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Static Analisys Of Cricker Bat With And Without Using Aluminun Plate

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Abstract—A number of games like cricket, tennis, baseball, etc have developed a lot due to the extensive research done in the sporting equipment. The main aim of this research is to detect the characteristics and change of cricket bat with using a metallic plate in static condition and compare it with the commonly using wooden bat. Since the introduction of the first aluminium bat, durability has been a great concern. Some work has been performed in the area of predicting bat performance, but little has been done in the way of quantifying their durability or longevity. The work performed hear sets out to pr edict the durability of a single wall aluminium plate bat by modelling a bat-ball collision using finite element analyses. This thesis presents the development of two fast-solving numerical models as well as a universal F EA model for the structural analysis of cricket bat. The models were developed using experimental data obtained from drop tests and high speed impact tests. These models predict impact characteristics with very little computing cost. . The inter action of a cricket ball and a bat are computationally modelled using commercially available software INVENTOR and modal analysis is done by using commercially available software ALTAIR. The model of the ball is creating using a viscoelastic material and for cricket bat orthotropic model used.

Keywords—Viscoelastic material , orthotropic model, finite element analysis, ALTAIR.

Introduction

Cricket has been about for more than a Century but until now, improvements in the piece of the Cricket bat have been fairly limited. It's to some extent due to game directive restrictions and partly because the application of proper high technology to the bat has been nearly non-existent. As everyone who played the game of Cricket knows, the result of hitting a ball away from the Sweet Spot may be very sore due to the transmitted structure-borne torsional and cross vibration on a player's hand and also a risk for batsman to be injured because of transient vibration. These transient vibrations have up until now, been inactively and mechanically damped by the inbuilt damping properties of wood and flat rubber panels in the handle. The variety is that the sort of still damping is effective for the high regularity vibrations only while the low regularity vibrations remain continuous.

BAT USING ALUMIMUM

The first aluminium bats come in the end of the year 1960's. These bats instantly well-liked between the players because of the raised less effort is required to bat the ball over then wood bats. Earlier to any knowledge of what is now known as the trampoline result, which is present in thin-plate aluminium bat, the performance of the first aluminium bats were not nearby to what they are now. Research on account of how to improve the performance of a plate aluminium bat by using different alloys or plate thicknesses has been increased and the performance eventually went up. But the swap to this increased performance was decreased durability. To neutralize this problem, manufacturers began to introduce bats with stronger aluminium alloys, added strengthening alloys such as scandium, or used totally different metals such as titanium. As the raw material cost is less in case of aluminium, it has become the first preference to be used for metal bats. Today the titanium is still being used, but not on the same level as that of aluminium. At the moment, there were a variety of procedures of bat performance, but there is no minimum obligation on a bat's level or sturdiness or period. Sturdiness and performance for a bat can be very estimated and judged based on the bat swung velocity, the ball hardness and the environment conditions such as temperature. Typically, a bat is designed to survive the wear and tear of a year's worth of use, but except firsthand knowledge is known about how the bat will hold up by a player of equivalent skill and strength. It is very difficult to provide any estimate of how long the bat will go without any denting for the person who is purchasing it. Manufacturers characteristically offer one year warranties due to this reason that permit for total bat replacement in case the bat dents extremely under normal use.

Literature review

The methodology used for baseball bat research is used for cricket bat. Lloyd Smith et al [1,10] in their paper determined dynamic interaction of bat and ball. Linear elastic property was used for bat and nonlinear property for ball. The bat and ball was given linear velocities. The effect of impact location on ball exit velocity was presented. Rochelle Nicholls et al [7,8] analyzed the dynamics of bat ball impact using finite element method. Kinematic input was obtained from experimental setup. Aluminum and wood baseball bat was used for analysis. Linear elastic isotopic model was used for bat. Both ends were assumed to be free to rotate and translate. Results between ball exit velocity and impact location is plotted to determine the location of maximum BEV. Sherwood et al [4, 11] analyzed the change in the performance of bat due to changes in wall thickness, handle flex, material properties, and weight distribution. Experimental data was calibrated using finite element method. Mooney rivilin material model was used for ball. Automatic surface to surface contact algorithm was selected. Aluminium bat made of C405 alloy was considered and meshed using shell element. Solid wood bat was also used for analysis. Graph was plotted between BEV and time for wood and aluminium bats. Aluminium bat had higher ball exit velocity. Shenoy et al [2,9] compared the performance for wooden bat and composite bat. The effect of bat constraints on stress and performance is determined. Graphs were plotted between hit ball speed and bat impact location and Bat impact location and axial stress. Larry noble [5,11] provided scientific basis for examining and developing new bat design and manner in which bat is swung and forces transmitted during swing and properties of bat were considered. Mass, Moment of inertia, Coefficient of restitution, COP and Fundamental node of vibration were the properties considered. The study is made on the cricket bat. The present concentrates the characterizing of cricket bat and its performance. Various Graphs are plotted for ball exit velocity and impact location from bottom of the bat.

MODELING OF CRICKET BAT

The analysis is carried out for the cricket bat. The geometry of the cricket bat is measured and modelled. Material properties of the bat are based on the type of wood used. Cricket ball dimensions are also measured and modelled with two assumptions. First the bat is to move linearly in order to reduce the computational time and the second one Cricket bat is assumed to be made of English willow wood. Modelling of the cricket, ball and plate is done on ALTAIR software. We using circular plate for reducing stress concentration. modelling of the cricket has created on the Ansys by the use of standards dimensions **Harrow: Length - 32.5" Width - 4.25" to fit player of 5ft 4" - 5ft 8"** and the back side maximum knob is 3 cm from the back blade surface. Thickness of the bat blade is 3 cm and the radius of the handle of the bat is 1.5 cm. the whole bat is as a single volume the handle and blade are not different volume .now a day's many companies making a this type of single volume bat and many research is going on for increasing their durability and performance. According our analysis we have created two model of bat. One is totally wood which are generally used in the cricket matches and another one is also wood but a steel plate dimension 4.5cm*35cm*2cm fitted inside the bat in the sandwich form and the same volume of wood removed from inside the bat .the mass of wood bat is 0.840 kg and the mass of bat with aluminium plate is 0.804 kg.

METHOD OF ANALYSIS

Computational analysis of bat ball analysis is performed in ALTAIR. It combines the ALTAIR finite element program with the powerful pre and post processing capabilities of it. The method used for analysis 'ALTAIR' that provides fast solutions for short-time, large deformation static, problems with large deformations and linearity's, contact/impact problems. Using the model in ALTAIR can obtain the static solution and evaluation of results using the standard ALTAIR post processing tools. The element is defined by nodes having the following all degrees of freedom is fix the handle at each node in x, y, and z directions. Define their properties Static elastic model is show and then apply a meshing tool using a triangular and free mesh and size of the element is 2 cm. Meshed model is shown in fig.4.

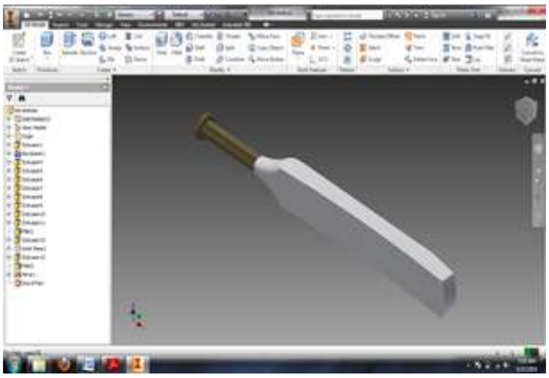


Fig-1 Wooden bat is shade

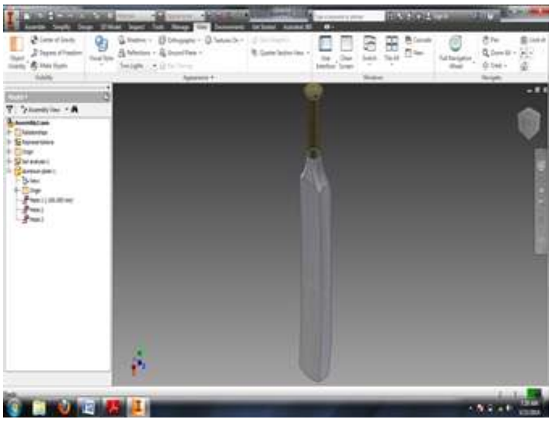


Fig-2 Aluminium bat in shade

S.No	Property	Value
1	Density	450 kg/m^3
2	Shear modulus	6.7 e9 N/m^2
3	Poisson ratio	0.3
4	Elastic modulus	9.8 e9 N/m^2

Table .1 Material properties of Cricket bat

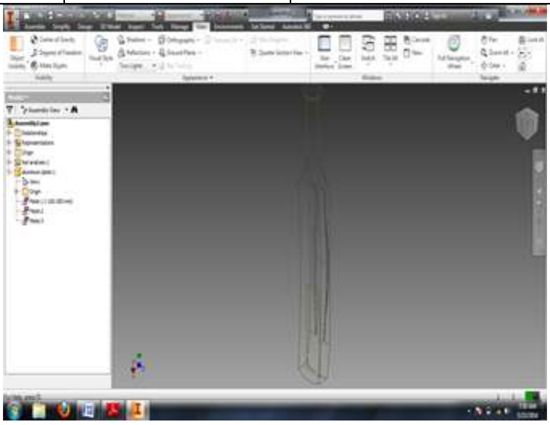


Fig-3 Aluminium bat in wireframe

BOUNDARY CONDITIONS

The bat is unspecified to be free-free beam and moved in linear direction. The ball is moving with velocity with linear path and angular path

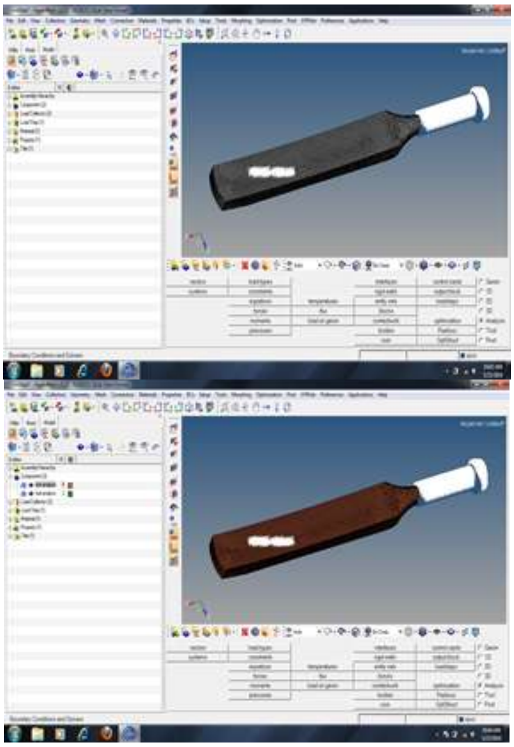


Fig-4 meshed model

There are abundant material models available for use in an explicit dynamic analysis. Orthotropic model is selected for bat and proper material properties are defined as in Table .1

A cricket ball is a object in which many nonlinear materials such as leather, twine or yarn and cork/rubber pill. A solely linear-elastic ball cannot be used in the modelling because it does not report for the nonlinear properties that a real ball reveals with respect to the stiffness of the ball. Viscoelastic model was taken for the ball defined from a time dependant on shear modulus as

$$G(t) = G_\alpha + (G_o - G_\alpha)\, e^{-\beta t}$$

Value of various constants are given in table.2

Table .2 Material properties of Cricket ball

S.No	Property	Value
1	Density	150 kg/m^3
2	β(material Constant)	9000
3	Shear modulus Go	41 e6 N/m^2
4	Bulk modulus K	69 e6 N/m^2
5	Shear modulus G_α	11 e6 N/m^2

A contact surface in ALTAIR allows to signify, a wide range of types of contact between components in a model. Bat surface and ball surface is selected as contact entities. Usually Surface-to-Surface algorithm is selected to efficiently represent the realistic contact. Variety of combination for bat impact such as 30-30, 40-30, 30-40 impacts and angular impacts of Ball. 30-30 impact means given velocity to the ball of 30 m/s and bat is given 30 m/s. Ball velocity obtained after is renowned for various locations from the bottom of the bat to find the stress strain and deflection on the bat model is plotted for all combinations. Material properties are defined in Table 3

Table 3 Material properties of Aluminium plate

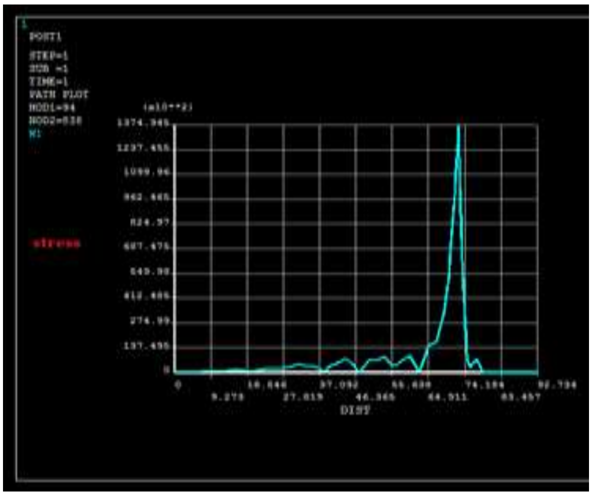
S.No	Property	Value
1	Density	2400
2	Young's modulus	7.00E+10
3	Poisson's ratio	0.300
4	Shear modulus	26000000 N/ m^2

RESULT AND DESCRIPTION

Wooden bat Result

The graph is plotted between stress on the bat and impact location so that we can determine the area of impact which creates maximum stress or deflection.
For example when ball is subjected to 145 km/hrs linear velocity at the distance 13cm from the bottom of the wood willows bat the force is generated on the bat

face is about 13583 N then maximum stress produce 204136 N/cm2 at the distance 65cm from the bottom and maximum deflection occur in the wood willows bat is 0.569874 cm



Graph-1 between the stress develop in the bat and distance from the bottom

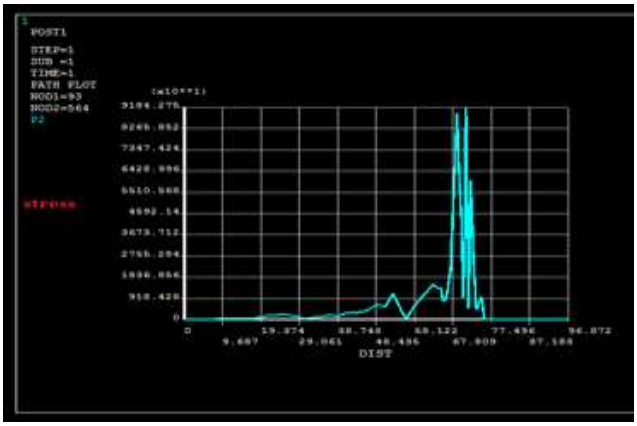
Five Analysis has been carried out with wooden bat by varying the impact location i.e distance from the bottom of the bat and the results are shown in Table 4.

Table 4 Result for the willow wood bat

Collision of bat and ball distance from the bottom (cm)	Maximum stress on the wood bat. (N/cm^2)	Maximum deflection on the wood bat. (cm)
13.47	204236	0.698
16.65	158141	0.486
30.10	109080	0.229
38.26	85598	0.209
49.33	47806	0.103

Result of wooden bat with Aluminium plate

After that at the same speed ball 145 km/hrs come on the aluminium plate bat and put their impact on the bat with the same force 13583 N, and also the collision of the ball and bat at the same position distance from the bottom is 13 cm then the outcome given by the Altair is totally different from the first one. Maximum stress on the aluminium plate bat is 174263N/cm2 at the distance of 67 cm from the bottom of the bat and the maximum deflection is 0.334779 cm. which is show in fig 8.5 and the Graph 9.2 is plotted between Stress and distance.



Graph-2: Between the stresses develop in the bat and distance from the bottom

Five Analysis has been carried out with Wooden bat with Aluminium plate by varying the impact location i.e distance from the bottom of the bat and the results are shown in Table.5

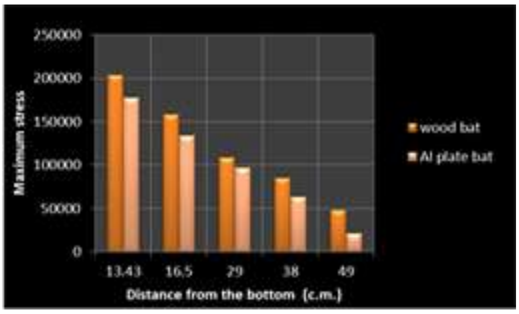
Table No 5: Results for the wood aluminum bat

Collision of bat and ball distance from the bottom(cm)	Maximum stress on the wood bat. (N/cm^2)	Maximum deflection on the wood bat. (cm)
13.47	177631	0.321
16.65	134308	0.213
30.10	96701	0.166
38.26	63724	0.102
49.33	21612	0.020

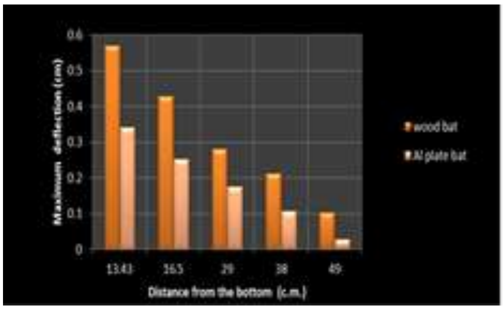
According to analysis bat is taken as a free beam so when the distance increases from the bottom of the bat then the value of the maximum stress is reduces and the deflection is also below the normal. Taken a five- five analysis on the both model at the different-different distance from the bottom and cap ire the variation in the stress, strain and the deflection on both model. And show which is the more durable wood bat or aluminium plate bat.

Final result and discussion

According to analysis bat is taken as a free beam so when the distance increases from the bottom of the bat then the value of the maximum stress is reduces and the deflection is also below the normal



Graph -3: Between stress and distance from bottom



Graph -4: Between deflection and distance from bottom

The results which have came for both model that shown on the Graph 7.3 to 7.4. It can easily compare to each other, by the compression of both model we can see that the maximum stress develop and the maximum deflection on the aluminium plate bat is less as compare to the willow wood bat. so the performance of the aluminium plate bat is better than the wood bat it can bear the maximum speed of the ball and maximum forces which impact by the ball on the bate face . The aluminium plate bat will more durable and also give a better performance as compare to the willows wood bat. batted ball speed by the aluminium plate bat will also greater than the wood bat and the effort will applied by the batsman with the aluminium plate bat will less. So the batsmen feel comfortable on the batting time and will get a better result. The aluminium plate bat is better option for the future in the place of willow wood bat. It can make more interesting to the cricket.

CONCLUSION

This study considered the performance of cricket bats. A analysis has been done to measure bat properties and the impact speeds of ball on the bat performance. The analysis method involved firing the cricket balls at various positions on a stationary cricket bat. Bat performance has been compared using the maximum stress and maximum deflection of cricket bats. The swing speed of the cricket bat was found from the flight of the cricket ball. The MOI of the cricket bat has a significant effect on the performance. Knock-in and oiling has a small effect on weight, MOI and performance. On average, the performance of aluminium plate bat was observed to be 10% higher than willow bat. The contribution of a sandwich aluminium plate to the inside of the blade of bat is also reduce (15%), the effort which is applied by the batsman. The purpose of using a aluminium plate inside the wood bat in the form of sandwich to reduce the stress concentration on the wood cricket bat and make a more durable. This finite element models provide an excellent simulation of the bat-ball impact and can be used to investigate the stress, strain and deflection. This modeling procedure yields a credible methodology for bat designers to use finite element methods to characterize cricket bat performance.

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