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Research Article

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Woodball mallet loading analysis during maximal swing stage: A finite element study

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ABSTRACT

This study aims to analyze the relevant mechanical properties of woodball shafts by applying numerical methods. The structures of woodball were constructed in Solidworks 2007 to form the solid models, and the numerical model was analyzed in ABAQUS to acquire the simulation results. The collision speed between ball and mallet was from the experiment of motion analysis. As the maximal stress of mallet was concentrated in the proximal part of bottle, some enforcement design could be carried out in this part to reduce the fracture incidence. Another important finding is the contact area at the mallet head was really small, the rubber cover at head part may thicken at the centre part and thinner at the outside area. For further study, it is important to represent the higher fidelity of the input conditions for the finite element analysis (FEA).

Keywords: woodball. finite element analysis. stress. contact pressure

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INTRODUCTION

Woodball is a sport where a mallet is used to pass a ball through gates [1]. As this game could be played in grass, sand or indoor, more and more people in Asia start to play with it. Mallet of woodball is made of wood with not highly sophisticated design. However, composites with their innate direction can not satisfy customers with a simple design concept [2, 3]. It is also impossible to develop highly efficient woodball clubs unless a variety of their innate mechanical parameters are considered in the process of designing the clubs. Therefore, this study aims to analyze the relevant mechanical properties of woodball shafts by applying numerical methods. The finite element method will be employed as a numerical method that will contribute to establish the basis to design powerful woodball mallet.

EXPERIMENTAL SECTION

As Fig.1 shows, the mallet is made of wood in T-shape. The bottle-shaped mallet head is 220 mm. Its bottom is wrapped with a rubber cap which has an outer diameter of 68 mm, a total height of 38mm and a wall thickness of 5 mm. The base thickness of the rubber cap is 13mm, and inside part was made of steel. The ball is spherical and made of natural wood with a diameter of 95 mm.

The material properties of woodball components was listed in table 1. The structures of woodball were constructed in Solidworks 2007 (SolidWorks Corporation, Massachusetts, USA) to form the solid models. It was then imported into the FE package ABAQUS (version 6.9) to build the numerical model. The contact surfaces were created between ball and mallet head, while 10m/s impact speed of the ball which was measured from the normal swing stage, was applied to simulate the loading condition. The top of the mallet, around quarter section, was fixed to representative the hand hold during playing. While the speed of collision between ball and mallet head was setup as 9.8 m/s, which was calculated from swing process of motion analysis.

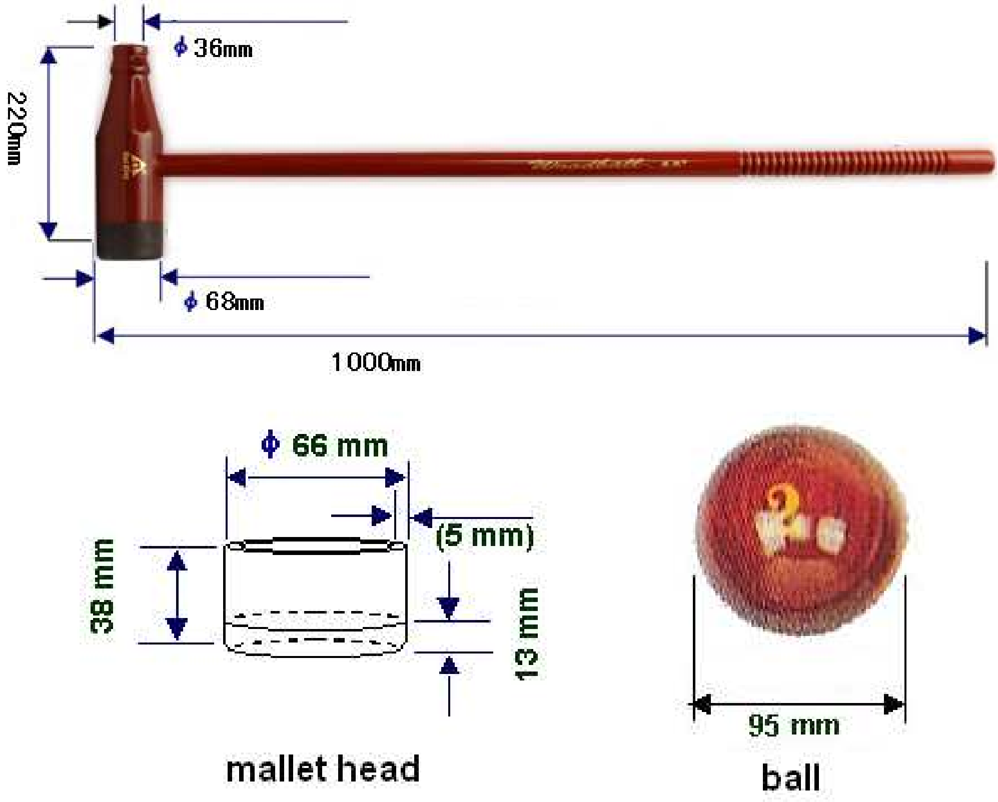

Fig. 1 The geometry information of woodball components

Table.1 The material properties of woodball components.

Material	Young's modulus [Gpa]	Poisson ration	Density[g/cm^3]
Wood	4.6	0.35	0.7
Steel	206	0.3	7.8
Rubber	0.0078	0.47	1.1

Fig.2 The maximal stress distribution of mallet (top) and fracture mallet in real performing event (bottom)

RESULTS

As shown in Fig.2, the maximal stress was concentrated in the proximal of the bottle, which was in good accordance with the mallet fracture happened in real performing event. It is very important to add some special design or material process for strength reinforcement on the proximal of the bottle.

As shown in Fig.2, the maximal stress was concentrated in the proximal of the bottle, which was in good accordance with the mallet fracture happened in real performing event. When looking at the contact area between ball and mallet head, the collision zone was quite small though the contact pressure was reach up to 2.1MPa (Fig.3). The simulation results also show that the minimal stress distribution of mallet. As we can see in the Fig.3, the minimal stress concentrates at the side of mallet head, which means the compression force was not important related to the mallet destroy.

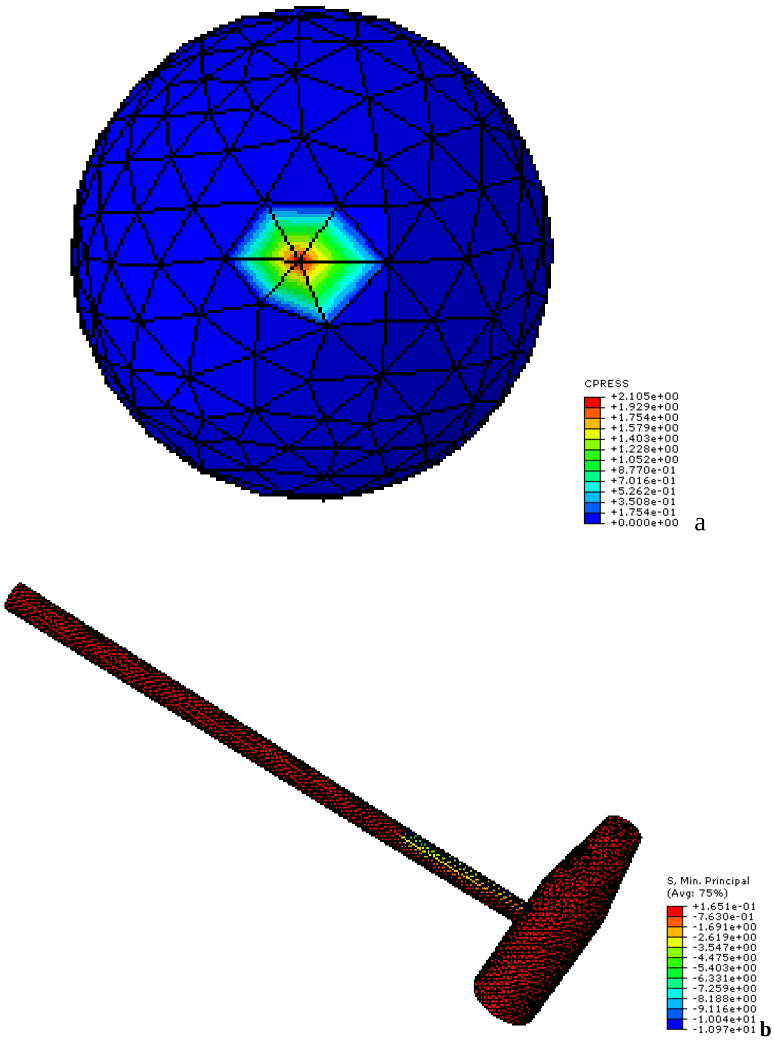

Fig.3 The contact area at the ball during the collision process (a), and minimal stress of mallet (b)

DISCUSSION

The FE model, which can simulate the behaviour of woodball mallet during swing and that of impact, was constructed. The collision speed between ball and mallet was from the experiment of motion analysis [4]. As the maximal stress of mallet was concentrated in the proximal part of bottle, some enforcement design could be carried out in this part to reduce the fracture incidence. Another important finding is the contact area at the mallet head was really small, the rubber cover at head part may thicken at the centre part and thinner at the outside area [5]. For further study, it is important to represent the higher fidelity of the input conditions for the FEA, such as the motion and constraint of the grip, in addition to that of the geometry and material properties of the FE models, and the input conditions were suitable for the constructed model.

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