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Numerical Simulation on Mechanical Strength of a Wooden Golf Stick

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Abstrak

Pada umumnya, pemain golf hanya tahu teknik-teknik yang digunakan dalam permainan olahraga Golf, tanpa mengetahui respon stik golf yang terjadi pada saat memukul bola. Respon yang dimaksud adalah tegangan dan regangan akibat beban dinamik impak yang terjadi. Tujuan penelitian ini ialah: (a) menganalisa respon stik golf saat pengimpakan secara experimental, dan (2) mengetahui respon mekanik stik golf akibat beban dinamik impak yang terjadi. Stick golf didesain menggunakan autodesk inventor. Material yang digunakan adalah Titanium untuk kepala stick dan Grafit untuk stick-nya. Prinsip dasar penelitian ini berdasarkan uji ayunan bandul sederhana. Variabel-variabel simulasi yang akan digunakan dalam simulasi ini adalah Kecepatan ayunan (pukulan), yaitu selisih dari kecepatan awal dan akhir Δv= 272,2 m/s, Waktu impact, yaitu waktu pada saat bola menyentuh pemukul Δt=0,0005 detik, Volume kepala stik 96727 mm3, luas penampang kepala stik A= 63504 mm2, massa jenis kepala stik ρ = 4620 kg/m3, dan modulus young titanium 9,6e+010 Pa. Dari hasil simulasi pada permukaan pemukul stik golf diperoleh sebagai berikut : σmax = 2.1231e10 Pa pada waktu 1.231e-06 s, εmax = 0.22115 m/m pada waktu 1.231e-06 s, dan tegangan dan regangan maksimum terletak di daerah sambungan antara stik dan kepala stik.

Kata Kunci: Metode Elemen Hingga, Respons Beban Impak, Simulasi Numerik, Stik Golf Kayu

Abstract

In general, golf players only know the techniques used in Golf games, but do not know the golf sticks response that occurs when the ball is hit. Referred to as response is the stress and strain that arises from the impact load that occurs when the hitting member touches the ball. The objectives of this research are: (a) to analyze golf sticks response when impact occurs, and (2) to know the stress distribution that occurs in golf sticks. The golf stick design in this study uses the autodesk inventor software. The material used is Titanium for head stick and Graphite for stick rod. The basic principle of this study is based on simple swing pendulum method. The variables that will be used for simulation are: swing speed, that is difference between start and end speed, that is Δv = 272,2 m / s, impact time, which is the time when the ball touches the batter Δt = 0.0005 seconds, the volume of the head of the stick Vo = 96,727 mm³, the cross-sectional area of the stick A = 63,504 mm², the head mass of the sticks ρ = 4620 kg / m³, and the modulus of titanium elasticity 9.6 e +10 Pa. From the simulation result on the surface of the golf club hitter is obtained as follows: σ_{max} = 2.1231e +10 Pa at 1.231e-06 s, ε_{max} = 0.22115 m / m at 1.231e-06 s, and the maximum stress and strain is located in the area the connection between the stick and the head of the stick.

***Keywords**: Finite Element Method, Impact Load Response, Numerical Simulation, Wood Golf Stik*

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INTRODUCTION

At this time, the equipment and the completeness of the game of golf has grown rapidly along with technological advances. In its development, hikori wood is used for sticks, while hard and strong American persimmons are used for heads of sticks (Parziale, 2014). In the late 1890s, Thomas Horsburgh (a blacksmith) began trying to make sticks of steel. The Royal and Ancient Golf Club of St Andrews allowed the use of sticks of steel after the Prince of Wales used them at St Andrews in 1929. Billy Burke was recorded as the first golfer to win a tournament with a steel sticks at the US Open golf championship in 1931 (Millington & Wilson, 2015).

In the early 1970s, steel rods were replaced with stalks made of graphite material that had lighter and stronger characteristics than steel. The first wooden metal sticks were made in the early 1980s, and slowly the metal replaced the wood because it was more durable in its use (Joyce, 2017). Golf Stick products with the latest technology using stalks of graphite and head sticks of titanium are light and very strong. The use of titanium material also causes the heads of sticks to be large enough but do not add too much weight.

Generally, golf players only know the techniques used in the game without knowing the golf sticks response that occurs when hitting the ball (Henrikson, Wood, & Hart, 2014). The response in this study is stress and strain. Strong or weak sticks greatly affect the response of golf sticks. But the response is not visible at the time of the game. This is because the state of golf sticks before and after the blow is almost no different. But actually, the golf sticks receive a response that can affect the strength of golf sticks. In this study, researchers will simulate the state of golf clubs when hitting the ball. This simulation aims to analyze the response of golf sticks during a blow. The simulation will be done using ansys software.

Golf sticks are the most important piece of equipment in a game of golf. Golf sticks are used to hit the ball towards the hole. In every blow, a player will use different golf sticks.

In general, a golf stick consists of handles of sticks, sticks, and heads of sticks. At the moment the materials used in golf sticks are: rubber for handrail sticks, graphite for sticks, and titanium for head sticks (Drane, Duffy, Fournier, Sherwood, & Breed, 2014). The golf sticks are shown in Fig. 1.

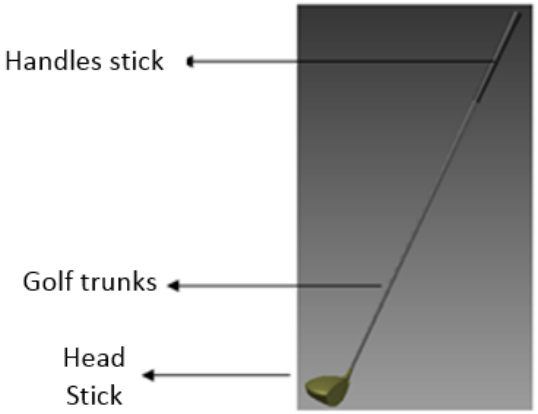

Figure 1. Golf Stick

Basically there are three types of golf sticks, namely: wood, iron, and putter sticks (Joyce, 2017). Some are designed with loft, accuracy, or more distance. In this section, we will discuss the characteristics of wooden, iron, and putter sticks.

Wood is a long golf sticks with a small pole used for long-range blows. Currently, golf sticks manufacturers use titanium or

steel to make these sticks. Stik wood usually consists of driver and groove parts, as shown in Figure 2.

Figure 2. Wood type golf sticks

A proper golf swing will have a great impact on the rate of hit golf balls. The golf swing has a physical mechanics and needs a good angle of motion to get the best results as well. Swing twist will produce torque on the golf rod. This is due to the change in the angular velocity of the stick that produces rotation, so the key to be able to hit the ball far away at the speed of the golf head and the ball will experience the impact load. The mechanics of the golf swing are shown in Fig. 3.

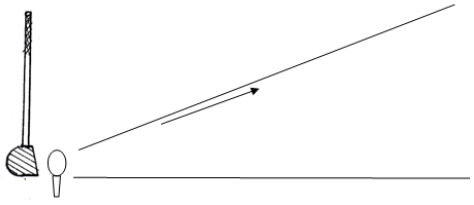

Figure 3. The mechanics of the golf swing

The basic principle of this analysis is based on a simple pendulum test as shown in FIG. 4.

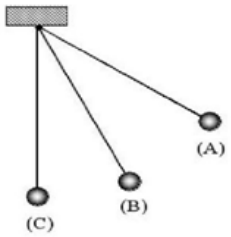

Figure 4. The simple pendulum test method

When the load is hung on the swing and is not released, the object will remain at the balance point B. If the load is drawn to point A and released, then the load will move to point B, C, then back again to point A. Movement of the object will occur repeated periodically called the simple harmonic motion.

The pendulum is an object that is attached to a rope and can swing freely periodically which becomes the basis of work of an ancient wall clock. In the field of physics, this principle was first discovered in 1602 by Galileo Galilei which states that the period (the duration of the oscillation motion of one swing, T) of an object is affected by the length of the rope and the acceleration of gravity. The popular oscillation (vibration) motion is the pendulum oscillation motion.

A simple pendulum consists of a lightweight rope and a small ball (ball of pendulum) of mass m being suspended at the end of the rope, where the friction force of the air is ignored and the rope mass is assumed to be so small that it can be neglected relative to the pendulum ball. A simple pendulum is a small object, usually a solid ball object suspended on a rope whose mass is negligible compared to the mass of the ball and the length of the pendulum compared to the ball radius of the pendulum. The other end of the rope is hung on a fixed hanger.

If the pendulum is given a small drift and then released, the pendulum will oscillate between two points, eg point A and B, with a fixed period T. One vibration (1 oscillation) is defined as the ball motion from A to B and returns to A, or from B keA and back to B. There are several parameters (or variables) in the pendulum analysis, namely: period (T), pendulum mass (m), angular drift (O), and length of rope (L).

An empirical approach has also been made to obtain the equations of the pendulum motion assuming a pendulum of mass m is attached to a long strap L. This massed mass is drawn so that the rope makes an angle of θ the vertical angle and released from its original state is idle are shown in Fig. 5.

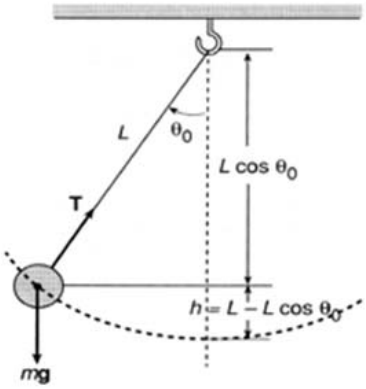

Figure 5. The basic principle of simple pendulum swing

The speed of the golf ball is higher than the clubhead speed at the time of impact. Cochran and Stobbs (1968) report that world golfers have a club speed of 272.2 m / s, equivalent to 160.9 kmph. The next ball speed is 362 m / s. This speed difference is due to the smaller ball mass. The facts show that the ball flattens its surface at impact and during the contact time of 0.0005 seconds with the ball, the condition of the object is elastic. Contact time is almost the same for all blows, even for putting, always less than 1 m / s.

The objectives of this study were: (a) to analyze golf sticks response during impact, and (2) to know the mechanical response of the golf rods due to the impact load.

METHODOLOGY

The golf stick is designed using autodesk inventors. Starting from the initial sketching of the golf stick to be made and then the program will automatically combine the sketches and make it solid. The shape of the golf club design using Autodesk Inventor software is shown in Figure 6.

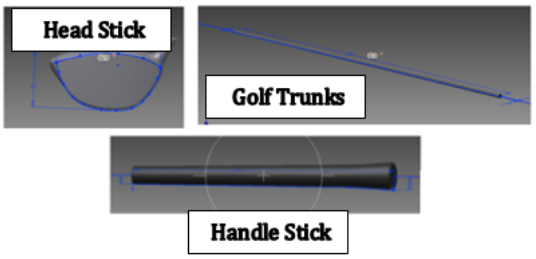

Figure 6. Wooden golf stick design

After the three components are designed, the next step is to merge each component into one whole piece, as shown in Figure 7. The shape of the batter surface is designed to be flat, as a variation of the standard sticks, in which the surface is convex, as shown in Figure 8.

Figure 7. Design of golf sticks that have been combined

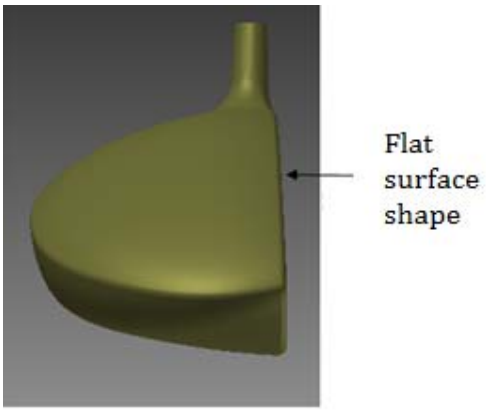

Figure 8. The head of the stick with the shape of the batter surface is designed flat

In this study, the material used was titanium for the stick head and graphite for the stick. This material is the standard material used for golf sticks in general.

The simulation variables used for the study are as follows:

1. The speed of swing (blow), ie the difference of initial and final velocity Δv is 272.2 m/s.
2. The impact time, ie the time at which the ball touches the batter Δt is 0.0005 seconds.
3. The head volume of the stick is 96727 mm^3.
4. The cross-sectional area of the head of the stick, A is 63504 mm^2.
5. The weight of the head of the sticks ρ is 4620 kg / m^3.
6. The elastic modulus of titanium is 9.6e+10 Pa.

RESULT AND DISCUSSION

The geometry shape of a golf stick designed with the autodesk inventor software and exported to ansys 14.0 software format is shown in Fig. 9.

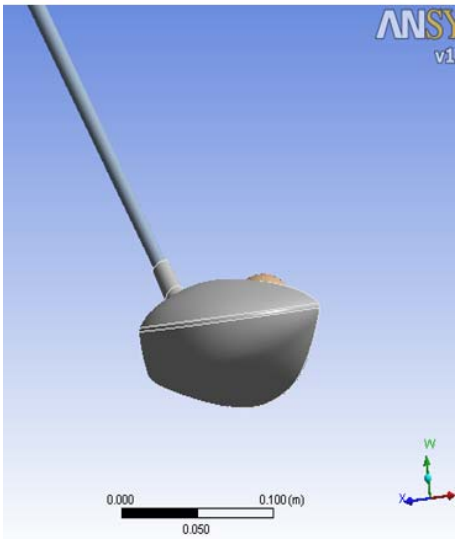

Figure 9. Models that have been exported to Ansys 14.0

The simulation results are shown to simulate the distribution of stresses and strains along the specimens. The simulation result of the stress distribution occurring on the golf club is shown in Figure 10.

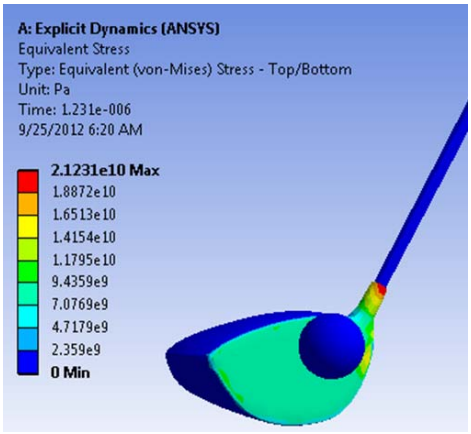

Figure 10. Stress distribution results from numerical simulations

The golf ball is struck with a stick, where the ball is right on the batting surface at the point above the center of the battering surface. Based on the simulation results, when the stick is swung at a speed of 272.2 m/s, and regarding the ball, the stress distribution starts to occur at 0.0005 s. When the battering surface of the ball, then start impact load that will cause stress on the golf club. Based on the simulation results it can be seen that the maximum stress generated is 2.1231e10 Pa. Maximum stress occurs in the connection between the sticks with the head of the stick. If the maximum stress is on the same point repeatedly, it will cause deformation which is a form of initiation of material damage.

Based on the simulation result, the impact time is shown in Figure 11.

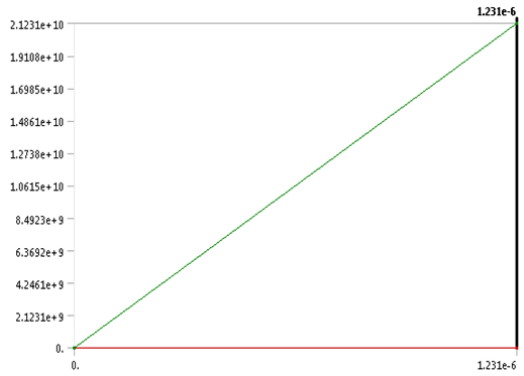

Figure 11. Impact time

Based on the graph it can be seen that the maximum stress occurs during impact time at 1.231e-06s. Stress will come back to a minimum when the ball is released from the hitting surface.

The strain distribution occurring at the time of impact is shown in Figure 12. Based on the simulation result, maximum strain is 0.22115 mm/mm. This strain occurs from the head of the stick touching the ball until the ball is released from the bat.

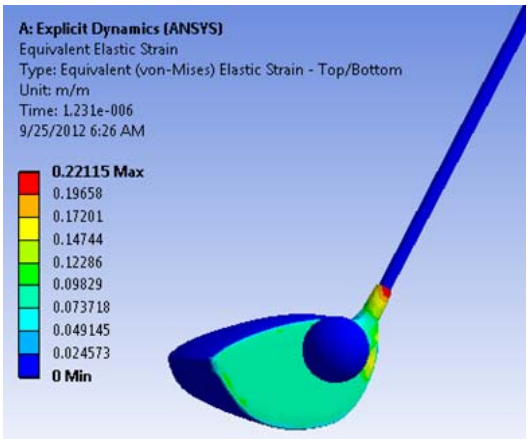

Figure 12. Strain distribution results from numerical simulations

CONCLUSION

Based on the research results obtained that the maximum stress occurs

on the surface of the stick head. The maximum stress level is 2.1231e10 Pa which occurs at impact time 1.231e-06 s. While the maximum strain is 0.22115 mm/mm. Stress and maximum strain occurs when the stick head touches the ball until it is released.

The maximum stress and strain occurs in the connection area between the stick pillar and the stick head. This is the cause of frequent damage to golf sticks beginning in this area.

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REFERENCES

Parziale, J. R. (2014). Golf in the United States An Evolution of Accessibility. *American Academy of Physical Medicine and Rehabilitation*, 825-827.

Drane, P., Duffy, M., Fournier, J., Sherwood, J., & Breed, M. (2014). The Behavior of Golf Ball Putting on Artificial Turf. *The 2014 conference of the International Sports Engineering Association* (pp. 599 – 604). Arizona: Elsevier Ltd.

Henrikson, E., Wood, P., & Hart, J. (2014). Experimental investigation of golf driver club head drag reduction through the use of aerodynamic features on the driver crown. *The 2014 conference of the International Sports Engineering Association* (pp. 726 – 731). Arizona: Elsevier Ltd.

Joyce, C. (2017). The most important "factor" in producing clubhead speed in golf. *Human Movement Science*, 138–144.

Millington, B., & Wilson, B. (2015). Golf and the environmental politics of modernization. *Geoforum*, 37–40.