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Comparison of the flow around rounded and sharp edges Ahmed bodies using hybrid RANS/LES turbulence models

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Abstract: Numerical simulations are performed and validated with experimental data in order to compare the flow around sharp and rounded edges 25° Ahmed bodies. Three different turbulence models SAS, DDES and SBES are computed. With a good choice of the model and the mesh property, the flow detachments and reattachments are well captured on the rear slant.

Keywords: Bluff body flows, hybrid methods, rounded and sharp edged 25° Ahmed bodies, turbulence.

1. Problem statement

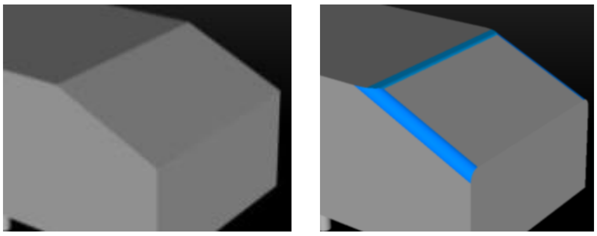
The aim of this work is to explore the efficiency of different improved RANS and hybrid LES/RANS approaches to study the external aerodynamics related to ground vehicles. Especially, these computational techniques should be able to build a bridge between accuracy and robustness in order to compute complex high Reynolds number bluff-body flows like ground vehicle flows. Bluff body flows are characterized by separated regions, containing wide spectra of turbulent scales. These regions, especially in the wake behind the body, are responsible for the main part of the drag forces. An accurate computation of these areas is a difficult task. Recently, different hybrid/modified models as DDES, SAS and SBES have been developed to take advantage from the RANS low computational time without totally losing the accuracy staying reasonably close to LES models. In order to get the best choice, the grid design is as critical as the model influence.

In this work DDES, SAS and SBES models with unstructured meshes are used to simulate the flow around two sharp and rounded edges 25° Ahmed bodies [1]. Comparing these two geometries is very interesting as, on one hand, they represent a complex flow detachment on the rear slant for the sharp edge case and on the other hand, this complexity can be sensibly smoothed by rounding appropriate edges of the same body.

2. Ahmed bodies description, grid and setup

2.1 Ahmed bodies description

Two different Ahmed bodies are used: a sharp one [1] and a rounded one [2]. These bluff bodies are illustrated in Fig. 1, on the left the Ahmed body with sharp edges and on the right, the Ahmed body with rounded edges at the roof junction and side edges (in blue).



(a) (b)

Fig. 1 (a) 25° Ahmed body with sharp edges and (b) 25° Ahmed body with rounded edges, in blue

2.2 Grids and computational setup

Applying industrial computational methodology implies the use of unstructured grids. Boundary layers are discretized using layers of prisms, based on triangle grid surface. The other part of the domain is composed of tetrahedron cells. Refinement boxes for tetrahedron cells are used in the wake of the body, especially close to the rear slant surface to capture flow separation. The grids contain respectively for sharp and rounded case, 22 and 19 million cells.
From the RANS family model, k-ω SST and SAS SST are used. The SAS is an improved RANS formulation, which allows the resolution of a part of the turbulent spectrum in unstable flow conditions. SAS formulation uses the von Kármán length scale to take into account the resolved turbulence scales, depending on the grid refinement. DDES and SBES are called “hybrid RANS/LES model”. In these approaches, the unsteady RANS models are employed in the boundary layers, while the LES treatment is applied to the separated regions. These models differ from the shielding function used for the switch between RANS and LES, to protect the boundary layer from LES intrusion. Furthermore, with SBES, LES model is not embedded in RANS model, and any combination of RANS and LES models could be used.

3. Results and discussion

CFD results are compared with experimental data from La Ferté Vidame (LFV) wind tunnel realized by Rossitto [2]. On the sharp case, SAS, DDES and SBES approaches show relevant results for drag and lift coefficients. Differences compared to experience give 2% on Cd and around 8% on Cl. With an appropriate grid refinement, the DDES approach presents the best results compared to experiments and demonstrates the importance of capturing the shear layer due to separation on the backlight. Moreover, the global wake flow is well captured with DDES and SBES turbulence models.

Considering the rounded case, aerodynamical coefficients are drastically reduced as shown by experiments. Drag and lift reductions, respectively of 16% and 18%, are observed. Indeed, the rounded edges at the roof junction suppress the bubble recirculation on the rear slant, resulting in pressure recovery over the slanted surface. Moreover, the intensity of longitudinal vortices is reduced, leading to drag and lift reduction.
Finally, in order to better understand the accuracy of numerical models, these results will be complemented with LES computations on the sharp edge case for the conference.

References

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