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Influence of Small Added Mass on Splitting Flexural Frequency Spectrum of Circular Ring with Initial Imperfection of Shape

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Abstract

The paper presents the results of the research into the problem of vibration of the infinitely long circular cylindrical shell, which has a symmetrical initial shape imperfection. The infinitely long shell is viewed as the ring of a single width in situations of planar deformation. It was discovered that the effect of splitting the bending spectrum frequency of the isolated ring not only occurs when the number of waves of asymmetric imperfection coincides with the number of waves of dynamic deformations, but also where the number of imperfections is twice as big as the number of the forming waves. This conclusion is correct provided that the number of waves of shape imperfection is even. An opportunity to remove the splitting frequency of the bending spectrum of a thin imperfect circular ring by acceding to it little linear mass is studied. The research has shown that neither the selection of attaching point of added mass nor its size allow discarding the unwanted in terms of a dynamic strength and reliability of the constructions, effect of staggering frequency. During the research a range of qualitative effects caused by the ring having inevitable deviations from the perfect geometrical form were identified.

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Keywords: a shell; a circular ring; initial irregularity; an added mass; bending vibration; splitting frequency spectrum.

1. Introduction

The real thin-walled circular cylindrical shells that are widely used in machine building and other technical industries, have an inevitable small initial imperfection of shape - w_0, with a significant impact on its steadiness [1-5] and dynamic characteristics [6-14]. In particular, it found that w_0, has resulted in splitting frequency bending spectrum, undesirable for dynamic strength and reliability of the constructions.

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The shells are characterized by the availability of additional inclusions (added masses) [15-20], which has also resulted a in splitting frequent bending spectrum and substantively changing of the mode of the construction. The subject would give rise to a good deal of debate in the scientific community currently. So, for instance, it was thought that the effect of declining the lowest of splitting proper frequency depends only on size added mass [21-22]. The academic writing analytically and numerically has showed that the effect of declining the lowest frequency spectrum of the "shell- mass" system, depend not only on size added mass, but also on geometrical and wave parameters of the shell, which qualitatively is consistent with experimental data [21-22]. This conclusion may require previously decided tasks of dynamics.

Not less interesting is the issue combined impact initial imperfection of shape and little added mass. According to [22] both splitting proper frequency of imperfection shell that better reflect the proper frequency of the perfect shell, and this double of the frequency content can be eliminated by acceding to the shell little mass.

In this academic writing as an example a simple (limit) issue of a vibration infinitely long circular cylindrical shell – the ring under planar deformation conditions is being studied influence asymmetrical initial deviations from perfect circular shape w_0, on the lowest of splitting proper frequency, and also an opportunity to remove splitting bending frequency spectrum by acceding to it little mass

For this article, results and conclusions received also had independent importance, because the isolated ring can be interpreted as a computable model of the ring-type complement elements [25] of the wave and soled state gyroscope [33-35] and other car parts and devices, occurring in different branches of industry.

2. Numerical results

The ring is considered with a range of $R = 1$ м, with a thickness $h = 0,005$ м ($R/h = 200$) and with a breadth $b = 0,005$ м, having initial imperfection of shape, changing by law $w_0(y) = ha_0 \sin(n_0 y/R)$, where y - circular coordinate; a_0 - expansible amplitude; n_0- number waves of imperfection (the figure 1).

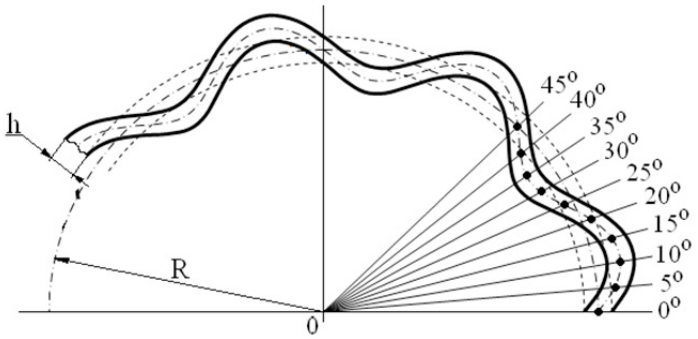

Fig. 1. The schematical image of ring with initial irregularity.

Splitting bending frequency spectrum of a ring without added mass with $n_0 = 8$ and $a_0 = 1$ presented in the figure 2 The solid line corresponds to expansible n-й proper frequency of ideal ring $\Omega_n = 1$, dashed – the lowest of splitting proper frequency $\Omega_{n01} = \lambda_{n01}/\lambda_n$ (λ_n – the frequency of ideal ring), and the dotted line – the biggest one $\Omega_{n02} = \lambda_{n02}/\lambda_n$.

And as you can see, adopted with even number circular waves initial irregularity $n_0 = 8$ visible splitting frequency spectrum is observed in both the $n = n_0/2 = 4$, and $n = n_0 = 8$. At the same time in the second case unbalancing of the proper frequency is more, than in the first [36]. In other cases, wave making of the ring splitting frequency spectrum is virtually non-existent.

It should also be noted that $\Omega_{n02} > 1$ only when $n = n_0/2 = 4$.