The Science Behind Baseball

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Introduction

The Annual Mathematical Contest in Modeling (MCM) is a multi-day mathematics competition held annually in USA, during the first or second weekend in February. It is distinguished from other major mathematical competitions such as Putnam by its strong focus on research, originality, teamwork, communication and justification of results. At the beginning of the contest, teams have a choice between two problems. Problem A involves a system that requires the use of continuous mathematics, and thus often involves concepts from geometry, physics, or engineering. Problem B involves a system that requires the use of discrete mathematics. The Teams have 96 hours to research and submit their solutions in the form of a research paper. During this time, they may consult any available references, but may not discuss their problem with anyone outside their teams. Several guides containing advice and recommendations for teams and/or advisors have been published online or in print. Around one thousand international teams of three undergraduates compete to produce original mathematical papers in response to one of two modeling problems. Initially, participation was largely from the United States, however in recent years international participation has grown significantly,

The effect of corking a bat is just a myth. A corked bat has a slightly less mass by means of drilling out the center of a wood bat and replacing it with cork. The player can shave about 1.5 ounces off of the weight of his bat but since the reduction of the weight the center-of-mass of the bat would shift slightly towards the handle end of the bat. This would mean that the moment of inertia of the bat would decrease and it would be easier to swing.
tells us that the speed of the swing of the bat has a higher effect on the speed of the ball after it has been hit and research has shown that faster bat swing speed results in faster batted-ball speed, though the change in ball speed would be minimal for most players. Less mass means a less effective collision. So, if by the bat being lighter, the player can swing it harder, this may result in a higher speed as it travels out into the field, after it has been hit. But lowering the mass and the moment-of-inertia may increase the bat swing speed; however the lower mass means that the collision between bat and ball is less effective. If the swing speed is kept constant, a heavier bat will always propel the ball faster and farther. So removing mass from the bat will actually reduce the batted-ball speed. The ratio of the bat composition would be affected, thus changing how the bat reacts. That's why the rule 6.06 from the national baseball rules refers only to bats that are "altered or tampered with in such a way to improve the distance factor or cause an unusual reaction on the baseball. This includes bats that are filled, flat-surfaced, nailed, hollowed, grooved or covered with a substance such as paraffin, wax, etc." The corking of the bat could also weaken a bat which could break easier.

Different Material

Throughout the years baseball bats have been made from different materials. From the beginning the wood of choice was oak and hickory. Later on white ash was used, but because of its rarity more bats are being made out of birch and hard maple. Metal bats have gone through similar changes. Older metal bats are normally composed of aluminum while the newer ones tend to be made out of composite metals. The major league prohibits the use of metal bats because of the advantage a player would get. Since the weight would decrease it would increase the speed of the bat, thus increasing the speed of the ball after being hit. Also this can be a safety issue since the ball has more speed, which gives the ball a greater impact force, making it more possible for players to be injured from catching or being hit by the ball.

A big question which seems to have many theories asks one thing: does the material which composes the bat hold a significant effect on the performance of the player during the swing? The constant problem is that while many studies have been performed to conclude whether it has a big effect or not, it is agreed that the results are not without flaw simply because it would be difficult to reproduce the conditions of the swings as they are performed in a game scenario. All of the tests are performed under experimental conditions as described in either the ASTM or NCAA method. Dr. Alan M. Nathan did his study on the differences between aluminum and wood bats in a baseball swing using the NCAA data and methods to determine the nature of both. He found that the aluminum bats perform better because the moment of inertia (MOI) is smaller due to the decreased mass of the aluminum bats in comparison to the wooden bats and that this would produce a faster swing with the aluminum bats. He also stated that two bats of different composition would perform identically in testing settings would be different in the playing field, but that even being of two different materials that they would perform

identically if they shared the same MOI. He gave the following reasons for how this could happen:

1. Make the MOI restriction on aluminum bats comparable to wood bats (i.e., 11,000 rather than 9700 for 34" bats). This would be quite easy to do in that bat manufacturers would shift weight from the knob to the barrel cap to increase the MOI.

2. Require that aluminum bats pass the laboratory test of hit ball speed less than 97 mph with a bat speed higher than 66 mph, with the exact speed depending on the MOI of the bat. Of course, one would need a prescription for the relationship between bat speed and MOI, which one could obtain from the data of Fleisig or of Crisco and Greenwald or from additional testing.

3. Use the same 66 mph bat speed as in the NCAA test but a "sliding scale" for the hit ball speed. That is, the upper limit on hit ball speed, currently set at 97 mph for all bats, would be less than 97 mph for bats with a lower MOI. Once again, one would need to obtain data (or a reasonable simulation of the ball-bat collision) to determine how to set the scale. (Nathan)

Of the mentioned above, the first options is the most viable. This seems to be a trend typically when discussing the work of L.V. Smith who made his own unofficial method in order to garner results. He found that the hollow nature of the aluminum bats coupled with the decreased coefficient of restitution (COR) makes for a higher velocity and lower energy loss due to longer contact during collision between the baseball and the bat and greater impulse to the ball. (Smith)

People may wonder if the velocity and energy exchange of a wooden bat can be held to the same standard with an increased MOI for aluminum bats. The answer is that while it is true aluminum bats could be modified to perform like their wooden counterparts; many people from the little leagues to the pros view the damages, injuries, and even death as too much to bear. A student during a Police Athletic League game in New Jersey received a hit to the chest from a swing of an aluminum bat. There are other cases where serious injury had been reported from baseballs hit with swings from aluminum bats. These cases have made arguments which have led to the banning of these instruments from all levels of play. When the New York judicial system held a decision to ban aluminum bats from high schools, it was met with opposing viewpoints, mainly because of the fear of such dangers. (Passan)

Summary

The term "sweet spot," when talking about a baseball bat, could be described as the place on the bat where the ball can achieve its maximum speed when struck. The team has defined the "sweet spot" as the spot in the bat where the ball hits and there is no force exerted on the batters hand. Through research and calculation, a model was found to explain how it works. The team has also shown through research and calculation that a corked bat does not performed up to the myth's standards. The team has also shown that the changes in materials which the bats are made of have made an effect on the speed and distance which the ball travels. This has led to the banning of aluminum bats in many leagues because of its increased speed.