Evaluation of Baseball Bats on Impact with a Baseball during a Bunt Hit

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Abstract *- This report describes the stresses on a baseball bat during a bunt and analyzes the differences of the ball exit velocity (BEV) when hit at different points on the bat. During a bunt hit, the bat stays stationary on approach of the ball. The bat was made of a white ash wood with 33in of length and the ball used was the model ROLB2 from Rawlings. Eight different spots were analyzed, all of then between 5 to 7 inches from the top of the bat. The pitcher ball velocity was assumed at 90 miles per hour. Abaqus/Explicit was use to run the simulation over time. Results showed that 7 inches from the tip of the barrel is the sweet spot i.e. the best spot to hit the ball, where the highest BEV was reached and the bat had the lowest stresses.*

Keywords: Baseball, Impact, Dynamic Loading

1. INTRODUCTION

The main purpose in a Baseball game is to hit the ball pitched and allow it to go as far as possible, without stressing the bat and the hitter. There is a sweet spot in every pitch. The sweet spot is known as the location on the bat, which results in the most effective contact with the ball, therefore obtaining the most effective ball exit velocity in a bat swing.

Professional experienced players have said that the best locations range on the bat to hit the ball is between 5 to 7 inches from the tip of the barrel. [Crisco, 1997]

In this study, a baseball wood bat was used due to the professional baseball league requirements. Another important concept is the center of percussion (COP). The COP is the point on the bat where the impact ball/bat will produce the minimal reactions to the batter's hands. In addition, the sweet spot is often misunderstood as the COP. [Natham,2003] [Natham,2001] [Brody,1986] [Brody 1999]

The main goal of this research is to study the sweet spot on the bat during a bunt specifically, consequently finding the optimum ball exit velocity (BEV) from a bunt.

2. METHODS

In order to achieve our research goals, a primary model of the baseball bat and he ball were developed using CAD software known as SolidWorks and shown in Figure 1. These models were made by looking at a bat and a ball of the professional baseball league (MLB – Major League Baseball) of the United States.

Once the models were made, they were imported to another software known as HyperMesh, which was used to create the mesh for the bat and the ball, as well as to place the ball in several spots along the bat. This is shown in Figure 2. After this, the simulations are setup to run in Abaqus/Explicit.

Abaqus/Explicit lends itself very well in allowing these types of simulations to be run, given its versatility in applying prescribed velocities and boundary conditions to the system. In addition, the mass scaling option allows the runs to be completed rather quickly, without losing accuracy. The setup time is rather straightforward, once the ball is modeled with the necessary layers, since the bat is one single solid part that is held stationary at the handle where the player would hold the bat. The handle is modeled as a rigid body that can be moved to potentially investigate the effects of holding the bat in different spots.

Different initial velocities are applied to ball right before hitting the bat. The simulations are run for a few milliseconds within a few hours of run time. Additionally, two handles can be placed, in case on were to investigate the effect of hand separation distance during a bunt. For simplicity, we modeled only one handle, assuming the two hands are close together during this analysis.

Different positions for the bat to hit the ball during a bunt were considered in order to find which positions provide the best BEV. It is also possible to study the general behavior along the bat finding where the bat will be undergoing the highest stresses.

We believe that results related to a bunt can be extrapolated to a full swing, even though a new set of simulations is required. This is a good starting point to create the methodology for further studies.

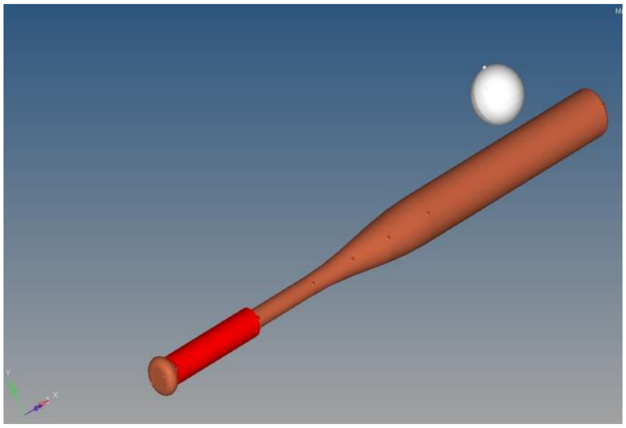

Figure 1 – CAD model

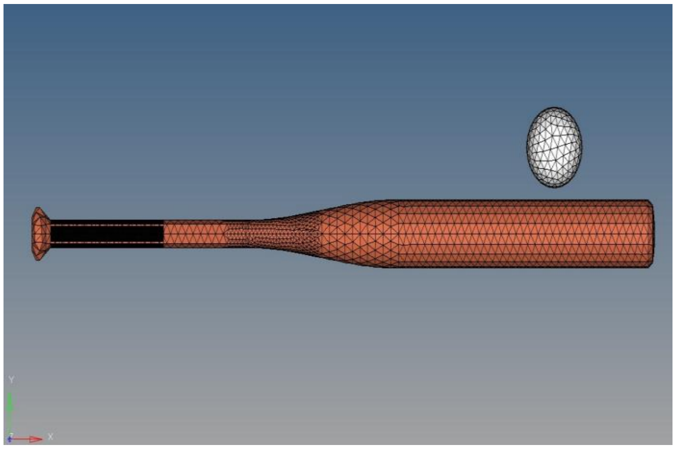

Figure 2 – Meshed Model

3. RESULTS

The results are related to the Ball Exit Velocity based on different points on the bat hitting the ball as well as the stresses on the bat. The figure below shows the plot of Ball Exit Velocity vs. Distance the ball is hit from the edge of the bat. Abaqus/Explicit allowed the dynamic impact simulation to be completed rather seamlessly.

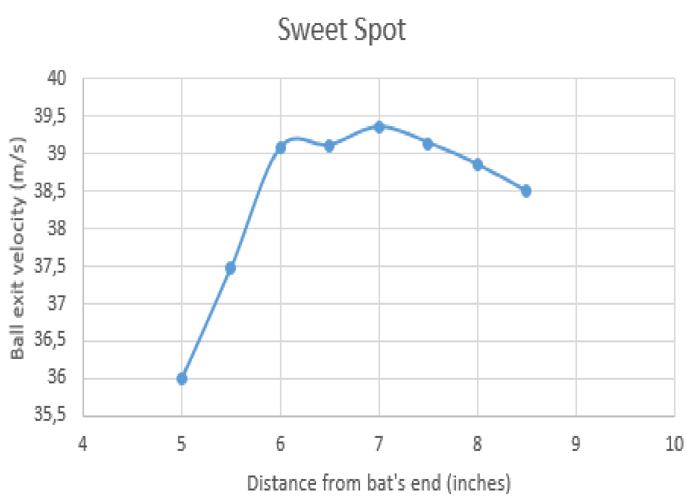

Figure 3 – Sweet Spot (inches) X Ball exit velocity (m/s)

From the graph above it is possible to notice that the sweet spot in our results was located at 7 inches from the bat's end. The small drop in velocity between the 6 and 7 inch mark, may be related to the fact that the ball velocity is averaged across the geometry of the ball, which is a deformable body and there might be some error due to this approximation, but the drop is very small. Despite this, the overall behavior of the BEV seems to follow a logical pattern where the position 7 inches or around this, is most likely the position where the batter will obtain the highest exit velocity of the ball.

Figure 4– Sweet Spot (inches) X Maximum Stresses (MPa)

In addition to Figure 3, the graph above represents the stress distribution along the bat. From Figure 4, it is noted that the lowest stresses occur near the 7 inch mark. Figures 5 and 6 show some velocity contours from the simulations. All results are summarized in Table 1.

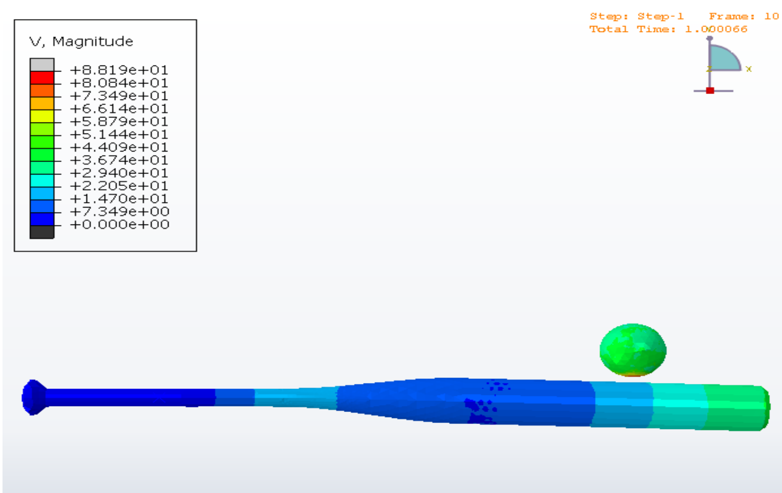

Figure 5 – Velocity (m/s) of the Ball at 6 inches

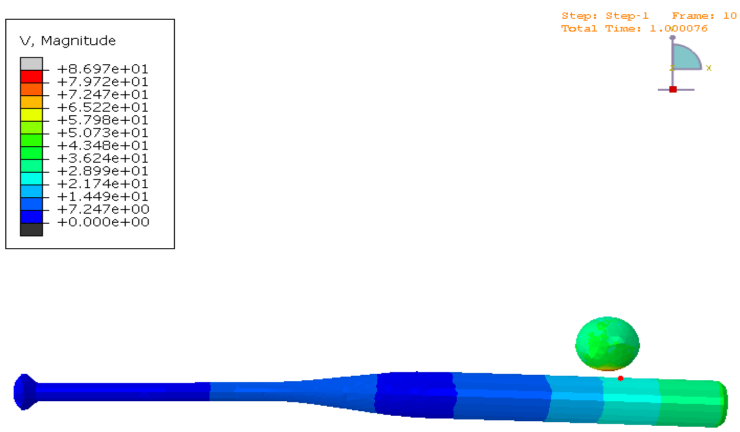

Figure 6 – Velocity (m/s) of the Ball at 5.5 inches

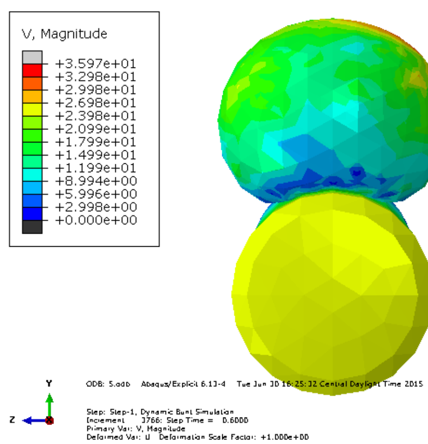

Figure 7 – Representation of the Ball Exit Velocity (m/s) from a Lateral Viewpoint

TABLE 1. SUMMARY OF RESULTS

Distance from Bat's end (Inches)	Ball Exit Velocity (m/s)	Stress at a point (MPa)
5	35.985	162.6
5.5	37.465	156.51
6	39.075	141.39
6.5	39.115	134.26
7	39.355	120.67
7.5	39.145	118.14
8	38.885	142.3
8.5	38.495	162.78

4. DISCUSSION

In this research the material used for the bat was Ash Wood, given the MLB (Major League Baseball) was the focus. Hence, the other materials used in different baseball leagues were not analyzed. The study was focused in finding the sweet spot and the Center of Percussion during a bunt. According to the results, the sweet spot was found. Furthermore the requirement of a spot, which combines both lower stresses and higher ball exit velocities was successfully determined.

5. CONCLUSION

This research aimed at testing out dynamic finite elements for the determination of sports equipment performance during play. In this particular case, the analysis of a bunt during a baseball play was studied.

The sweet spot was defined at 7 inches from the bat's superior end and gave us the velocity of 39.355 m/s combined with a stress of value 120.67 MPa as the lower velocity was obtained at 5 inches from the bat's superior end presenting a stress of 162.6 MPa. We have proven that we can simulate a sports event using Finite Element Analysis, achieving results that can be correlated with tabulated data. Abaqus/Explicit proved to be an invaluable tool to accomplish this task in a rather simple manner.

6. REFERNCES

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