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Critical Reynolds number for onset of oscillatory flow around Ahmed body of slant angle 31 degree

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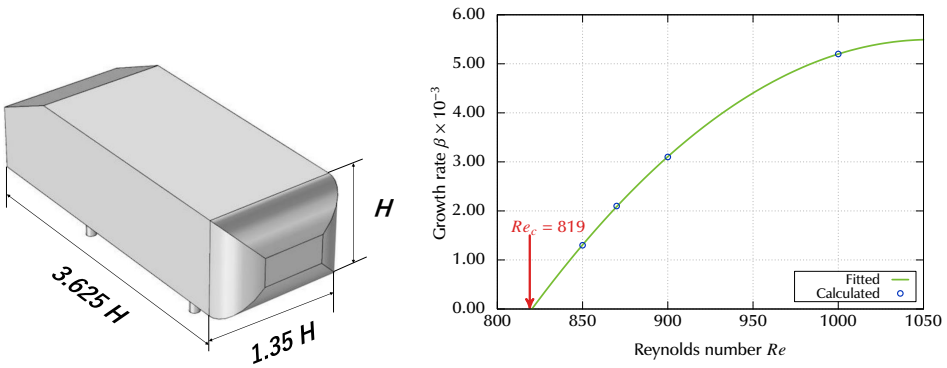
The Ahmed body is one of the most widely studied vehicle models in basic research on aerodynamic and drag-reduction for automobiles. Aerodynamic drag on the Ahmed body may change suddenly at slant angle $\theta = 30°$, due to a transition of the flow[*1]. This transition has been observed by the experiment for a Reynolds number of $Re = \mathcal{O}\left(10^4\right)$ or higher, whereas no past numerical research has reproduced the transition of the flow. For such a high Re, direct numerical simulations require a huge number of computational grids to resolve the boundary layer flow and small vortices. Several components that are involved in the flow at a higher Re, such as trailing vortices and the separation-reattachment flow, possibly take place even for the low-Reynolds number conditions. In order to clarify this question, the authors' research group has carried out the series of three-dimensional numerical simulations. The critical Reynolds number for the slant angle $\theta = 29°$ and the mechanism of the oscillatory flow have been reported [*2]

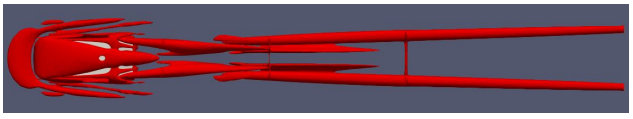
In the present study, a three-dimensional unsteady flow around the Ahmed body of the slant angle 31° for low Reynolds number is numerically investigated. The critical Reynolds number was calculated as $Re_c = 819$, and the Strohal numbers and the structure of the oscillatory flow were investigated. The amplitude of the oscillation was about half of that has been reported for 29°, whereas the oscillation was found to be extremely localized. At least the Renolds number range for $Re \leqslant 1000$, the flow can be regarded as almost steady, because the oscillatory component is small and localized.

[*1] S.R. Ahmed, G. Ramm, and G. Faltin, *SAE Paper 840300,* (1984).
[*2] M. Mikasa *et al.*,a *Trans. JSAE* **52***(6) p.1254 (2021).*

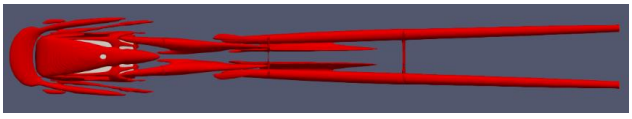


(a)　(b)

Fig.1: (a) Ahmed body. (b) Growth rate of the deviated flow component as a function of Reynolds number.



(a) $Q = 0.1$ for $\theta = 31°$, $\hat{t} = 0.0$



(b) $Q = 0.1$ for $\theta = 31°$, $\hat{t} = 0.5$

(c) $Q = 0.1$(red) and $Q = 0.05$(blue) for $\theta = 29°$, $\hat{t} = 0.0$

(d) $Q = 0.1$(red) and $Q = 0.05$(blue) for $\theta = 29°$, $\hat{t} = 0.5$

Fig.2: The contour surfaces of 2nd invariants of velocity gradient tensor Q.