Simulation design airframe and evaluation of aircraft skin frequency characteristics for determination of activities for deviation from vibration impact of engine.

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Abstract.

The paper describes simplified method of oscillation calculation of the aircraft fuselage panels. Verification of results of the eigenmodes calculations of the rectangular plate and fuselage compartment was performed.

1.   Introduction.

The evolution of new generation engines develops in the direction of increasing bypass ratio and widening of the vibrational spectrum of engine. In the wake of current crisis and high oil prices the focal point is not the new aircraft development but installation of new generation engines on the current aircraft - to improve fuel efficiency.

The greatest increase in fuel efficiency provide engines with extra high bypass ratio, especially with the implementation of geared scheme, which significantly reduces fan speed, which produces most part of engine vibration.

Structural noise becomes dominant in the noise of pressurized cabin; level of low-frequency components inside the cabin is determined by the vibrations that occur at frequencies of rotor engine and its units. In this case comfort level for passengers reduces significantly in aircraft cabins.

The main topic of this paper is possibility of reducing the response of the aircraft fuselage to vibroacoustic effects of high-bypass fan engines.

All calculations were performed with the use the finite-element analysis **MSC / NASTRAN**.

2.   Results of solving problems of fuselage compartment oscillations.

Traditionally to determine the oscillations modes a finite-element model of a aircraft fuselage fragment is implemented [1].

Sheathing is modeled with the use of shell elements of the moment. Stringers and bulkheads are modeled in beam elements.

The geometric model is broke up into stringers.

There was modeled a fragment of fuselage consisting of 5 sections. The fragment consists of 6 frames. Boundary effect produces practically no effect on the middle section. That is why it is better to analyze estimation of the forms of proper oscillations of fuselage components in the middle section, dividing it in a more detailed way. A detailed division of the middle section allows us find panel frequency more minutely. For the mathematical model an edge-stiffened pinning is adopted.
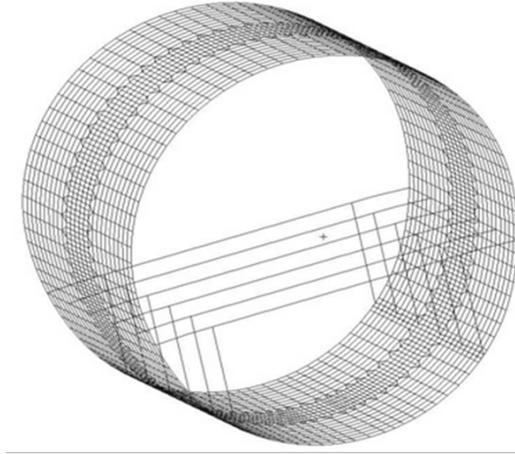
Figure. 1.1 Mathematical model of an aircraft fuselage element.

In the solution equation was used [2, 3, 4]:

$$[M]\{\ddot{u}\} + [K]\{u\} = 0, \qquad \textbf{(1)}$$

where [M] - system mass matrix;

    {u} - acceleration vector;

    [K] - stiffness matrix of the design;

    {u} – displacement vector.

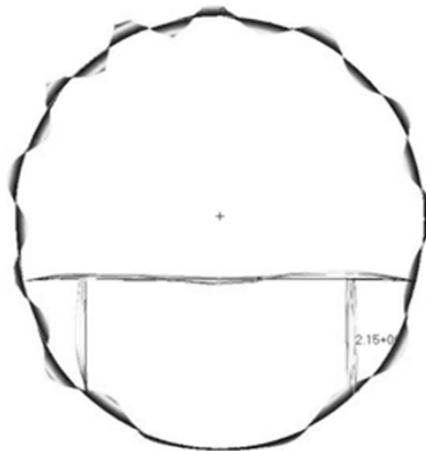The results of numerical design works are presented in Fig. 2.2.

Fig. 1.2 The result of numerical design works on the eigenvibration by frequency 93.39 Hz .

3.   The results of solving problems on vibrations of rectangular plates with various boundary conditions, MKE.

3.1. Calculation models.

As a possible simplification of the calculation on the eigenmodes of the aircraft skin eigenmodes of a rectangular piece shell was analyzed (isotropic rectangular plate). A shell fragment between adjacent stringers and bulkheads was chosen, and was simulated with the use of shell elements.

Plate dimensions 500X157X 1 5 mm.

To determine the forms of natural oscillations of the plate the following cases of boundary conditions were examined:

- Plate hinged along the contour;
- Plate fastened along the contour ;
- Plate hinged on two opposite sides and free along the long edge.

The results are shown in Fig.21.1-2.9.
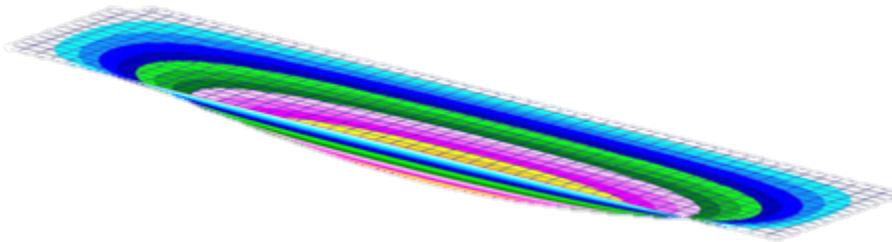
3.1.1. Plate hinged along the contour.

Figure 3.1 The result of numerical calculation of the plate on the eigenmodes at the 1st natural frequency (p = 160.94 Hz).
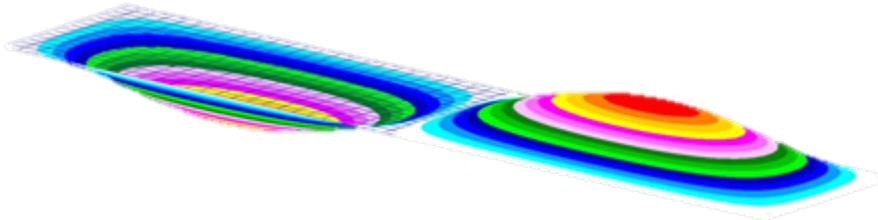

Figure 3.2 The result of numerical calculation of the plate on the eigenmodes at the 2nd natural frequency (p = 203.76 Hz).\
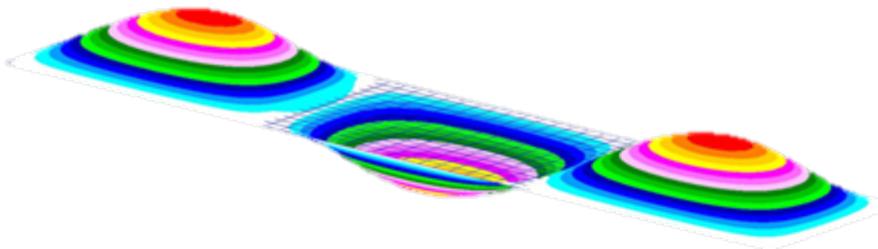

Figure. 3.3 The result of numerical calculation of the plate on the eigenmodes at the 3rd natural frequency (p = 275.23 Hz).

3.1.2. Plates clamped along the contour.

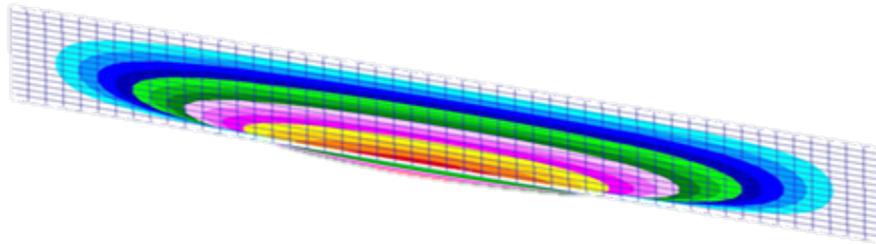Figure. 3.4. The result of numerical calculation of the plate on the eigenmodes at the 1st natural frequency (p = 342.76 Hz).
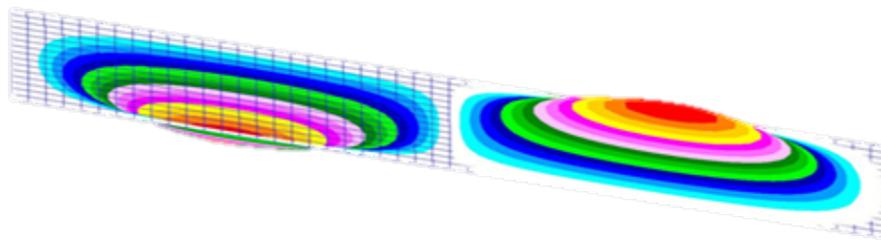

Figure. 3.5. The result of numerical calculation of the plate on the eigenmodes at the 2nd natural frequency (p = 375.88 Hz).
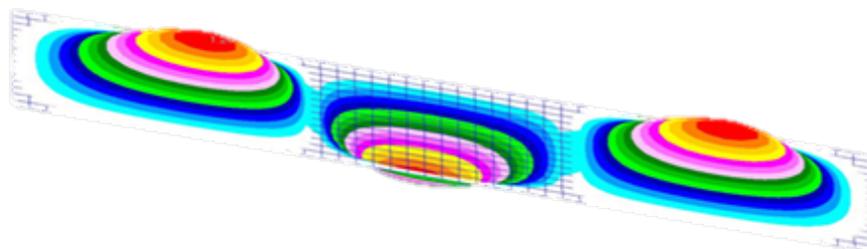

Figure 3.6. The result of numerical calculation of the plate on the eigenmodes at the 3rd natural frequency (p = 436.9 Hz).

3.1.3. Plate hinged on two opposite sides and free along the long edge.

The stringers were added at the free edge of the plate to increase rigidity. Stringers were modeled in beam elements.
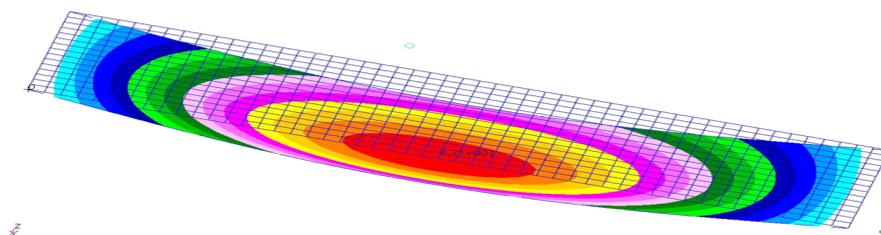
Figure. 3.7. The result of numerical calculation of the plate on the eigenmodes at the 1st natural frequency
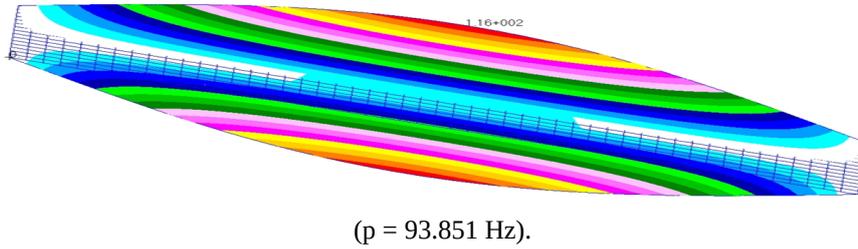

(p = 93.851 Hz).

Figure. 3.8. The result of numerical calculation of the plate on the eigenmodes in the 2nd natural frequency
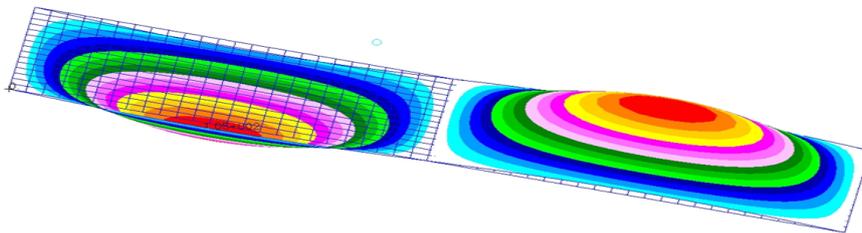
(p = 176.43 Hz).

Figure. 3.9. The result of numerical calculation of the plate on the eigenmodes for the 3rd natural frequency
(p = 191.91 Hz).

Analysis of natural vibration modes of an isotropic rectangular plate, which showed that:

- for a plate hinged along the contour first two forms of vibration are close to the rotary frequency;
- for a plate clamped along the contour, there are no forms close to the rotor frequency;
- for a plate hinged on two opposite sides and free along the long edges, to a rotary motor frequency is close to the first three forms.

Hereby, in the outcome of a fragment of shell analysis, it turned out that the frequencies of natural oscillations of a rectangular plate (case 3) are close to the panel natural frequencies of the fuselage (p = 93.39 Hz).

So the problem of oscillations of the fuselage skin can be simplified.

4.   Conclusion.

Consequently due to installation of new generation engines (remontorizatsia), on the one hand a new generation engines vibration spectrum reduces the lower modes of vibration of the fuselage panels, but approaches the natural vibration modes of the airframe.

Acoustic field of pressure cabin undergoes significant change together with a change of engines with extra high bypass ratio.

The proposed in paper simplified method of fuselage vibrations calculation is very topical, because it allows quick estimate the expected vibroacoustic environment on the plane when replacing motors.

References

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