Modeling Conventional Swing of a Cricket Ball

R. Latchman A. Pooransingh
The University of the West Indies - St. Augustine
Department of Electrical and Computer Engineering, St. Augustine, Trinidad & Tobago

Introduction: The commercialization of cricket has increased the stakes for all involved. Conventional swing is one phenomenon which a bowler uses to gain an advantage over the batsman.

Conventional swing occurs as a result of asymmetric boundary layer separation. It is dependent on the following key parameters: ball velocity, seam angle and backspin on the ball.

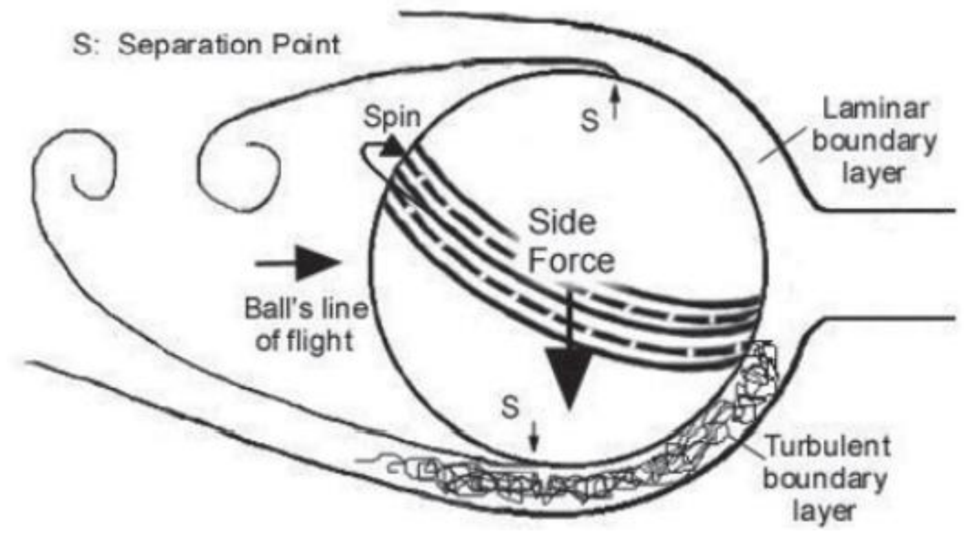

Figure 1. Schematic of flow over a cricket ball for conventional swing (Mehta 2008)

This study involves simulating conventional swing in the CFD module of COMSOL Multiphysics® and comparing the results with experimental results of previous researchers.

Computational Methods: A computational model of a cricket ball was placed at a distance of 150 mm from the inlet boundary of the computational domain (Figure 2). A multi-stage modeling strategy was implemented.

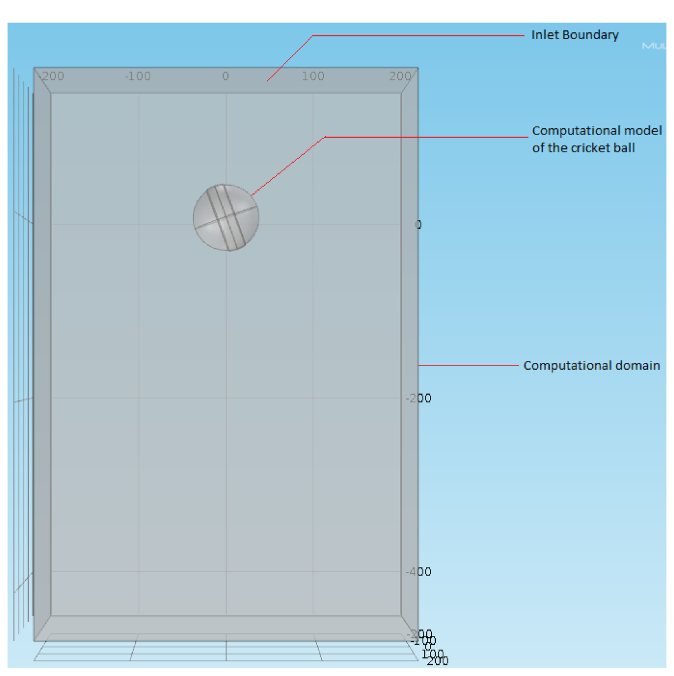

Figure 2. Computational model of the cricket ball positioned at 150 mm from the inlet boundary of the computational domain

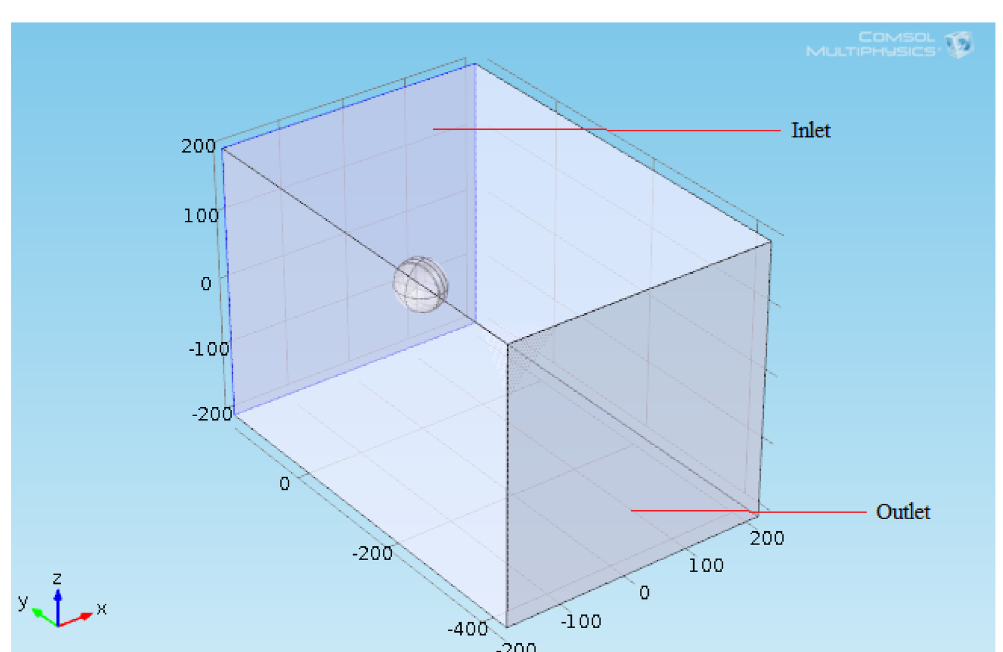

Figure 3. Inlet and outlet boundaries of the computational domain

The Turbulent Flow, k-ε interface was used to simulate the flow for a non-rotating ball while the Rotating Machinery, Turbulent Flow, k-ε interface was used for simulating flows in which backspin of the ball was considered.

Both interfaces solve the Navier Stokes equations.

The continuity equation that represents the conservation of mass:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{u}) = 0 \quad \text{.............................. (1)}$$

Vector equation that represents the conservation of momentum:

$$\rho \frac{\partial \boldsymbol{u}}{\partial t} + \rho(\boldsymbol{u} \cdot \nabla)\boldsymbol{u} = \nabla \cdot [-p\boldsymbol{I} + \tau] + \boldsymbol{F} \quad \text{...................... (2)}$$

Results:

Still Ball Flow Profile Analysis

2D Model

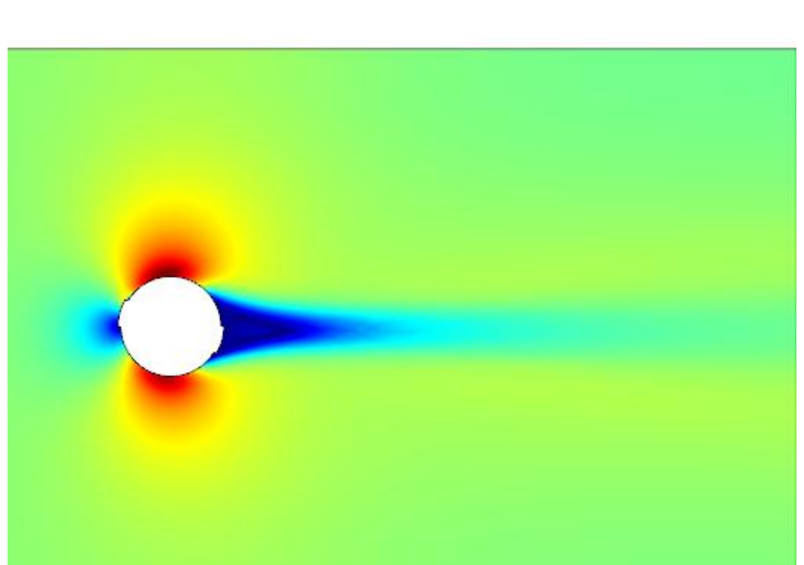

Figure 4. Velocity magnitude plot for 2D model

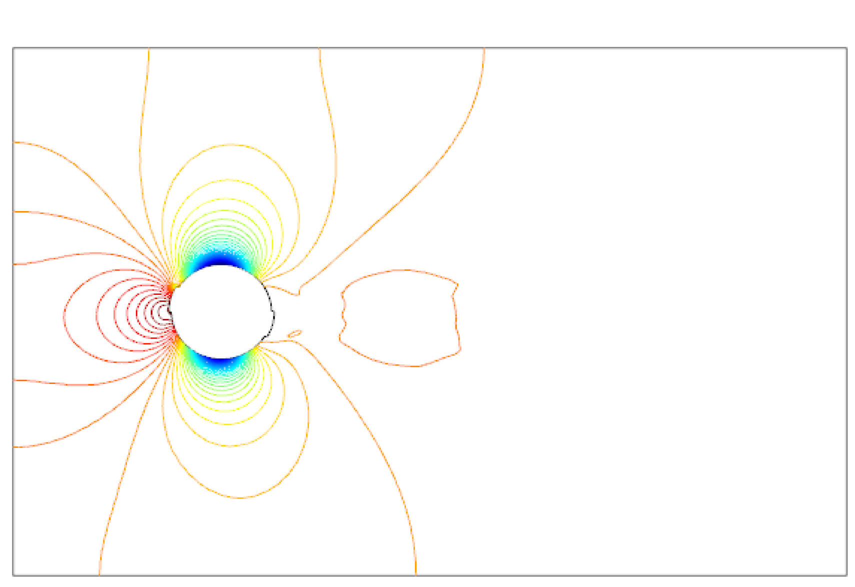

Figure 5. Pressure contour plot for 2D model

3D Model

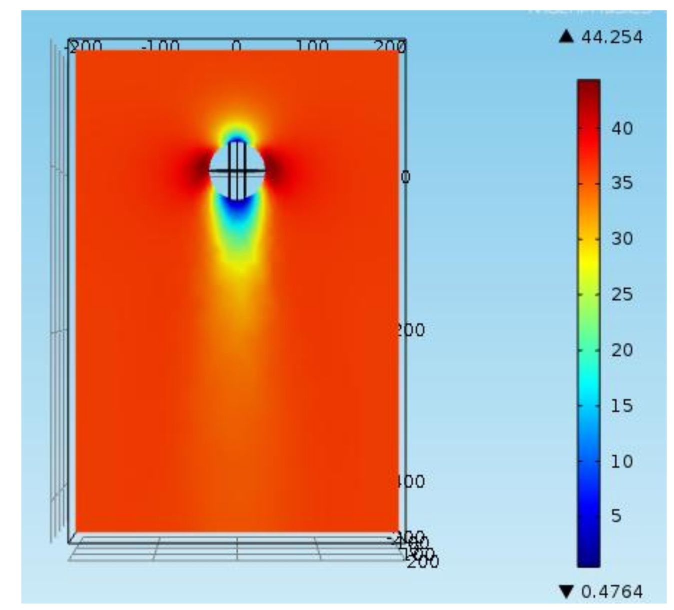

Figure 6. Velocity magnitude plot for a still ball at a seam angle of 0°

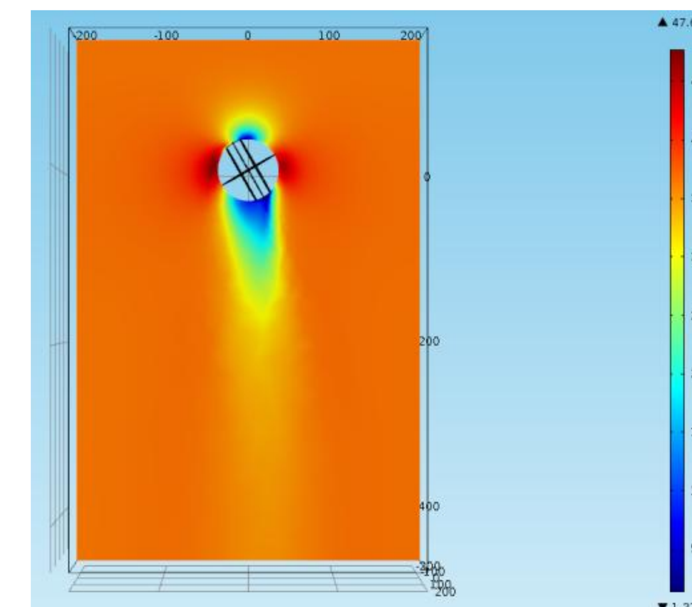

Figure 7. Velocity magnitude plot for a still ball at a seam angle of 20°

Still Ball Force Analysis

	Side Force / N			Side Force Coefficient, C_S		
Seam Angle	10°	20°	30°	10°	20°	30°
Vel. / mph						
50	0.131	0.255	0.467	0.109	0.213	0.390
55	0.159	0.308	0.565	0.110	0.213	0.390
60	0.189	0.365	0.672	0.110	0.212	0.390
65	0.222	0.429	0.789	0.110	0.212	0.390
67	0.236	0.455	0.838	0.110	0.212	0.390
70	0.257	0.497	0.915	0.110	0.212	0.390
75	0.314	0.570	1.050	0.117	0.212	0.390
80	0.336	0.649	1.194	0.110	0.212	0.390
85	0.379	0.733	1.349	0.110	0.212	0.390
90	0.425	0.820	1.513	0.110	0.212	0.390
95	0.473	0.915	1.685	0.109	0.212	0.390
100	0.524	1.012	1.868	0.109	0.211	0.390

Table 1 . Side force and side force coefficients for varying seam angles and ball velocity

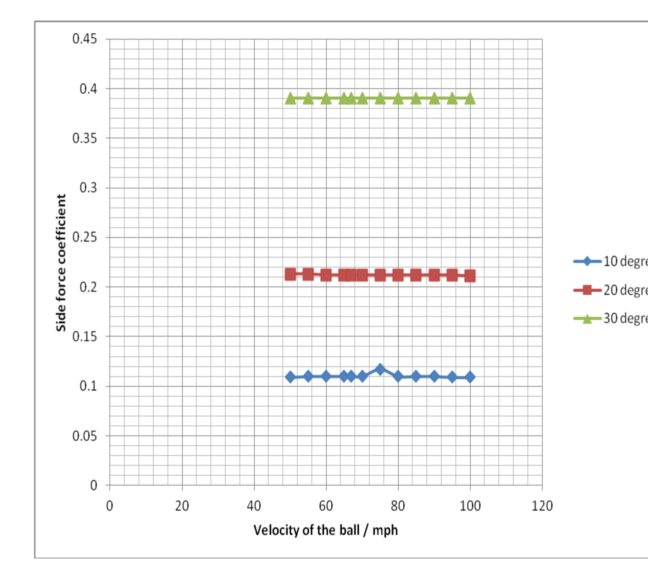

Figure 8. Graph showing the variation of the side force coefficient for differing velocities and seam angles

Rotating Ball Flow Profile Analysis

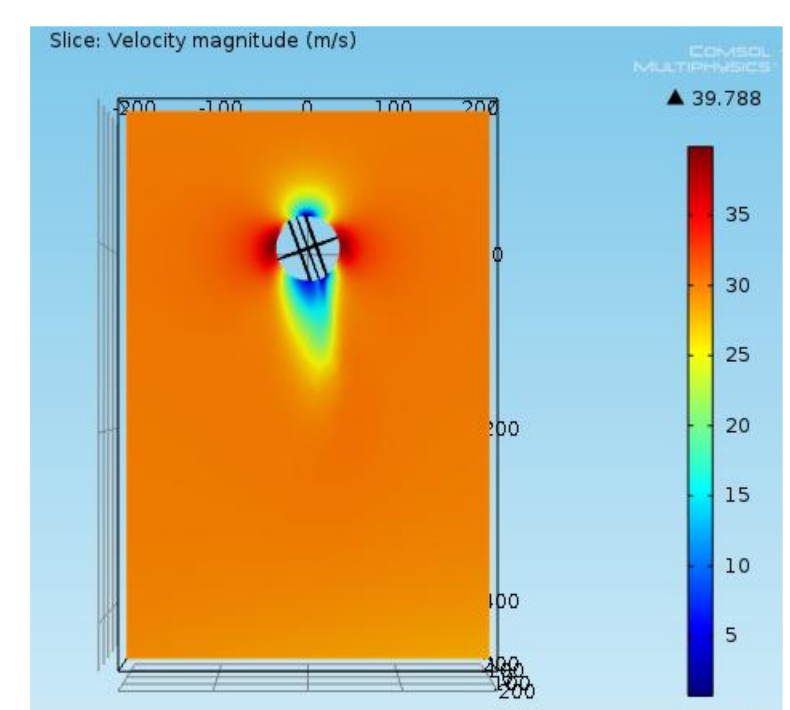

Figure 9. Velocity magnitude plot showing the flow profile for a ball velocity of 67mph, seam angle of 20° and backspin rate of 11.4 rev/s

Rotating Ball Force Analysis

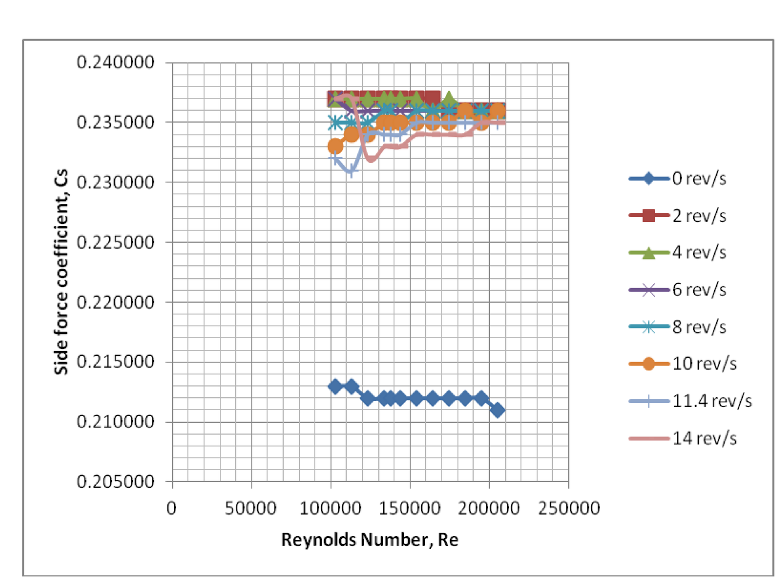

Figure 10. Graph showing the variation of the side force coefficient for varying backspin rates for a seam angle of 20°

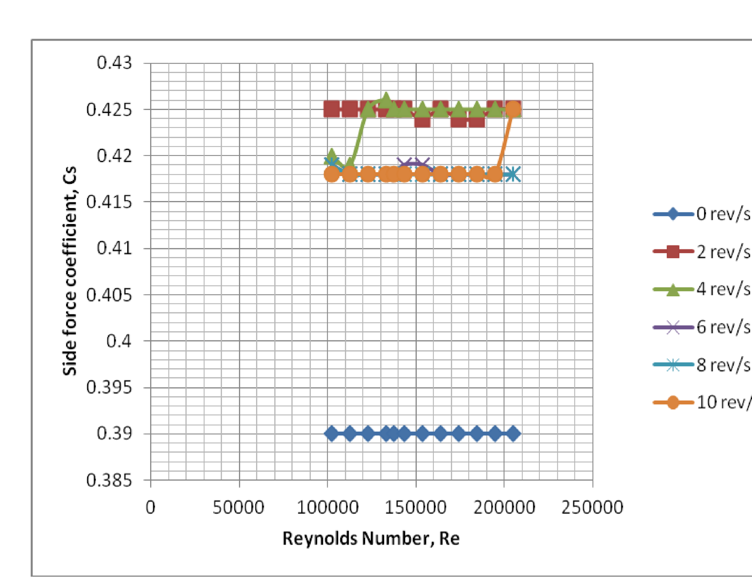

Figure 11. Graph showing the variation of the side force coefficient for varying backspin rates for a seam angle of 20°

Conclusions:
- ❑ Moderate agreement with experimental research, namely the flow velocity profile and increase in side force coefficient with backspin.
- ❑ In the simulations conducted, no case showed an expected transition region.
- ❑ The k-ε turbulence model may not be suitable for this application or the model constants need to be redefined.
- ❑This study will allow the cricket community better understand the phenomenon of conventional swing and can be an integral part in the development of a conventional swing training aid.

References:

1. R. M. P. S. Bandara and N. S. Rathnayaka, Modelling of Conventional Swing of the Cricket Ball using Computational Fluid Dynamics, *KDU International Symposium 2012*, 447- 457 (2012)
2. Rabindra Mehta, Sports ball aerodynamics, Springer Vienna, USA (2008)

Excerpt from the Proceedings of the 2015 COMSOL Conference in Boston