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旋转悬臂梁的刚柔耦合动力学建模与频率分析

Rigid-flexible coupling dynamic modeling and frequency analysis of a rotating cantilever beam

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中文关键词: 悬臂梁 刚柔耦合 一次近似耦合模型 一次近似简化模型 频率分析

英文关键词:cantilever beam rigid-flexible coupling first-order approximation coupling(FOAC) model first-order approximation simplified(FOAS) model frequency analysis

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作者	单位	E-mail
方建士	南京工程学院 材料工程学院, 南京 211167;南京理工大学 理学院, 南京 210094	zhangdg419@mail.njust.edu.cn
章定国	南京理工大学 理学院, 南京 210094	

中文摘要:

对固结于转动刚体上外接柔性梁的刚柔耦合动力学建模和频率特性进行了研究,在精确描述柔性梁非线性变形的基础上,利用Hamilton变分原理和假设模态法,在计入柔性梁由于横向变形而引起的轴向变形二阶耦合量的条件下,推导出考虑"动力刚化"项的一次近似耦合模型。首先忽略柔性梁纵向变形的影响,给出一次近似简化模型,引入无量纲变量,对简化模型做无量纲化处理,分析梁固有频率对模态截断数的依赖性;其次研究在一次近似简化模型和零次近似简化模型下,调谐角速度与共振现象的关系;最后分析一次近似耦合模型的动力特性。研究发现,为保证计算的精度,模态截断数应随无量纲角速度的增大而增加,合理的模态截断数具有收敛值;一次近似简化模型下悬臂梁横向弯曲振动不存在共振调谐角速度,一次耦合模型下柔性梁并没有出现屈曲失稳现象。现有典型文献的相关结论是值得商榷的。

英文摘要:

The rigid-flexible coupling dynamics and frequency analysis of a cantilever beam attached to a rotating hub is studied.Based on the accurate description of non-linear deformation of the flexible beam,the first-order approximation coupling(FOAC) model with the dynamic stiffening terms are derived from Hamilton theory and assumed mode method,taking the second-order coupling quantity of axial displacement caused by transverse displacement of the beam into account.The first-order approximation simplified(FOAS) model which neglects the effect of axial deformation of a beam is presented.The simplified model is transformed into dimensionless form in which dimensionless parameters are identified.Firstly,the dependence of natural frequency of a flexible beam on number of modes is analyzed.Then,the relation between the tuned angular speed and the resonant phenomenon is studied.Finally,the dynamic characteristic of the first-order approximation coupling model is analyzed.Generally,as the dimensionless angular speed increases,the used number of modes should increase properly to obtain the adequate accuracy,and it has a convergent value.There is no tuned angular speed of a cantilever beam in the first-order approximation simplified model.And there is also no the so called buckling unstable phenomenon.The results in the typical existing references are arguable.