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# Increment of Panel Flutter Margin Using Adaptive Stiffeners

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**Abstract :** Fluid-structure interaction is a crucial consideration in the design of many engineering systems such as flight vehicles and bridges. Aircraft lifting surfaces and turbine blades can fail due to oscillations caused by fluid-structure interaction. Hence, it is focussed to study the fluid-structure interaction in the present research. First, the effect of free vibration over the panel is studied. It is well known that the deformation of a panel and flow induced forces affects one another. The selected panel has a span 300mm, chord 300mm and thickness 2 mm. The project is to study, the effect of cross-sectional area and the stiffener location is carried out for the same panel. The stiffener spacing is varied along both the chordwise and span-wise direction. Then for that optimal location the ideal stiffener length is identified. The effect of stiffener cross-section shapes (T, I, Hat, Z) over flutter velocity has been conducted. The flutter velocities of the selected panel with two rectangular stiffeners of cantilever configuration are estimated using MSC NASTRAN software package. As the flow passes over the panel, deformation takes place which further changes the flow structure over it. With increasing velocity, the deformation goes on increasing, but the stiffness of the system tries to dampen the excitation and maintain equilibrium. But beyond a critical velocity, the system damping suddenly becomes ineffective, so it loses its equilibrium. This estimated in NASTRAN using PK method. The first 10 modal frequencies of a simple panel and stiffened panel are estimated numerically and are validated with open literature. A grid independence study is also carried out and the modal frequency values remain the same for element lengths less than 20 mm. The current investigation concludes that the span-wise stiffener placement is more effective than the chord-wise placement. The maximum flutter velocity achieved for chord-wise placement is 204 m/s while for a span-wise arrangement it is augmented to 963 m/s for the stiffeners location of ¼ and ¾ of the chord from the panel edge (50% of chord from either side of the mid-chord line). The flutter velocity is directly proportional to the stiffener cross-sectional area. A significant increment in flutter velocity from 218m/s to 1024m/s is observed for the stiffener lengths varying from 50% to 60% of the span. The maximum flutter velocity above Mach 3 is achieved. It is also observed that for a stiffened panel, the full effect of stiffener can be achieved only when the stiffener end is clamped. Stiffeners with Z cross section incremented the flutter velocity from 142m/s (Panel with no stiffener) to 328 m/s, which is 2.3 times that of simple panel.

**Keywords :** stiffener placement, stiffener cross-sectional area, stiffener length, stiffener cross sectional area shape
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