THE STUDY OF ENERGY LOSS FROM IMPACT ON A CURVED BALL OF GOLF SWINGS

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Practicing and correcting positions and movements without understanding the principles were involved with the ball impact and subsequent flight path. This research was focused on the relationships between energy creation and loss when open and closed clubfaces were used to create a curved flight path of the ball. Based on the results of the experiments, the energy loss from different clubface angles was varied and caused different flight trajectories of the ball.

KEY WORDS: flight path, club face, angle

INTRODUCTION: Golf was a sport full of techniques, the swing postures from the setup phase, to the backswing phase, the downswing phase, to the follow through phase and then the take away phase (Lan & Lin, 2000), all require accuracy and consistency. Normally, during the learning period, repeated practices of the swings is required to attain correct and accurate movements, which however, ignores the consistency of the striking motions and often the curved ball does not reach the expected distance even for a forceful strike. The reasons for this lack of distance are: inconsistent motion, poor kinetic force summation so that energy is not effectively transmitted to the ball when attempting to achieve a curved flight path. Furthermore, the use of different angles of the clubface to strike the curved ball also influences how the energy is lost and results in different outcomes. During competitions, professional golfers observe terrain of the golf course and weather conditions and strike the ball with different clubface angles to achieve (Williams & Sih, 2002) different spin and thus varying flight paths of the ball. This study therefore seeks to understand the relationship between the ball-striking angle, energy loss at impact compared with that generated and the resultant spin on the ball.

METHODS: The study was conducted by filming golf swing motions of a Handicap 5 amateur (the testee). The testee was holding a Japanese standards Taylor Made R540 shaft golf club, TM-500 PLUS hardness S-FLEX, clubface angle 9.5 degree driver, the club head mass was 0.36 kg, the golf ball was TOP-FLITE XL3000 mass 0.046 kg, radius 0.021 m. Three 90-degree-angle forward swings were struck with the clubface; Opened with the club face aimed to the right with five different angles. This procedure was then repeated to the left. Data from different striking angles were captured using high-speed camera at 5000 fps frame rate and with a shutter speed of 1/3000 second, then analyzed with Silicon Coach Pro motion analysis software to extract images (Figure 1) to analyze the relationship between angular velocity of the curved ball and its energy when the ball was hit by the clubface using different angles.

The images were used to calculate the speeds pre-and post-impact for the club and the ball. The following formula was used to calculate the energy loss of both before and after the strike.

\[ E_i = \frac{1}{2} m_v v_i^2 - \frac{1}{2} m_v v_f^2 - \frac{1}{2} m_b v_b^2 - \frac{1}{2} I_b \omega_b^2 \]

where
- \( v_i \): velocity of the clubhead before the strike
- \( v_f \): velocity of the clubhead after the strike
- \( v_b \): velocity of the curved ball after the strike
- \( I_b \): moment of inertia of the ball
- \( \omega_b \): angular velocity of the curved ball
RESULTS AND DISCUSSION: This study did not take into account of impact on the curved ball from different shaft mass and only calculated the effects of the clubhead mass on the energy loss owing to the energy transferring after the curved ball was struck in order to avoid computation errors. After the experiment, various calculations were made including: the angle of the club head and the angle of the swing paths for each swing (Figure 2), the speed of various club heads before and after the strike, the angular velocity and the speed of the curved ball, analyzing the relationship between the angle of the clubface and the angular velocity of the strikes (Figure 3). Moreover, to calculate the motion energy of the golf shaft before and after the strikes, the motion energy of the curved ball after the strike and lastly, to calculate the rate of energy loss, to analyze the relationship between the energy loss and the...
角度的飞行路径的球（图4）。在图4中，轴x代表角度；在零的右边是正的，在左边是负的。

图3  正义击球面角度和角速度的关系。

关系的角度的摆动路径和能量损失。

图4  飞行路径的角度和能量损失的关系。

上述图表展示了能量损失和能量通过击球头传递给弯曲球之间的条件。打击的速度对弯曲球的角速度没有重大影响。根据能量守恒定律，能量应该完全转移，因此可以推断能量的损失是由于弯曲球的侧旋。因此，为了精确的击球，需要更低的能量损失，更多的能量从球杆转移到球。同样重要的是控制击球面的角度来转动弯曲球以达到预期的飞行路径。从能量传递的角度来看，一个好的打击应该首先考虑一致性，即是否能够将整个能量从击球头传递给弯曲球。这意媳妇，如果不能连接能量链从整个运动的打击，一个有力的打击将是能量的浪费。
CONCLUSION: The purpose of this study was to verify the theory by experiment to allow golfers to understand the source of energy transfer in hitting a curved ball; to emphasize consistency and rhythm of swinging motions to reduce the energy loss and preserve the highest energy from the strike of the club head on the ball. Furthermore, the change in ball trajectory, a result of spin, was caused by varying the angle and trajectory of approach of the clubface at impact. The above may clarify and provide the basis of theory for various golf instructors.

REFERENCES: