коли маса зменшується до цього рівня, нитка може почати зазнавати значних змін, включаючи руйнування.

Опір нитки зростає внаслідок втрати маси. Оскільки опір залежить від довжини та площі поперечного перерізу, зменшення маси призводить до збільшення опору.

Висновки. Моделювання процесу вигорання вольфрамової нитки може бути здійснено за допомогою системи рівнянь, яка описує термічні та електричні аспекти роботи лампочки. Для отримання точних результатів можна використовувати чисельні методи, такі як метод Ейлера або метод Рунге-Кутти.

Моделювання показує, як вольфрамова нитка втрачає масу і нагрівається до високих температур. Ці дані важливі для розуміння термодинамічних процесів у лампочках розжарювання та можуть допомогти у вдосконаленні їх дизайну для зменшення втрат та підвищення ефективності.

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Abstract. *The paper investigates the process of tungsten filament burnout in an incandescent light bulb by mathematical modeling. Thermal and electrical aspects of filament degradation are considered, including changes in mass, temperature, and resistance during operation. The results obtained can be used to improve the design of lamps and increase their durability.*

Keywords: *tungsten filament, incandescent lamp, modeling, thermal processes, electrical resistance, evaporation, thermodynamics, energy efficiency.*

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Study of bending vibrations of a thin elastic circular insert and their effect on stress concentration in an unconfined environment

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Abstract. *The paper investigates the bending vibrations of a thin elastic circular insert in an unconfined medium and performs a numerical analysis of stress concentration near the inclusion under the action of a harmonic normal load. The influence of the ratio of the elastic properties of the matrix and the inclusion on the value of the stress intensity factor (SIF) is established. It is shown that with a decrease in the stiffness of the inclusion, the dependence of SIF on the wave number becomes more complicated, exhibiting multiple maxima and minima, and taking into account the elasticity of the inclusion significantly changes both the value of SIF and the nature of its dependence on the wave number. The possibility of approximating highly rigid inclusions as absolutely rigid in practical calculations for various material combinations is assessed.*
Keywords: *bending oscillations, an unbounded elastic body (matrix), elastic circular inclusions.*

Introduction. Contemporary challenges in dynamic fracture mechanics, along with the need to enhance nondestructive testing and flaw detection techniques, call for continued development of methods to analyze the dynamic interaction of thin-walled inclusions with their surroundings [1]. A particularly significant case involves circular (disk-shaped) inclusions. This is largely because thin, disc-like reinforcing elements are commonly found in machine components and building structures. Such thin inclusions act not only as stress concentrators but also as fillers in composite materials. In the fabrication of composites, the matrix is frequently reinforced with coin-shaped elements of high stiffness [2]. Consequently, these types of inclusions have consistently been the focus of considerable research attention. The aim of this study is to examine the bending vibrations of a thin elastic circular inclusion within an unbounded medium, with the goal of eventually determining the elastic modulus ratios for a wide range of materials.

Research results. The issue of bending vibrations of a thin circular elastic plate inclusion is addressed (Fig. 1). These oscillations are induced by the application of a normal harmonic load on the inclusion.

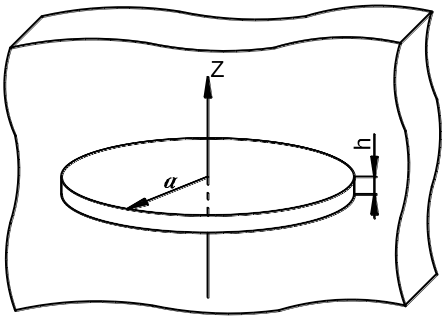


Fig. 1. Image of a round elastic plate

Let us examine the results of a numerical analysis of stress concentration around the inclusion, conducted under the assumption that the inclusion is subjected to a uniformly distributed load. In this context, the expressions for the load function acting on the inclusion are as follows:

$$f(y)=\frac{1}{2\pi}\int_{-1}^{1}S(\zeta)F(\zeta,y)d\zeta\,;\,S(y)=\frac{P_0(ay)}{a\mu_1};\,P_0(\tau)=\int_{r}^{a}\frac{rp(r)}{\sqrt{\tau^2-r^2}}\,.$$

Need to put

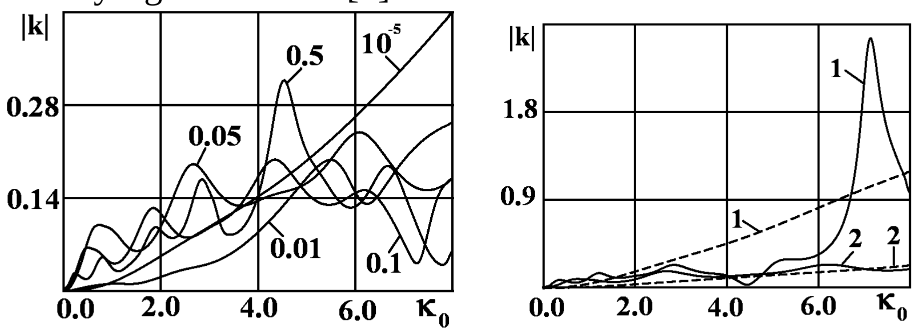
$$S(y)=\frac{P_0}{\mu_1}\sqrt{1-y^2}\,.$$

It was also assumed in the calculations that $\varepsilon=0{,}05$, and in the systemlinear algebraic equations

$$\frac{1+\xi^2}{4}g_k+\frac{1}{2\pi}\sum_{m=1}^{n}A_m g_m\left[Q(y_m-y_k)-F(y_m,y_k)\right]=i\alpha_0,$$

up to 30 interpolation nodes were used, which ensured obtaining RIF values with a relative error of less than 0.1% for the entire wavenumber range.

The stress intensity factor (SIF) values are influenced by the ratio of the elastic properties of the matrix and the inclusion, including their densities, elastic moduli, and Poisson’s ratios. To investigate the effect of inclusion stiffness on the SIF, it was assumed that the inclusion and the matrix share the same density and identical Poisson’s ratios. The results are presented as graphs in Fig. 2(a), with each curve representing a specific ratio of the elastic moduli. One of the curves exactly coincides with that of a perfectly rigid inclusion [3].



a) b)

Fig. 2. Research results

Analysis of the graphs indicates that as the rigidity of the inclusion decreases, the relationship between the SIF and the wave number becomes more complex, exhibiting multiple minima and maxima. Overall, a reduction in inclusion stiffness leads to a decrease in stress concentration around it. However, even for very stiff inclusions, the SIF at certain frequencies can exceed the values corresponding to a perfectly rigid inclusion.

To assess whether highly rigid inclusions can be approximated as absolutely rigid in practical strength calculations, the recovery factor was calculated for several specific material combinations. The results are shown in Fig. 2(b). Solid curves account for the elasticity of the inclusion, while dashed curves assume the inclusion is perfectly rigid. Curves 1 correspond to concrete as the matrix and steel as the inclusion, whereas curves 2 represent a steel inclusion in a lead matrix. It is evident that considering the inclusion’s elasticity significantly alters both the magnitude of the SIF and its dependence on the wave number.

Conclusion. The study analyzed the bending vibrations of a thin elastic circular insert in an unconfined environment and performed a numerical analysis of the stress concentration near it. It was found that the values of the stress intensity factor (SIF) depend on the ratio of the elastic properties of the matrix and the inclusion, in particular, the density, elastic moduli, and Poisson's ratios.

The study showed that with a decrease in the stiffness of the inclusion, the dependence of SIF on the wave number becomes more complicated, exhibiting numerous minima and maxima. In general, a decrease in stiffness leads to a decrease in the stress concentration in its vicinity, but even for very stiff inclusions at certain frequencies the SIF can exceed the value for an absolutely stiff inclusion.

An assessment of the possibility of approximating highly stiff inclusions as absolutely stiff in practical calculations showed that taking into account the elasticity of the inclusion significantly affects the value of SIF and the nature of its dependence on the wave number for various material combinations, in particular for concrete with steel inclusions and steel in a lead matrix.

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Анотація. *У роботі досліджено згинальні коливання тонкої еластичної круглої вставки в необмеженому середовищі та проведено чисельний аналіз концентрації напружень біля включення під дією гармонійного нормального навантаження. Встановлено вплив співвідношення пружних властивостей матриці та включення на значення коефіцієнта інтенсивності напружень (SIF). Показано, що зі зменшенням жорсткості включення залежність SIF від числа хвиль ускладнюється, проявляючи множинні максимуми та мінімуми, а врахування пружності включення суттєво змінює як величину SIF, так і характер його залежності від числа хвиль. Проведено оцінку можливості апроксимації високо-жорстких включень як абсолютно жорстких у практичних розрахунках для різних матеріальних комбінацій.*

Ключові слова: *згинальні коливання, необмежене пружне тіло (матриця), пружні кругові включення.*

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