NHL's hardest shot competition: what physics has to say

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The highpoint of the NHL's annual All-Star game Skills Competition is certainly the hardest shot competition. A puck is dropped in front of the net some 30 feet away, and each competing player takes turn at slapping the puck as fast as they can. The puck speed is recorded by radar from behind the net, and the fastest shooter wins the title. The unofficial target for players to reach is 100 mph: fans don't react much to a 99.5 mph shot, but they go crazy when they see 100.5 mph on the screen (go figure). At a 100 mph, the puck finds the net in 2/10 of a second, or about the same amount of time it takes for a person to start moving.

This article will try to determine what is and isn't important when trying to clock the fastest slapshot.

Keep the puck low?

Let's begin with a simple observation concerning radars used for measuring speeds: they can only record the motion of something coming *towards* or *away* from them. In other words, something moving up and down fast in front of the radar would register a speed of 0. That's why policemen need to be behind or in front of your car to clock your speed accurately. The radar used at the Skills Competition is put at ice-level, so when a puck is shot up at an angle, its upward velocity is not measured; that component is lost, it doesn't count. How much difference does it make? Let's compare two slapshots, one sending the puck at 100 mph flat against the ice, the other upwards towards the center of the net. The first puck will register 100 mph, but the second one rises to a height of 2 feet (or half the net height) over a distance of 30 feet; that's a 4^o slope. Using high school trigonometry, we find that the puck would register 99.8 mph[1]. That's a -0.2% drop, not likely to make the difference between 1st and 2nd place at the 2008 Skills Competition (see the Table 1 below).

There's another argument for keeping the puck low. It has to do with the fact that a projectile slows down when it rises in the air. The principle of conservation of energy wants it so: kinetic energy (or "speed energy") is converted in potential energy when the projectile goes up and vice-versa when it falls back. Using this principle, we can find how much slower a puck will move

[1] For math-savvy readers, the registered speed is corrected by a speed of $(1-\cos A)$, where A is the slope angle.

when shot up compared to a puck moving along the ice[2]. In the previous example, the puck shot at the center of the net would be 0.3 mph slower by the time it reaches the net. Adding to it the radar angle correction, it makes for a 0.5 mph difference. That difference could not have made Vincent Lecavalier beat Zdeno Chara at the 2008 Hardest Shot Competition.

We conclude that keeping the puck low helps, but it's not a huge factor.

NHL 2008 All-Star Hardest Shot Competition: Zdeno Chara on his way to claim a second title in a row.

[2] The correction factor here is $\sqrt{1-2gh/v_o^2}$, where g is the acceleration due to gravity (9.8 m/s²), h is the height of the puck and v_o is the velocity of the puck at launch.

Table 1: Results for the 2008 All-Star Hardest Shot Competition

Player	attempt #	speed(mph)
Chara	2	103.1
Lecavalier	1	101.9
Chara	1	101.4
Arnott	2	100.3
Pronger	2	99.7
Pronger	1	99.5
Arnott	1	99.1
Lecavalier	2	98.6
Ovechkin	1	98.3
Markov	2	96.9
Phaneuf	2	96.2
Markov	1	95.9
Iginla	1	95.7
Ovechkin	2	95.6
Phaneuf	1	94.6
	average	98.5
	stdev	2.6

Uncertainty and inaccuracy

When we say that Jason Arnott's shot clocked 100.3 mph, what does that mean? From what we just discussed, we can say that if he didn't shoot in line with the radar that we might add ~0.5 mph or so to that number.

But there's more to the story. What about the fact that the puck is slowing down because, well, things always slow down when there is friction? Indeed, a fast moving puck experience significant air drag. In my book, I estimate, based on aerodynamic data of pucks that a 100 mph slapshot slows down by 0.2 mph per foot of distance traveled[3]. Assuming the radar registers the speed when the puck has traveled 30 feet, it means Arnott's shot would have been 6 mph faster at launch, or 106.3 instead of 100.3 mph. The same being true for all shooters, it can't be a deciding factor, but it's still interesting to see that air drag is a much bigger effect than shooting angle.

It is also legitimate to question the intrinsic accuracy of the radar system. A number like 100.3 mph implies an accuracy of, in the jargon of scientists, 4 significant digits. Is the radar really that precise, especially when looking through the net at an object whose front surface is half the size of a business card? My gut

[3] See *The Physics of Hockey* (Johns Hopkins University Press, 2003) page 76.

feeling tells me that the uncertainty could be much higher than the assumed 0.1 mph, but I don't have data to support that hypothesis.

Hard shooters and the Bobby Hull enigma

Chicago left winger Bobby Hull had a legendary slapshot. Goalies of his era might well have called him Bobby Hell, for his shot was apparently clocked at near 120 mph. That seems like an extraordinary number considering the fastest shots of the past 15 years rarely exceed 103 mph. Al Iafrate's 105.2 mph (the competition's record since 1994) looks tame in comparison, as does Chad Kilger's 106.6 mph clocked at the 2007 Maple Leafs' skill competition. In fact, when we take 100 mph as a typical slapshot in the NHL, that's a slight exaggeration, because as Table 1 shows, the best shooters rarely reach that mark when they focus just on that task. Athletes are only getting stronger, faster and better (see graph below), so how could a guy have a shot that was 20% harder in the 1960's?

A combination of factor might explain why. Measurement uncertainties of equipments used at the time might have played a role. It's also possible that measurements were done with Bobby Hull skating with the puck (don't forget players can skate faster than 20 mph), in which case the speeds add up. The fact that Hull sometimes used a stick that is heavier than today's legal limit was probably not a factor[4]. But all this doesn't mean Hull didn't have a powerful shot or couldn't have competed or beaten today's best shooters.

Is a slapshot above 110 mph humanly possible? It's probable. Don't forget that we're only looking at NHL data here. Just like the longest golf drivers don't play in the PGA, the fastest puck ever shot probably didn't come from an NHLer but some guy playing, who knows, in some bush league in Siberia or Northern New Brunswick.

[4] See *The Physics of Hockey* p. 89.

Speed of the winning slapshot at the NHL All-Star competition since 1990