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Energy Harvesting – Heated Hockey Skate

Will Donahue

The game of hockey has not had a very major break through in skate technology within the past three decades. This proposal introduces the idea of a self-heated hockey skate that is powered by motion using electromagnetics, which heats the skate blade to a temperature that dramatically reduces the friction between the players skate and the ice surface. The skate appear to be a normal skate, but the technology to reduce friction will be hidden within while improving the player's game drastically. The self-heated skate will be tested against a normal skate with similar specifications for differences in acceleration, gliding speeds, and endurance.

Advisor Luke Dosiek

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Introduction

Hockey is a high intensity sport. It is played on a sheet of ice. The sport of hockey is a sport that is enjoyed internationally by people ranging from the age of 3-80. The sport has become more and more popular over the years due to the NHL and the Olympics. Hockey players are able to glide on the ice because there is a thin layer of water, approximately 10 microns thick, lying between the blade of the skate and the ice itself, which is set to stay at the optimal temperature of 23°F by using a cooling system. When the players skate, the thin layer of water becomes a type of 'snow, as the players continue to skate the layer of 'snow' becomes thicker and thicker and the ice becomes harder to skate on due to the increase of friction between the skate blade and the ice. As a result, it is necessary for a Zamboni to resurface the ice between periods of play.

Figure 1 Typical Skate Used by Professionals and Amateurs

The hockey skate has three main parts to it. The first part is the boot. The boot is where the player's foot is within the skate. The second part is the TUUK holder. In Figure 1, the TUUK holder is the black piece that is above the steel blade. The TUUK holder has a hollow inside underneath the heel and the toe of the boot. The third part is the blade. The blade is removable within modern skates, which allows for an easy swap if the blade is cracked.

Figure 2 A TUUK Holder and Steel Blade

Players dress in gear from head to toe, but the most important piece of equipment that they wear is their skates. Modern hockey skates are very lightweight and continue to become lighter, which allows the players to become less fatigued and accelerate faster. The typical weight of a decent hockey skate is less than 1 kg. A new approach to improving the hockey skate has been pursued over the past couple of years, the heated blade.

Thermablade, a company based out of Canada, has recently designed a skate that heats the steel blade to a temperature that melts the ice just enough to double the micro-layer of water between the blade and the ice [2]. The company's research shows that the heated blade reduces the starting resistance for the skater by 65-75% and reduces the gliding resistance by 50-55% [3]. The player experiences less friction and vibration as opposed to wearing a normal skate allowing the player to be less fatigued as the game goes on and achieve higher speeds than a player would normally be capable of on an untreated ice surface [2].

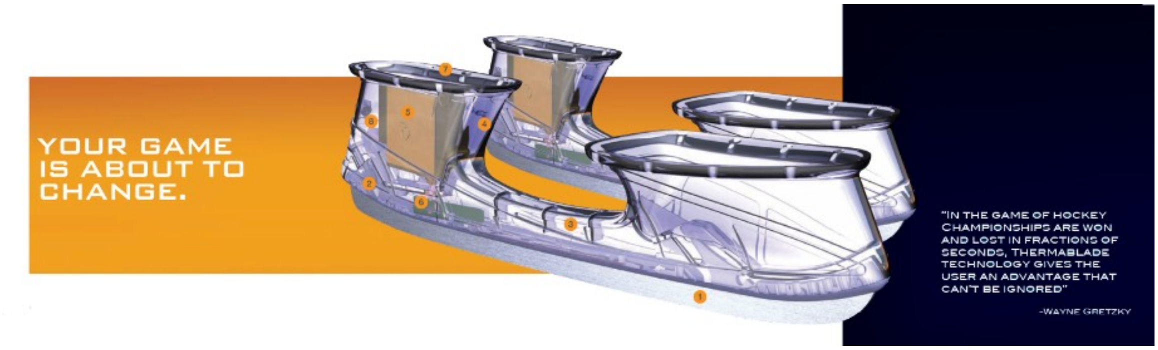

Figure 3 A See-Through Thermablade [2]

The improvement that will be made to the skate will use Faraday's Law of Induction to allow the actual skate to power itself through motion [4]. Faraday's Law of Induction states that if a magnet is passed through a coil of magnetic wire it will induce a current on the wire. The strength of the current depends on the velocity the magnets pass through the coil, the strength of the magnet, and the number of turns in the coil. There will be multiple coils within the TUUK that are connected to the battery in separate compartments. This will allow the blade to heat up without the player even knowing the technology is occurring within the TUUK of the skate.

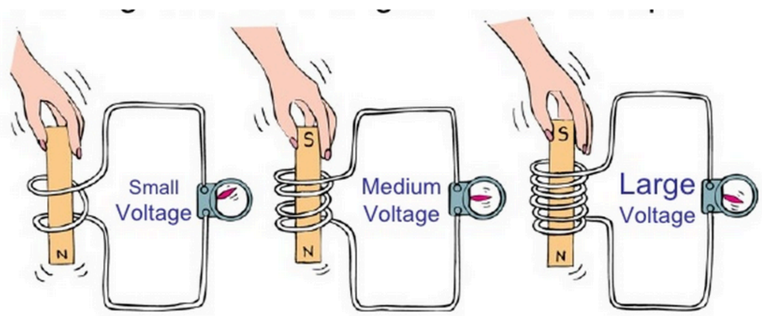

Figure 4 Faraday's Law of Induction [4]

Problem Definition

Skate technology has not been changed drastically by any manufacturer within the past 5-7 years. The skate design being discussed could be the most drastic design enhancement that will make an impact of the game since carbon fiber was introduced to the sport, which allowed for lighter and stronger equipment. This allows the game to become a faster sport, which draws more fans and revenue allowing the players to get a needed pay raise in comparison to other sports.

The Thermablade is an add-on to skates [2]. It costs $300 for the pair. The top of the line skates cost around $1000 now. The player would have to buy the pair of skates and then detach the TUUK currently on the skate and rivet the Thermablades to the boot. The Thermablade also needs to be charged after every use in order for the blade to heat up like it is supposed to [3].

The project being proposed will solve the problem of charging and also the cost problem. The Thermablade is very expensive as stated in the last paragraph. The device being created would be attached skates already, which lowers costs because there is no need to buy and add-on and waste the TUUK that is already on the skate. When the heated blade is just a couple degrees above the temperature of the ice the ice surface will become more fluid which reduces friction throughout the entire hockey game. This product will allow for a faster game that is more entertaining. The game will also become more challenging.

The project is targeting the higher levels of competition, such as the NHL, IIHL, AHL, Olympics, Juniors and College. These levels pay for the player's equipment, so everyone would have the ability to use the heated blade. Younger kids could use this product, but skates are very expensive and their skate sizes change frequently. This product would make more of an impact with experienced skaters. A major goal of this project is having a final product at that end that could be sold to a hockey company, such as Bauer, or sold under its own name brand. If the product is sold the system will already be within the skate when purchased, ultimately lowering costs.

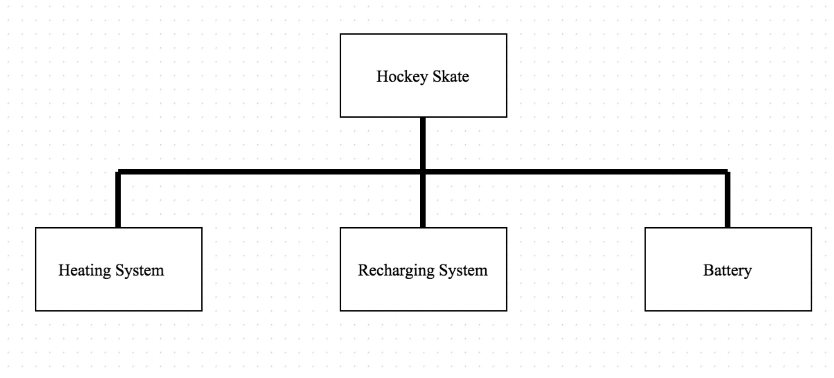

Figure 5 Block Diagram of Subsystems

There will be three subsystems in this design, the heating system, the recharging system and the battery. The heating system will consist of a resistive heating strip that will be placed on the top of the blade. The heating system will allow the blade to reach a higher temperature. The recharging system will use electromagnetics, specifically Faraday's Law of Induction, to recharge the battery system. The recharging system will be placed in the front compartment of the TUUK holder. The battery system will be placed in the back of the TUUK holder. The battery system will contain a 7.4V lithium ion thin battery that is connected to the heating system and the recharging system through circuits.

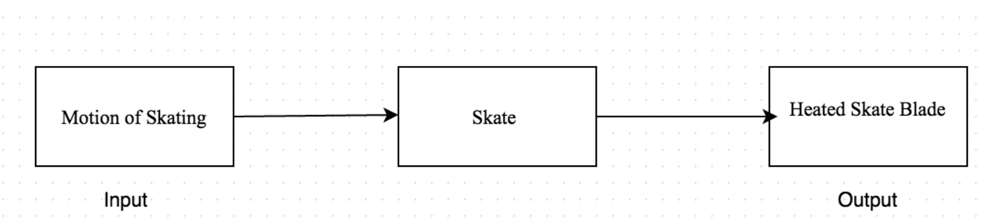

Figure 6 Block Diagram of Input and Output

The system will only have one input and one output. The input will be the motion of skating, which causes the magnets to move through the coil and produce a current due to Faraday's Law of Induction. Once the player is skating rigorously, the current will be enough to charge the battery. The recharging mechanism will be connected to the battery through circuitry containing voltage regulators that ensure a voltage of 7.4V [1]. The battery will hold its charge for a longer time than a capacitor will, which allows the skate blade to remain at the desired temperature of 41°F for the duration of the time on ice [3]. The battery is hooked up to the resistive heated tape that produces enough heat to raise the temperature of the blade to 41°F. There will need to be an element within the design that controls the temperature to keep the blade at 41 degrees while on and off the ice. The storage of energy will be very important when thinking about the storage of energy due to the periods the player will be sitting on the bench. The output of the system will be the increased layer of water between the blade and the ice from 10 microns to 20 microns as a result of the heated blade. The increase in water reduces the friction drastically [3]. The overall goals of this project are to decrease the overall cost of the Thermablade and improve on the Thermablade's design by harvesting energy to heat the blade through the motion of skating.

Design Requirements

The skate must be a size 9 so that it can be tested because a friend or myself can easily wear it. The blade of the skate will be 280mm in length. The TUUK holder will be the Tuuk Lightspeed Pro to lower the weight of the skate, which allows for the add-ons within the TUUK holder. The skate brand will be Bauer because it is the most popular hockey skate brand on the market to date [10]. These requirements are crucial for the prototype because it will allow for fair testing against the normal pair of skates. The hollow of the blade when testing starts will be 5/8" on both pairs of skates.

Skate Parts	Specifications
Skate Size	9
Blade Length	280mm
TUUK Holder	Tuuk Lightspeed Pro
Brand	Bauer
Hollow	5/8"

Table 1 Skate Requirements

Figure 7 Length of Front of TUUK Holder

Figure 8 Width of Back of TUUK Holder

Figure 9 Length of Back of TUUK Holder

The recharging mechanism will consist of a plastic tube or tubes with an outer diameter of 11mm and a length of 60mm. The plastic tube will house three dense neodymium magnets that have a diameter of 10mm and a height of 10mm. The coil wrapped around the plastic tube will be 50 mm long and have 1300 turns of #28 AWG magnet wire. The size of the coil and the number of coils may change due to calculations and size restrictions. There may be springs on the ends of the outer magnets if it causes the velocity of the magnets passing through the tube to be greater than if the springs were not there. The set up must produce 7.4V to heat the blade up to the required temperature to double the thickness of the water between the skate and the blade. The battery will be a 7.4 V rechargeable lithium ion battery and the heating system will consist of a heating strip that is 200 mm long. The temperature the blade will reach is 41°F. The heating system has been developed before, while the energy-harvesting unit has not. The specifications for the heating system will be used to model the skate that is being developed, while using an energy-harvesting system.

Part	Size
3 Neodymium Magnets	10mm x 10mm
Diameter of Plastic Tube	11mm
Length of Coil	50mm
Number of Turns in Coil	1300
Size of Magnet Wire	#28 AWG
Plastic Tube Length	60mm
Voltage	7.4V
Battery	7.4 V Rechargeable Lithium Ion
Heating Strip Length	200 mm
Temperature of Blade	41°F

Table 2 Heating System and Recharging System Requirements

Testing Plan

Once the prototype has been finished a number of tests will be conducted to assure the skate now functions the way it was desired to. The first test that will be conducted shall be measuring the temperature of the blade after the skate has experienced vigorous motion and the battery has been charged up. The blade should measure 41°F in order for the ice to reach 32°F when contact is made. This is a necessity to increases the layer of water between the blade and the ice to 20 microns.

The next test that will be conducted will be timing how long the blade stays the desired temperature after an allotted time of vigorous motion. After a minute of motion, the battery should stay charged for a half an hour. A minute is the length of an average hockey shift and the battery should stay charged long enough so the temperature of the blade stays at 41°F. Each shift occurs about 2-3 minutes apart based on different coaching strategies. The battery should hold a thirty-minute charge to allow the blade to stay warm if the player is on the bench for a longer duration than normal.

An acceleration test will be conducted by comparing the prototype to a normal skate. A distance 30' will be used to test acceleration. The same player will wear the skate and be timed from a dead stop until they make it through the finishing point. This will be conducted on a new sheet of ice and a chopped up sheet of ice. The data will be compared.

Testing gliding speed will be a similar test. The player will reach full speed and travel a distance 50', which is blue line to blue line in hockey, and be timed from start to finish and the times will be compared to the data collected by Thermablade [3].

Project Schedule

Week Number	What Should Be Completed
1	Start/Improve on a detailed design of the recharging mechanism. Start to look into grants for the money needed for the project. Create a budget for the project.
2	Use calculations to determine what values will be need for the battery to harvest the correct amount of power. Decide on parts for recharging mechanism based on calculations.
3	Choose how the wiring will be done through out the skate. Decide if there should be an LED or a way to notify the player if the skate is charged.
4	Decide on the number of coils that will be desirable within the skate for energy harvesting.
5	Order parts for energy harvesting to allow for early testing.
6	Complete the design of the heating tape on the blade, which allows for the blade to be removed for easy changing without affecting the mechanism.
7	Have the design of the battery complete.
8	Complete the energy harvesting design a couple different ways so there are options if one fails.
9	Do patent research to see if the design can be patented if successful.
10	Have design of the total skate completed. Have all parts ordered as well as back up parts. Record all specifications that will be in the final design. Have website up to date.

Table 3 Week By Week Schedule of Fall Term 2015

Conclusions

In conclusion, the heated skate will revolutionize the game of hockey. There will be little to no visual change to the skate, which matters to the players and the companies who sell the gear. The project will allow for the skate to be self-charging, which improves on Thermablade's design of the heated skate blade. The overall goals of this project are to decrease the overall cost of the Thermablade and improve on the Thermablade's design by harvesting energy to heat the blade through the motion of skating. The goals of this project are reasonable and achievable within the next year if the plan is strictly followed. There is also a lot of research that has already been done and it is about putting all of the pieces together. The first prototype may weigh more than desired, but if the design works it will be considered a success and the design will be improved in the future. Ideally, this design will mimic a top of the line hockey skate, while reducing friction with the ice due to the heated blade.

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