Project proposal template
Graduate School studentships
March 2015

Project title	Drag reduction mechanism in turbulent flow over hydrophobic coating surface	
First Supervisor	Professor	Jian Wang
Second Supervisor	Dr Sing Lo	
School	Aerospace and Aircraft Engineering	
Other member of supervisory team (no more than three KU supervisors in total)	Dr Peter Barrington	
Specific requirements beyond 2:1 degree	1st or 2:1 Plus MSc	

Project summary

(max 4,000 characters)

The efficiency and economic performance of modern transportation methods like aircrafts, ships and cars, have a close relationship with the drag reduction in boundary layer. Much work has been conducted on drag reduction in the boundary layer such as microbubble injection, addition of polymers, riblets and active blowing and suction. In recent years, great emphasis has been laid on the properties of drag reduction due to the appearance of hydrophobic surface or super-hydrophobic surface. Numerous studies have confirmed that the chemical treatment of the surface produces a slip length in the order of 1 , while a longer slip length up to 100 can be achieved through a combination of hydrophobic surface with hierarchical rough structure. It is conventionally implied that a longer slip length leads to greater drag reduction.

Although some research has demonstrated that the slip length depends on the shear rate at the wall, most numerical simulations assume that the slip length is independent of shear rate, which is reasonable in a moderate shear rate. To investigate the drag reduction effects on hydrophobic surface with slip boundary condition, DNS is the most frequently used method. However, the computational cost for DNS is high as it theoretically requires the mesh size to be smaller than the local Kolmogorov scale. This can result in a very big mesh size, especially for the case of high Reynolds number. In such situations, the grid size may be beyond the computational capacity of the available resources. Hence, DNS is more suitable for low-Reynolds-number flow with a small computational domain. There are great demands for low-cost numerical methods such as Large Eddy Simulation (LES) and has received a lot of attention lately.

The purpose of the current proposal is to validate the slip boundary condition on hydrophobic coating surface and to study the physics of drag reduction with a slip boundary condition, including:

1. A comprehensive review of the slip length theory, its development and applications on hydrophobic surface;
2. Comparison of slip and non-slip boundary conditions, validation of the slip boundary condition;
3. Perform LES numerical simulations incorporating the slip boundary condition.
4. Comparison of flow structure within the boundary layer with and without hydrophobic coating;
5. Research on the physics of drag reduction on hydrophobic coating boundary layer.

Supervisor team: Professor Jian Wang, Dr Sing Lo, Dr Peter Barrington