FEATURE ARTICLE

Fielding

How Best to Throw the Ball In!

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Throwing in the ball to the wicketkeeper or the bowler could be critical. There is some mathematics involved behind 'good' throws.

IN cricket, often one focuses only on improving one's batting or bowling skills. Fielding is looked upon as drab, unglamorous and non-productive. But then, we all know now that it is not so. It used to be a taken-for-granted activity on the cricket field. But it is often good fielding that sets a team apart from the others – a few notches higher.

Whether it is javelin, shot-put, baseball or cricket, sportsmen know that at a particular angle, for any given velocity of release, the range is the maximum. This angle is 45°. If the fielder can throw at greater velocities, he can choose to shoot at angles below 45° or above 45°. The cardinal rule is that the ball has to settle in the keeper's gloves or the bowler's palms 'on-the-full', without having bounced along the way. This is the quickest path it can take. A double trajectory with an intermittent bounce takes a slightly longer time as the ball slows down after the bounce.

Throwing the ball in at an angle of 45°, gives the best results. However, we have assumed here that the ball is thrown from and received at the same height above the ground. This generally is not the case as the keeper would like to receive the ball much below shoulder level (so as to be able to effect a run-out easily, if the occasion arises). Hence, the fielder aims at a range 'R' less than the distance between him and the stumps. After tracing a full parabolic loop, much ahead of the keeper, the throw descends into his gloves further on.

So how do you throw the ball while fielding? The elbow should be above the shoulder level when you throw) for the over-arm return. Fieldsmen closer to the wicket throw in with a side-arm action – a hard, flat throw, making a much smaller angle than 45°. The velocity is much higher and the time taken to reach the destination is shorter. In this case, it is not the range but the quickness with which the ball is returned that is vital for it could mean running a batsman out, when he attempts a cheeky single. Under-arm throws are also quite common, in the case of fielders well inside the now-famous '30-yard' circle, courtesy the shorter versions of the game – one day matches.

Some Mathematics

Let us dabble in some figures, for a while. Consider a case when a fielder picks up the ball at a distance of 50 metres from the batting end and watches the batsmen coming back for a second run. The batsman who is heading towards the batting end, can manage a maximum speed of 6 metres/second. When the fielder throws in, the batsman is still 10 metres short of the safety of the crease. It will take him another 10/6 = 1.67 seconds to complete the second run safely.

The ball has either to hit the wicket directly before the batsman 'reaches home' or it has to lodge itself securely in

Left: Fielding positions in cricket. Schematic bird's-eye view of a cricket field, with the 'cardinal' fielding positions (in bold font) marked and their variants/combinations with regard to the batsman indicated (Note the adjectives used – Deep, Short, Square etc.). Running and stopping the ball and returning it back to the bowler or the wicket-keeper is what may be termed as a regulation activity of the fielders in the outfield. Bowlers when they are not bowling, are fielders. The wicket-keeper is stationed permanently behind the stumps at the batting end (note that the other fielders can be moved around by the captain/bowler, at will). (*Courtesy: www.soscc.org.uk)*

the gloves of the wicket-keeper, and give him enough time to whip off the bails. The time at hand is short. Hence, directing the ball up into the air, to make it describe a tall parabola, will just be an exercise in delaying the approach of the ball. It will be eating into useful time and at such a juncture, every tenth-of-a-second matters! Hence, this option is to be eliminated. So, the fielder could send a flat and horizontal throw into the keeper's gloves or send the ball nose-pointing downward, describing a very flat and elongated semi-parabola, starting from a point about 2 metres from the ground.

To make the ball move horizontally all the way to the keeper for 50 metres, the fielder has to direct it at an angle of zero with the vertical. Well, that is not easy though. Side-arm throws are able to trace this linear path all the way from source to target. Now, to make the ball move in this way, it has to be equipped with energy to do work against the force of gravity that will be acting on it. We assume that there is no air resistance, or even if it is there, it is minimal. Hence, the forward momentum of the ball has to, while moving forward, counter the force of gravity. If the ball has enough energy in it, it will be able to continue on the path along which it has been directed, for some time, without being deviated (in this case, pulled down by the gravity of the earth).

Thus we frame the equation:

- Kinetic energy imparted to the ball = Distance over which the force of gravity is resisted.
- $0.5 * m * V * V = m * 9.81 * 50$
- $V = (9.81 * 50 *2)^{0.5}$
- $V = 31.32$ m/s

At this speed, the ball would reach the keeper's gloves in 50/31.32 = 1.596 second.

The keeper gathers it at a height of say about 1.6 metre from the ground (which is just above chest height, for a reasonably tall wicket keeper), and he has to bring it down by a distance of 82 centimetres, to whip off the bails. (The

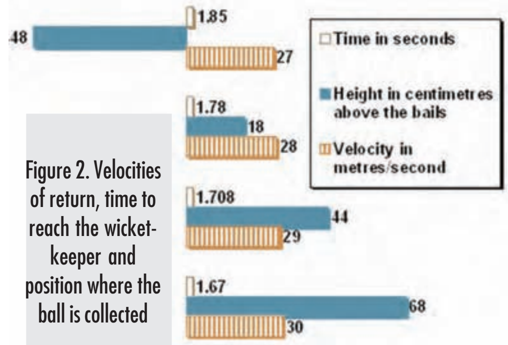

Figure 2. Velocities of return, time to reach the wicket-keeper and position where the ball is collected

stumps are about 78 centimetres tall.) When the ball reaches the keeper (in 1.6 second), the batsman is almost home and in all likelihood he may have grounded his bat, by stretching himself forward. If the ball should descend down over the bails, the velocity of release should be lower and this would mean that the ball would be spending more time in the air, and the accuracy would be of no avail, as the batsman would have made his ground. (Refer to *Figure 2,* which depicts the distance above the bails at which the keeper would be gathering the ball, at certain sample velocities below 31.32 m/s, and also the time it would take for the ball to reach the keeper's gloves.)

The negative value at the top, indicates that the ball descends on to the stumps, and hits it at 48 centimetres below the 'bails-level'. If a graph is plotted between the velocities and the descent above bails, the velocity at which it will just dislodge the bails can be calculated. This value lies between 27 m/s and 28 m/s. If the fielder had more time on his hands, say around 2 seconds, then he could have run the batsman out by directly hitting the bails by throwing in at the aforesaid velocity.

If the fielder can shoot in at a speed greater than 31.32 seconds, well, it would be a scorcher into the keeper's gloves, the batsman may find himself stranded. However, the fielder should have a strong arm for this purpose and one cannot expect all fielders to be powerful throwers, even from a distance of 50 metres. Besides, some time would also be expended by the keeper in taking the ball from the point of collection to the bails.

What if the fielder has to throw in along a short and elongated parabola, having its highest point at the point of release, which would be about 2 metres from the ground. The horizontal distance here, for the ball to hit the bails directly, or reach the keeper just above them, is 50 metres. The height descended would be 1.22 metre.

Thus,

- $V * \cos A * t = 50$
- $V * \sin A * t - 4.9 t^2 = -1.22$

If the ball is to directly hit the bails, it has to do it in say 1.5 second, for the decision to be clearly in favour of the fielding side, as during that time, the batsman will still be about a metre short from the safety of the crease.

Solving, we get:

- $V * \cos A = 33.33$
- $1.5 * V * \sin A = 11.03 - 1.22 = 9.81$

Dividing,

- $[\cos A/(1.5 * \sin A)] = 33.33/9.81 = 3.4$
- $\cot A = 5.1$
- Therefore, $\tan A = 0.196$
- Hence, angle $A = 11.1°$

Now, the velocity at which the ball has to be released at an angle of 11.1° is given by:

- $33.33/\cos 11.1 = 34$ m/s

Thus, by throwing in at 34 m/s, from a point 2 metres above the ground and keeping the angle at 11.1° below the horizontal, the fielder can break the bails, if his directionality is accurate, in about 1.5 second, from the point of release.

If the fielder has the luxury of more time, he can even get the job done for his team by throwing in high from his fielding position or even shooting it under-arm. But in the instance considered above, he does not have time on his side.

Mathematics here, more often than not, is a 'post-mortem' analytical procedure. At the instant of throwing in, the fielder has certain 'givens' which are important to him. These are the distance between him and the stumps, how fast the batsman who is moving towards the danger end is running, and the separation between the batsman and the safety of the crease when he is about to throw in. Everything happens in a split-second, but the cardinal rule is to always make it as quick as possible, no matter what.

They say that statistics are usually misleading. Mathematics is certainly not!

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