Aerodynamic Analysis of a Ski Jumper: A CFD Approach

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Abstract

At the 2006 Winter Olympics, the jump length difference between first and second place was only 5cm. This illustrates why ski jumpers are constantly tinkering with their posture in order to gain even the smallest of advantages. Experiments such as those shown in Figures 1 and 2 (b), conducted with ski jumpers in large-scale wind tunnels showed that even small changes in position can lead to marked changes of the lift and drag areas. These comprehensive experiments in large-scale wind tunnels involving very detailed modifications, however, involve excessive measurement time and costs, and require that world-class athletes be available for unreasonably long periods (Meile et al., 2006).

Commercial CFD simulation tools are being utilized as an alternative to wind tunnel measurements to predict flow field and evaluate aerodynamic forces for sporting applications. The Magnus Effect of a soccer ball was illustrated by Fontes (2014) and conventional swing of a cricket ball was modelled by Latchman and Pooransingh (2015). Meile et. al (2006) investigated the possibility of using CFD as an alternative for optimizing lift and drag of ski jumpers. The comparison of the simulation and experimental results showed poor agreement. They explained that the difference in results could be as a result of too coarse a mesh or the unsuitability of k-ϵ turbulence model used. They recommended that further work using more advanced turbulence models and refined meshes was required. It must also be noted that the human body model used (Figure 3), consisted of geometrically simple bodies, prismatic in nature. The geometrical difference between the model used and the actual human body may also account for discrepancies in the results.

Using SOLIDWORKS®, a computational model of the human body (together with skis) that is similar to that shown in Figure 2 (a) is developed. This model has the functionality to vary the angles shown in Figure 3. The angles are as follows: angle of attack of the skis, α, body to ski angle, β, hip angle, γ and angle of the skis to each other, V. The human body model is imported into the COMSOL Multiphysics® software and suitably positioned within a prescribed computational domain. Using the various turbulence models within the CFD Module of the COMSOL® software, the flow fields and aerodynamic forces will be evaluated for varying angles of α, β, γ and V, as well as varying velocities of the ski jumper through air.

The results of the simulations will be compared to the experimental results conducted on the model shown in Figure 2 (a). The analysis will show how the various turbulence models compare against each other for this application. It will also determine whether the CFD

Module of the COMSOL Multiphysics® software could be used to give a ski jumper the extra advantage that could be used to win a gold medal.

Reference

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Figures used in the abstract

Figure 1: Wind tunnel analysis of a ski jumper during the in-run phase. (Muller, 2008)

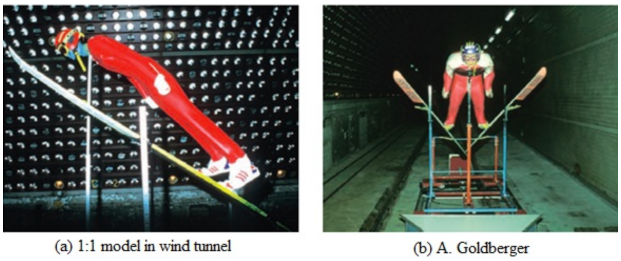

Figure 2: (a) Large scale wind tunnel measurements using a 1:1 model of a ski jumper (b) Wind tunnel measurements with A. Goldberger (Muller, 2008)

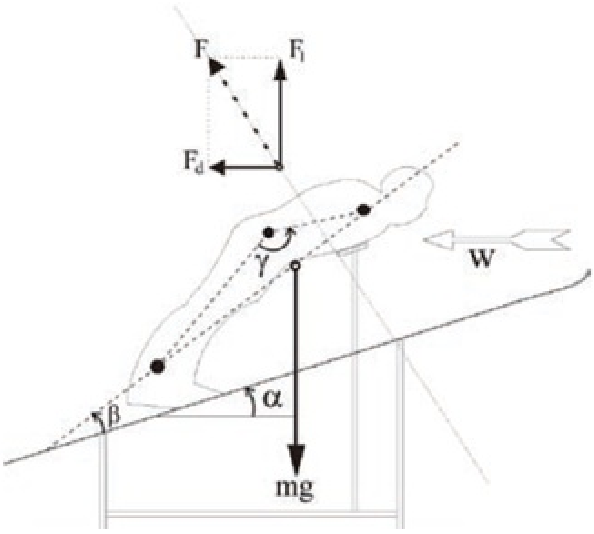

Figure 3: Schematic showing the nomenclature of the position angles (Muller, 2008)

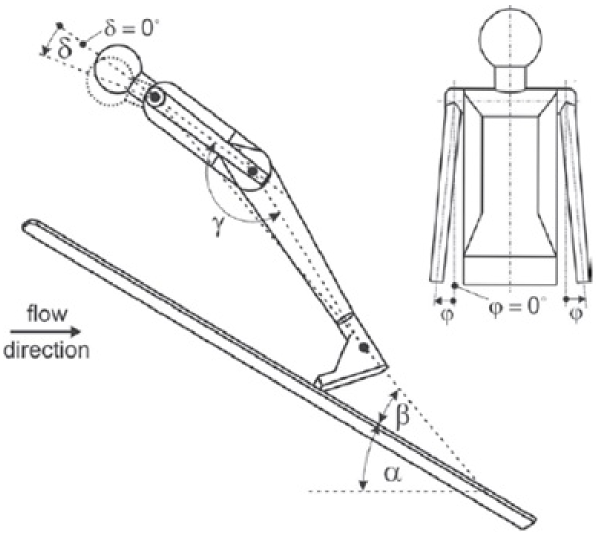

Figure 4: Human body model comprising geometrically simple bodies (Meile et. al, 2006)