Graduate Research in Engineering and Technology (GRET)

Volume 1
Issue 5 *Reviews on Modern Technologies for Aircraft and Aero-Engines.*

Article 10

April 2022

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Recommended Citation

Shanker, shiva; sai vamshidher, ramagiri; and sandeep, potlapalli (2022) "Aerodynamics of cricket ball," *Graduate Research in Engineering and Technology (GRET)*: Vol. 1: Iss. 5, Article 10.
DOI: 10.47893/GRET.2022.1091
Available at: https://www.interscience.in/gret/vol1/iss5/10

Aerodynamics of a cricket ball

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Abstract

This paper describes experiments performed on stationary cricket ball to determine the aerodynamic forces acting on the ball over a range of bowling speeds. Co-efficient of drag was measured directly and it was found for the stationary ball. At air velocities above 112kmph, the drag coefficient increased with increasing air speed being weakly influenced by the vertical seam angle. Roughening one side of the ball increased the side force but delayed until a marginally higher velocity was reached. When bowler was applied to the smooth ball, the side force increased almost linearly but there was no resultant lift force. The development of the measured drag are discussed in terms of boundary layer flow

Notation

C_D	drag coefficient {▾▾ *D*/(0.5 ρ n○**d**/4)}	
D	drag force (*x* direction),	N
d	diameter,	m
Re	Reynolds number, (○*d*/*v*)	
ρ	Air density,	kg/m^3
μ	Dynamic viscosity,	
V	Air velocity	m/s

Keywords: Cricket ball, sphere, lift, conventional swing, drag

1. INTRODUCTION

Cricket is an international sport that's performed with bat and ball. The cricket recreation is watched by way of hundreds of thousands of human beings throughout the sector both live in stadiums, and on televisions. In India, the cricket recreation isn't any much less a religion and the players who play for the are worshipped with full devotion. As the years pass, gamers have discovered/evolved/invented several tactics to turn the sport into their favor to win, be it from a batsman or a bowler. One of the methods used by the bowler to confuse the batsman and is controlling the lateral movement of the ball at some stage in its flight (swing). Conventional swing is a one of the phenomenon which a bowler uses to advantage a asset over the batsman. Almost, cricket as a game of limitless difficulties, no longer most effective in approach and processes but additionally in its most of the fundamental mechanics. In very transport, the ball can have a unique trajectory, numerous via changing the pace (speed), period, line or, by way of swinging the ball through the air so that it moves sideways. The fabrication and the precept of a cricket ball by which the quicker bowlers swing the ball isn't always similar and not same movement, line, duration, etc. In a cricket, the outer cowl of a cricket ball includes four or two portions of leather-based, which are stitched together. Six rows of outstanding sewing alongside its equator make up the “number one” seam, with commonly 60 to eighty stitches in every row. On the four-piece balls, used in all first elegance and international matches, each hemisphere additionally has a line of inner stitching forming the “sector” or “secondary” seam.

Experimental information on the drag skilled via a smooth sphere in a flowing movement rarely assists in explaining the reasons for the flight trajectories of a cricket ball. This is due to the surface roughness of the leather cowl and the presence of the seam and which protrude about 1 mm above the floor of the ball. Thus the orientation of the seam to the free steam course whilst bowling, the speed of the ball (i.e. The Reynolds quantity) and whether or not the ball is spinning about one among three axes will all to some extent affect the movement of the ball through the air. Fast and slow bowlers can also spin the ball to give introduced “motion” to it because it flies via the air. Shining of the ball on one aspect of the seam at the same time as permitting the other side to emerge as rough and worn via play can affect boundary layer glide and the strain distribution across the surface of the ball, as a consequence influencing the internet pressure on the ball.

While experimental data for the aerodynamic forces on easy spheres and baseballs is with no trouble to be had, the special floor traits of a cricket ball makes extrapolation of that statistics, to account for the aerodynamic forces appearing on it. When a cricket ball, pendulum like, suspended in an air circulation and measured the sideways angular deflection, from which he calculated the aspect force on the ball. When used (20 over) balls were further examined, he observed that at 0° seam angle, an enormously big side force additionally abruptly advanced. He regretted that checks had been no longer executed at zero° on a brand new ball. The facet forces were calculated from measured deflections upon touchdown, and known datum situations. The ball is located a setup round a smooth sphere to simulate the seam on a cricket ball and in comparison the sideways pressure and drag force with that on a cricket ball at seam. Although no longer considered on this paper, atmospheric situations can also effect on a cricket ball.

DESCRIPTION

The bowler is within the problem to take-down the wicket if the batsman while bowling in the straight line. The new ball having the both facets of the number one seam are with clean and identical surfaces which ends up the equal

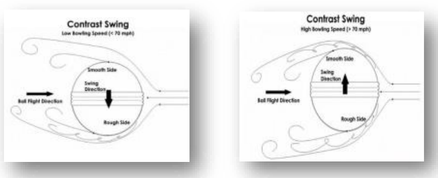

Fig 1,2: swing with angle of attack of 0°

facet forces on the ball because the tempo is high. After few over's, the ball loss the smooth surface and the ball gets special roughness on both aspects of the number one seam. The bowler try and change the angle of assault of the ball to gain the swing but it is hard to bowl with the perspective. The bowler bowled with the low speed or low Reynolds variety then the era of aspect forces is hard. For conventional swing, an outstanding primary seam glaringly facilitates the transition system, whereas a smooth polished surface on the non-seam side helps to keep a laminar boundary layer. So, the bowler ease's one facet of the ball to get laminar drifts. In the preliminary over, the opening bowler need to select the aspect on the ball with the smaller or lighter (much less hard) embossment and keep to shine that side at some point of over the path of the healthy. The different sides of the ball (seam) need to be allowed to roughen throughout the direction of play to help the manufacturing of swing of the ball. Once the seam aspect has roughened sufficient, swing is virtually obtained by turning the ball over the rough aspect face and resource of gain over the batsman.

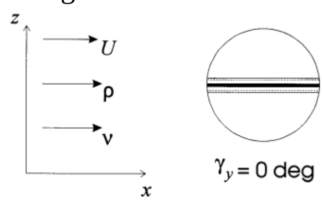

Fig 3: Ball at 0° angle of attack

In popular, the manufacturing of conventional and opposite swing will now not be affected drastically by means of having a contrasting floor situation on the facet facing far away from the batsman. The primary seam plays a critical position in each forms of swing. It trips the laminar boundary layer into a turbulent kingdom for traditional swing and thickens and weakens the turbulent boundary layer for reverse swing. During the route of play, the number one seam turns into worn and much less mentioned and not plenty may be performed approximately it unless illegal methods are invoked to repair it, as mentioned above. However, a ball with a worn seam can nevertheless be swung, as long as a pointy assessment in floor roughness exists between the 2 facets. In this case, the difference in roughness, instead of the seam, can be used to supply the uneven float. The seam is orientated going through the batsman (straight down the pitch) at zero levels prevalence. The honestly complicated real reverse swing with assessment swing. More often than not, while the ball swings toward the smooth aspect, it does so inside the comparison swing mode.

Fig. 4. Mounting of the stationary ball in 0°

rough aspect and so, in a positive Re variety, the boundary layer on the difficult facet becomes turbulent, while that on the easy aspect remains laminar. The laminar boundary layer separates early in comparison to the turbulent boundary layer, within the same manner as for conventional swing, and an asymmetric go with the flow, and consequently side pressure, is produced. The ball, in this case, will swing toward the rough side. At higher speeds, the boundary layers on both sides are turbulent. However, the layer at the tough facet will go through transitions in advance after which broaden over the tough surface, accordingly enhancing boundary layer boom (thickness) and for this reason reduction in the skin friction coefficient. An asymmetry is evolved over again, only this time, the ball will swing towards the easy aspect. This type of swing is coined as the contrast swing. The most exciting feature about contrast swing is that pretty much any bowler can put into effect it in exercise.

Commentators and gamers often state that when the ball is reversing, it swings towards the easy aspect. They are

EXPERIMENTAL APPARATUS

- *Wind tunnel*

The wind tunnel used becomes of the open jet go back circuit kind. It had a check cross-sectional vicinity of 870 mm×580 mm, with corner fillets and a working duration of 1.6 m. The pace variant throughout the check phase became 1% and the turbulence intensity was zero.4%. The maximum speed workable inside the check section was 36 m/s while the ratio among the location of the settling chamber and region of the test section turned into 10:1. A velocity version of two.6% came about over the 1.6 m jet length. This became small enough to be taken into consideration negligible. Blockage within the open jet check section turned into also negligible.

- *Coefficient of drag measurement*

A pressure manometers of the wind tunnel was used to degree the aerodynamic assets (drag coefficient) at the ball. Drag coefficient, in the degrees

(0-1) may be measured with accuracy. One silver metallic sting 6 mm in diameter had been utilized for mounting the balls during the desk bound take a look at. These are proven in Fig.4 wherein the flow path is contrary to the page. For check the ball changed into set up on a 6 mm diameter metal shaft supported in an aluminum frame (Fig. 4). Provision turned into made for the ball help frame to be established on the balance with the shaft in the horizontal planes.

A pressure manometer of the wind tunnel was used to measure the aerodynamic property (drag coefficient) at the ball. Drag coefficient, within the levels (0-1) may be measured with accuracy. One silver metal sting 6 mm in diameter have been utilized for mounting the balls at some point of the stationary take a look at. These are proven in Fig. 4 wherein the go with the flow direction is contrary to the page. For take a look at the ball changed into mounted on a 6 mm diameter metallic shaft supported in an aluminum frame (Fig. 4). Provision was made for the ball assist body to be established on the stability with the shaft within the horizontal planes.

- *Cricket ball*


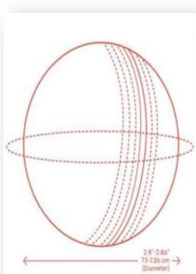

Fig 5,6: cricket ball and its dimensions

Standard piece leather-based blanketed SG (0.156 kg) balls of seventy two mm diameter were used. The seam was hand sewn with six rows of stitches and had a median top of 1 mm above the clean leather-based floor.

CONCEPT FORMULATION

The Reynolds number,

$$Re = \frac{\rho V d}{\mu}$$

The drag force were converted to non-dimensional drag coefficient,

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 A}$$

Whereas, D – drag; V- wind velocity; μ - dynamic viscosity, ρ – air density; A- Projected fontal area of the ball

RESULTS

From the above experiment the drag coefficient for a smooth sphere in free stream flow over the Reynolds number range $2.3*10^4<Re<1.6*10^5$. At the critical Reynolds number of approximately $3*10^5$ the boundary layer of the smooth sphere becomes turbulent, the separation point moves downstream around the surface of the sphere.

CONCLUSIONS

The data presented in this paper quantifies some of the aerodynamic force acting on a cricket ball and explains their occurrence in terms of broad aerodynamic and fluid dynamic principles. But, no attempt has been made to explain the subtleties of bowling or to advise bowlers how to deliver the ball. Some bowlers achieve incredible feats in moving the ball first one way and then the other before it reaches the bat, but the complexity of the variables affecting ball motion are demonstrated by the inability of most bowlers to bowl consistently similar balls, and therefore much of their skill might be considered a chance. This is what makes cricket the interesting game

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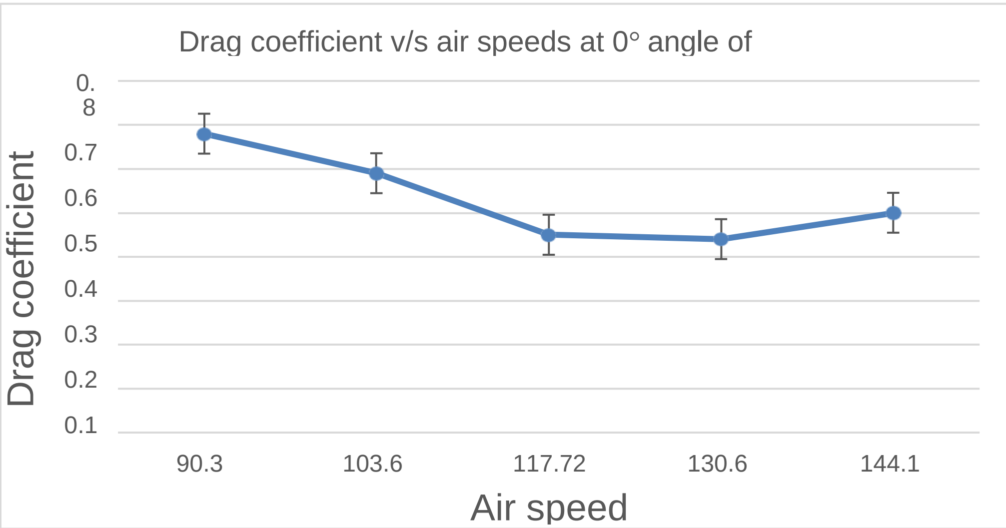

Fig.7 Shows the drag coefficient variation as the airspeeds with constant angle of the vertical seam.