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RESONANCE PHENOMENON AND LOCAL STRENGTHS IN A CONICAL SHELL

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Annotation: This article studies the conditions for the occurrence of resonance phenomena in conical shells and their influence on the distribution of local stresses. The vibration characteristics of the shell under the influence of external dynamic loads, its natural frequencies, and the sharp increase in deformations and stresses in resonance cases are analyzed. In particular, the influence of changes in geometry, shell thickness, and boundary conditions on the formation of local stresses is studied. Based on the results of theoretical and numerical modeling, it was found that the resonance phenomenon has a significant impact on the strength and stability of the conical shell. The results obtained can be used to develop practical recommendations for avoiding resonance and reducing dangerous local stresses in the design of engineering structures.

Keywords: conical shell, resonance phenomenon, vibrations, natural frequency, dynamic loading, local stresses, deformation, stress concentration, elasticity theory, numerical modeling, boundary conditions, stability, strength.

Shell elements, in particular conical shells, are widely used in modern engineering structures. Such structures are of great importance in rocket and aviation technology, mechanical engineering, oil and gas industry structures, and energy sectors. One of the advantages of conical shells is that they provide high strength along with a relatively small mass.

However, under the influence of dynamic loads, vibrations occur in conical shells, and under certain conditions, resonance phenomena can occur. In the case of resonance, the amplitude of vibrations increases sharply, which leads to the appearance of local stresses and damage to the structure. Therefore, a thorough study of the resonance phenomenon and the characteristics of local stresses is one of the urgent issues from an engineering point of view.

This article analyzes the theoretical foundations of the resonance phenomenon in conical shells, the mechanisms of local stress formation, and their effect on the strength of the structure.

Geometric and mechanical properties of conical shells

A conical shell is a thin-walled structure in the shape of a cone of revolution, characterized by a radius that varies along its length. The main geometric parameters of the shell are:

a) half angle of the cone;
b) shell length;
c) initial and final radii;
d) shell thickness.

Mechanically, conical shells are considered elastic bodies and their behavior is described by the theory of elasticity. According to the theory of thin shells, when the ratio of thickness to radius is very small, deformations and stresses are distributed over the surface.

Geometrical uncertainties, thickness non-uniformity, and boundary conditions significantly affect the vibrational properties of the shell. It is these factors that cause the increase in local stresses at resonance.

Resonance occurs when the frequency of the external dynamic load approaches the natural vibration frequency of the structure. In this case, energy accumulates in the system and the vibration amplitude increases sharply.

The natural frequencies of vibrations in conical shells depend on the following factors:

a) elastic properties of the material;
b) geometric parameters of the shell;
c) boundary conditions of fastening;
d) mass distribution.

From a mathematical point of view, the resonance phenomenon is expressed by differential equations. When the vibration equations of the shell are solved, natural frequencies are determined under certain conditions. If the frequency of the external force is equal to or very close to one of these natural frequencies, resonance occurs. The resonance state is dangerous for the structure, as it can lead to excessive deformations and violation of the strength limit.

Local stresses are characterized by a sharp increase in stresses in certain small areas of the structure. Local stresses in conical shells mainly occur in the following cases:

a) when there are geometric discontinuities and sharp transitions;
b) uneven load distribution;
c) when the amplitude of oscillation increases in the resonance state.

During resonance, the vibration patterns cause maximum displacements in certain parts of the shell. As a result, stress concentrations occur in these areas. This accelerates the fatigue process in the material and can lead to the formation of cracks.

Numerical modeling methods, in particular the finite element method, are widely used to determine local stresses. This method allows us to determine the spatial distribution of stresses and the most dangerous zones.

Numerical modeling and analysis results

Numerical modeling plays an important role in studying resonance phenomena in conical shells. Using a finite element model, the natural frequencies, vibration modes, and stress states of the shell are determined.

The modeling results show that decreasing the shell thickness leads to a decrease in the resonant frequencies. Also, increasing the cone angle leads to a more complex vibration pattern. The largest local stresses usually occur in the fixed parts of the shell or in areas where the radius changes sharply.

The results obtained confirm that the resonance phenomenon directly affects the stability and strength of the conical shell.

Based on the research results, the following practical recommendations can be made:

a) optimize design parameters to avoid resonant frequencies;
b) increasing the shell thickness in hazardous areas;
c) use of additional stiffening elements;
d) use of mechanisms to reduce or dampen dynamic loads.

These measures will help ensure the long-term reliable operation of conical shells.

The article studies the phenomenon of resonance and the formation of local stresses in conical shells. The analysis showed that the resonance state leads to a sharp increase in stresses in the structure, which poses a serious threat to its strength. Using numerical modeling, the most dangerous areas of local stresses were identified and engineering recommendations were developed to reduce them. The results obtained are of practical importance in the design and operation of conical shells.

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