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Aerodynamic Design of Three-Dimensional Bellmouth for Low-Speed Open-Circuit Wind Tunnel

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Abstract : A systematic parametric study to find the optimum bellmouth profile by relating geometric and performance parameters to satisfy a set of specifications is reported. A careful aerodynamic design of bellmouth intake is critical to properly direct the flow with minimal losses and maximal flow uniformity into the honeycomb located inside the settling chamber of an indraft wind tunnel, thus improving the efficiency of the entire unit. Design charts for elliptically profiled bellmouths with two different contraction ratios (9 and 18) and three different test section speeds (25 m/s, 50 m/s, and 75 m/s) were presented. A significant performance improvement - especially in the Coefficient of discharge and in the flow angularity and boundary layer thickness at the honeycomb inlet - was observed when an entry corner radius (r/D = 0.08) was added to the bellmouth profile. The nonuniformity at the honeycomb inlet drops by about three times (~1% to 0.3%) when moving from square to regular octagonal cross-section. An octagonal cross-sectioned bellmouth intake with L/d = 0.55, D/d = 1.625, and r/D = 0.08 met all the four target performance specifications and is proposed as the best choice for a low-speed wind tunnel.

Keywords : bellmouth intake, low-speed wind tunnel, coefficient of discharge, nonuniformity, flow angularity, boundary layer thickness, CFD, aerodynamics
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