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不同流向下低质量比方形四立柱涡激运动特性研究

Study on vortex induced characteristics of four square columns with lowmass ratio under different flow approach

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中文关键词: 方形四立柱 涡激运动 数值模拟 动网格

英文关键词:four square columns vortex-induced motion numerical simulation dynamic mesh

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中文摘要:

本文采用有限体积法对方形四立柱涡激运动进行数值模拟。方形四立柱涡激运动系统简化为两自由度的质量-弹簧-阻尼模型,引入雷诺平均应力模型求解不可压缩粘性Navier-Stokes方程,并结合SST 湍流模型对低质量比弹性支撑的方形四立柱涡激运动进行模拟。将四阶Runge-Kutta代码嵌入用户自定义函数UDF(User Defined Function)中求解四立柱的动力响应,采用动网格技术来实现立柱和流场之间的耦合。研究发现：0_O来流工况下的流向振幅和横向振幅最小,15_O来流方向下的工况的流向振幅最大,在折合速度为11.0时达到了最大值1.60D,是0_O来流方向最大值的5倍。横向振幅的最大值出现在30_O来流方向下折合速度为12.0时,其值为2.15D,大小是0_O来流方向最大幅值的3倍多。4种不同来流角度下的平衡位置随着折合速度的增大而增大。不同来流方向下方形四立柱升力系数的主频率随着折合速度的变化趋势不相同。最后本文对不同折合速度下方形四立柱运动轨迹和尾涡脱落模式进行讨论分析。

英文摘要:

In this paper, the finite volume method is used to simulate vortex-induced motion of four circular columns. The vortex-induced motion system of four circular columns is simplified into spring-mass-damping model. Reynolds-Averaged Navier-Stokes solver combined with the SST (Shear-Stress Transport) k-ω turbulence model for the Navier-Stokes equation has been used to simulate the vortex induced motion at low mass ratio. Fourth order Runge-Kutta method was manually written into the User Defined Functions to solve the dynamic response of four circular columns, and then dynamic mesh technology was adopted to resolve the coupling fluid structure interaction. It is found that the stream-wise and transverse amplitude of 0 degree is minimal, but the stream-wise amplitude of 15 degree is maximum. The maximum amplitude is 1.60D when the reduced velocity reaches11.0, which is 5 times larger than that of 0 degree. The maximum transverse amplitude appear at reduced velocity of 12.0 from 30 degree flow, and the value is 2.15D that is 3 times lager than the tranverse amplitude of 0 degree.In-line balance position of square column increase with the increase of reduced velocity from four different flow approaching angles. The changing treand of main frquency of lift coefficient is not the same. Finally, the trajectory and vortex shedding pattern of four square columns at different velocities are discussed.

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