ANALYSIS OF GREENSIDE BUNKER SHOTS IN GOLF

Josefa Wivou[1], Lanka Udawatta[2] and Pubudu Pathirana[1]

School of Engineering, Deakin University, Melbourne, Australia[1]
Higher Colleges of Technology, RAK Men's Campus, RAK, UAE[2]

This paper presents an analysis of greenside sand bunker shots in golf to identify the key parameters in a given situation to achieve the desired distance to the pin. Different depths and corresponding entry distances of a down swing were measured in order to analyse the situation. Experiments for taking the required data were conducted in a sand bunker of a golf course. Samples were taken from different golfers whose handicaps are ranging from 5 to 25. Results can be used to train amateur golfers, especially for reaching different distances towards the pin from greenside sand bunkers.

KEY WORDS: Sand bunker, club head speed, divot depth, point of entry.

INTRODUCTION: There has been a growing interest in golf related research studies during the past couple of decades. General study of golf swing can be found in many research studies. Moreover, there have been some studies on common golf swing analysis (Penner, 2003), kinematics and kinetics of a golf swing (Nesbit, 2005), identification of the biomechanical performance of golf swing (Healy, 2009) and etc.

(a) Tropical climate bunker (b) Cold climate bunker (c) Deep bunker

Figure 1: Different bunkers in various golf courses

One of the key challenges in golf is coming out from a bunker (Figure 1). There has not been detailed analysis on the bio-kinematic aspects of the underlying process aimed at achieving this goal. Figure 2 shows the possible laying of the golf ball in sand bunkers. This paper demonstrates how to project the divot and entry distance in order to reach the desired distance to the pin.

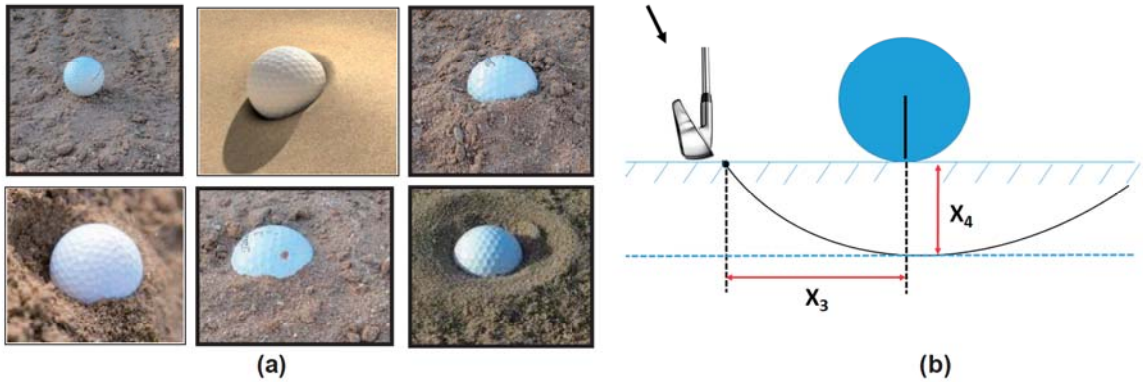


Figure 2: (a) Different ball lay and (b) Entry distance (x_3) & Divot depth (x_4)

METHOD: For a given distance, from the ball position to the pin location, different parameters should be optimally combined and swing should be executed. However, this is a challenging task, especially when it involves sand bunkers. Following variables (may not be an exhaustive list by any means) in Table 1 is considered as relevant for the underlying process.

Table 1
Key factors to determine effective distance

Variable	Factors	Description (Effective shot)
x_1	Club head speed at impact	Optimum speed means effective shot
x_2	Swing	Smaller swing angle more distance
x_3	Point of entry	Closer entry point means more distance
x_4	Divot depth	More depth means less distance
x_5	Grip	Choked firm grip easier hinge means effective shot
x_6	Stance	More open stance to target means less distance
x_7	Stability	Better stance stability means more effective shot
x_8	Club (equipment)	More loft means more effective shot
x_9	Sand type	Less course & damp means less distance
x_{10}	Ball lie	More plugged into the sand means less distance

In fact, club head speed (x_1) is one of the key parameters and there are many studies on club head speed (Anderson, 2007). Most important biomechnical principles behind hitting an effective greenside bunker shot includes the following key factors from the list above that link in with one another and provide a clear answer to an effective shot. These are: club head speed (x_1), swing (x_2), point of entry (x_3), divot depth (x_4), grip (x_5), stance (x_6), stability (x_7), club (x_8), sand type (x_9), and ball lie (x_{10}). Trajectory and spin being the key elements of the shot as a result of combination of several key factors. However, due to the bunker shot not being classified as 'normal' because when placed in the sand the player is meant to make contact with the sand preferably 25-50 mm before the ball with no actual contact made to the ball as the sand 'pushes' the ball forward. A golfer's hands when playing out of the sand tend to be as close together as possible. The reason for this is because it makes it easier to 'hinge' the wrists, which is the key control of the shot. As for equipment, depending on the distance from the pin the lower lob wedge is required. Entry distance (x_3) and divot depth (x_4) are defined as shown in Figure 2. Setup shown in Figure 3 with measuring equipment is used to capture the required data. Data was taken from different golfers whose handicaps were ranging from 5 to 25. Different data for varying the club speed, entry distance and divot depth were captured while keeping the other parameters unaffected and correlations were calculated.

Figure 3: Experimental setup in the golf course

RESULTS: This experiment was design to observe the effect of two key parameters mentioned in Table 1. However, when all the parameters are subjected to variation, it is challenging to investigate the individual effect. Figure 4 shows the travel distance of the golf ball against the entry distance on impact while changing the other parameters. It can be noticed that the travelled distance of the ball has no relationship with entry distance when you change the other variables simultaneously as depicted in Table 1.

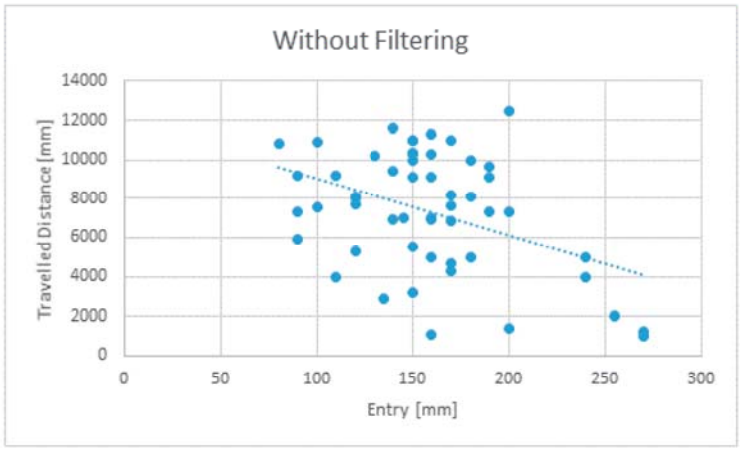


Figure 4: Travelled distance vs. entry distance [mm]

For data in Figure 4, correlation coefficient was -0.42. Aforementioned mentioned data was separated in order to observe the individual effect of divot depth on the distance. Filtered data for different divot depths and corresponding distance to the pin position while keeping the other parameters unchanged were graphed. It can be clearly noticed that larger divot depths has resulted less the travel distances (Refer to Figure 5(a)).

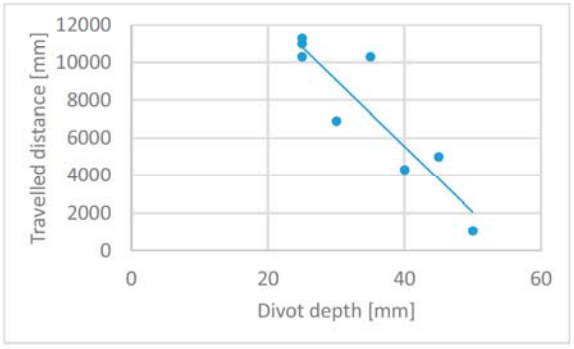
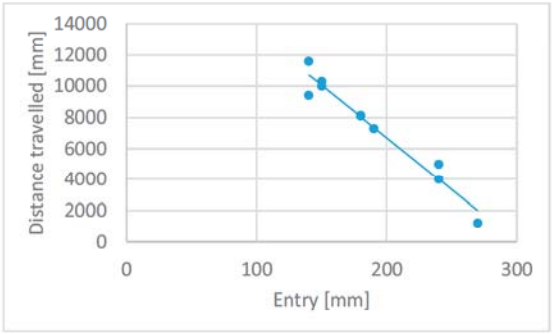


Figure 5: (a) Travelled distance vs. divot



(b) Travelled distance vs. entry

Similarly, travelled distance of ball against the entry distance was observed while keeping the other parameters unchanged. It can be clearly noticed that smaller the entry distance, further the ball is travelled (Refer to Figure 5(b)). Correlation coefficients for Figure 5: (a) and Figure 5: (b) are -0.91 and -0.98 respectively.

DISCUSSION: Due to the bunker shot not being about power but about finesse, a choked grip is best served to this shot as it gives you better control of the club-head. The actual swing determines that the club head is coming through and impacting the sand at the optimum speed, as well as in the centre of the club head aiming to push the ball straight. If these two elements can effeictively be exercised the energy transfer will be optimised and

the ball will head in the intended direction. Speed of the downswing is vital in creating backspin on the ball, which can be essential part to playing from the bunkers.
In light of the two selected key factors experimented, the result showed that these factors are very closely linked in to one another in relation to obtaining the desired and effective greenside bunker shot. Experimental results showed that club head speed played a vital role in creating the spin. It was also revealed that larger the depth of the divot, greater the back spin created, hence lesser distance is covered. It was also evident that closer the point of entry into the sand before the ball, further the distance reached. It must be noted that the following factors: stance, club, sand and balls were maintained unchanged to the best of our ability, however the grip, stability and swing were not investigated yet in this experiment as it differed from varied handicappers performing the shots.

CONCLUSION: Analysis of golf swing is significant and important when it comes to training and coaching. This study investigated two critical parameters of greenside sand bunker shots in order to get the desired distance, namely, divot depth and entry distance. After analysing the bunker shot data, we can now define our clear answer on how we can explore the biomechanics of this shot to get the ball as close to the hole as possible. First, it is found that entry distance and depth of divot in sand play key parametric roles in obtaining the desired distance to the pin. Secondly, we need to accelerate on the way down and continue that through the line of the ball and throughout the contact. Combining these key ideas when using a preferable lob wedge club, the improved performance can be seen. The impact of the sand will generate enough force to propel the ball forward into the air and land on the green with superior performance. It should be noted that during the experiment the stance, ball position, ball, bunker sand and grip were kept unchanged. Further experimental data is to be collected to investigate the correlation between wrist and hip movement during the entire swing.

REFERENCES:

Anderson, B.A. (2007). Speed generation in the Golf swing: An analysis of angular kinematics, kinetic energy and angular momentum in player body segments. *Masters of Science thesis*. Department of Mechanical Engineering, University of Calgary.

Healy A. (2009). Identification of the biomechanical performance determining factors of the 5 iron golf swing when hitting for maximum distance. *Masters by Research in Biomechanics thesis*. School of Health and Human Performance, Dublin City University.

Hume, P.A., Keogh J. & Reid, D. (2005). The role of biomechanics in maximising distance and accuracy of golf shots. Sports Med. 35(5): 429-449.

Neal, R.J. & Sprigings, E.J. (1999). Optimal golf swing kinetics and kinematics. Journal of Science and Medicine in Sports, 14, 416-417.

Nesbit, S.M. (2005) Three-dimensional kinematics and kinetics of a golf swing. *Journal of Sports Science and Medicine,* 4, 499-519.

Penner, A.R. (2003). The physics of golf. Institute of Physics Publishing. *Journal of Reports on Progress in Physics*, 66, 131-171.

Acknowledgement

Authors would like to convey their sincere thanks to Tower Links Golf Club for using their facilities to obtain the data during the training sessions.