Proceedings of the 9th World Congress on Mechanical, Chemical, and Material Engineering (MCM'23)
Brunel University, London, United Kingdom –August 06-08, 2023
Paper No. HTFF 175
DOI: 10.11159/htff23.175

Onset and Mechanism of the Oscillatory Flow around Ahmed Body of Slant Angle 31 Degrees

Yusuke Atsumi[1], Suguru Shiratori[2], Itsuhei Kohri[2], Hideaki Nagano[2] and Kenjiro Shimano[2]
[1] Graduate School of Integrative Science and Engineering, Tokyo City University
1-28-1 Tamazutsumi, Setagaya-ku, Tokyo, Japan
[2] Mechanical Systems Engineering, Tokyo City University
1-28-1 Tamazutsumi, Setagaya-ku, Tokyo, Japan
g2281002@tcu.ac.jp (Y. Atsumi); sshrator@tcu.ac.jp (S. Shiratori)

Extended Abstract

The flow around the Ahmed body, proposed by Ahmed et al. [1] has become a paradigm in fundamental fluid dynamics research from viewpoints of instability, drag reduction, and body shape optimization. The drag coefficient C_D of the flow around Ahmed body changes according to the angle θ of the slanted surface at the top-rear part of the body. In particular, C_D changes steeply at the slant angle θ , where the flow regime also changes at this angle. In vehicle body design, the slant angle θ is not preferable for the body design, because of the aerodynamic drag, increased fuel consumption, and driving stability. However, the mechanism of the sudden C_D change at θ has not been clarified. This phenomenon has been confirmed experimentally in high Reynolds number (Re) conditions above ^{4}, whereas it has not been reproduced in numerical simulations. In such high-Re flows, direct numerical simulations (DNS) require a huge amount of computational resources. Although the use of turbulence models can reduce the computational cost, it still remains the problem of the selection of the appropriate turbulence model. The author's research group focused on low-Re flow, which does not require the turbulence model. We have investigated the conditions when oscillatory flow takes place from the steady flow. It has been confirmed that oscillatory flow occurs at Re at θ [2]. However, the dependence of the slant angle θ on the critical Re has not been clarified. If we understand the transition mechanism to oscillatory flow at low Re, then this will contribute to our understanding of the θ transition at high Re.

To clarify this question, a three-dimensional numerical simulation of the flow around Ahmed body at the slant angle θ was carried out in the present study. For the case of θ , an oscillatory flow takes place at Re_c , nevertheless, the amplitude of the oscillation is very small and spatially localized. At further increased Reynolds number, a different type of oscillatory flow appears, and its amplitude and spatial extent are sufficiently large. The Reynolds number for the onset of this secondary oscillatory flow was predicted as a range of $Re \leq$. The mechanism of this secondary oscillatory flow was investigated from the viewpoint of the energy supply from the time-averaged field to the deviation field. Both of time-averaged field and energy supply field were qualitatively different from the case of θ . The time-averaged fields for both θ and are mainly composed of vortices shed from the side-top of the slanted surface and a vortex shed from the middle top of the body. The middle-top vortex of in the case of θ is stronger than that of the θ case. Concerning the energy supply from the time-averaged field to the deviation field, the strong energy supply was found in the middle top of the body for the case of θ . Besides the above-mentioned qualitative difference, the frequency of the oscillatory flows was considerably different. The Strohal number for θ is approximately 8 times larger than that for θ .

References

[1] S.R. Ahmed, G. Ramm and G. Faltim, "Some salient features of the time-averaged ground vehicle wake", SAE Technical Paper, No. 840300, 1984
[2] Masatoshi Mikasa, Suguru Shiratori, Itsuhei Kohri, Hideaki Nagano, Kenjiro Shimano, "Mechanism of Oscillatory Flow around the Ahmed Body at low Reynolds Numbers." Transactions of Society of Automotive Engineers of Japan. 2021, Vol.52, No.6, p.1254. (in Japanese)