Cast Saw Cooling Device

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Abstract

The application of hard plaster or fiberglass casts is common in clinical settings to immobilize appendages or larger sections of the torso and aid in the healing process. Casts are most often used in long bone fractures which occur with the greatest frequency in adolescent and elderly patients. Friction between casts and cast saws used in cast removal is known to heat the vibrating saw blade. While burns can occur at temperatures as low as 44°C, cast saw blades can reach 101°C during the removal process[1]. While studies have attempted to use extra padding, different cutting techniques, heat sinks, pressurized air/water, blade material, and vacuums to cool saw blades, no solution has been practical and effective enough to change hospital practices. The goal is to design a system that keeps saw blade temperatures below 44°C and is adaptable enough to function for the various cast saw models used in hospitals.

Problem Definition

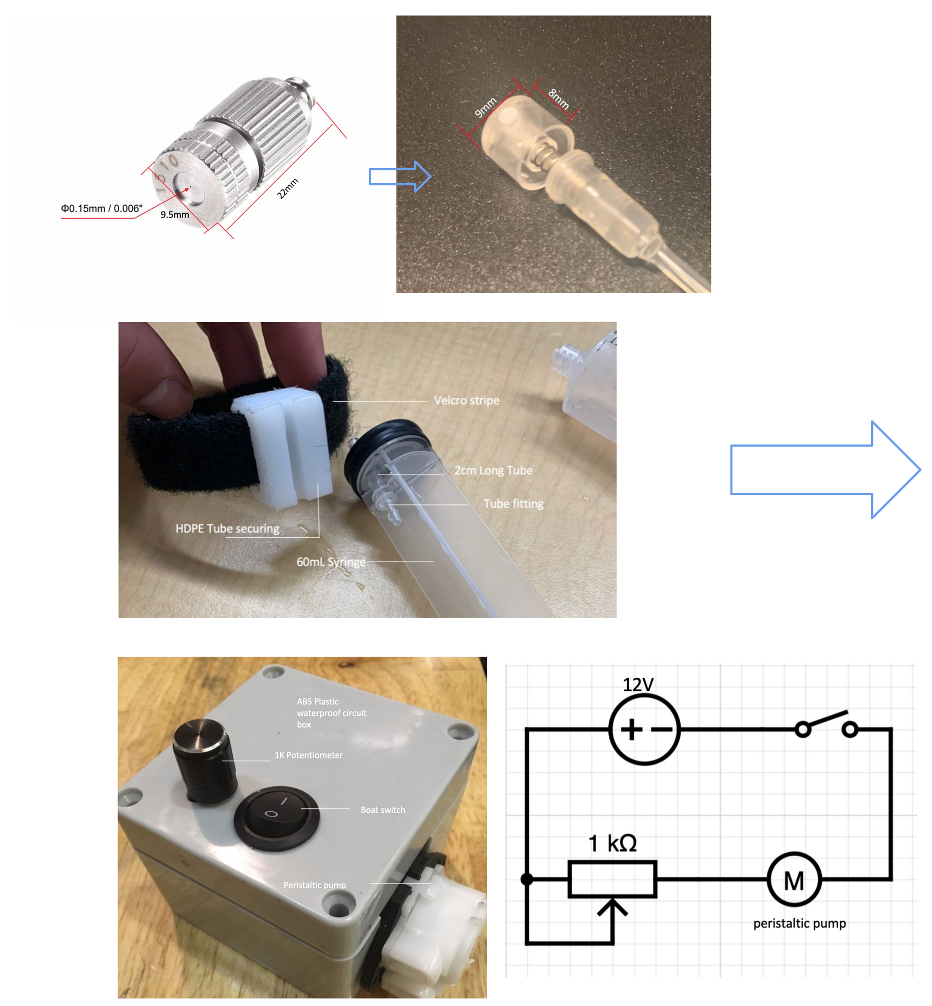
- Cast saw is a vibratory tool (small-toothed blade oscillating back and forth)
- Orthopedic casts are frequently made from plaster or fiberglass along with a cotton bandage as a padding to skin.
- The cast saw generates friction with the cast during cutting -- major cause for heat burn.
- Due to the vibration of the cast saw blade, high temperatures can result from the friction of the blade against the cast material
- Saw blade temperatures can reach up to 101°C[1]
- Temperatures as low as 44°C and 60°C can result in second and third degree burns, respectively
- Goal: Design a system that prevents heat damage to the patient's skin

Fig 2. Cast Cutting by Unhappy Dan (Youtube)

Design Specification

- Performance requirements: Safety temperature < 44°C when using a prescribed technique.[2]
- Weight: The entire assembly should be no more than 2.94 kg (cast saw weighs 1.36 kg). Cooling device should be no more than 1.59 kg
- Materials: Doesn't cause shorter lifespan of the metal blades (rusting). Materials that may melt or emit toxic fumes below temperatures of 101°C should not be used.
- Quantity: Currently, looking to provide one model but eventually would want to supply all of the UW Hospital and other hospitals in the United States
- Target Product Cost: under $100

Final Design



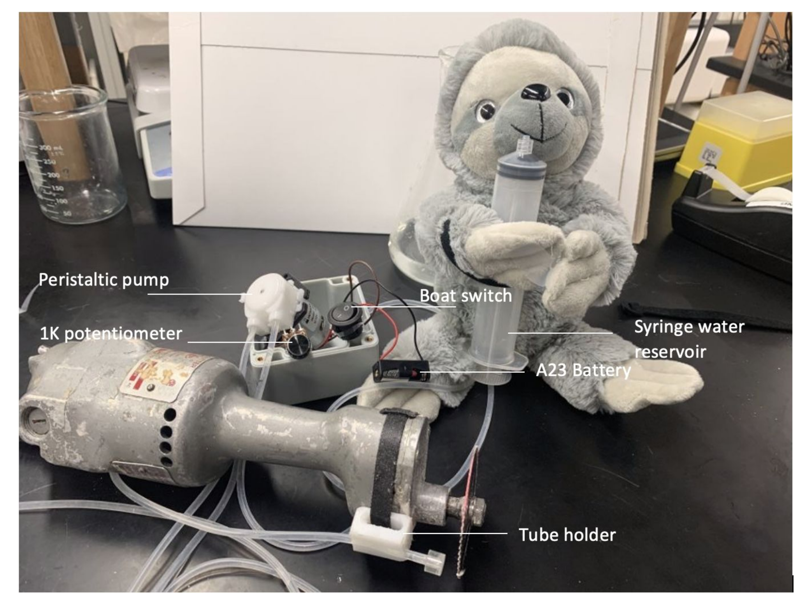


Fig 1. Design process, including perfume nozzle, HDPE tube holder, 60mL Syringe water reservoir, circuit diagram, ABS circuit box and circuit component.

- Mister attached with velcro
- Nozzle angled at lower arc of saw blade
- Water pumped from reservoir by peristaltic pump
- Flow rate was tested at various lengths of tubing, leading to decision for separate unit

Testing

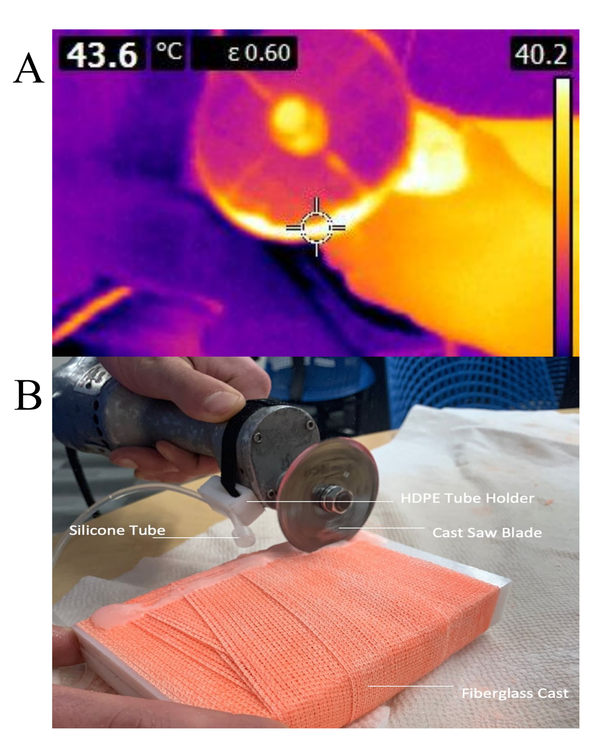


Fig 3. A. Sample IR Camera image; B. Testing setup

- Three species are measured (tap water, 70% ethanol, control without treatment) each contain five trials.
- Pump was performed on 12V (flow rate = 0.0528 L/min)
- Each trial was performed with 1 minute cutting duration.
- IR camera measured blade temperature prior to cutting and immediately after cutting

T-test p-value

	Water	Control
70% Ethanol	0.0545	3.57e-5
Water		1.21e-4

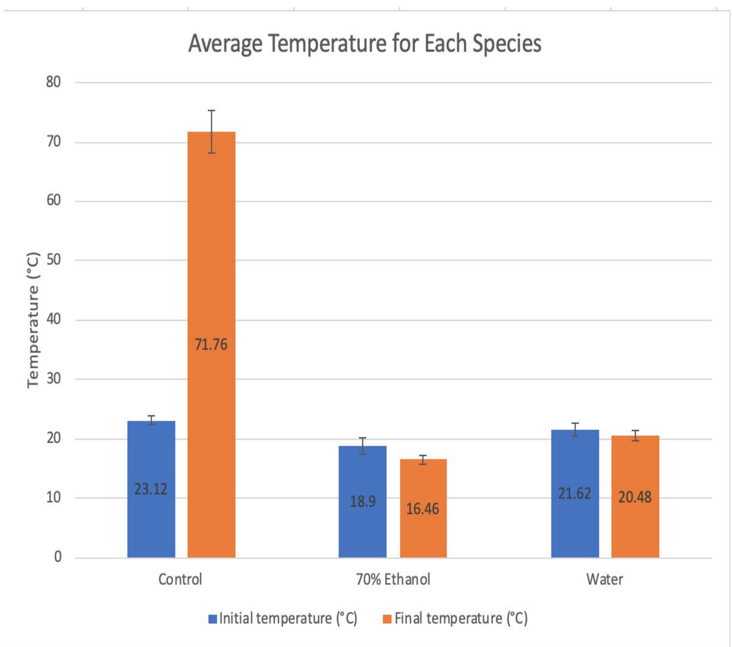


Fig 4. Average initial and final temperature for water, 70% ethanol, and control trials.

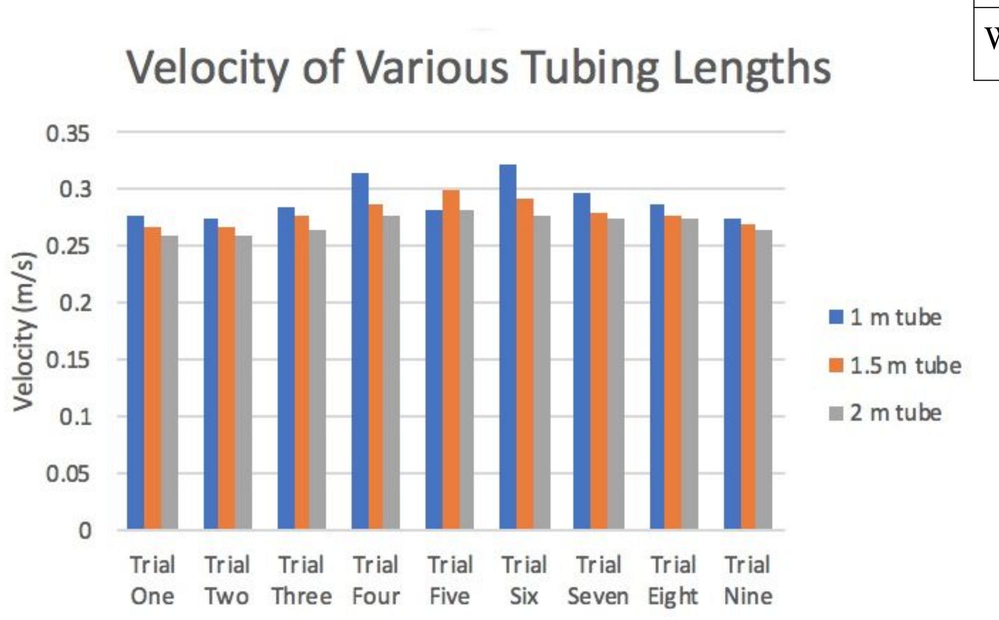


Fig 5. Flow velocity testing for each length of the silicone tubing. Nine trials were completed. The velocity was measured by marking the tube with at lengths of 1 m, 1.5 m, 2 m, then recording the time for flow to reach the markers.

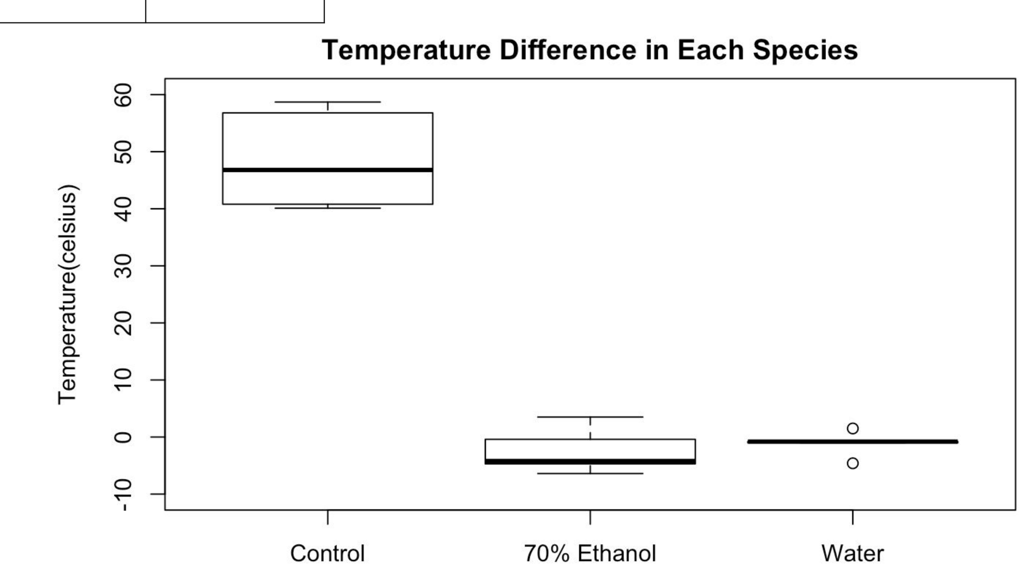


Fig 6. Boxplot for temperature difference in each species. Temperature difference was measured by final temperature - initial temperature. A negative value means the final temperature is lower than the initial temperature. From the t-test result, no statistical difference resulted in the cooling between water and 70% ethanol trials.

Future work

- Include detailed CAD Drawing
- Implant the vacuum system
- Research ways to recycle water and eliminate cast debris during cutting
- Find compatible nozzle and get long-lasting battery (compare the durability and size)
- Getting Feedback from medical professionals (in-person interviews)
- Make prototype mass producible
- Test different flow rates (energy efficiency)

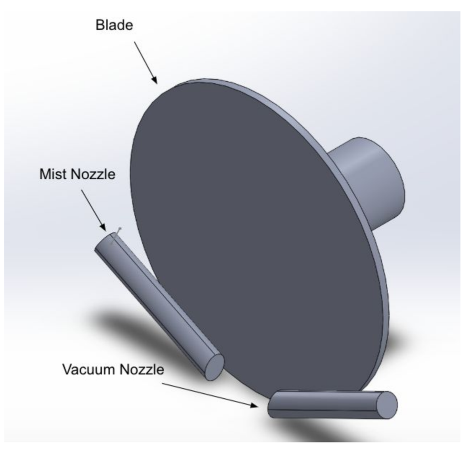


Fig 7. Current CAD Drawing for the mist/vacuum combination design. The vacuum nozzle is able to take up the water mist and fiberglass powders, leaving less mess. It can also cool down the blade by taking away heat .

References

[1] J. Killian, S. White and L. Lenning, "Cast-Saw Burns: Comparison of Technique Versus Material Versus Saws", Journal of Pediatric Orthopaedics, vol. 19, no. 5, 1999. Available: 10.1097/01241398-199909000-00026 [Accessed 11 September 2019].
[2] "General data about burns," Burn Centre Care. [Online]. Available: http://burncentrecare.co.uk/about_burned_skin.html.

Acknowledgments

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