STABILITY ANALYSIS OF THE NON-LINEAR DYNAMICS OF CLAMPED CIRCULAR CYLINDRICAL SHELLS CONTAINING FLOWING FLUID

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Abstract: This study presents theoretical and experimental results on the non-linear dynamics and stability characteristics of a thin-walled clamped-clamped circular cylindrical shell containing inviscid incompressible flowing fluid. In the theoretical study the non-linear Donnell shallow shell theory, with structural damping, is used to describe the large-amplitude shell motion. The interaction between the flowing fluid and the shell structure is formulated with linear potential flow theory. The assumed deflection mode satisfies exactly the boundary conditions and the continuity condition of the circumferential displacement allowing for the existence of a traveling wave solution. The system is discretized using Galerkin's method and the time amplitude shell response is integrated using an arc-length continuation technique employed in the AUTO software. The aim of the experimental study was twofold: first, to gather for the first time important data points for the critical flow velocity for instability, maximum flexural displacement, and pre-buckling shell frequency; secondly, to analyze the experimental results and use them to validate the theoretical model. The experimental study involved two set-ups one containing a clamped-clamped silicone rubber shell and flowing air in internal and external flow configurations, and the second an aluminum shell and water as the flowing fluid. The interaction between the shell and the fully developed flow, in both cases, gives instability in the form of divergence at sufficiently high flow velocities. The experimental results show a softening type nonlinear displacement behavior with a large hysteresis in the velocity for the onset and cessation of divergence. Good agreement between the theoretical analysis and the experimental results is obtained for the natural frequency, the softening type of the non-linearity and the stability analysis of the shell systems.

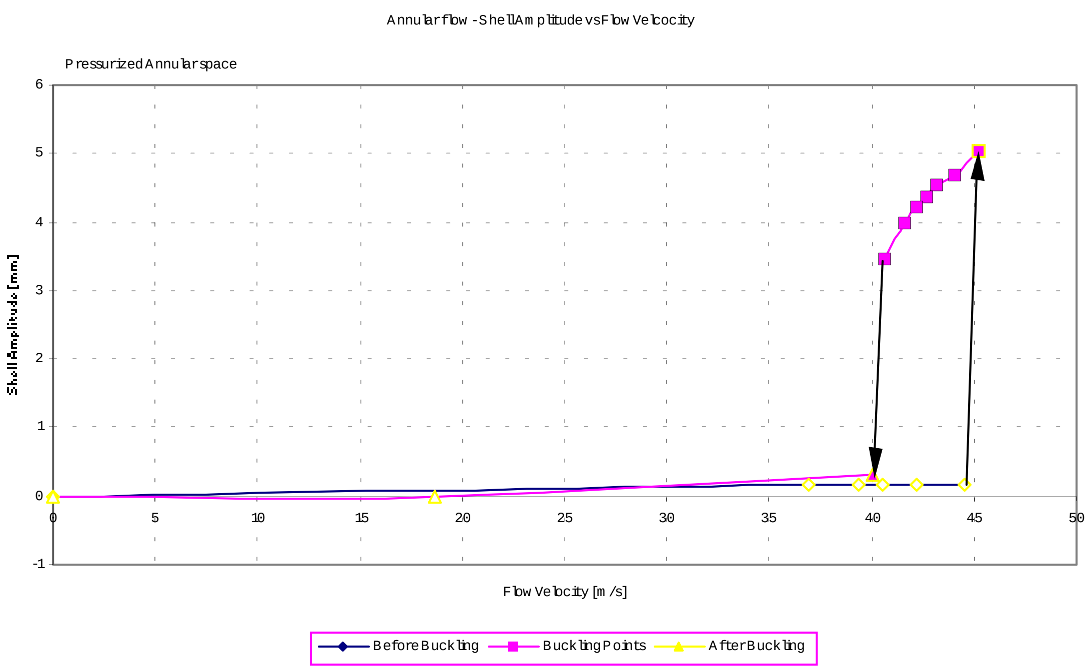

Figure 1: Experimental results showing shell amplitude versus flow velocity for a rubber-shell in external air flow configuration.

References

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