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Study and Optimize the Effects of Wall Y+ Values and Boundary Layer Mesh on Lift/Drag Values of Wings in Different Configurations

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ABSTRACT

In Computational Fluid Dynamics, the near wall flow region or boundary layer is represented using prism layer cells which are high aspect ratio orthogonal cells aligned to the surface (wall). Proper resolution of the boundary layer is essential to capture points of flow separation, reattachment, transition from laminar to turbulent flow, heat transfer, skin friction drag etc. This depends on factors such as number of prism layers, wall y+, prism layer total thickness etc (discussed later). It is necessary to increase these parameters in order to increase the accuracy of your simulations but there is a trade off. Increasing the number of prism layers (and hence reducing wall y+) and boundary layer mesh thickness tends to increase the cell size drastically which requires additional computational resources during meshing and running of the simulation. Hence it slows down the time between iterations significantly. Therefore, optimizing the boundary layer mesh is of key importance to students, amateurs, and enthusiasts etc who have access to very limited computational resources.

So focus of this focus of this paper is to study the effects of these parameters which affect the boundary layer mesh.

1. INTRODUCTION

In fluid dynamics, the law of the wall states that the average velocity of a turbulent flow at a certain point is proportional to the logarithm of the distance from that point to the "wall", or the boundary of the fluid region[1]. Wall y+ is the wall coordinate: the distance y to the wall, made dimensionless with the friction velocity u_τ and kinematic viscosity ν. It is generally preferred of keep wall y+ values under one where the turbulence model actually solves for the boundary layer and resolves the viscous sub layer. For values between one and five, relatively accurate results can be obtained but it uses a logarithmic fit to model the viscous sub layer. For values between five and thirty, neither law holds good and very large variations can be obtained. For higher than 30, the logarithmic law holds good but the viscous effects are not modelled in detail.

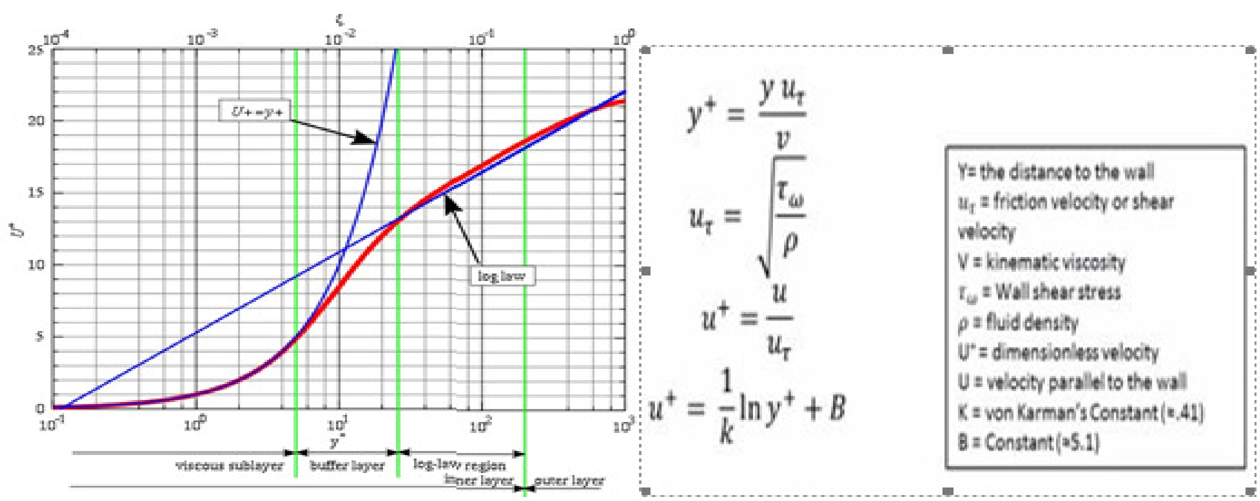

Fig. 1. Law of the Wall

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The boundary layer is the layer of fluid in the immediate vicinity of a bounding surface where the effects of viscosity are significant [2]. For good results, it is necessary for the thickness of the prism layers to capture the entire boundary layer. There is no perfect method to calculate the boundary layer thickness of a wing as it varies along the chord and at different angles of attack.

So the following sections detail the effects of wall y+ and prism layer thickness on a wing in different configurations aimed at optimizing these parameters.

2. EXPERIMENTAL SETUP

The simulations have been carried on a straight wing with the eppler423 airfoil with a chord length of 250mm and wing span of 1250mm. This is based on something a student, amateur or enthusiast may typically use in a car or R/C Plane. The wing has been tested in three configurations 1) At 0 degree angle of attack 2) At 12 degrees Angle of Attack where flow separation begins to occur and 3) Upside down in ground effect with a 40% flap. The idea being that the thickness of the boundary layer and cell size needed to resolve it increase in each case

All simulations have been carried out on STAR CCM+ V9.06.009 on a computer with Intel i5-3330 CPU 3.00GHz with 4GB RAM. The procedure followed and settings used are on the basis of the best practices mentioned in the STAR CCM+ User Guide [3] and YouTube Channel [4]-

The simulations were carried out in a “bullet shaped” domain corresponding to 10 wing lengths or 12500mm size. The steady state RANS approach was used with the Standard Realizable kE model with all y+ wall treatment.

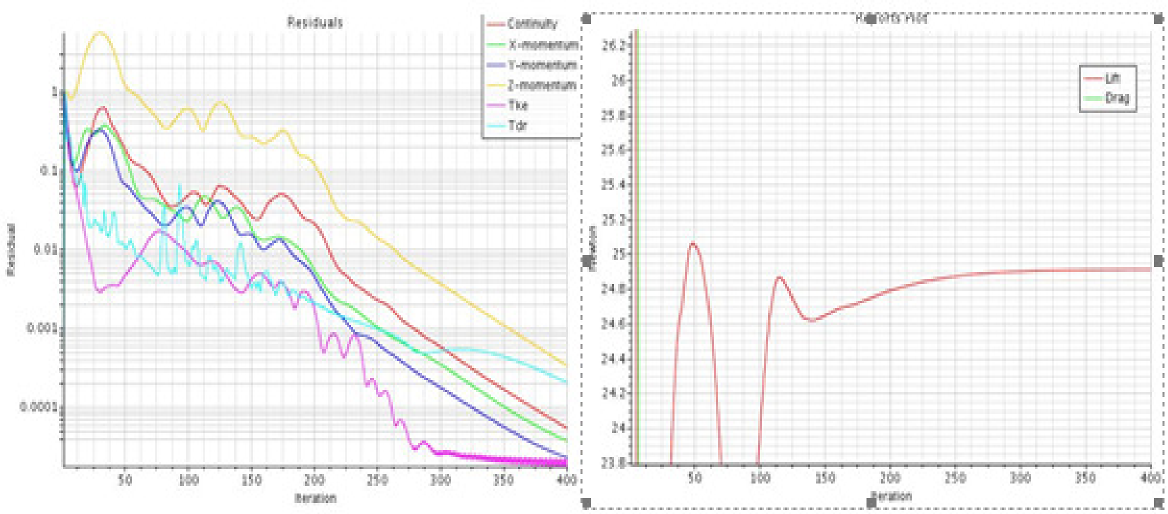

Fig. 2. Residuals and Lift Plots

Mesh consisted to trimmer cells with a base size of 15mm with leading, trailing edge and wake refinements with a volumetric refinement for the wing tip (in order to capture the wing tip vortices). Results were only accepted after convergence of at least 5 degrees of magnitude of all the residuals and stabilization of the variables.

3. EFFECTS OF WALL Y+

Three cases have been considered for each configuration- 1)

4. RESULTS

The values of wall y+ do not have a major effect on lift/drag values especially in cases of attached flow. Hence high wall y+ values with lower cell counts can be used when high accuracy is not of major importance and time for design iterations and simulations is less.

REFERENCES

[1] Law of the Wall, Wikipedia.com, 2015. https://en.wikipedia.org/wiki/Law_of_the_wall (Accessed on August 1, 2015).

[2] Boundary layer, Wikipedia.com, 2015. https://en.wikipedia.org/wiki/Boundary_layer (Accessed on August 1, 2015).

[3] STARCCM+UserGuide Best Practices Guidelinesfor Aerodynamics Calculations > Incompressible External Aerodynamics: Steady State RANS ApproachSteady State RANS Approach

[4] Star CCM+ YouTube Channel https://www.youtube.com/watch?v=xKqN1T6NoIY