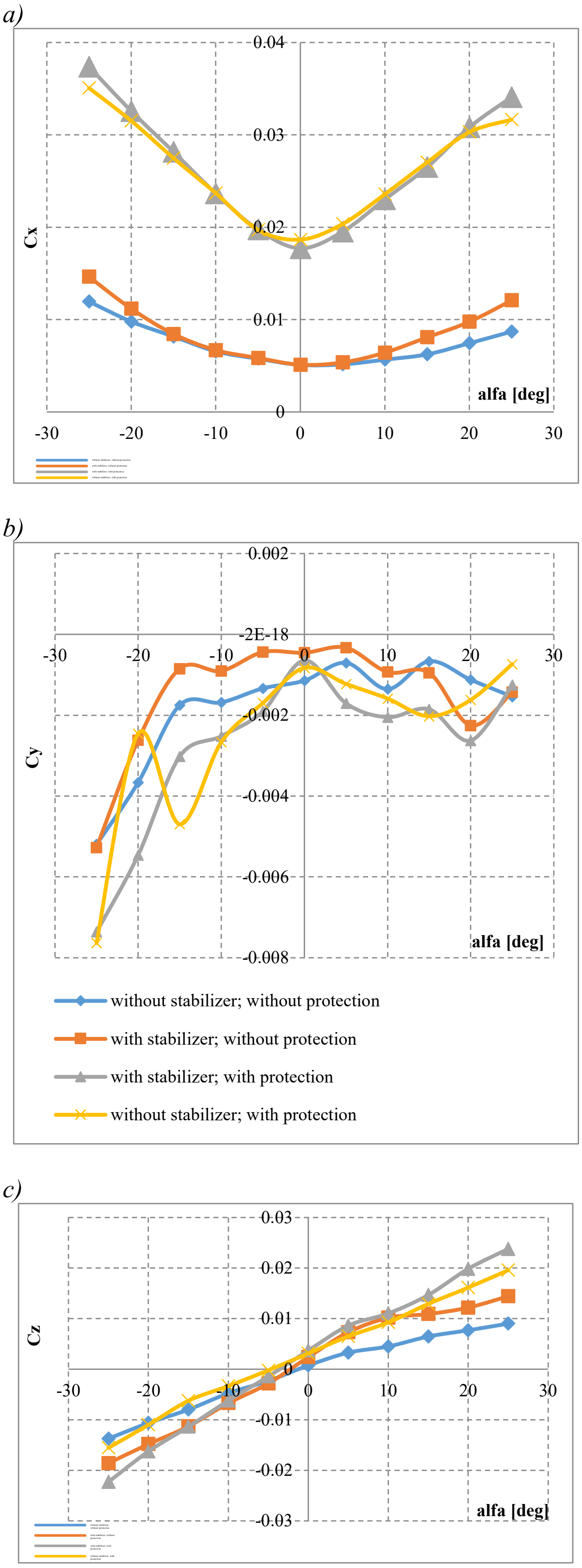

Fig. 7. The influence of: the passive protection or lack of protection, and stabilizer or lack of stabilizer on: a) Cx drag force coefficient, b) Cy side force coefficient, c) Cz lift force coefficient, of the helicopter fuselage model for various angles of attack and the sideslip angles β = 0 deg

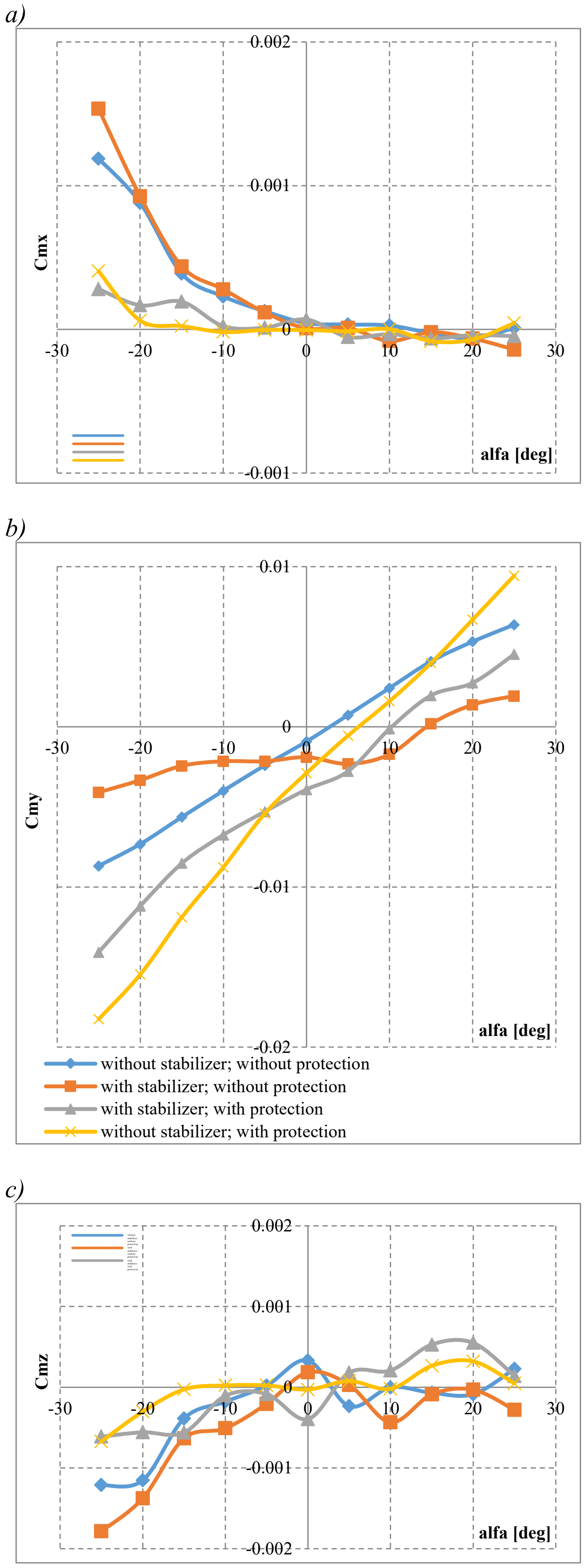

Fig. 8. The influence of: the PAWA-1 protection or lack of protection, and stabilizer or lack of stabilizer on: a) Cmx rolling moment coefficient, b) Cmy pitching moment coefficient, c) Cmz yawing moment coefficient, of the helicopter fuselage model for various angles of attack and the sideslip angles β = 0 deg

speed fall by less than 25% and the possibility of minimizing resistances (drag, side force lift) and moments (bank, pitch and yaw) coefficients which influence the manoeuvrability of a helicopter (by the increase of a vertical stabilizer area) to improve flight.
4. It is noticeable that the increase of a vertical stabilizer area can decrease aerodynamic helicopter drags and increase airworthiness while flying.
5. Tests of the passive armour should be carried out in the future in order to check:
   – possibility of different assembling of the helicopter protection,
   – final protection level with the use of helicopter wreck.
6. The scope of this work will consist of analysis where the underneath of the helicopter fuselage electronic elements could be installed and aerodynamic tests of the model of the *Sokol* or another type of helicopter, having installed the modernized one-layer passive armour. Due to the parameters (area, shape) of the modernized *Sokol* model or other types of the helicopter there is a possibility to design and build different types of one or two-layer passive armours for protecting helicopters against RPG launchers.
7. It is expected that it will be possible to define the influence of the modernized passive armour on the final aerodynamic drags and moments of a helicopter model.

5. References

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