EAN '97

35th International Conference on
Experimental Stress Analysis
June 4 - 6, 1997, Olomouc, Czech Republic

DETERMINATION OF INFLUENCE OF CHANGE THE COVERS ON THE HELICOPTER TAILPLANE BY MEANS OF TENSOMETRIC MEASUREMENT IN FLIGHT

Bigoš P., Trebuňa F., Ritók J.

Working experiences show on low resistance and durability of tailplanes linen cover. The mentioned relevant defects of linen cover lead to replacement of the Mi 24 helicopter tailplanes linen cover by more resistant material covers. The replacement of linen coat on to metal one a next box is formed, which transfers a part of inner force quantities. For the experimental verification of replacement of linen cover by metal cover we have chosen the method of resistance tensometry. If we compare the maximum measured values of shear and bending tensions of tailplanes with metal cover it is possible to state a good coincidence

Helicopters Mi24 (fig.1.) have on their tailplanes back part a linen cover. Working experiences show on low resistance and durability of this cover with effects leading to destruction of the tailplane cover during the flight. The mentioned relevant defect and the high number of damage of linen cover lead to replacement of the Mi 24 helicopter tailplanes linen cover by more resistant material covers.

Much more used are full-metal or composite covers. As an example we can mention the full-metal cover of AH-64 APACHE helicopters tailplane or the composite cover of Bell-Notar helicopters tailplane (fig.2). Concerning the price and technology light alloy based covers, especially aluminium ones are available. It lead to a decision for using these materials to replace the cover ofMi -24 helicopter tailplanes.

The tailplane of Mi 24 has a trapezoid view from above and assures higher along stability.

The deviation of the tailplane depends on movement of the collective control bar and in this way assures the along balancing of the helicopter at all field and transient flight regimes.

In fact the tailplane introduces a one girder bearing surface with torsional cavity in front part. The main bearing element is a box type girder with changing cross section. The rigid cover of the front part is bearing and together with the girder base they close the torsion cavity. This completely conveys along with the girder the tangential forces, the bending moments and the torque's from the distributed load. The cover of the back part of the tailplane conveys only the distributed loads through the ribs to the torsional box onto the main girder. For that reason a linen cover is used on the original tailplane.

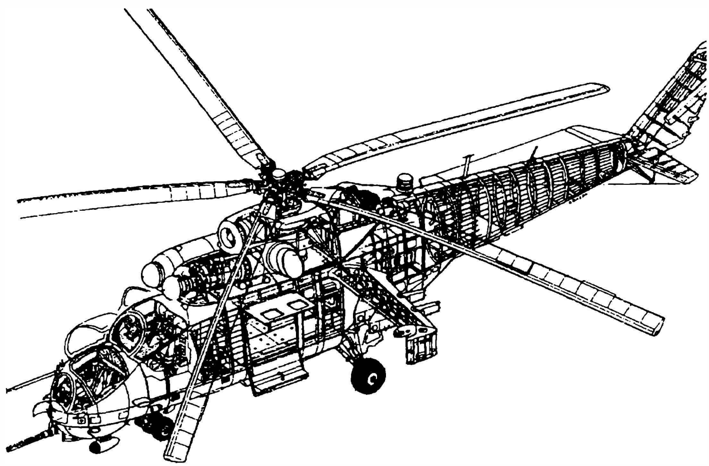


Fig.1

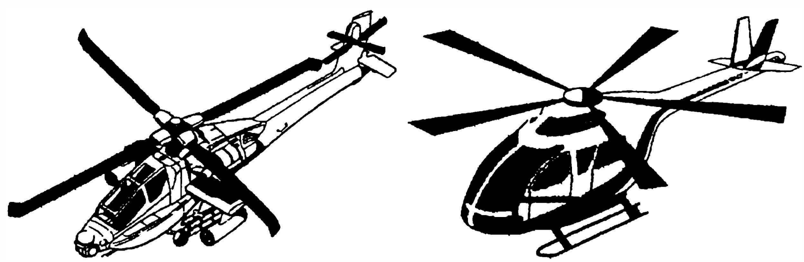


Fig.2

To judge the effects of the replacement of linen cover by full-metal cover on the tailplane it was necessary to perform strength analysis of both types. At the original tailpalne the linen cover serves to convey the distributed load from aerodynamical forces to the ribs and through them to the bearing construction of the tailplane. The bearing construction of the tailpalne with linen cover is formed by a box girder and a torsion box with metal cover of the front edge. The bending moment, torque and tangential force is transferred just by this part of the tailplane.

The replacement of linen coat onto metal one a next box is formed, which transferees a part of these inner force quantities. It should relieve the bearing part of the tailplane especially at bending. For calculation judgement of the effect of replacement of linen coat onto metal coat it was necessary to state the flight loads of the tailplanes of Mi24 helicopters. For that purpose Reynolds number was determined for the maximum speed of flight for individual versions and variations. For the maximum speed of flight $v_{max}=94{,}4\ ms^{-1}$ it is $R_e=5{,}14.10^6$. For the NACA 0012 profile used on the tailplane the maximum theoretical coefficient of buoyancy of the profile from its characteristics is

$$c_{ystat,max} = 1.2,$$

and the buoyancy force outlet at flight above the ground at maximum speed

$$Y_{stat,max} = 5790 \text{ N}.$$

For this profile the aerodynamical center lies at 25% of the depth and so the maximum torque will be evoked by the buoyancy force on the arm which is given by the difference between the position of the elastic axis and the application point of buoyancy force of the aerodynamical profile in the watched cross section. By replacing the linen cover by metal one the elastical axis shifts to the back edge (maximally but to depth 50% of the profile depth) what increases the arm of the application point so increases the value of the torque.

To determine the influence of replacement of linen cover by metal cover on the size of stress and behaviour of the construction, geometrical characteristics were determined at the places of tension measurements from bending moment and torque. For the reference section of the tailplane it was chosen the section which lies at distance of 600 mm from the widest section of the tailpalne with linen cover and also with metal cover (fig.3a and fig.3b).

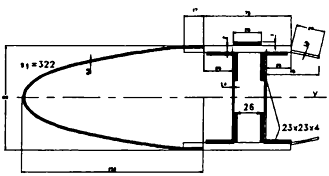


Fig.3a

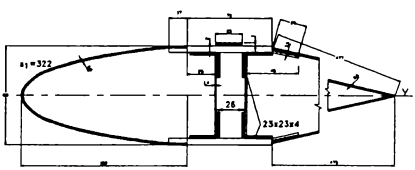


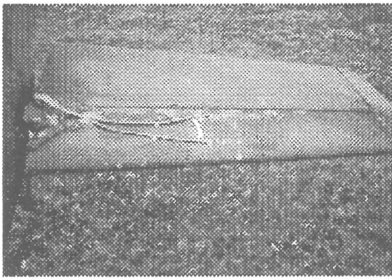
Fig.3b

For these sections according to relations for repeatedly closed sections the tensions were determined from the torque and bending moment.

In the case that the torque stay without changes, so the strength values of the tailplane with metal cover will decrease.

At the solution of the bending stress the tension change is caused only by the different characteristics .The lowering of bending tension at metal cover is determined in measured section by coefficient k=0.876, because for profile according fig.3a $W_y=59229\text{mm}^3$ and for profile according fig 3b. $W_y=67625\ \text{mm}^3$.

For the experimental verification of replacement of linen cover by metal cover we have chosen the method of resistance tensometry. For the measurement of tensions from torsion we used HBM gauges at the places of the front edge for both the linen and metal covered tailplanes (fig. 4a and fig.4b). From bending the tension was measured at the same section on the strip of main girder. Resistance sensors LY 120 were applied from the above mentioned firm. (fig 4a and 4b).



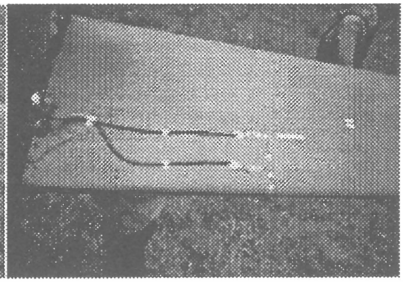
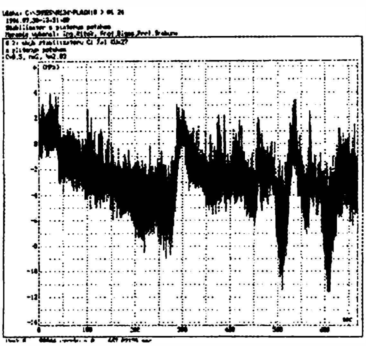


Fig.4a Fig.4b

The measurement was performed at the following specified regimes :

- take off and rise on the hight,
- hanging in hight,
- horizontal flight at speeds from 160 to 360 km/h,
- curves of 180° at speed 240 km/h and traverse angularities of 30° and 40°,
- steep rise of angle 30° from initial speed 280 Km/h onto 100 km/h,
- braked left curve with transverse angularity of 3O° from speed 250 km/h onto 100Km/h,
- subsidence for landing with the longest possible endurance onto speeds 50-70 km/h,
- landing.

Fig.5a shows the time response of bending tensions during the flight at specified regime on tailplane with linen cover. Fig. 5b shows the spectral power density from the time response in fig. 5a.



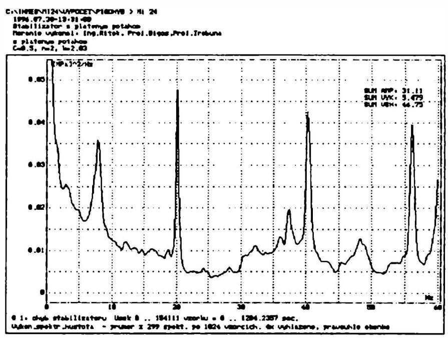
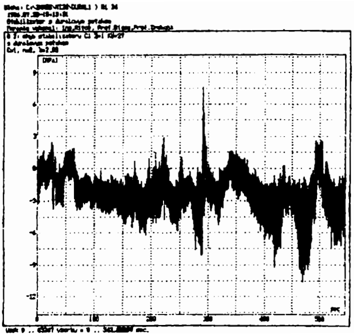


Fig.5a Fig.5b

Fig. 6a shows the time response of bending tensions during the flight at specified regime on tailplane with metal cover. Fig. 6b shows the spectral power density from time response in fig.6a.



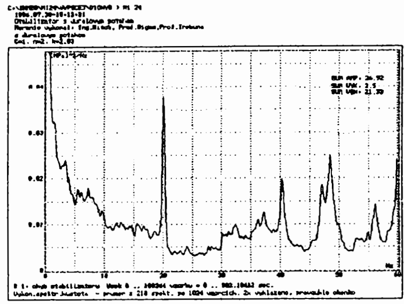
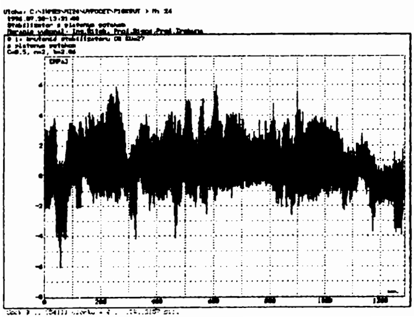


Fig.6a Fig.6b

Fig. 7a shows the time response of shear tensions during the flight at specified regime on tailplane with linen cover. Fig. 7b shows the spectral power density from time response in fig.7a.

Fig. 8a shows the time response of shear tensions during the flight at specified regime on tailplane with metal cover. Fig. 8b shows the spectral power density from time response in fig.8a.



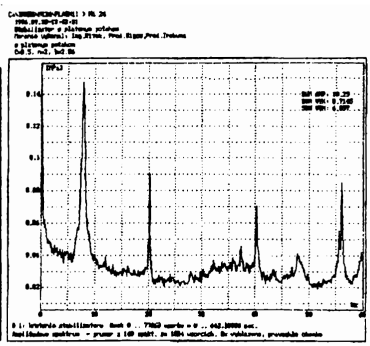
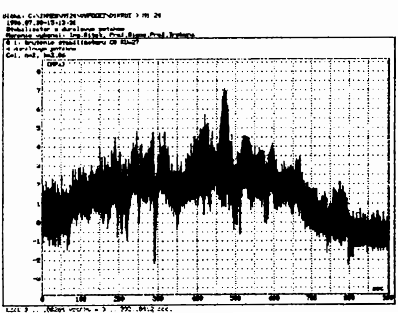


Fig.7a Fig.7b



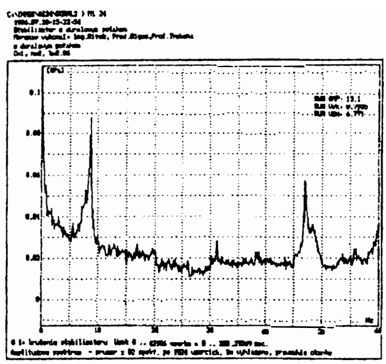


Fig.8a Fig.8b

If we compare the measured and calculated values of shear and bending tensions of the tailplane with liner cover we can see a good coincidence. If we compare the measured and calculated values of bending tensions at the tailplane with metal cover we can state a good coincidence. However at the tailplane with dural cover the calculated value of shear tension is three times higher than the measured one. This difference can be caused by the fact that at the calculation of torsion moment we considered a shift of the elastic axis to the back edge with maximum value ,that means 50% of depth of the tailplane with metal cover.

If it was considered e.g. a 40% shift, the calculated shear tension would be 10.6 MPa. If we compare the maximum measured values of shear and bending tensions of tailplanes with metal cover it is possible to state a good coincidence. Some differences can be caused by more factros, like e.g. real working regimes and atmospheric conditions at the measurement during the flight of Mi 24.

Comparison of the dynamic behaviour of tailplanes with linen and dural cover from the time responses of bending and shear tensions from figs. 6a,7a,8a and 9a is very difficult. The main difficulty is also that during the flights when the measurements were performed on the tailplanes the sequence of the specified flight regimes were not kept. From this reason we performed spectral analysis and statistical calculations of the measured time responses of bending and shear tensions on tailplanes with linen and metal cover (fig.5b,6b,7b and 8b) in laboratorial conditions.

From spectral power densities of measured responses of bending and shear tensions at specified flight regimes of helicopter Mi 24 on tailpalnes with linen and dural cover results that at replacement of linen cover by dural cover dynamical functional quantities will not worsen.

By change of tailplanes with linen cover to tailplanes with dural cover their working reliability will increase especially by increase of their resistance against mechanical damage at keeping their functional qualities.

Literature

[1.] Trebuňa,F.,Bigoš,P.,Ritók,J.: Numerické a experimentálne overenie pevnostných a dynamických parametrov častí vrtuľníka Mi24. Katedra dopravy a manipulačnej techniky, Strojnícka fakulta, TU Košice,1996.

[2.] Kan,S.,N,: Pevnost letounu. Naše vojsko, Praha 1957.

[3.] Ševlenko,P.,S. a kol.: Příručka leteckého technika. Naše vojsko, Praha 1989.

František Trebuňa,Prof.Ing.CSc., Bigoš Peter, Prof.Ing.CSc., Ritók Juraj,Ing., Technical university of Košice, Faculty of mechanical engineering, Letná 9, 041 87 Košice. E=mail: trebuna,bigi,ritok@ccsun.tuke.sk