Determination of the "Sweet Spot" of a Cricket Bat Using COMSOL Multiphysics® Software

Y. Mulchand[1], A. Pooransingh[1], R. Latchman[1]

[1]The University of the West Indies, St. Augustine, Trinidad and Tobago

Abstract

Scientific simulation tools are beginning to play a role in facilitating a deeper understanding of sports equipment under various playing conditions. Fontes (2014) illustrated the Magnus Effect for the soccer ball while Latchman and Pooransingh (2015) modeled the conventional swing of the cricket ball. Similar to Boochie (2015) who investigated the physics of tennis racket sweet spots, this study enlists the Structural Mechanics Module of the COMSOL Multiphysics® software to determine the "sweet spot" of the cricket bat. Knowledge of the "sweet spot" may assist batsmen in improving their ability to deliver powerful shots as well as dominate over various bowling attacks. A 3-dimensional model of a regular willow cricket bat was constructed in the COMSOL Multiphysics® software using the Solid Mechanics interface of the Structural Mechanics Module (Figure 1). According to Du Plessis (2014) willow wood is used because of its ductile nature as it is not easily dented nor does not splinter upon impact from high speed cricket balls. The mechanical properties of cricket bats were investigated by Matbase (2016) and Northgate Ltd (2016). An eigenfrequency analysis was performed to determine the bat's natural frequencies of vibration as well as the corresponding mode shapes. The bat was simulated using extra fine free tetrahedral and edge mesh. According to John and Bang Li (2002) the "sweet spot" of a cricket bat is typically located approximately 12cm-18cm from the toe of the bat which also corresponds to that of a baseball bat which is, according to Russell (2015), approximately 5-7 inches (12.7cm-17.78cm) from the toe of the bat. Impacts on this point of the bat do not result in any vibrations being produced and as such the initial energy of the ball is not lost to deformation thus result in a large exit velocity (Hariharan and Srinivasan 2012). Figures 2, 3 and 4 illustrate the resulting modes of vibration obtained at varying the various natural frequencies. For all models the motion was fixed about the handle. (Figure 2) shows the vertical motion of the bat after it was deformed and there was no displacement in the lower mid region of the bat. (Figure 3) shows the twist motion obtained after it was deformed. No displacement and vibrations occurred along the entire middle of the bat. (Figure 4) shows the horizontal motion produced after the bat is deformed. At this frequency no displacement and vibrations were experienced in the lower mid region. For all the simulations done at the various frequencies, it was observed that the greatest excitation of the bat occurred at the toe and along the edges of the bat. These modes were obtained at the following frequencies: 9.6195Hz, 10.344Hz and 17.217Hz. Based on the graphs presented, it was observed that the sweet spot is located along the middle of the bat in the lower mid region, approximately 12cm-15cm from the toe of the bat where all the frequencies overlap.

Reference

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Figures used in the abstract

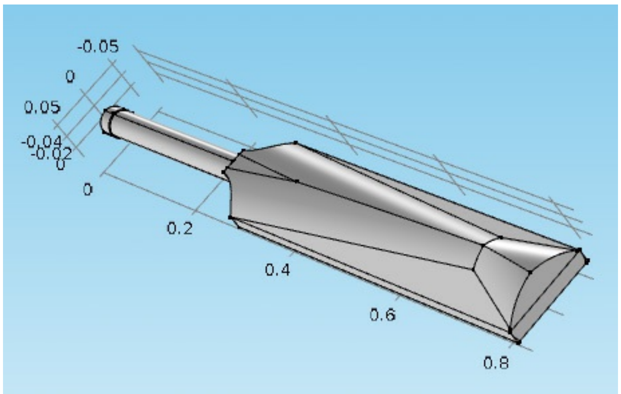

Figure 1: 3-D Model of the Cricket Bat created in COMSOL Multiphysics® in the Structural Mechanics Module

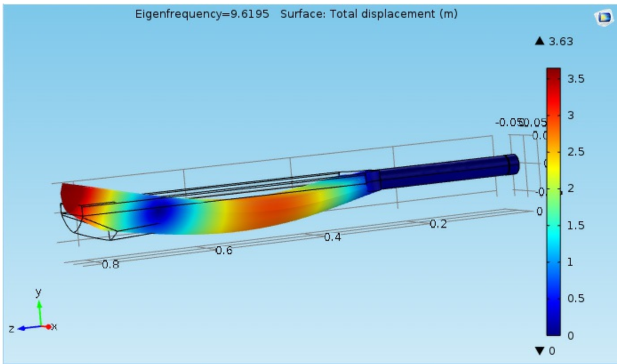

Figure 2: Mode Shape at Eigenfrequency 9.6195 Hz

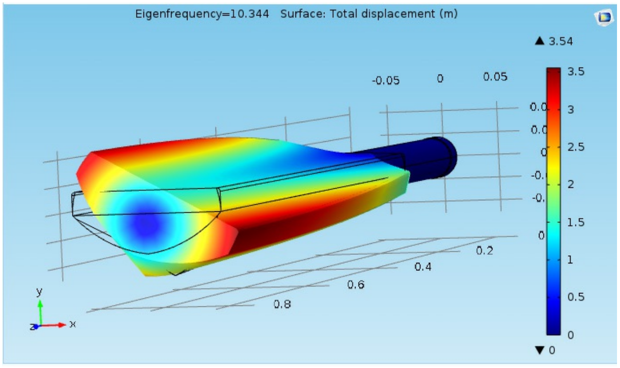

Figure 3: Mode Shape at Eigenfrequency 10.344 Hz

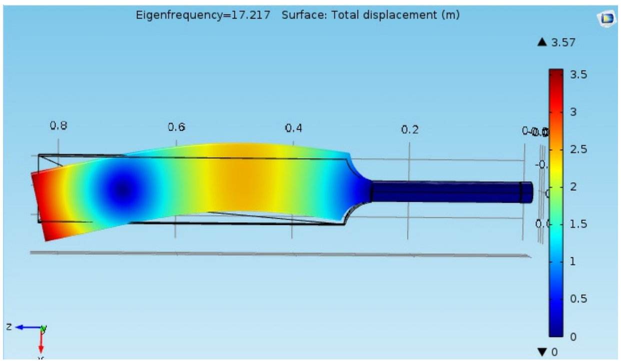

Figure 4: Mode Shape at Eigenfrequency 17.217 Hz