BME Design-Fall 2019 - NOAH Nicol
Complete Notebook

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REBECCA SWANSON

on

Dec 11, 2019 @01:50 PM CST

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Team contact Information

▪ REBECCA SWANSON ▪ Oct 09, 2019 @12:30 PM CDT

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Project description

• NOAH Nicol • Sep 06, 2019 @06:59 PM CDT

Course Number: 63316, Lab 315

Project Name: #49 Cast saw cooling device

Project description/problem statement:

Engineering Specialty: Biomechanics, Bioinstrumentation
Medical Specialty: Orthopedics
Skills: Electronics, Mechanics, Software

Summary
In Orthopedics, we apply casts to patients all the time. During the removal of the cast, we use a cast saw. This is an oscillating saw that cuts through the plaster or fiberglass material. As it is cutting through the material the saw generates heat and the blade can often get quite hot. This has resulted in the burning of patients at times. Burning a patient during the removal of a cast should be a "never event" but unfortunately due to the amount of friction generated by the saw against the fiberglass or plaster, this can occur. I want to create a device that cools the saw blade as the saw runs. This would help alleviate the risk associated with cast saw usage in the clinical setting. I have thoughts on how to make the device or how to optimize current cast saws to help solve this issue.

Materials
cast materials, cast saw readily usable.

References
https://www.ncbi.nlm.nih.gov/pubmed/19047707

https://www.ncbi.nlm.nih.gov/pubmed/25075891

https://online.boneandjoint.org.uk/doi/abs/10.1302/1358-992X.94BSUPP_II.BOA2005-010

About the client:

Dr. Rahul Samtani
Orthopedic Surgery
University of Wisconsin
(301) 524-9903
rsamtani@uwhealth.org

Project Overview (final summary)

▪ Xu He ▪ Dec 11, 2019 @12:04 AM CST

Title: Project Overview (ended semester conclusion)

Date: 12/10/19

Content by: Xu

Present: Individual

Goals: End semester conclusion

Content:

Needs of the biomedical problem

The overview of our project is to develop a cast saw cooling system to decrease the temperature of the saw blade thus doesn't cause thermal burns to pediatric patients. It was known that above 44 degrees will cause secondary injury, and above 69 degrees will cause burn within 1 sec skin contact. However, according to the final testings, the blade would reach higher than 70 degrees, which is not ideal. As a result, the team aims to develop a cooling system design to deal with this problem. The team gathered lots of design ideas, such as using PC solid metal conducting the heat or implanting the vacuum system. Finally, the team choose a very simple solution. The water cooling is based on the wood saw blade cooling technique where the big rotary saw needs a large amount of coolant for cooling down.

According to FDA, the cast saw project belongs in CFR (code of federal regulation) Class I, which means that general controls of the cast saw is sufficient to provide reasonable assurance of safety and effectiveness. and the saw device could be exempt from premarket notification.

- public health

The design is really necessary when considering public health. The main target patients are children. Children's bone is more flexible and more prone to fracture. As children are more active than adults, they are more likely to get bone fractures. Because the bone is so flexible, they much keep a cast on until the fracture is completely healed to avoid more injury during play and activities. Moreover, children cannot tolerate the heat as adults do. When they see the roaring saw, they would not likely be corporative, which increases the risk of getting burnt.

- economics

The team decides budget is under $100 although the client doesn't provide a number for the budget. The device is cheap to manufacture and easy to be implanted into use. The budget is aimed at mass production of the device so that clinicians can purchase the device with the saw without paying too many extras.

- environment

The final prototype saves energy as it would be powered by 12V battery sources, and the mist is very fine and is directly applied to the blade contact point. According to the experiment and flow rate calculation, the device only consumes about 40mL water for the saw to run 2mins.Right now the design is using ethanol and tap water as the coolant (those two are commonly available in the examination room), but in the future, the team will consider recycling the water by implanting another vacuum device.

Multiple design constrains throughout the process

There are many constrain in the design process. First of all, the saw that the client provided is very old (many debris, heavy), thus using such a saw as an example for designing a prototype may not be compatible with new saw types. Also, many of the new saws have an implanted vacuum system, which would improve the cooling ability. Moreover, the team doesn't have the knowledge to integrate the device with the saw (need to be familiar with saw circuit and have the background of transforming voltage and current AC:DC). The integrated device definitely will be more convenient to use.

Future alternatives/plans

For future. First of all, is to get some professional background knowledge used to integrate the cooling system for the saw. Also, the team should find other solutions that will not cause additional mess. The possible solutions including using the vacuum to recycle and reuse water, or finding some solid or gaseous coolings. (the team has tried to find, but nothing showed up on the internet. One creative thought: using tubing to direct dry ice to the blade, but be aware not to cause ice burn). Moreover, if the team still wants to go with the current prototype design, the team needs to consider making the whole design mass-producible by determining the exact size of each component. Because of the time limit, many of the team designs don't have detailed CAD drawings. For the future, the team need to have well-defined dimensions for everything.

Conclusions/action items:

Noah and I both decide not to continue to this project because both of us are in the biomaterial track rather than the biomechanics or bioinstrumentation track. I think if both of us have more experience in making the circuit and building mechanical structures, we could come up with a nicer design. Hopefully, some one will still be able to work on this project because I don't think our prototype is the best one. Lastly, I want to acknowledge Dr. P to be our advisor this semester and provides many thoughtful ideas throughout the process, and thanks to Dr. Samtani gives us the opportunity to improve cast saw device. Also, thanks to those BME 200's who participate and contribute a lot to the design project.

10/01/19 Client meeting

▪ REBECCA SWANSON ▪ Dec 08, 2019 @01:50 PM CST

Title: Client Skype meeting

Date: 10/01/19

Content by: Xu

Present: Xu, Angelica, Rebecca

Goals: Notes for the meeting.

1. Procedure of using the saw and the cast

- One should always wear gloves to handle the saw.
- Find some HDPE block to mimic the injured arm, the cast should be around 6-7 turns, and warm water could make the cast stiffer.
- When cutting the cast, be sure that the saw should be lifted up for each cuttings rather than cutting in a line.

2. Cost

- The client is funding the project. The cost should be no more than $1,000. Every purchase should be recorded in detail in order to receive reimbursement.

09/13/19 Meeting 1

• NOAH Nicol • Sep 15, 2019 @07:17 PM CDT

Title: Advisor meeting

Date: 09/13/19

Content by: Xu

Present: Xu, Noah, Rebecca

Goals: Notes for the meeting.

Content:

- Stryker (brand) saw: most types
- Research on what causes the burn (blade friction, dust?) idea of using insulator?
- Acquire Infrared camera to test the heat generation (from Dr. P).
- BWIG may ask for access of previous saw projects in BME Design (mostly done on the cast but not saw)
- Progress report email should include team name in the subject.
- Progress report revision
- Redo the problem statement (should not include solution
- Provide 2-3 words detail in 'status update and member research'
- etc...
- Review the expectation on BME Design page (criteria)
- Future: scheduling client meeting, suggest late hours in the evening.
- Meeting date: 9:00 am Fri Room 3219 ECB

Design Ideas:

- Misting of Alcohol or water during cutting
- Vacuum
- Biocompatible cutting lubricant?

Client questions:

- Most common saws designs?
- Cutting technique demo?
- Blade cutting material -are they all stainless steel?
- Budget? Materials (plaster + fiberglass)?

Conclusions/action items:

The cast burn comes from the vibration of the cast saw blade. High temperatures can result from the friction of the blade against the cast material.

09/20/19 Meeting 2

• REBECCA SWANSON • Dec 08, 2019 @01:53 PM CST

Title: Advisory meeting 2

Date: 09/20/19

Content by: Xu

Present: All

Goals: Meeting with advisor to get checked.

Content:

- Schedule meeting with the client (shadowing paperwork?)
    - Update (11/24/19)- Sadly, we were not able to find a time to meet with the client this semester due to various schedule conflicts. However, on 10/7/19, we communicated with client over Facetime to receive instruction on casting procedures and answers to various questions (information on this is located under client meetings).
- Find different coolant other than liquid (water, alcohol), ask the client whether he is OK with using water
- Research of coolant from other devices (PC coolant?)
- Get an alternative saw for testing the coolant in lab
- PDS should be quantitative (important for the design: regulation on cast saw, operating system (sterile), ergonomic.

Conclusions/action items:

1. Submit PDS

09/27/19 Meeting 3

▪ REBECCA SWANSON ▪ Nov 24, 2019 @09:31 PM CST

Title: group meeting 3

Date: 09/27/19

Content by: Xu

Present: All

Goals: Improve design idea, comments on PDS and design matrix

Content:

- Talk about next week's plan, get access for rm 2003
- Design matrix comments

-Low safety for the actual saw

- Manufacturability process (think beyond our ability) from the perspective of the manufacturer (more techniques to use: inject molding)

Explain the idea using easily accessible product

- Weight 35-40 for cooling reliability otherwise it could override some of the design ideas.

- Add durability when thinking about how the saw actually works (vibration).

- It would be nice if we could have the internal structure of the saw and modified it internally..(disassemble the saw?).

- Consider cooling devices in the operation room (bucket ice /water circulating) separate entity or the availability in the examination room

-think about how to make design idea board (contact cooling, air cooling, liquid cooling) +simple graph: cartoon picture.

- look over the PDS
- Next Friday 10/04/19, 3126 ME preliminary presentation (look at evaluation, guideline).. 10min
- --Powerpoint slide sent by Wed to advisor for comment
- —PWIG: pdf slide + google slide link.
- IR camera Filr online software to make graph

Conclusions/action items:

1. Test different techniques on Tues (water, tube vacuum)
2. IR camera (better to get some graph from that)
3. Making powerpoint during weekends, send to advisor on Wed
4. Facetime with the client before Tue: protocols or procedure for how to use the saw.

10/11/19 Meeting 4

▪ Xu He ▪ Oct 11, 2019 @12:33 PM CDT

Title: Advisor meeting 4

Date: 10/11/19

Content by: Xu

Present: Angelica, Rebecca, Xu

Goals: Feedback from advisor

Content:

- Saw design: manually or with the saw switch together. Integrated with the current design, add on (apply to more design)- ask client,
- Oral Presentation was excellent.
- Do more Patent search using 'classification'
- Mist system might be better (or cold tubing).
- Other ways to test the design.
- Think in larger scope, not only just client. (Patent: WARF).
- BSAC: arrange Individual advisor meetings (peer evaluation).

Conclusions/action items:

We had a good start on our design project, the next step would be determining the final design idea, selecting materials, requesting budget and buying stuffs.

10/18/19 Meeting 5

▪ Xu He ▪ Oct 18, 2019 @11:28 AM CDT

Title: Advisor meeting 5

Date: 10/18/19

Content by: Xu

Present: All except Caleb

Goals: Asking for feedback and suggestions from advisor.

Content:

- Keep design convenient for the client.
- Size, time range to cut off the cast, feasibility
- Continuous spray
- Pump type, nozzle
- The motion of the spray, not disturb client
- diastolic pump, syringe pump in Rm 2005
- Parts that create mist (conserve water)
- Using ethanol concentration
- More testing can be done.
- Presentation: competing design: benefit/ drawback
- Drawing: no background and contrast, well-labeled (typing), scale bar.
- Figure on design matrix: discussion of criteria (why important and weight highly). Animated.
- Preliminary testing before the matrix
- send material to the advisor prior to order.

Conclusions/action items:

Many improvements can be made to the final design idea, and we are kind of behind on the process. We could do testings using the pump form RM 2005 before deciding the orders.

10/25/19 Meeting 6

• REBECCA SWANSON • Nov 24, 2019 @09:32 PM CST

Title: Advisor meeting 6

Date: 10/25/19

Content by: Xu

Present: All

Goals: get checked with advisor, more suggestions on the design

Content:

10/24/19 testings

- rotate the blade, the same piece of cast used, Cast procedure is correct
- Question for client: blade change for every person (dullness)
- Research if 70% ethanol will damage the skin

- Concerns: 12v pump, compatibility with saw transformer (AC/DC power motor); available to the saw
- Metal nozzle may be better(heat influence) check MSC supply, Grainger
- Check pressure requirement for the mist(45psi)
- Aerosol spray (https://www.amazon.com/dp/B072Z5JN2F?aaxitk=kf3C1F5vrHBbtqcZiU8Wwg&pd_rd_i=B072Z5JN2F&pf_rd_p=44fc3e0f-4b9e-4ed8-b33b-363a7257163d&hsa_cr_id=1636483530501&sb-ci-n=asinImage&sb-ci-v=https%3A%2F%2Fm.media-amazon.com%2Fimages%2FI%2F61HlVdzYSlL.jpg&sb-ci-a=B072Z5JN2F)
- Switch and personal interpretion (mist when in air or along with the saw switch)

Conclusions/action items:

More testing need to be done; approximate ordering time is next Wed (10/30); schedule meeting time with advisor. Two weeks from now is the show and tell.

11/08/19 Meeting 7

▪ Xu He ▪ Nov 08, 2019 @02:46 PM CST

Title: Advisory meeting 7

Date: 11/08/19

Content by: Xu

Present: All

Goals:

Content:

- measure of the water consumption
- saline water/ethanol: sterilized bottle
- client: done of the saw between procedures(change the blade, or rotate)
- disposble tubing
- flow rate, tube length (testing)

11/21/19 Meeting 8

▪ NOAH Nicol ▪ Dec 02, 2019 @08:05 PM CST

Title: Advisor meeting 8

Date: 11/22/19

Content by: All

Present: All

Goals: Get feedback from advisor

Content:

Topics of discussion:

- switch + potentiometers available for free? --> in makerspace?
- thoughts on drilling syringe reservoir
- flow rate not an issue
- Literature search, ask company for saw procedure

To do list:

- Find correctly sized box
- Stuffed toy
- drill syringe reservoir
- attachment to saw
- Find time to meet after poster session for final meeting

Conclusions/action items:

See to do list

9/19/19 Original PDS (Design Constraints)

• REBECCA SWANSON • Dec 08, 2019 @01:23 PM CST

Title: Original PDS

Date: 9/15/19

Content by: Rebecca Swanson

Present: Xu He, Rebecca Swanson, Caleb Ravn, Angelica Lopez, Noah Nicol

Goals: Create product design specifications highlighting what criteria is important to the project.

Content:

Date of Last Revision: 9/15/19

- Client: Rahul Samtani
- Function- The oscillatory cast saw blades used today are generating too much much heat from the friction, resulting in burning and blistering of patients
- Client needs- a saw blade/cooling device elimination cast saw burns on patient
- Important Requirements:
    - Blade temperature needs to stay below 44°C so that burns do not result
    - Service life- will the design be reusable? If so, extreme care must be taken into account to make sure contamination does not result
    - Design should not hinder operation for operator
        - If design is attached to cast saw itself, the design should not have an added weight of more than 1.59kg
    - Materials:
        - Materials that shorten the lifespan of cast saw should not be used
        - Materials that melt or emit toxic fumes should not be used
    - Aesthetics:
        - working to make design blue or white to match current cast saws
        - plastic finish texture so that design is smooth
    - One unit is required at the moment
    - BUDGET- Unknown, client has mentioned that he will likely get reimbursed by the UW Hospital the product cost
        - at first, we were unable to meet with client so we were unaware of the budget
        - working to make budget as low as possible while still implementing the best design possible
    - Standards
        - for future: look into FDA approval needs for design; hospital sterility concerns
    - What does our client want?
        - Has been difficult to meet with client, unaware of client needs other than the fact the the cast saw blade should not cause burns
    - Competing Designs-
        - Individually, team members researched one to two competing designs
        - Two designs were particularly useful
            1. Cooling system for rotary blade used in sawing of concrete
            2. Patent for vacuumized Surgical Cast Saw Cutter

Conclusions/action items:

- Determine more criteria that our client would like for the designs before we look into brainstorming designs

9/24/19 Preliminary Design Matrix

REBECCA SWANSON · Dec 11, 2019 @01:10 PM CST

Title: Preliminary Design Matrix Criteria

Date: 9/24/19

Content by: Rebecca Swanson

Present: N/A

Goals: Explain design constraints for the project

Content:

Cooling Reliability

- Most important criteria
- Major problem that the client brought to our attention
- We need to make sure that the cast saw does not reach burning temperatures

Ease of Fabrication/Assembly

- We have one semester to fabricate (approx. 3 months)
- Take into consideration that it might be easy to fabricate one design but impossible to mass-produce/manufacture
- Therefore, design should be autoclavable.
- Client came to us asking for one unit

Ergonomics/Ease of Use

- Design should not make removing casts more difficult for technicians/operators, easy removal
- Should not be too heavy

Durability

- Cast saw must work under varying/normal operating conditions
- Materials used should not emit toxic fumes
- Blade should withstand normal wear and tear

Aesthetics

- Design shape is relatively unimportant, however, design should look professional
- Design shapes were unknown at the beginning of the development process.
- Is design compatible with target population (pediatric patients)?

Cost

- Originally unaware of our budget (was told around $100)
- How much do parts cost/design?

Safety

- Safety will always be a criteria when creating a design, especially in a health-related setting
- Most of the injuries come from the saw itself, design should not cause injuries

Fear Factor

- Working with pediatric patients

- Vacuum and mist designs could scare patients
- No discomfort to patient should result from design

11/08/19 Preliminary Prototype for Show and Tell

▪ Xu He ▪ Nov 08, 2019 @03:08 PM CST

Title: Preliminary Prototype

Date: 08/11/19

Content by: Xu

Present: All

Content:

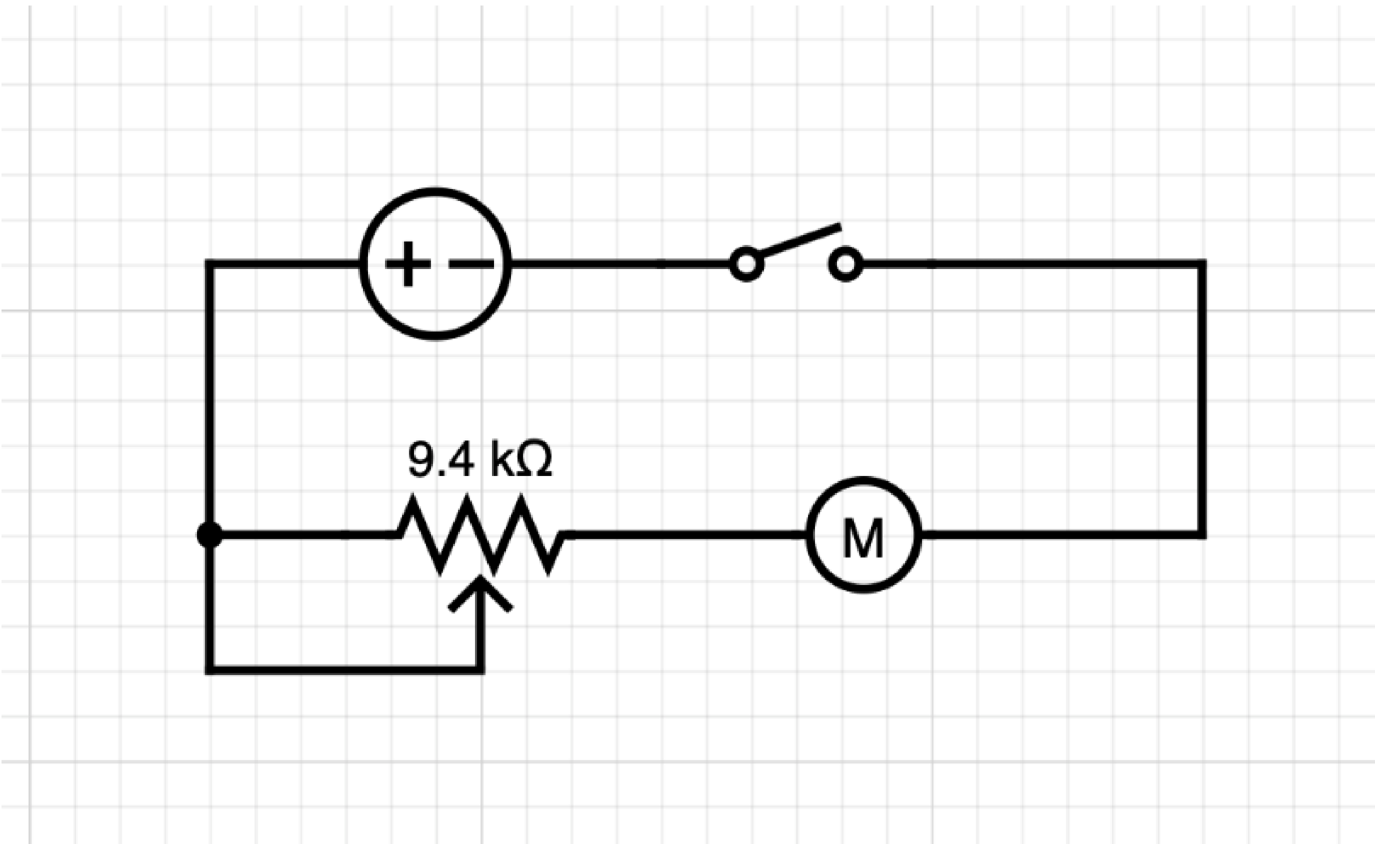


Fig 1 Circuit set up for the peristaltic pump in series with potentiometer and a 6V DC battery sources.

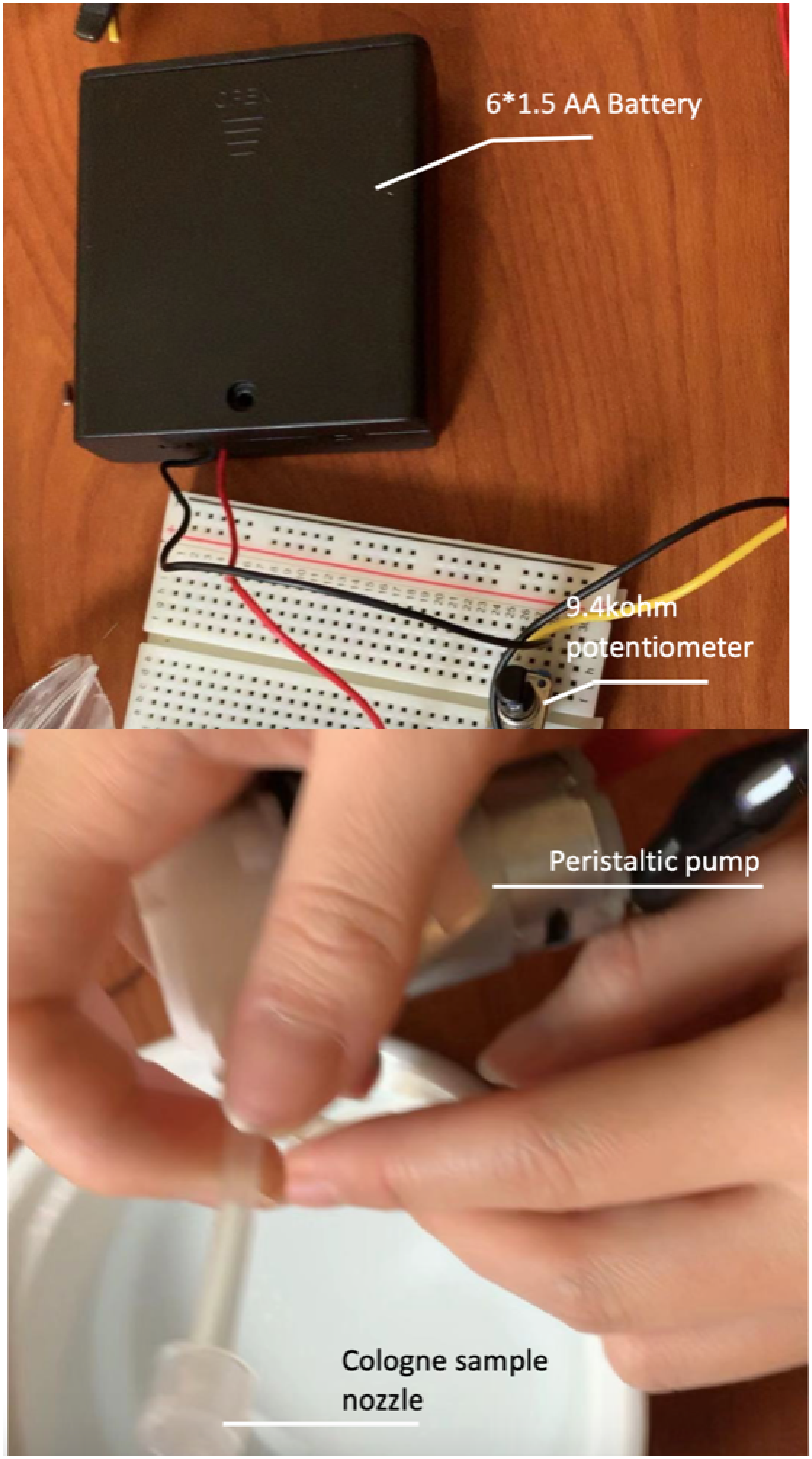


Fig 2 Picture of the real set up, the nozzle was from perfume sample because our metal nozzle didn't arrive before Friday

Conclusions/action items:

The design is used to produce mists to the saw blade in order to cool down the temperature.
Limitation with current design

- The potentiometer resistance is too big to be used as a voltage diver (control the flow rate).
- Need to consider the tube length when implanting the voltage (may need > 6V)
- The stainless steel nozzle requires very high pressure to be used, but the perfume nozzle is not sterile.

Future Works (before poster session)

- Do more testing using the designed prototype.
- design a reservoir and determine how the parts is going to be attached to the saw.
- Check arability in the clinical room (ethanol/water).
- Try metal nozzle and longer tube.
- Find compatible voltage source and potentiometer (soldier them together).
- Integrate circuit together in a circuit box.

11/24/19- Revised PDS

▪ REBECCA SWANSON ▪ Dec 08, 2019 @01:41 PM CST

Title: Revised PDS

Date: 11/24/19

Content by: Rebecca Swanson

Present: N/A

Goals: Create product design specifications highlighting what criteria is important to the project.

Content:

Date of Last Revision:12/8/19

- Function- The oscillatory cast saw blades used today are generating too much much heat from the friction, resulting in burning and blistering of patients
- Client needs- a saw blade/cooling device elimination cast saw burns on patient
- Important Requirements:
  - Blade temperature needs to stay below 44°C so that burns do not result
  - Update on Safety:
    - General- saw remains unplugged when not in use
    - Patient- cooling device or mechanism should not cause adverse side effects to patient; prolonged skin contact with ethanol is not good. Water will be used instead
  - Service life- will the design be reusable? If so, extreme care must be taken into account to make sure contamination does not result
    - Yes! Design will be reusable.
    - Design should not shorten length of cast saw life; for example, hospitals should not have to change the blades more often. We are working with ambient clinical conditions
    - Future work: implementing a surgical steel grade nozzle onto the design instead of using a plastic perfume bottle
  - Design should not hinder operation for operator (cutting ability is not impeded)
    - If design is attached to cast saw itself, the design should not have an added weight of more than 1.59kg
    - Cast saw itself weighs 1.36kg
    - Device needs to stay portable
  - Materials:
    - Materials that shorten the lifespan of cast saw should not be used; i.e. no rusting
    - Materials that melt or emit toxic fumes should not be used
    - Water will be used instead of ethanol; water has a very large heat capacity making it useful for cooling the blade
  - Aesthetics:
    - working to make design blue or white to match current cast saws
    - plastic finish texture so that design is smooth
  - One unit is required at the moment; looking at making the product mass producible so design can be supplied throughout many hospitals and clinics
  - BUDGET- Less than $100
    - Client has informed us he will reimburse us
  - Standards
    - FDA approval is needed
    - Cast I saws are often exempt from premarket notification requirements
    - Blade sterility is not as important as we thought originally; survey response showed blade is rarely changed or sterilized
  - Current customers are hospitals, orthopedic surgeons, and clinics
  - Competing Designs-
    - Patent for vacuumized Surgical Cast Saw Cutter
    - Cooling system for rotary blade used in sawing of concrete

Conclusions/action items:

- Edit the PDS on the final report to reflect any changes from the original PDS

9/11/19 Team Meeting 1

▪ Xu He ▪ Sep 11, 2019 @07:49 PM CDT

Title: Team meeting

Date: 09/11/19

Content by: All

Present: All

Goals: Gather thoughts about the project, share design ideas and prepare for the client meeting.

Content:

Design Ideas:
-Misting of Alcohol or water during cutting
-Vacuum
- Biocompatible cutting lubricant?

Client questions:
1. Most common saws designs?
2. Cutting technique demo?
3. Blade cutting material -are they all stainless steel?
4. Budget? Materials (plaster + fiberglass)?

Possible methods of cooling.
1. Liquid Coolants
pros: more effective than water
cons: more expensive, possible more mess
2. water mist
pros: possibly continuous cutting can control dust, cost-effective
cons: may not cool enough, maybe too large

Conclusions/action items:
Our team shared ideas and discuss few solutions to cool the saw. The next week's goal for the team is to come up with design ideas and arrange a meeting with the client.

09/15/19 Team Meeting 2

· REBECCA SWANSON · Dec 11, 2019 @01:13 PM CST

Title: Team meeting 2

Date: 09/15/19

Content by: Xu

Present: All

Goals:

- Finishing PDS and gathering thoughts

Content:

- Revise preliminary design specifications to reflect recent changes (i.e. we have been notified of budget)
- Schedule a time to meet with the client (knowing his needs and expectations)
- Test the water mist system for cooling temperature.
- Brainstorm on the design idea of the device.

Conclusions/action items:

The team had a good start on the PDS and hope to finish it after meeting with client. Some great design ideas were discussed during the meeting and the team decides to test the feasibility of using water to cool down the saw. Next week's major goal would be to get contact with the client.

09/24/19 Team Meeting 3

▪ Xu He ▪ Sep 24, 2019 @10:13 PM CDT

Title: group meeting 3

Date: 09/24/19

Content by: Xu

Present: All

Goals: Finish design matrix, discuss what to do next.

Content:

- Continue to get in contact with the client.
- Finish the design matrix
- Planning to meet and make a presentation.

Conclusions/action items:

This week, we are still not able to get in contact with the client to get the saw. Therefore we might decide to get a piece of metal (or stainless steel) to test our cooling system. Next week's goal is to write the oral presentation.

10/20/19 Team Meeting 5

▪ REBECCA SWANSON ▪ Nov 24, 2019 @09:40 PM CST

NOTE: Meeting page from team meeting 4 was deleted as it was not needed, thus this page is still team meeting 5

Title: Parts Meeting

Date: 10/20/19

Content by: Noah

Present: All

Goals: Find parts that may work and filter out the best for ordering

Content:

Looked at pumps and nozzles primarily

Link to google spreadsheet with all items collected: https://docs.google.com/spreadsheets/d/1PNI4yTv3ieROBwKM-U9C0lvlRHMjWsvW7Qr_es2Noh4/edit#gid=0

Conclusions/action items:

Sent best couple to mentor and will order after allowing time for feedback.

10/18/19 BPAG meeting

▪ Xu He ▪ Oct 18, 2019 @03:56 PM CDT

Title: BPAG meeting

Date: 10/18/19

Content by: Xu

Content:

- Please see the slide on BME design page for details
- Ask client if he has the personal funding or UW funding (funding strings, MD number) and discusses the payment method
- Better to let client buy everything, but do not buy from different websites
- If it's reimbursed, need to be done within 90 days (prior to poster session)
- All the receipts need to be uploaded in lab archive; for reimbursement, need to be in hard copy
- Update the accountant spreadsheet
- some tiny things such as glue, hot gun etc are covered under Team-lab 50$ fee

12/8/19 Final Expenses

• REBECCA SWANSON • Dec 08, 2019 @01:49 PM CST

Title: Final Expenses

Date: 12/8/19

Content by: Rebecca Swanson

Content:

Expenses

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
12V Peristaltic pump	Peristaltic Liquid Pump Dosing Pump for Aquarium Lab Analytical 2mm ID x 4mm OD . (6L/h)	INTLLAB		04/11/19	1	9.80	9.80	Link
Component 2								
Connector	Connect Fittings 5/32 OD -Plastic Push to Connect Fittings Tube Straight Connect 4 Mm to 4 Mm Push Fit Fittings Tube Fittings Push Lock-15 Pcs	HONJIE	HJCP0248	04/11/19	15	6.99	6.99	Link
Component 3								
nozzle	Misting Nozzle - 3/16-inch Threaded 0.15mm Orifice Dia Fogging Spray Head for Outdoor Cooling System	uxcell		09/11/19	1	7.49	7.49	LINk
Component 4								
Potentiometer (1k)		uxcell	a15011600ux0213	29/11/19	5	1.2	6	link
Component 5								
2pin snap Roker Switch		U.S. solid	USS-WBS00001	27/11/19	6	0.99	5.94	link
Component 6								
A23 battery		Energizer		29/11/19	2	1.8	3.6	link
Component 7								
A23 battery case holder		VQVAAQ		29/11/19	12	0.415	4.98	link

Component 8

Plastic junction box	3.3’’*3.2’’*2.2’’	Awclub	29/11/19	6.99	1	6.99	link

Component 9

reusable Cable Zip Ties	8 inch	Amazonbasics	29/11/19	0.1332	50	6.66	link

TOTAL: **$58.45 + tax = $66.25**

11/27/19 Tube securing + water reservoir fabrication

• NOAH Nicol • Dec 04, 2019 @03:41 PM CST

Title: fabrication

Date: 11/27/19

Content by: Xu, Noah

Present: Noah, Xu

Goals: Protocols for fabrication

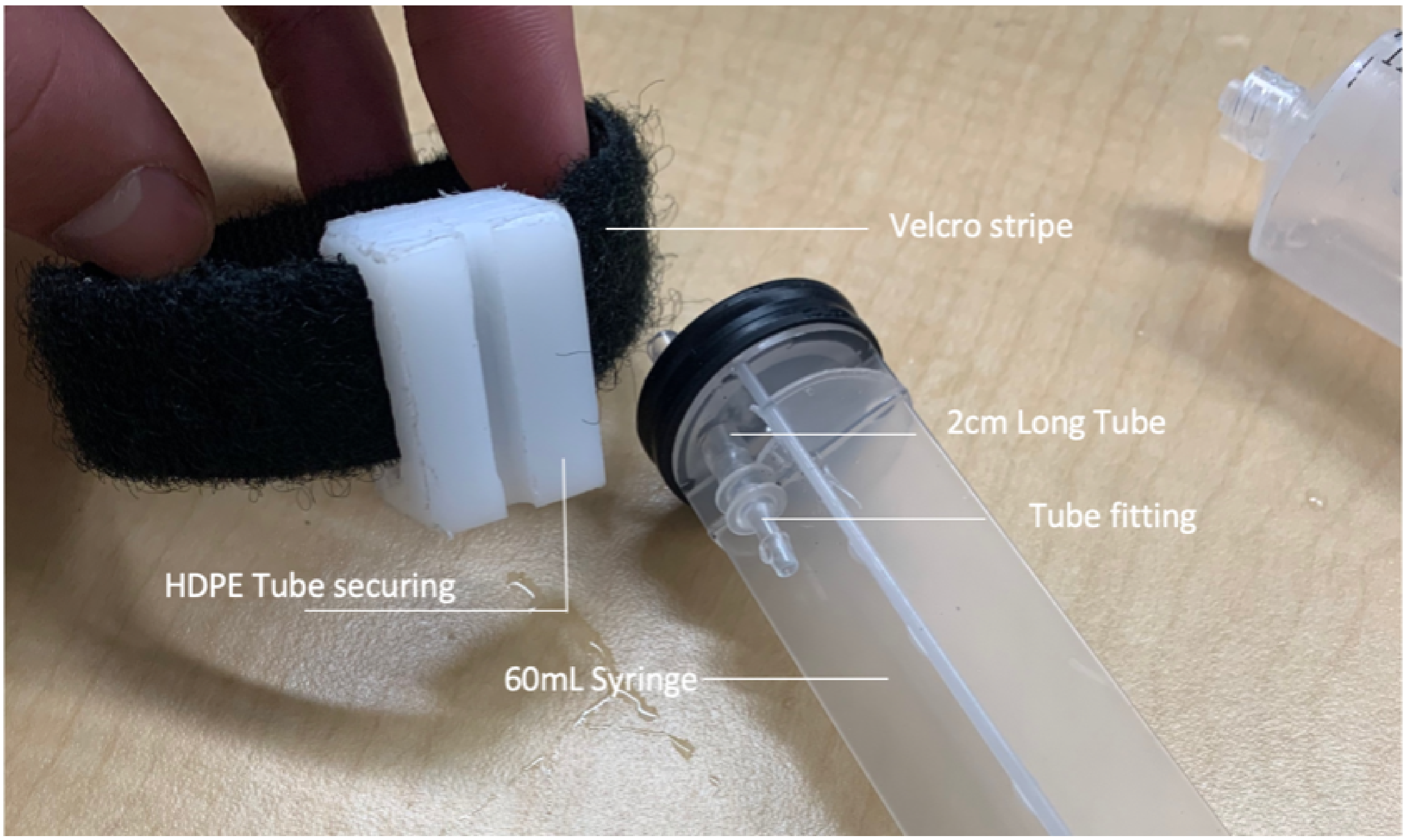


Fig 1 Fabricated components

Tube securing

materials: Velcro stripe, HDPE block; Esien mills, 4mm drill bit, center drill, vertical saw

1. Secure the block vertically to the mill using 1inch parallel and rubber hammer.

2. Insert 4mm drill bit in the chuck, open the mill to rpm 900, drill the hole for tube securing (4mm)

3. Use the center drill file the block and leave the hole at the edge, forming a notch.

4. Again use the center drill mill the stripe holes. (locked the drill and move table).

5. Cut the square pieces using vertical saw, file the edge.

6. Tape 2 Velcro stripe back to back across the holes.

Water reservoir is a 60 mL syringe.After syringe suck water in, put it upside down as a reservoir.

material: 4mm drill bit, electric drill, 2cm long silicon tube (d=4mm), a tube fitting(used to connect pump tube), glue gun.

1. put 4mm drill bit into the electric drill, drill the hole across the black rubber as well as the plastic.

2. put the 2cm long tube through the rubber, and secure with super glue gel to make sure it's perfectly sealed.

3. put the tube fitting in .

▪ NOAH Nicol ▪ Dec 02, 2019 @08:39 PM CST

Fitted_to_outdated_saw.jpg(507.8 KB) - download

▪ NOAH Nicol ▪ Dec 02, 2019 @08:40 PM CST

Pumping_video.mov(6.5 MB) - download

12/10/19 Circuit Box Design

▪ Xu He ▪ Dec 10, 2019 @06:01 PM CST

Title: Circuit Box

Date: 12/10/19

Content by: Angelica

Present: Xu, Caleb

Goals: create the circuit box with the stuffed animal

Content:

Circuit box

- 2 holes were drilled for the potentiometer and the switch using the hand drill in team lab.
- The pump hole was done using the mill (square like)
- The circuit set up follows that preliminary design prototype except changing the voltage source to a outlet cord(please see 11/08/19 Preliminary prototype for show and tell)
- All the components were being soldered to together using tin solders.

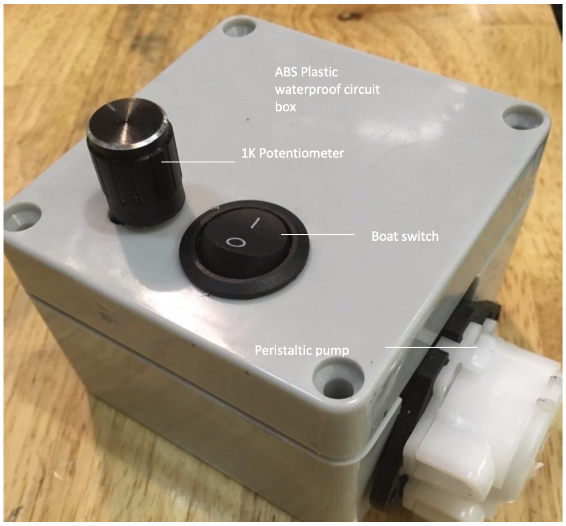


fig 1 Final circuit component, assembled in a circuit box

Toy

- The toy is not big enough for the circuit box, thus the team did two cuts though the back of the animal
- Each cuts was about 20cm in length, the cotton was being removed from the toy's body and one hand.
- the tube directly across over the hand of the toy, and the other hand was pinned for water reservoir support .

Conclusions/action items:

For Aesthetics purpose, the team need to find a larger toy and use a zipper to hide the circuit inside. Also, the team aims to find a compatible battery because the cord makes it hard for the clinician to relocate the device.

10/07/19 Preliminary testing protocol

• REBECCA SWANSON • Dec 11, 2019 @12:41 PM CST

Title: Preliminary testing

Date: 10/07/19

Content by: Xu

Present: Caleb, Angelica, Rebecca

Goals: Writing protocols for preliminary testing

Content:

Control

- One person take the HDPE rod and make sure it doesn't move.
- Another person turn on the switch and cut the cast. Make sure that during the cutting process, the saw should be lifted after each cuts.
- Make two cuts in a row, then using the IR camera to record the blade temperature at the cutting point.

Mist

- Repeat the procedure for the control.
- During the process, one person uses a water spray bottle continuously spraying at the blade/cast attaching point.

Cold tubing

- Take a plastic tubing (d= 0.5cm), one end attaches to the tap, then wrap the tube around the blade attaching point.
- Open the tap, let the water run though the entire tube
- Repeat the process denoted in Control.

Compressed air

- One person open the air compressor and directly blow the air to the blade bottom.
- Follow the procedure in Control.

fig 1 Preliminary testing set up.

An HDPE rode was used to represent the patient’s arm, and the temperature was recorded after two cutting processes in a row (the cast is too short). The stationary result was recorded by placing the cast and the saw directly on the table, so they were nearly room temperature. The control trial was performed without any cooling system installed. The mist system was performed by using spray bottles to spray water directly to the cut. Cold Tubing design is basically using 1mm diameter PVC tubing wrapped 360° to the blade attachment. And compressed air design is using an air compression nozzle blowing directly into the cast

11/13/19 -Pump style testing

▪ Xu He ▪ Nov 29, 2019 @03:07 PM CST

Title: Pump style and H2O vs EtOH testing

Date: 11/13/19

Content by: Noah

Present: Noah, Xu

Goals: Determine whether a pump in the BME lab would be suitable for our purposes or if one needs to be purchased, Test H2O vs 70% EtOH.

Content:

tested syringe pump, 4 small peristaltic pumps, and one large peristaltic pump.

Used syringe pump to test H2O vs EtOH because it could be set to the same flow rate to increase uniformity between trials.

- Set to the syringe pump with :Syringe: 60ml, d = 1 in. flow rate: 20ml/min.
- Record the initial temperature for each trials using both screened IR camera and unscreened camera.
- Control trial was performed exactly the same as procedure in 10/07/19 Pre-Testing Control.
- For water trial, put water in the syringe pump, connect the pump with a PVC tubing (inner diameter = 2mm). Then start the pump first.
- At the same time, one person performed the cutting process (follow the procedure in 10/07/19 Pre-Testing Control).
- The other person hold the PVC tube and let the water run through the blade bottom (similar as procedure in 10/07/19 Pre-Testing Mist)
- After two rounds of cutting process, record the temperature using both cameras.
- Then change water to alcohol in the syringe pump, repeat the step above and record temperature.

11/17/19 Tube length vs Flow rate

▪ Xu He ▪ Dec 11, 2019 @01:00 AM CST

Title: Tube length vs Flow Velocity

Date: 11/17/2019

Content by: Noah

Present: Noah, Rebecca, Angelica, Xu

Goals: Measure flow velocity and use to determine how quickly flow rate decreases with length

Procedure:

- Tubing was laid out horizontally and a blue room
- DC voltage source set to 12V was used to pump water from a 500mL beaker.
- The tube was marked at 1m, 1.5m, and 2m. Ten trials were recorded.
- In each trial, the tube began void of any water, then the pump and a hand timer were started simultaneously.
- Time recordings were recorded with the "lap" function of the hand timer when the water reached each of the three marked lengths on the tubing.
- This was recorded and repeated 10 times in total.
- Statistically analyze the test afterwards

Conclusions/action items:

The test aims to find out whether the tube length will impact the flow rate. In our design, the tube should be as long as possible (convenient to localize on table; considering about water/ethanol source availability).

12/3/2019 Final testing protocols

▪ Xu He ▪ Dec 10, 2019 @05:34 PM CST

Title: Final Temperature Testing

Date: 12/3/2019

Content by: Xu

Present: Xu, Noah

Goals: Protocols for the final testing

Content:

- 3 different species in the testing: control (no cooling), tap water and 70% ethanol
- One person cut the cast for one minute by moving along the fiberglass continuously
- Record the initial temperature by placing the saw on the table prior to testing
- Final temperature was recorded immediately after 1 min cutting and the saw was placed on the table.
- IR camera was used to record temperature for each trials. Only the blade temperature was measured.
- After each trials, clean the blade with paper towel and wait for 1 min for it's to dry out.
- Repeat the above steps for 5 time with each species, and record initial and final temperature.
- Compute average temperature and the temperature difference (initial - final) for each species

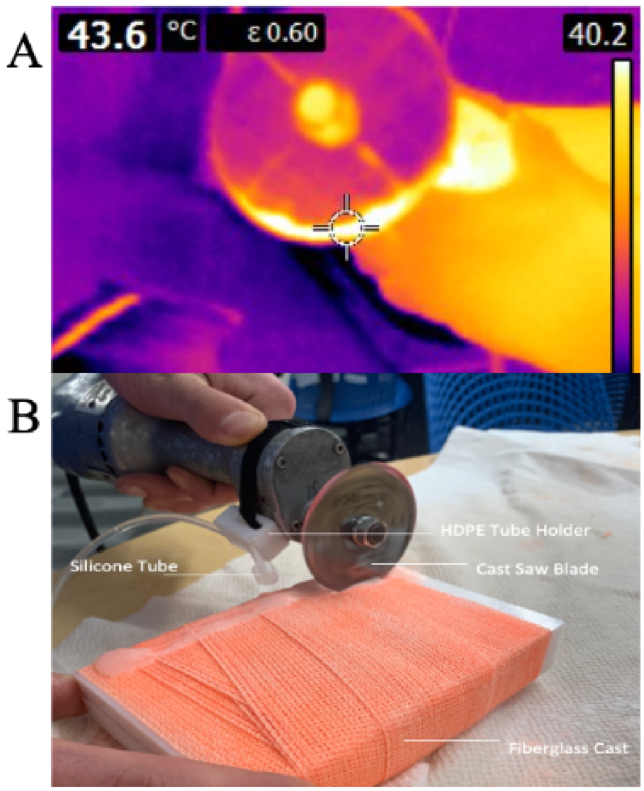


Fig 1 A Sample IR camera image. Only the lower blade part temperature is being recorded. B the basic set up for each trial testing. No solution was being pumped in control trial, but the tube still attaches.

10/07/19 Preliminary testing

▪ Xu He ▪ Dec 11, 2019 @01:14 AM CST

Title: Preliminary testing

Date: 10/07/19

Content by: Xu

Present: Caleb, Angelica, Rebecca

Goals: Analysis preliminary testing

Content:

Table 1 Preliminary testing results for three trials

	Blade Temp (°C)	Cast Temp (°C)
Stationary	22	22
Control	113	47
Cold tubing	50	46
Mist	32	45
Compressed air	43	25 (measurement delayed after 30s)

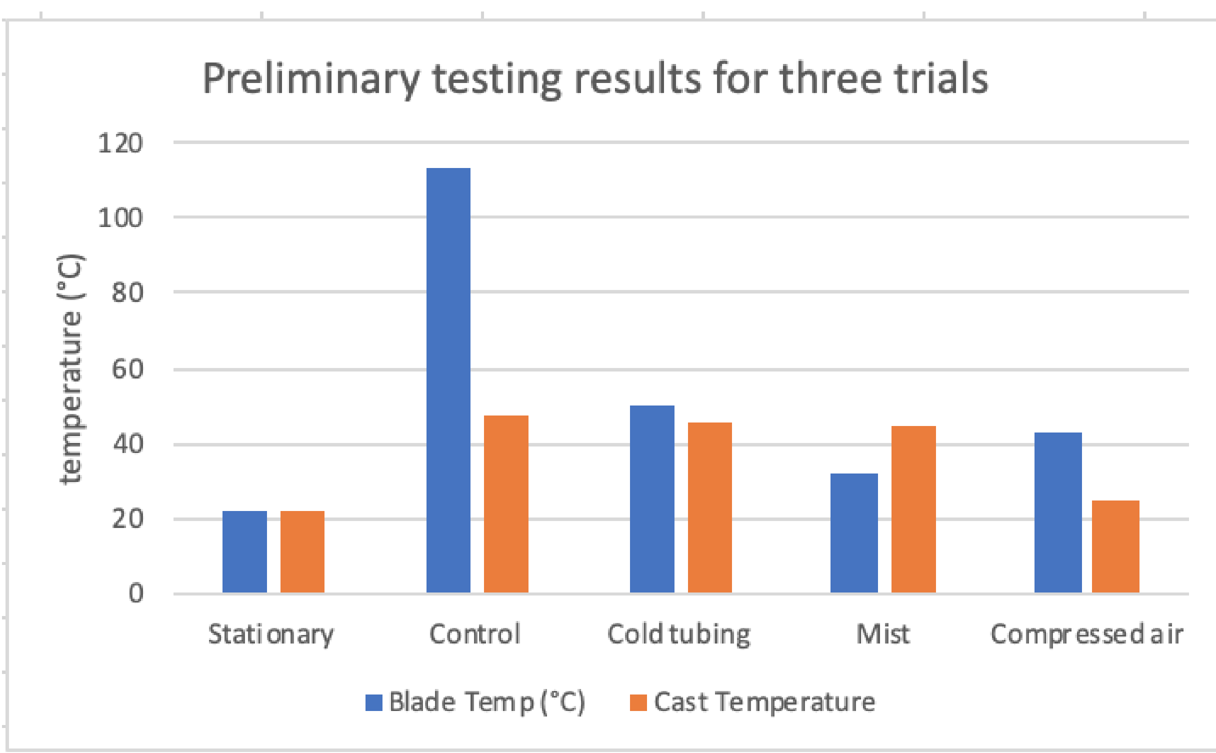


fig 1 Preliminary testing results for three trials. Note: the compressed air blade temperature measurement delayed for 30s

The stationary temperature was measured at room temperature, and each trial only performed once. According to Table1, when looking at the cast temperature,none of system fulfill the requirement of cooling temperature below 44 degrees, but cold tubing and misting were very close to the desired temperature. The measurement of compressed air delayed for about 30secs, but it provided one insight that the cast temperature can be cooled down by only putting the cast in stationary (compared temperature 45/46 to 25). As a result, the cast temperature can be cooled down by changing the procedure by letting each cuts sits for about 1 min. Moreover, when comparing the blade temperature, only mist system achieved the goal. This is the reason why the team want to focus on misting system for the final prototype. Some improvements can be made for testings. Firstly, each trial should be repeated for 5 times and initial temperature should be recorded for each trials.

10/24/19 Syringe pump testing

▪ Xu He ▪ Dec 11, 2019 @01:21 PM CST

Title: Syringe pump testing

Date: 10/14/19

Content by: Xu

Present: Noah, Xu

Goals: determine the ideal flow rate

Content:

Syringe: 60ml, d = 1 in. flow rate: 20ml/min

Table 1 Raw testing data for blade temperature using Syringe pump to set stationary flow rate

°C	Control		Water		Ethanol (70%)	
	init.	fin.	init.	fin.	init.	fin.
IR camera with screen	19.5	24	20	21.5	18.5	17
without screen	21.8	23.5	17.8	23	21.7	21.4

Table 2 Processed data for each trials

Change °C	Control	Water	Ethanol (70%)
Screen	4.5 (23.1%)	1.5 (7.5%)	-1.5 (-8.1%)
no Screen	1.7 (7.8%)	5.2 (22.6%)	-0.3(-1.4%)
Average	3.1 (13.0%)	3.35(17.7%)	-0.9 (-4.5%)

* Negative value means the final temperature is lower than the initial temp.

Change = finial value - initial value;   % change = (final - initial)/initial

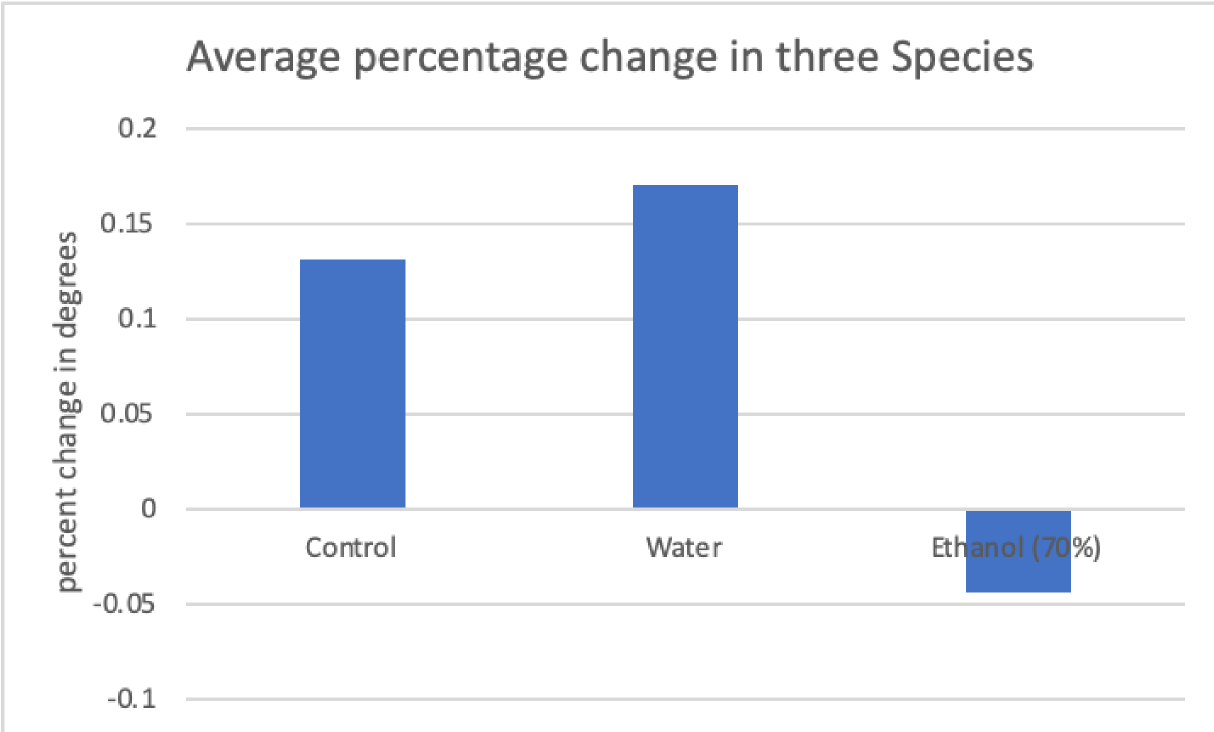


Fig 1 Plot of average percentage change in temperature for 3 species, refer to Table 2

Conclusions/action items:

The temperature didn't vary too much between control data and water (maybe due to two cameras). For the screen camera, the control showed a 23.2% increase for control, but the no screen camera showed a 22.6% temperature increase for water. However, both trials showed negative data for ethanol, which means that ethanol gets more cooling ability. All temperatures seemed to decrease a lot from previous preliminary trials.
Limitations: performed in a wet cast, a different person does testing (decrease the duration), stationary control.

11/10/19 Flow Rate

▪ ANGELICA LOPEZ ▪ Nov 10, 2019 @08:36 PM CST

Title: Flow Rate Trials

Date: 11/10/19

Content by: Angelica Lopez

Present: Caleb Ravn, Rebecca Swanson, Noah Nicol

Goals: Test short tubing flow rate

Content:

Flow Rate Trials

1. 10.02 sec 8.2 mL
2. 9.25 sec 7.3 mL
3. 9.6 sec 8 mL
4. 8.95 sec 7.2 mL
5. 8.85 sec 7.4 mL

Conclusions/action items:

▪ Xu He ▪ Dec 11, 2019 @01:16 PM CST

	Trial One	Trial Two	Trial Three	Trial Four	Trial Five
length (m)	time (s)				
1	3.61	3.62	3.51	3.16	3.55
1.5	5.59	5.62	5.41	5.22	4.99
2	7.65	7.69	7.56	7.22	7.07
	velocity (m/s)				
Length (m)	Trial One	Trial Two	Trial Three	Trial Four	Trial Five
1	0.277	0.276	0.285	0.316	0.282
1.5	0.268	0.267	0.277	0.287	0.301
2	0.261	0.260	0.265	0.277	0.283
average velo	0.281				

flow_rate_data.pdf(63 KB) - download The flow rate raw data used in calculating 11/17/19 Cont. Flow rate, and 11/21/19 Calculation for Flow rates

11/17/19 Cont. Flow Rate Testing

· REBECCA SWANSON · Nov 24, 2019 @09:08 PM CST

Title: Flow Rate Trials

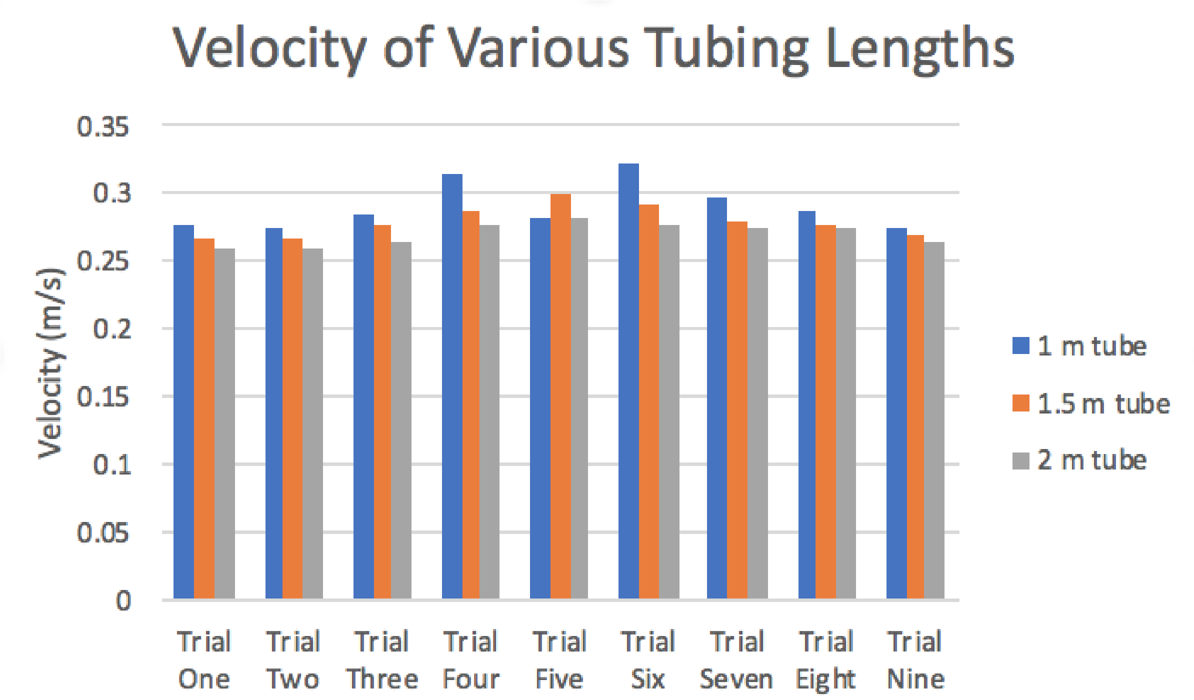
Date: 11/17/19

Content by: Rebecca Swanson

Present: Angelica Lopez, Rebecca Swanson, Noah Nicol, Xu He

Goals: Test flow rate of various tube lengths

Content:



Conclusions/action items: Each tubing length had similar velocities. The next step is choosing the tubing length that will work best with the final design.

12/8/19 Analysis of Experimental Results

▪ REBECCA SWANSON ▪ Dec 09, 2019 @10:02 PM CST

Title: Flow Rate Trials

Date: 12/8/19

Content by: Rebecca Swanson

Goals: Analyze experimental results

Content:

From Preliminary testing:

- Each design cooled the blade to half of the control temperature
- Misting system and compressed air were the two designs cooling the blade to below 44 degrees Celcius
- Cast temperature was hardly cooled.

From Syringe Pump testing:

- Ethanol was the most effective cooling solution
- However, t-test showed there is no statistical difference in cooling temperatures between water and ethanol
- Water still cooled blade effectively and is more prevalent, so water will be used in final design

From Flow Rate Testing:

- There was not a large difference in flow rate for the different tubing lengths
- Each trial was consistent with previous trials for an average velocity of 0.275m/s
- 3 m tubing will be used in the final design in case cast of a large extremity needs to be removed (adds more flexibility)

Conclusions/action items: Add information to final report

12/10/19 Final testing

▪ Xu He ▪ Dec 10, 2019 @05:46 PM CST

Title: Final Testing

Date: 12/10/19

Content by: Angelica

Present: All

Goals: Show our trials for the final testing

Content:

Figure 1 represented average temperature for each trials following the procedure in Protocols section. The figure showed that without our design implanted, the final temperature of the blade could reach about 71°C, which could result in second or third degree burns. While using ethanol or water to cool down the blade will result in a final temperature that was very close to the initial room temperature, which suggested that our design could help to prevent injury. The standard error bars for the trials is really small, indicating that the data is constant thoughout each trials.

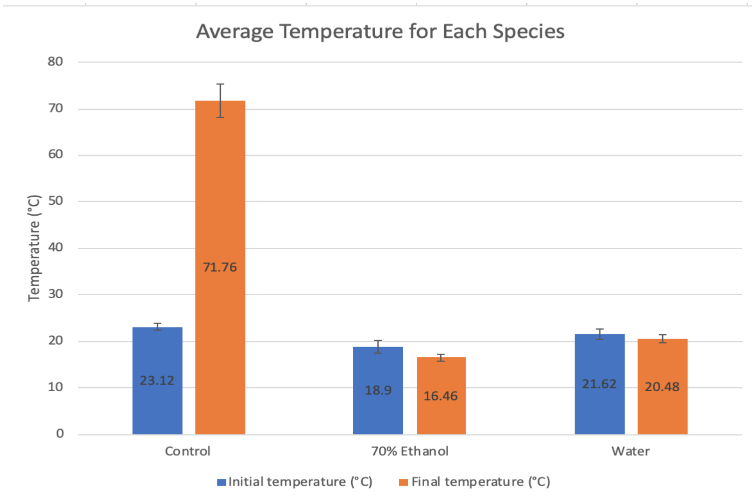


Figure 1. Average initial and final temperature for water, 70% ethanol, and control trials.

Fig 2 is a box plot compared temperature difference (final-initial) in each species. From the figure, the control group has the highest temperature difference, while water and ethanol were kind of similar. Those two groups had temperature difference slightly below zero, indicating that the blade can be cooled below room temperature. From the independent t-test, the p-value between water and ethanol is 0.0545, which indicated no significant difference within those two groups of treatments. However, the control group with ethanol/water gave p-values of about 3.57e-5/1.21e-4 respectively, which were far less than 0.05, suggesting that there were significant difference between the control group and the treatment groups. As a result, our design successfully lowering the temperature for the saw blade, and both ethanol and water would provide similar cooling effect. Therefore, the clinician would choose either of the coolant depending on the availability in the examination room.

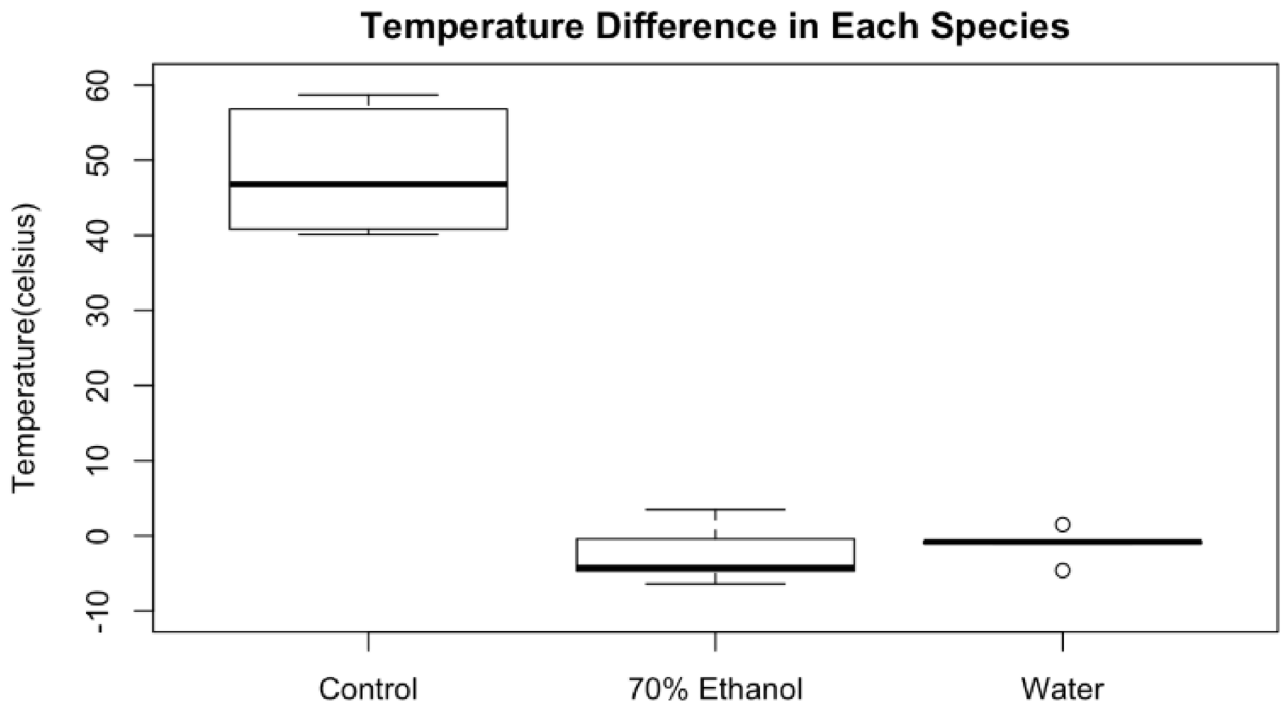
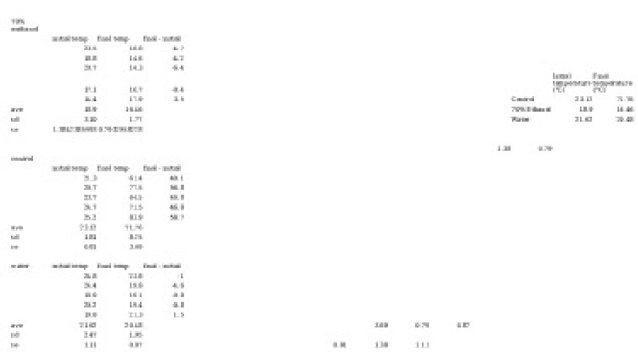


Figure 2. Boxplot for temperature difference in each species. Temperature difference was measured by final temperature - initial temperature. A negative value means the final temperature is lower than the initial temperature. From the t-test result, no statistical difference resulted in the cooling between water and 70% ethanol trials.

Conclusions/action items:

The testing significantly show the cooling ability of our design, but the design still need many improvements. For example, water/ethanol makes the fiberglass power condensed at the cast surface, which makes lot of messes. Also, the water sprays everywhere during testing. As a result, there should be a better way to get rid of the debris as well as the water. The team thinks about introducing a vacuum system which may help with the situation.

▪ Xu He ▪ Dec 10, 2019 @05:46 PM CST



Final_testing.xlsx(16.1 KB) - download Attached are the raw data

FDA regulations

▪ NOAH Nicol ▪ Dec 10, 2019 @02:59 PM CST

Title: FDA regulation link

Date: 12/10/2019

Content by: Noah

Present: Noah

Goals: Document medical product regulation

Content:

I didn't specifically find cast saw regulations, so ring cutter regulations were investigated to determine what kinds of standards must be held. There were no cast saw cooling device specific regulations. I expect the category of General Hospital and Personal Use Miscellaneous Devices to be the same for a cooling device: "*Classification.* `Class I (general controls). The device is exempt from the premarket notification procedures in subpart E of part 807 of this chapter, subject to the limitations in 880.9. The device also is exempt from the current good manufacturing practice requirements of the quality system regulation in part 820 of this chapter, with the exception of 820.180, with respect to general requirements concerning records, and 820.198, with respect to complaint files."`

FDA Regulations can be found here:

https://www.mastercontrol.com/fda/?source=g0g-Regulationssn-sl2&gclid=EAIaIQobChMIiv_B4fmr5gIVi-NkCh1vqADpEAAYASABEgKyAfD_BwE#mcui-modal

Conclusions/action items: None

Sources:

Accessdata.fda.gov. (2019). *CFR - Code of Federal Regulations Title 21*. [online] Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=880.6200 [Accessed 10 Dec. 2019].

09/08/19 Background research 1

▪ Xu He ▪ Sep 09, 2019 @12:34 AM CDT

Title: Background research #1

Date: 09/08/19

Content by: Xu

Present: individual

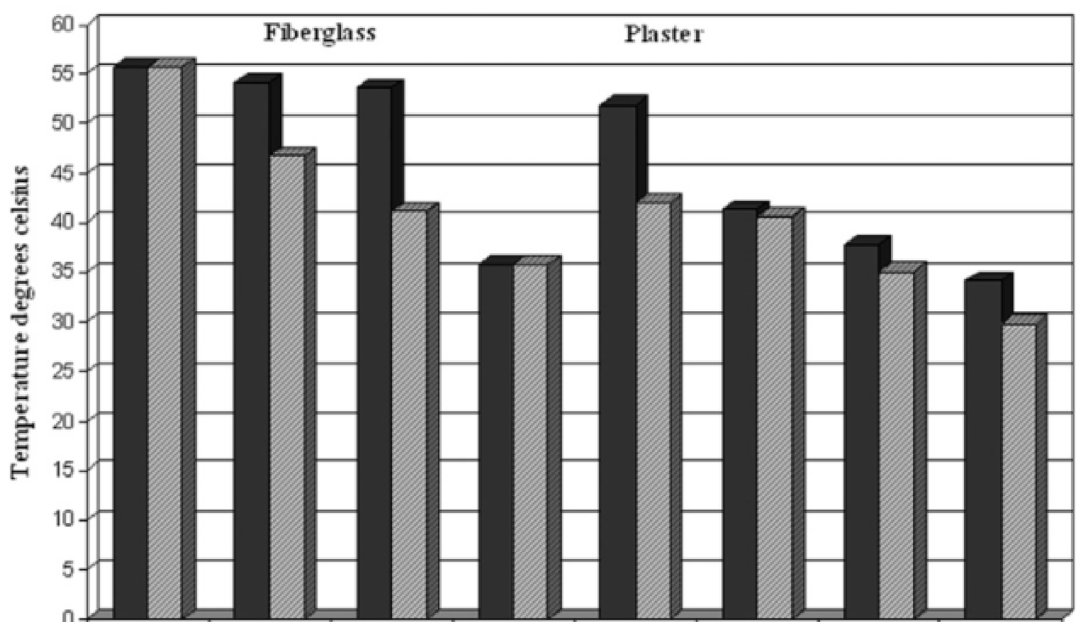
Goals: To get a scope of the project and useful information

Content:

Reference:

F. D. Shuler and F. N. Grisafi, “Cast-Saw Burns: Evaluation of Skin, Cast, and Blade Temperatures Generated During Cast Removal,” *The Journal of Bone and Joint Surgery-American Volume*, vol. 90, no. 12, pp. 2626–2630, 2008.

- Burns and abrasions can occur from the heat created by frictional forces and direct blade contact.
- More layers of the cast padding decrease temperature change.
- Cast: fiberglass cast and plaster cast are often used in clinical(2mm).
- One way to reduce burn is to cast point by point rather than continuous casting.
- New blade reduces burns.
- Main focus is skin padding interface temperature.
- Padding 2 inches wide is used for the hands, 2 to 4 inches for upper extremities, 3 inches for feet, and 4 to 6 inches for lower extremities.
- Testing could involve different numbers of padding layers or different part of the body. Material of the cast or multiple trials.
- Need to maintain body temperature (37°C, discomfort when reaching 43°C).
- 60°C, for five seconds can cause an edematous fat papule; and 60°C, for ten seconds can cause a skin blister.



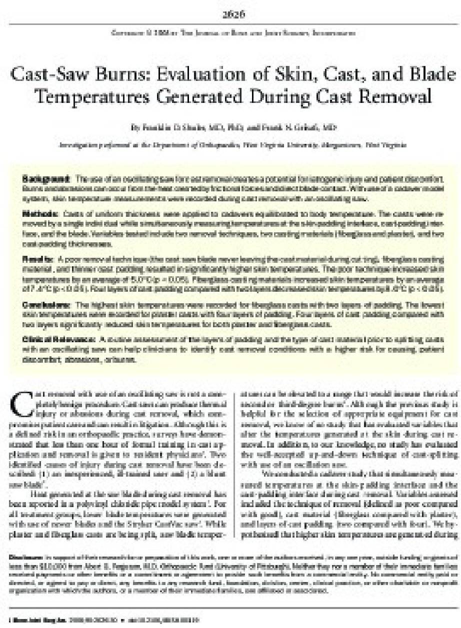
	Blade	Cast	Skin/2 layers	Skin/4 layers	Blade	Cast	Skin/2 layers	Skin/4 layers
■ Poor technique	55.7	54.1	53.6	35.8	51.9	41.3	37.8	34.2
▨ Good technique	55.7	46.7	41.1	35.8	42.0	40.6	35.1	29.8

Figure 1. The average temperatures measured at the saw blade, the cast, and the skin with two and four layers of cast padding for each removal condition. The averages are from duplicate experiments (Shuler & Grisafi, 2008).

Conclusions/action items:

First of all increase the thickness could eventually decrease the potential of getting burnt, while a new blade would decrease the friction which reduces injury chances. Moreover, the injury would also relate to human factor such as ill-training. From the article, I get some basic information such as the cast types and thickness are different for distinct injury part (need to ask client). Also, I was thinking about the industrial saw cast which they use water as coolant, and I need to do more research on that (temperature range, pump design etc). I was also wondering if we could use gases as coolant.

▪ Xu He ▪ Sep 09, 2019 @12:34 AM CDT



2626

Cast-Saw Burns: Evaluation of Skin, Cast, and Blade Temperatures Generated During Cast Removal

By [illegible]

Investigation performed at the Department of Orthopaedics, West Virginia University, Morgantown, West Virginia

Background: The use of an oscillating saw for cast removal creates a potential for iatrogenic injury and patient discomfort. Burns and abrasions can occur from the heat created by frictional forces and direct blade contact. With use of a cadaver model system, skin temperature measurements were recorded during cast removal with an oscillating saw.

Methods: Casts of uniform thickness were applied to cadavers equilibrated to body temperature. The casts were removed by a single individual while simultaneously measuring temperatures at the skin-padding interface, cast-padding interface, and the blade. Variables tested include two removal techniques, two casting materials (fiberglass and plaster), and two cast-padding thicknesses.

Results: A poor removal technique (the cast saw blade never leaving the cast material during cutting), fiberglass casting material, and thinner cast padding resulted in significantly higher skin temperatures. The poor technique increased skin temperatures by an average of 5.0°C (p < 0.05). Fiberglass-casting materials increased skin temperatures by an average of 7.4°C (p < 0.05). Four layers of cast padding compared with two layers decreased skin temperatures by 4.0°C (p < 0.05).

Conclusions: The highest skin temperatures were recorded for fiberglass casts with two layers of padding. The lowest skin temperatures were recorded for plaster casts with four layers of padding. Four layers of cast padding compared with two layers significantly reduced skin temperatures for both plaster and fiberglass casts.

Clinical Relevance: A routine assessment of the layers of padding and the type of cast material prior to splitting casts with an oscillating saw can help clinicians to identify cast removal conditions with a higher risk for causing patient discomfort, abrasions, or burns.

Cast-Saw_Burns-_Evaluation_of_Skin_Cast_and_Blade_Temperatures_Generated_During_Cast_Removal_.pdf(736.7 KB) - download

09/09/19 Background search 2

▪ Xu He ▪ Sep 09, 2019 @09:22 PM CDT

Title: Backround research #2

Date: 09/09/19

Content by: Xu

Present: individual

Goals: To get a better understanding of the project

Content:

reference

A. C. Puddy, J. A. Sunkin, J. K. Aden, K. S. Walick, and J. R. Hsu, “Cast Saw Burns,” *Journal of Pediatric Orthopaedics*, vol. 34, no. 8, 2014.

- Testing: alcohol or water, vacuum.
- Prior experimentation demonstrated a temperature of 49C requires >5 minutes to result in a burn, whereas 65C needs <1 second

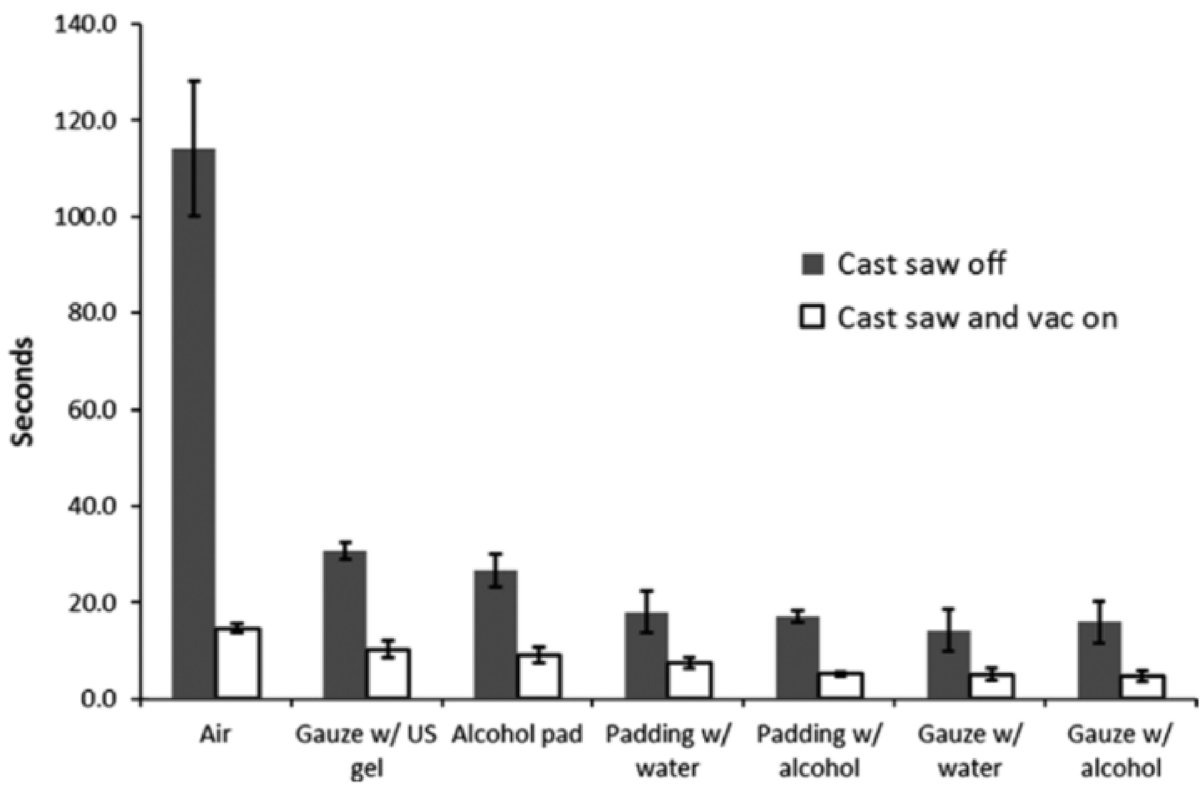
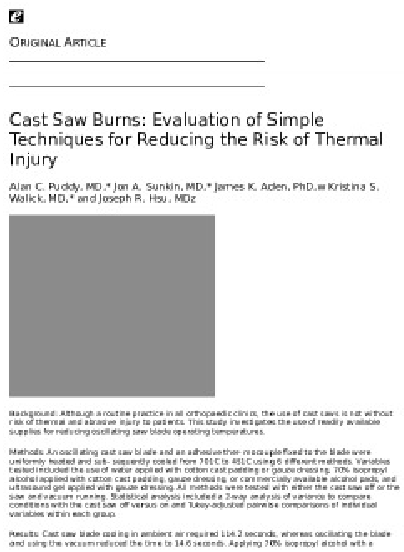


Figure 1 Mean time required for cooling of cast saw blade from 70°C to 45°C with a cast saw at rest or cast saw blade oscillating and vacuum attachment running. Air indicates cooling in ambient air without additional intervention; gauze, 4*4 gauze dressing; padding, WEBRIL cotton cast padding; alcohol, 70% isopropyl alcohol; US gel, ultrasound gel; alcohol pad, commercially available 70% isopropyl alcohol pre-saturated pad. Error bars indicate the SEM.

Conclusions/action items:

The article compares several method of cooling the saw using alcohol, water or gel along with Stryker Cast Vac. The result shows that alcohol is better than water than gel when cast saw is oscillating. However, this article only mentions using padding or gauze, which may be hard to apply during the operation. I was thinking about using a spraying system(if the vacuum is present) or using pads stick to cast blade if it doesn't interfere with the oscillation.

▪ Xu He ▪ Nov 29, 2019 @04:10 PM CST



ORIGINAL ARTICLE

Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

Alan C. Puddy, MD,* Jon A. Sunkin, MD,* James K. Aden, PhD,w Kristina S. Walick, MD,* and Joseph R. Hsu, MDz

Background: Although a routine practice in all orthopaedic clinics, the use of cast saws is not without risk of thermal and abrasive injury to patients. This study investigates the use of readily available supplies for reducing oscillating saw blade operating temperatures.

Methods: An oscillating cast saw blade and an adhesive ther- mocouple fixed to the blade were uniformly heated and sub- sequently cooled from 701C to 451C using 6 different methods. Variables tested included the use of water applied with cotton cast padding or gauze dressing, 70% isopropyl alcohol applied with cotton cast padding, gauze dressing, or commercially available alcohol pads, and ultrasound gel applied with gauze dressing. All methods were tested with either the cast saw off or the saw and vacuum running. Statistical analysis included a 2-way analysis of variance to compare conditions with the cast saw off versus on and Tukey-adjusted pairwise comparisons of individual variables within each group.

Results: Cast saw blade cooling in ambient air required 114.2 seconds, whereas oscillating the blade and using the vacuum reduced the time to 14.6 seconds. Applying 70% isopropyl alcohol with a

Cast_Saw_Burns-_Evaluation_of_Simple_Techniques_for_Reducing_the_Risk_of_Thermal_Injury_.docx(62 KB) - download

09/22/19 Thermal conductivity research

• Xu He • Sep 22, 2019 @06:39 PM CDT

Title: Polymer thermal conductivity research

Date: 09/22/19

Content by: Xu

Goals: Get some idea of the material that we could use

Content:

cooling pad

A. R. J. Hussain, A. A. Alahyari, S. A. Eastman, C. Thibaud-Erkey, S. Johnston, and M. J. Sobkowicz, "Review of polymers for heat exchanger applications: Factors concerning thermal conductivity," *Applied Thermal Engineering*, vol. 113, pp. 1118–1127, Feb. 2017.

- Conventionally, metals are used for applications where effective and efficient heat exchange is required, since many metals exhibit thermal conductivity over 100 W/m K. (Cu:231, Al:236, stainless steel~8).
- Thermoplastics have inherently higher thermal conductivity.
- As temperature increases above Tg in crystalline thermoplastics, the thermal conductivity decreases due to thermal expansion; however, amorphous thermoplastics show a monotonic increase in thermal conductivity with increasing temperature due to more molecular mobility.
- Composite thermal conductivity increases with filler content and decreases with particle size.
- Criteria: the thickness of the tubes, interfacial resistances between the fluids and the walls of the tube, and fluid flow rates.

"Cooling 101: The Basics of Heat Transfer." [Online]. Available: https://koolance.com/cooling101-heat-transfer. [Accessed: 22-Sep-2019].

Solids	
Diamond	1000 - 2500
Silver	429
Copper	401
Gold	318
Aluminum	237
Brass (37/15 Cu/Zn)	159
Iron, pure	80.4
Carbon Steel	54
Bronze	50
Lead	35.3
Titanium, pure	21.9
Stainless Steel	16.3
Ice (H_2O @ -5°C)	1.6
Glass	1.2 - 1.4
Concrete	1.1
Rubber	0.16
Wood	0.12 - 0.04

Liquids	
Mercury	8.3
Water	0.67
Methanol	0.25
Glycol, Antifreeze	0.25
Ethanol	0.14
Liquid Nitrogen	0.14
3M Flourinert FC-43	0.065

Gases	
Hydrogen	0.18
Helium	0.15
Air	0.026
Nitrogen	0.025
Oxygen	0.023

Fig 1 Thermal conductivity of some materials. Thermal Conductivity is the amount of heat a particular substance can carry through it in unit time. Usually expressed in W/(mK)

Solids	
Human Body	3.47
Concrete	3.3
Ice (H_2O @ -5°C)	2.1
Wood	1.7 - 2.7
Rubber	1.6
Aluminum	0.89
Glass	0.84
Carbon	0.71
Diamond	0.50
Iron / Steel	0.45
Copper	0.39
Silver	0.23
Lead	0.13
Gold	0.13

Liquids	
Water	4.18
Methanol	2.55
Ethanol	2.48
Glycol, Antifreeze	2.38
Liquid Nitrogen	2.04
Benzene	1.72
3M Flourinert FC-43	1.10
Freon 11	0.87
Mercury	0.14

Gases	
Hydrogen	14.32
Helium	5.23
Steam (at 110°C)	1.97
Nitrogen	1.04
Air (at 100°C)	1.0
Oxygen	0.91

Fig 2 Heat capacity of some materials. Specific Heat Capacity is the amount of heat a particular substance can hold. Typically expressed in KJ/(kgK), the rate depicts how many kilojoules of energy are required to change the temperature of one kilogram of a said substance by one Kelvin.

Conclusions/action items:

In the email, the client provided an idea that using cold tubing to drives the heat away (like people used in their computer cooling system). For computer applications, water is the most common coolant to be used due to its large heat compacity. However, the tubing's thermal conductivity is also very important as well. Since the blade is already stainless steel, there is no need to add a copper to transfer heat (erosion and electric conductivity need to be in consideration) I think the most viable way is to create a closed polymer tube (need to be a very thin wall) and contain water in it. If possible, we could have a water circulating system with it.

12/10/19 Biology of burn injury

▪ Xu He ▪ Dec 10, 2019 @10:51 PM CST

Title: Biology of burn injury

Date: 12/10/19

Content by: Xu

Present: individual

Goals: Deepen the understanding of thermal burns

Reference:

L. H. Evers, D. Bhavsar, and P. Mailänder, "The biology of burn injury," *Experimental Dermatology*, vol. 19, no. 9, pp. 777–783, 2010.

Content:

- Burn wound depths are internationally classified in the degree I–III
- Wounds that start as superficial partial or deep partial burns may progress to deep partial or deep burns over period of 2–4 days after burn injury.
- burn injury is a dynamic process that peaks at about 3 days.
- Partial thickness burns that are predicted not to heal by 3 weeks should be excised and grafted.

Table 1. Description of clinical characteristics of burn wounds of various depth

Degree/depth	Aetiology	Layer of skin involved	Appearance	Pain	Healing time
Superficial I°	Sun exposure, hot liquids with low viscosity and short exposure	Epidermis only	Pink to red, moist, no blisters	Moderate-Severe	3–7 days
Superficial partial IIa°	Hot liquids, chemical burns with weak acid or alkali, flash	Superficial (papillary) dermis	Blister, red, moist, intact epidermal appendages, blanches of pressure	Severe	1–3 weeks, long-term pigment changes may occur
Deep partial IIb°	Flame, chemical, electrical, hot liquids with high viscosity	Deeper layer (reticular) dermis	Dry, white, non-blanching, loss of all epidermal appendages	Minimal	3–6 weeks, with scars
Deep III°	Flame, electrical, chemical, blast, self immolation	Full thickness of skin and in to the subcutaneous fat or deeper	Leathery, dry, white or red with thrombosed vessels	No	Does not heal by primary intention, requires skin graft

Fig 1 A screen shot of table in the paper by Evers et. al., The table provides detailed record of each kind of burns and the effect that may cause from the burns.

local effect of burns

- Temperatures higher than 40°C leads to denaturation of proteins and burning out plasma membrane
- The burning may only take a second when exposed to temperatures higher than 60°C.
- Initial topical cooling immediately after burn maximizes epithelization and decreases scarring. Room temperature water (15°C) is equal to cooled water (2°C) for early re-epithelization and also late scarring.
- Toxic metabolites as well as antigens and immunomodulatory agents are released resulting in burn shock pathophysiologic effects.
- The local mediators released are histamine, serotonin, bradykinin, nitric oxide etc.
- Histamine is most likely to be the mediator most responsible for the early phase of increased microvascular permeability seen immediately after burn, causing inflammation response.

Temperature in °C	Duration of exposure in sec
45.0	3600
54.4	30
60.0	10
69.0	1

Fig 2 Relationship of duration of temperature exposure and occurence of full thickness burn

Conclusions/action items:

According to fig 1, cast saw burn may cause superficial I° burns, which enveloped in Epidermis only/ However, as the article mentioned above, the burn may process to deep partial burns and the effect would last for about three days, which may impact young patients' daily lives. According to fig 2 , 69°C for only 1 sec would cause burn. However, through our final testing, the average blade temperature could reach above 69°C, which may cause serious effect to patients. Moreover, thermal burn would induce inflammatory response by local release of cytokines (histamine), which may induce large endothelial gaps to transiently form

▪ Xu He ▪ Dec 10, 2019 @10:51 PM CST


Review Article

The biology of burn injury

Lars H. Evers[1,2], Dhaval Bhavsar[2] and Peter Mailänder[1]

Burn injury

Background and incidence

Classification

Experimental Dermatology

777

Evers_et_al-2010-Experimental_Dermatology.pdf(371.7 KB) - download

11/21/19 Calculation for Flow Rate

▪ Xu He ▪ Dec 11, 2019 @01:17 PM CST

Title: Calculation for average flow rate

Date: 11/21/19

Content by: Xu

Content:

$$Q = \int vdA$$
$$= \int v \times 2\pi r dr$$
$$= v \times \pi r^2$$
$$= \frac{0.281m}{s} \times \pi \times \ 0.001^2 m^2$$
$$= 8.8 \times 10^{-7} m^3/s$$
$$= 0.0528\, L^3/min$$

The data was gathered from actual testing, Row data please refers to Experimentation 11/10/19 Flow Rate

12/11/19 Cool Cast saw Blade design

▪ Xu He ▪ Dec 11, 2019 @01:35 AM CST

Title: Cool Cut Cast saw blade

Date: 12/11/19

Content by: Xu

Goals: Final alternative way to cool cast saw

Reference

D. Amanatullah, "US20150157515A1 - Cool Cut Cast Saw Blade - Google Patents." [Online]. Available: https://patents.google.com/patent/US20150157515?oq=cast+saw+cooling. [Accessed: 11-Dec-2019].

Patent number US20150157515A1

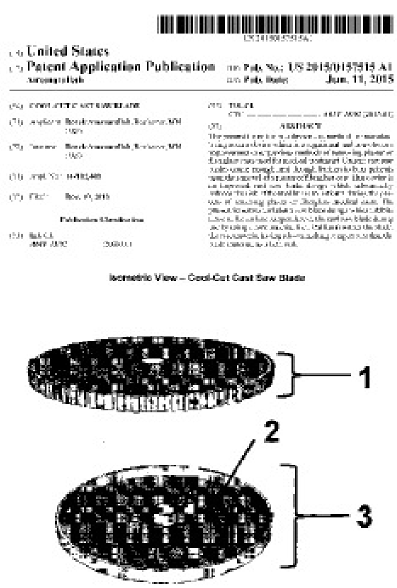
Content:

- Implanted a low melting point core material within the blade as a heat sink.
- The heat is disbursed throughout the center of the blade, thus the edge is cool.
- The material at the center can go through a phase change when absorbing the heat.
- Any low melting point material can be used as a sink.
- When the temperature reaches the melting point of the low melting point material. it will absorb energy but remain at a constant temperature while making the phase transition from a solid to a liquid. This will slow heating material.
- Double metallic gallium was used as the sink.

Conclusions/action items:

This innovation was done on the blade, but we could use some of its concept. For example, finding a low melting point material or some metal with extreme heat concavity as a sacrifice material that absorb the heat. Many PC computers use copper to conduct heat, then a watering system is used to cooling down the copper. Utilizing heat conduction would be a good idea to reduce messes caused by misting system.

▪ Xu He ▪ Dec 11, 2019 @01:36 AM CST



US20150157515A1.pdf(1.1 MB) - download

09/15/19 Mist cooling system

• Xu He • Sep 15, 2019 @08:57 PM CDT

Title: Mist cooling system

Date: 09/15/19

Content by: Xu

Present: individual

Goals: Make a preliminary sketch for device

Content:

- **A polyethylene bottle (15ml, h:16mm, d:25mm) is attached to the saw body**
- A mist maker (d = 20mm) attached to a sponge(alcohol) is being used to produce mist to the blade.
- The circuit of mist maker is connected outside the bottle.
- The mist will come through the hole on the bottle cap.
- If the mist is not enough, thinking about adding a computer fan to the design.
-

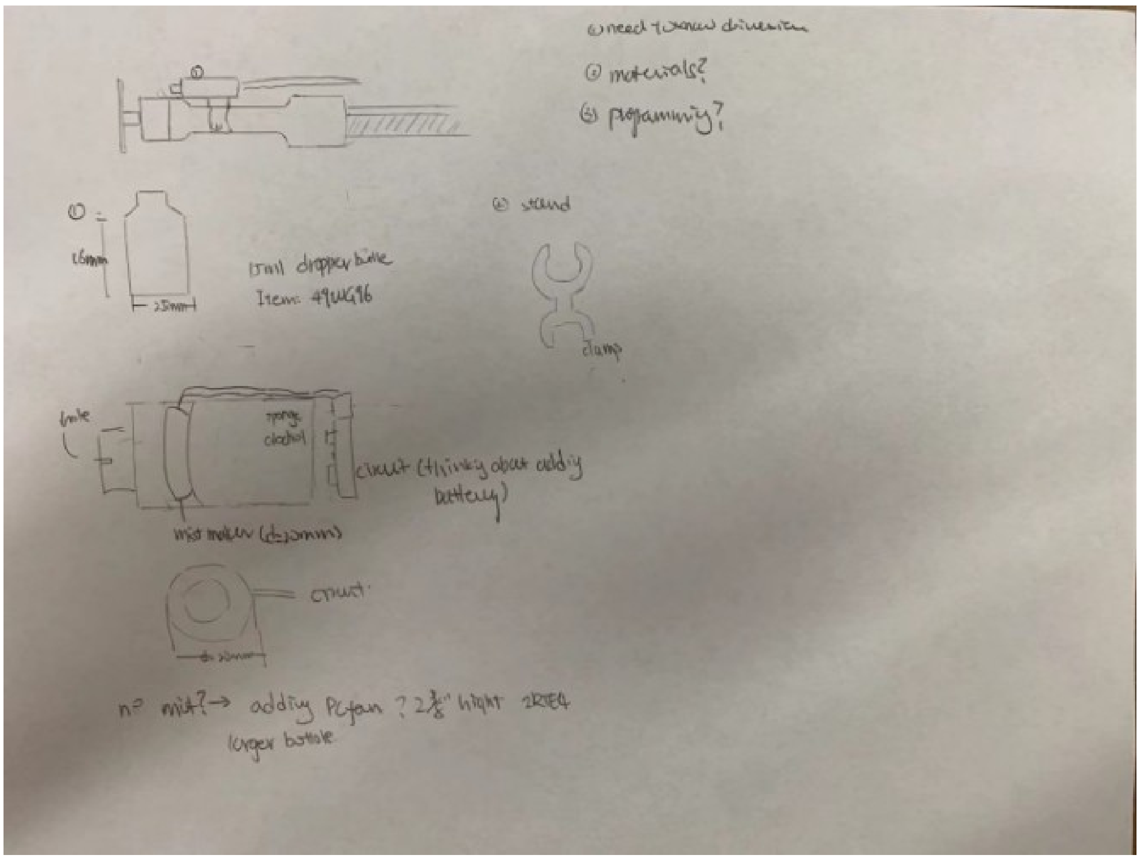


figure 1 Sketch of the mist cooling system design

Conclusions/action items:

The major problem is that there is no grantee that the mist would be able to cool down the blade, and the team will figure it out during the client meeting. Moreover, the mist maker cannot be purchased in UW shop system. Also, the circuit is hard to build at some point, so we actually need to simplify the design.

04/10/19 Mist+cold tubing design

· Xu He · Dec 11, 2019 @01:12 PM CST

Title: Combined mist and tube design

Date: 04/10/19

Content by: Xu

Present: individual

Goals: improve the previous design after the preliminary testing.

Content:

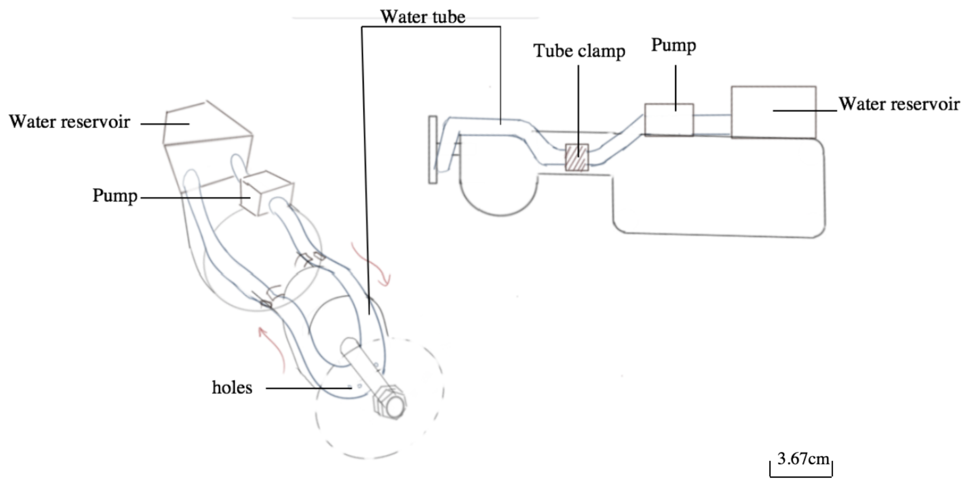


Fig 1 Design drawing (front and side view) of the new cooling device

- A water tube with holes drilled in the blade attachment point
- A water pump used to pump water through the tube
- A reservoir was used to maintain water flowing
- The tube clamp will be designed not to interference user performance
- The whole design can be separated from the saw is needed

Conclusions/action items:

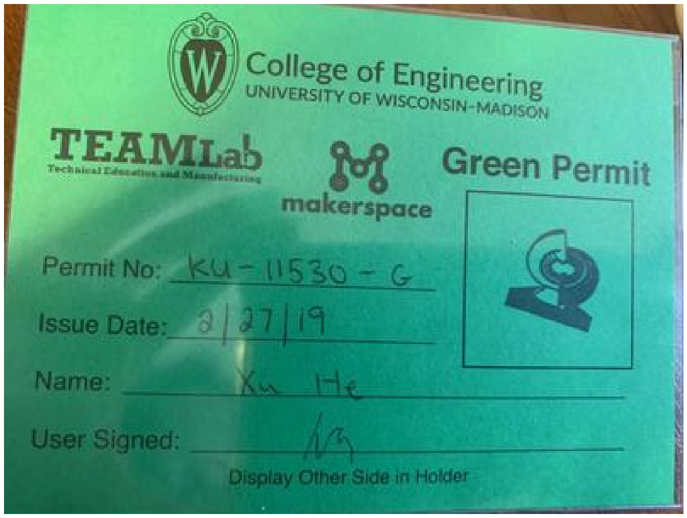
This is a rough sketch that I came up with before the night of the presentation. I have searched for some small pumps available, but the water reservoir is usually very big.

Limitations

- The weight and the size of the reservoir/ pump
- Water may make a mess on the blade
- Cast dust may enter the reservoir, but water is not being recycled
- The specific design of the clamp

06/09/19 Green permit

▪ Xu He ▪ Sep 06, 2019 @08:42 PM CDT



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11/29/19 Biosafety

▪ Xu He ▪ Nov 29, 2019 @04:12 PM CST

University of Wisconsin-Madison

This certifies that XU HE has completed training for the following course(s):

Course Name	Curriculum or Quiz Name	Completion Date	Expiration Date
Biosafety Required Training	Biosafety Required Training Quiz	2/23/2018	

Data Effective: Wed Jun 6 9:02:21 2018
Report Generated: Sat Mar 16 12:32:16 2019

Screen_Shot_2019-03-16_at_12.32.19_PM.png(76.3 KB) - download

9/9/19 Background Research

• REBECCA SWANSON • Sep 10, 2019 @03:23 PM CDT

Title: Background Research

Date: 9/9/2019

Content by: Rebecca Swanson

Goals: Document research regarding current cast saw cooling devices and helpful information pertaining to casts, fiberglass/plaster, friction/heat and/or cast saws

Content:

Source 1:

Stork, N. C., Lenhart, R. L., Nemeth, B. A., Noonan, K. J., & Halanski, M. A. (2016, July). To Cast, to Saw, and Not to Injure: Can Safety Strips Decrease Cast Saw Injuries? Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4887358/

- Safety strip may lessen the chance of burns while removing casts
- Research method-
    - 25 inexperienced healthcare personnel removed fiberglass casts either with or without safety strip
    - Amount of skin touches and heat transfer was recorded
    - Pressure data was then collected
- Safety strip tended to reduce the total number of skin touches
- Safety strip prevented temperature of cast-skin interface from reaching 50 °C
- No pressure increase was detected between present and absent safety strip
- More testing, specifically in a clinical setting, is required

Fig. 3A–B

(**A**) The safety strip was placed on top of four layers of padding before application of casting tape. (**B**) The safety strip was placed between four layers of padding: two layers are applied over the skin, the safety strip is positioned, and then overwrapped with another two layers of padding before application of casting tape.

Source 2:

Puddy, A. C., Sunkin, J. A., & Aden, J. K. (2014, December). Cast Saw Burns: Evaluation of Simple Techniques for... : Journal of Pediatric Orthopaedics. Retrieved from https://journals.lww.com/pedorthopaedics/Fulltext/2014/12000/Cast_Saw_Burns__Evaluation_of_Simple_Techniques.17.aspx

- Study attempted to see which variable (70% isopropyl alcohol, water, ultrasound gel, etc.) resulted in the fastest cast saw cooling temperatures
- Oscillating the blade and using the vacuum significantly reduced the cooling time from 114.2 to 14.6 seconds
- Cast saw burns can cause significant scarring and litigation
- Higher temperatures resulted from:
    - Fiberglass compared to plaster
    - Two vs. Four layers of padding
    - Poor-cutting technique

Conclusions/action items:

More data and research needs to be collected on the effectiveness of cast-saw cooling strips. However, current data shows optimism in the use of safety strips in future casts.

▪ REBECCA SWANSON ▪ Nov 24, 2019 @09:44 PM CST

To_Cast_to_Saw_and_Not_to_Injure-_Can_Safety_Strips_Decrease_Cast_Saw_Injuries_.pdf(1.4 MB) - download

12/8/19 Skin and Burning Conditions

▪ REBECCA SWANSON ▪ Dec 08, 2019 @12:54 PM CST

Title: Background Research

Date: 12/8/19

Content by: Rebecca Swanson

Goals: Document research regarding the biology and physiology of the skin and how it relates to the severity of burns

Content:

Source #1:

P. A. J. Kolarsick, *et al.* "Anatomy and Physiology of the Skin : Journal of the Dermatology Nurses' Association," *Journal of the Dermatology Nurse's Association* , Oct-1997. [Online]. Available: https://journals.lww.com/jdnaonline/fulltext/2011/07000/Anatomy_and_Physiology_of_the_Skin.3.aspx#pdf-link.

- Three layers to skin: epidermis, dermis, and subcutaneous tissue
- Epidermis:
    - continually renews itself
- Dermis:
    - made up of collagen; contains fibrous connective tissue
    - Majority of skin makeup
    - Protects body from mechanical injury, bings water, aids in thermal regulation, etc
    - Once damaged, it is unable to be repaired, resulting in scarring

Source #2:

H. Ye and S. De, "Thermal injury of skin and subcutaneous tissues: A review of experimental approaches and numerical models," *Burns : journal of the International Society for Burn Injuries*, Aug-2017. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5459687/.

- Burns are common injuries
- 1 million burn injury victims/year need medical attention
- Three levels of burn injury:
    - First degree- superficial
    - Second degree- superficial partial and deep partial thickness/dermal
    - Third degree- full thickness
- Infants, young children, and the elderly have thinner dermal layers (related to pediatric orthopedics)
- Depth of the burn is related to temperature and time exposed to heat source

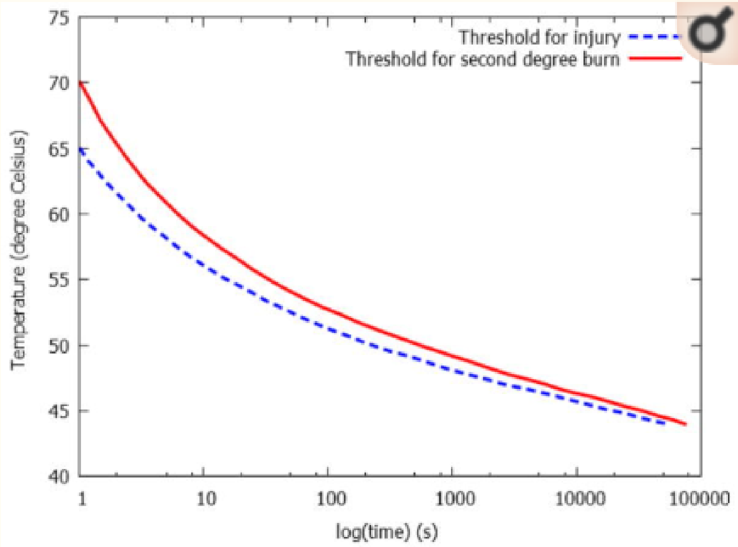


Fig. 16

Time-temperature threshold for thermal injury and second degree burn, replotted with permission from [110].

Conclusions/action items:

Add the research onto the Skin and Conditions for Burning section under the Background header in the final report.

• REBECCA SWANSON • Dec 08, 2019 @12:55 PM CST

FEATURE ARTICLE

CE

Anatomy and Physiology of the Skin

Paul A. J. Kolarsick, BS, Maria Ann Kolarsick, MSN, ARNP-C
Carolyn Goodwin, APRN-BC, FNP

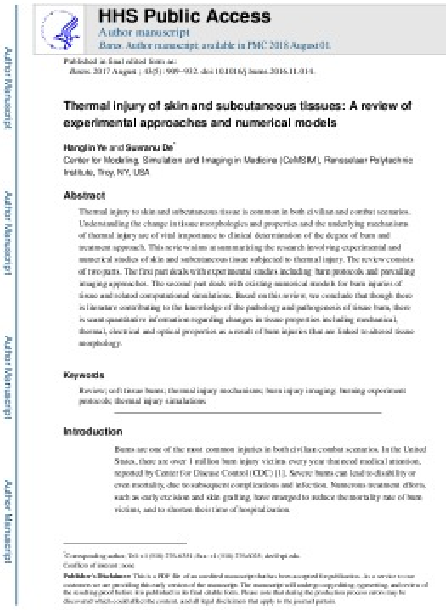
INTRODUCTION

EPIDERMIS

Keratinocytes

Anatomy_and_Physiology_of_the_Skin.3.pdf(13.7 MB) - download

▪ REBECCA SWANSON ▪ Dec 08, 2019 @12:55 PM CST



HHS Public Access

Author manuscript

Burns. Author manuscript; available in PMC 2018 August 01.

Published in final edited form as:
Burns. 2017 August ; 43(5): 909–932. doi:10.1016/j.burns.2016.11.014.

Thermal injury of skin and subcutaneous tissues: A review of experimental approaches and numerical models

Hanglin Ye and Suvranu De*
Center for Modeling, Simulation and Imaging in Medicine (CeMSIM), Rensselaer Polytechnic Institute, Troy, NY, USA

Abstract

Thermal injury to skin and subcutaneous tissue is common in both civilian and combat scenarios. Understanding the change in tissue morphologies and properties and the underlying mechanisms of thermal injury are of vital importance to clinical determination of the degree of burn and treatment approach. This review aims at summarizing the research involving experimental and numerical studies of skin and subcutaneous tissue subjected to thermal injury. The review consists of two parts. The first part deals with experimental studies including burn protocols and prevailing imaging approaches. The second part deals with existing numerical models for burn injuries of tissue and related computational simulations. Based on this review, we conclude that though there is literature contributing to the knowledge of the pathology and pathogenesis of tissue burn, there is scant quantitative information regarding changes in tissue properties including mechanical, thermal, electrical and optical properties as a result of burn injuries that are linked to altered tissue morphology.

Keywords

Review; soft tissue burns; thermal injury mechanisms; burn injury imaging; burning experiment protocols; thermal injury simulations

Introduction

Burns are one of the most common injuries in both civilian combat scenarios. In the United States, there are over 1 million burn injury victims every year that need medical attention, reported by Center for Disease Control (CDC) [1]. Severe burns can lead to disability or even mortality, due to subsequent complications and infection. Numerous treatment efforts, such as early excision and skin grafting, have emerged to reduce the mortality rate of burn victims, and to shorten their time of hospitalization.

*Corresponding author.

Conflicts of interest: none

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Thermal_injury_of_skin_and_subcutaneous_tissues.pdf(2.6 MB) - download

12/11/19 Rotary Blade Design

• REBECCA SWANSON • Dec 11, 2019 @12:39 PM CST

Title: Rotary Blade Cooking System

Date: 12/11/19

Content by: Rebecca Swanson

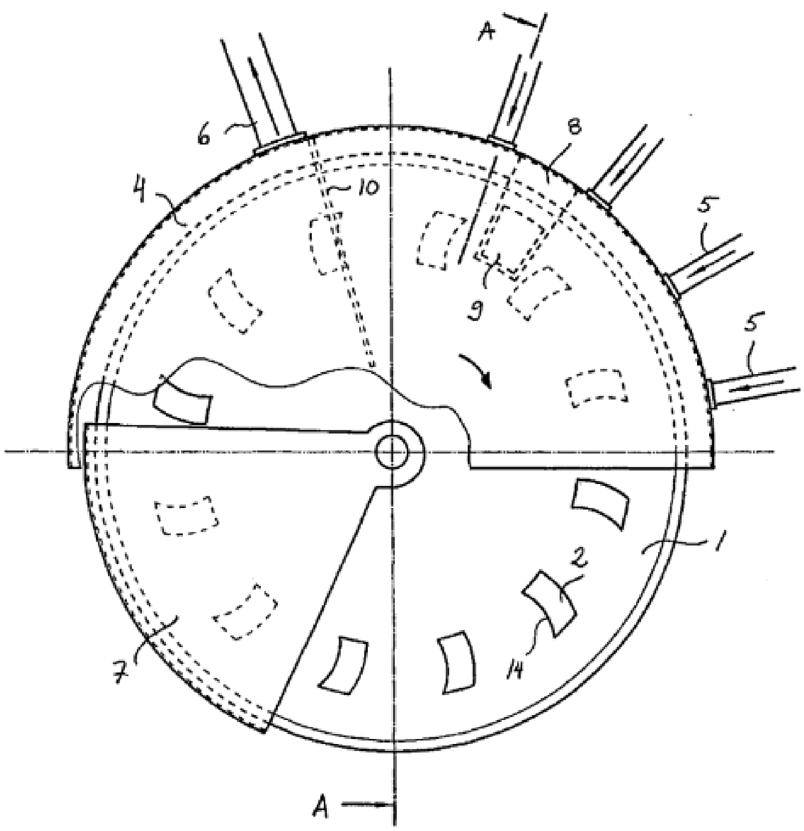
Goals: Document research regarding the importance and relativity of cast saw burns.

Content:

Source #1:

L. Jaervinen, L. Sandqvist, A. Seppaenen, and H. Kankkunen, "*Method for Cooling a Cutting Blade When Sawing Concrete, and Cutting Blade*," WO0023234 (A1), Apr. 2000.

- Cooling medium such as water is lead into blade body
- Water is a conventional cooling method
- High noise level of 105-110 decibels results from saw blade
- If water is not used, saw blade oscillation speed must be reduced to limit temperature
- Inlet pipes remove water as well as saw debris
- Little water is required



12/8/19 Casting Burns Larger Impact

▪ REBECCA SWANSON ▪ Dec 09, 2019 @10:08 PM CST

Title: Broad Impact of Casting Burns

Date: 12/8/19

Content by: Rebecca Swanson

Goals: Document research regarding the importance and relativity of cast saw burns.

Content:

Source #1:

N. C. Stork, R. L. Lenhart, B. A. Nemeth *et al.*, "To Cast, to Saw, and Not to Injure: Can Safety Strips Decrease Cast Saw Injuries?," *Clin Orthop Relat Res*, vol. 474, no. 7, pp. 1543–1552, Jul. 2016.

- Few studies have been conducted regarding the percentage of cast removals resulting in burns
- In one study, 28 out of the 3,875 (0.72%) of patients who had a cast removed suffered burning and blistering of skin
- Cost for dealing with litigations and treatment are reported to be as high $15,898 per patient per year
- Large cost that hospitals and clinics want to avoid.

Conclusions/action items:

Add the research onto the Skin and Conditions for Burning section under the Background header in the final report.

9/15/19 Preliminary Design Drawing

▪ REBECCA SWANSON ▪ Nov 24, 2019 @09:50 PM CST

Title: Design Idea 1

Date: 9/15/2019

Content by: Rebecca Swanson

Present: Rebecca

Goals: Create a preliminary design to be shared at the next team meeting.

Content:

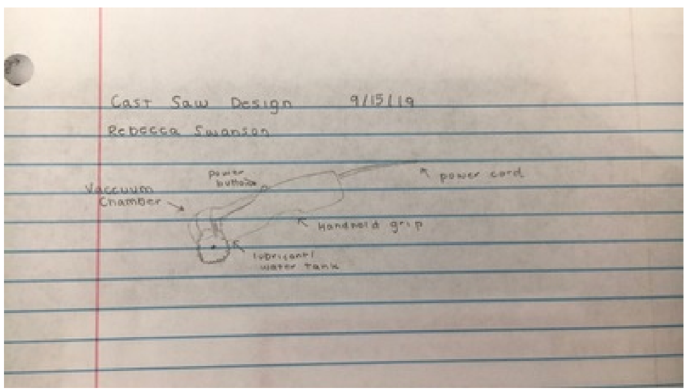
I started off by drawing a picture of the cast saw, similar to today's cast saws. Then, I added a vacuum chamber and a water/lubricant tank. For this design, water from the tank will be sprayed onto the blade of the saw. The vacuum chamber will remove saw debris and absorb the water to eliminate the possibility of a mess.

Drawbacks to this design include:

- finding a way to position the water tank so that it sprays directly onto a desired spot on the blade for every use

-creating a vacuum chamber with enough power to suction the water

▪ REBECCA SWANSON ▪ Oct 09, 2019 @12:38 PM CDT



IMG_2954.jpeg(179 KB) - download

Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

▪ ANGELICA LOPEZ ▪ Sep 12, 2019 @06:15 PM CDT

Title: Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury Notes

Date: 9/11/19

Content by: Angelica Lopez

Present:

Goals:

Content:

According to the article by Alan C. Puddy, MD,* Jon A. Sunkin, MD,* James K. Aden, PhD,w Kristina S. Walick, MD,* and Joseph R. Hsu, MDz, cooling the cast saw blade with 70% isopropyl alcohol or with water resulted with the fastest cool down times for the blade as opposed to air cooling. This would be good information to include in design and have constant or intermittent spray on the blade as it is on and cutting.

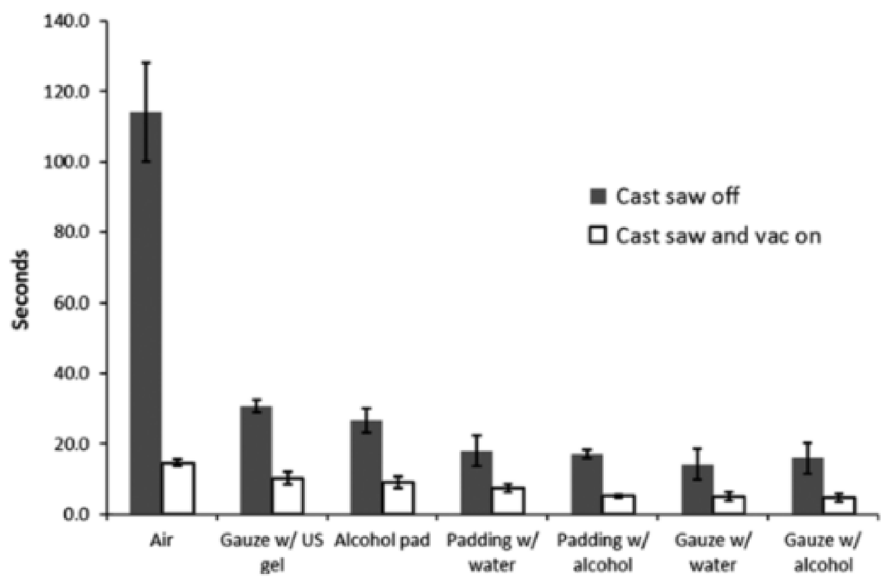


FIGURE 1. Mean time required for cooling of cast saw blade from 70°C to 45°C with cast saw at rest or cast saw blade oscillating and vacuum attachment running. Air indicates cooling in ambient air without additional intervention; gauze, 4 × 4 gauze dressing; padding, WEBRIL cotton cast padding; alcohol, 70% isopropyl alcohol; US gel, ultrasound gel; alcohol pad, commercially available 70% isopropyl alcohol presaturated pad. Error bars indicate the SEM.

e64 | www.pedorthopaedics.com © 2014 Lippincott Williams & Wilkins

Conclusions/action items: Create a preliminary design with a spraying mechanism on the saw.

Biology of Burns

▪ ANGELICA LOPEZ ▪ Nov 18, 2019 @10:33 AM CST

Title: Biology of Burns

Date: 11/18/19

Content by: Angelica Lopez

Present:

Goals: Describe the biology of a burn

Content:

Burns are damage to the skin and its tissue from "heat, chemicals, electricity, sunlight, or nuclear radiation" (NIGMS Burns).

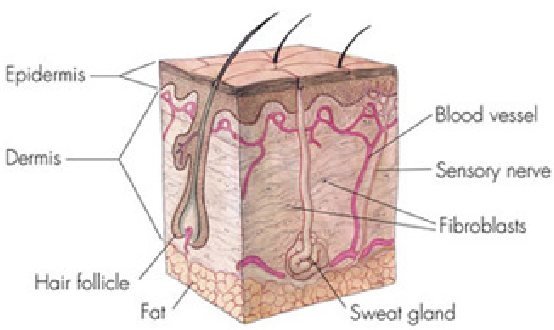


image from the NIGMS Burns webpage

1st-degree burns are damage to the epidermis, take a week to heal

2nd-degree burns are damage to the epidermis and the dermis and may require skin grafts

3rd-degree burns destroy to the epidermis and the dermis and require skin grafts to heal

https://www.nigms.nih.gov/education/pages/factsheet_burns.aspx

Conclusions/action items: We need to prevent burns on patients as a 1st or 2nd-degree burn are uncomfortable and there shouldn't be a need for unnecessary pain

Cool Cut Cast Saw Blade

▪ ANGELICA LOPEZ ▪ Nov 18, 2019 @12:41 PM CST

Title: Competing Design: Cool Cut Cast Saw Blade

Date: 11/18/19

Content by: Angelica Lopez

Present:

Goals: Present competing design

Content:

This design is a self-cooling blade to reduce the risk of burns to the patients when they get their casts removed. The blade is made of a heat-resistant material (ie. Gallium) to prevent the blade temperature from rising.

https://patents.google.com/patent/US20150157515

Conclusions/action items: This design is intriguing but quite a different path than what our team is taking.

Background Cast Cutting Videos

▪ ANGELICA LOPEZ ▪ Sep 12, 2019 @06:18 PM CDT

Title: Background: Cast Cutting Videos

Date: 9/9/19

Content by: Angelica Lopez

Present:

Goals: Understand the procedure for cutting casts off patient

Content:

Video: CAST CUTTING by Unhappy Dan

link: https://youtu.be/kQDF7Qd57ow

- blade oscillates back and forth, does not rotate 360 degrees
- cutting motion is push down, pull up, move along cast along a line (see picture)
- saw is already noisy, try to make cooling device not noisy to not add to noise level and not to scare patients more

Video: CUTTING OFF MY CAST!! by DanTDM

link: https://youtu.be/bwpzQdbXKb0

- some saws have blade guard (see picture)
- cut in line, push down and pull up movement

Conclusions/action items: Take this understanding and knowledge into consideration as I make preliminary designs

Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:23 PM CDT

Title:

Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

Date: 10/30/19

Content by: Angelica Lopez

Present:

Goals:

Content:

Conclusions/action items:

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:24 PM CDT


ORIGINAL ARTICLE

Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

cast1.pdf(222.6 KB) - download

Effectiveness of a Low Fidelity Cast Removal Module in Orthopaedic Surgical Simulation

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:25 PM CDT

Title:

Effectiveness of a Low Fidelity Cast Removal Module in Orthopaedic Surgical Simulation

Date: 10/30/19

Content by: Angelica Lopez

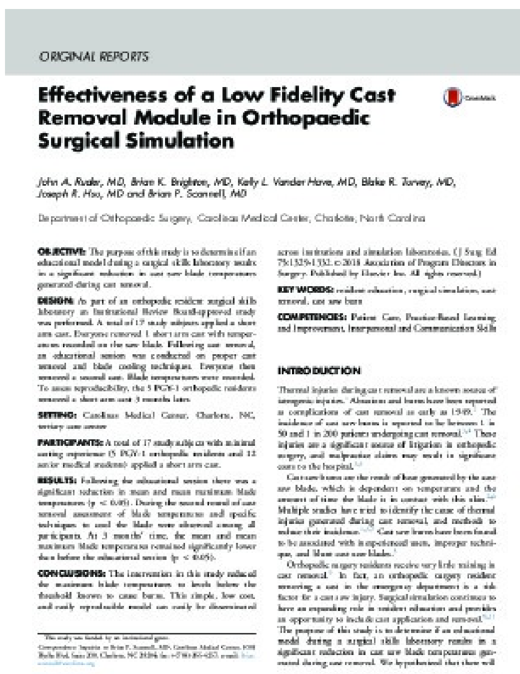
Present:

Goals:

Content:

Conclusions/action items:

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:26 PM CDT



ORIGINAL REPORTS

Effectiveness of a Low Fidelity Cast Removal Module in Orthopaedic Surgical Simulation

John A. Ruder, MD, Brian K. Brighton, MD, Kelly L. Vander Have, MD, Blake R. Turvey, MD, Joseph R. Hsu, MD and Brian P. Scannell, MD

Department of Orthopaedic Surgery, Carolinas Medical Center, Charlotte, North Carolina

OBJECTIVE: The purpose of this study is to determine if an educational model during a surgical skills laboratory results in a significant reduction in cast saw blade temperatures generated during cast removal.

DESIGN: As part of an orthopedic resident surgical skills laboratory an Institutional Review Board-approved study was performed. A total of 17 study subjects applied a short arm cast. Everyone removed 1 short arm cast with temperatures recorded on the saw blade. Following cast removal, an educational session was conducted on proper cast removal and blade cooling techniques. Everyone then removed a second cast. Blade temperatures were recorded. To assess reproducibility, the 5 PGY-1 orthopedic residents removed a short arm cast 3 months later.

SETTING: Carolinas Medical Center, Charlotte, NC, tertiary care center

PARTICIPANTS: A total of 17 study subjects with minimal casting experience (5 PGY-1 orthopedic residents and 12 senior medical students) applied a short arm cast.

RESULTS: Following the educational session there was a significant reduction in mean and mean maximum blade temperatures ($p < 0.05$). During the second round of cast removal assessment of blade temperatures and specific techniques to cool the blade were observed among all participants. At 3 months' time, the mean and mean maximum blade temperatures remained significantly lower than before the educational session ($p < 0.05$).

CONCLUSIONS: The intervention in this study reduced the maximum blade temperatures to levels below the threshold known to cause burns. This simple, low cost, and easily reproducible model can easily be disseminated across institutions and simulation laboratories. (J Surg Ed 75:1325-1332. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: resident education, surgical simulation, cast removal, cast saw burn

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement, Interpersonal and Communication Skills

INTRODUCTION

Thermal injuries during cast removal are a known source of iatrogenic injuries. Abrasions and burns have been reported as complications of cast removal as early as 1949. The incidence of cast saw burns is reported to be between 1 in 50 and 1 in 200 patients undergoing cast removal. These injuries are a significant source of litigation in orthopedic surgery, and malpractice claims may result in significant costs to the hospital.

Cast saw burns are the result of heat generated by the cast saw blade, which is dependent on temperature and the amount of time the blade is in contact with the skin. Multiple studies have tried to identify the cause of thermal injuries generated during cast removal, and methods to reduce their incidence. Cast saw burns have been found to be associated with inexperienced users, improper technique, and blunt cast saw blades.

Orthopedic surgery residents receive very little training in cast removal. In fact, an orthopedic surgery resident removing a cast in the emergency department is a risk factor for a cast saw injury. Surgical simulation continues to have an expanding role in resident education and provides an opportunity to include cast application and removal. The purpose of this study is to determine if an educational model during a surgical skills laboratory results in a significant reduction in cast saw blade temperatures generated during cast removal. We hypothesized that there will

This study was funded by an institutional grant.

cast2.pdf(245.3 KB) - download

How to Avoid Cast Saw Complications

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:27 PM CDT

Title:

How to Avoid Cast Saw Complications

Date: 10/30/19

Content by: Angelica Lopez

Present:

Goals:

Content:

Conclusions/action items:

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:27 PM CDT


SUPPLEMENT

How to Avoid Cast Saw Complications

Matthew A. Halanski, MD

PRINCIPLES OF MANAGEMENT

Risk Factors for Thermal Injury

cast3.pdf(292.8 KB) - download

Heatsink Reference

▪ ANGELICA LOPEZ ▪ Dec 03, 2019 @04:43 PM CST

Title: How a Heatsink Works

Date: 12/3/19

Content by: Angelica Lopez

Present: All

Goals: Understand how a heatsink cools a computer

Content:

"Conduction is the way heat is transferred in a solid, and therefore is the way it is transferred in a heat sink."

"where the two objects meet, the faster moving molecules of the warmer object crash into the slower moving molecules of the cooler object"

"Copper has a very high thermal conductivity of 400 W/mK. It is, however, heavier than aluminum and more expensive. But for operating systems that require an extensive amount of heat dissipation, copper is frequently used."

"A fan inside the computer moves air across the heat sink and out the computer. Most computers also have an additional fan installed directly above the heat sink to help properly cool the processor."

Link: https://computer.howstuffworks.com/heat-sink.htm

Citation: Hartle, Robert. “How Heat Sinks Work.” *HowStuffWorks*, HowStuffWorks, 31 Aug. 2010, computer.howstuffworks.com/heat-sink1.htm.

Conclusions/action items: Surface area along with moving air helps cool computers

Compressed Air in Hospitals

▪ ANGELICA LOPEZ ▪ Dec 03, 2019 @05:07 PM CST

Title: 5 Common Medical Gases Used in Hospitals

Date: 12/3/19

Content by: Angelica Lopez

Present: All

Goals: Understand if compressed air is available in hospitals

Content:

"Medical Air refers to a clean supply of compressed air used in hospitals and healthcare facilities to distribute medical gas. It is free of contamination and particles, has no oil or odors, and is dry to prevent water buildup in your facility's pipeline."

Link: https://www.chthealthcare.com/blog/5-common-med-gas

Citation: Marco, Jason Di. "5 Common Medical Gases Used in Hospitals." *CHT Healthcare*, CHT Healthcare, 14 Feb. 2018, www.chthealthcare.com/blog/5-common-med-gas.

Conclusions/action items: Compressed air is available in hospital patient rooms

Design Idea 1 Angelica Lopez

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:41 PM CDT

Title: Design Idea 1

Date: 9/15/19

Content by: Angelica Lopez

Present:

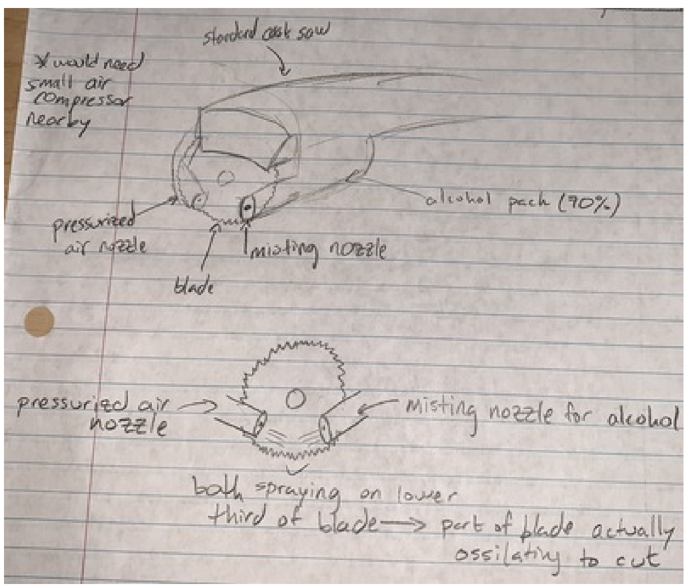
Goals:

Content:

This design has a mister on one side of the blade, angled towards the cutting surface. It can spray water or ethanol (based on Cast Saw Burns paper -- see background). On the opposite side there is a pressurized air nozzle to also blow cool air at the cutting surface.

Conclusions/action items: Compare and discuss designs with team members

▪ ANGELICA LOPEZ ▪ Oct 30, 2019 @11:29 PM CDT



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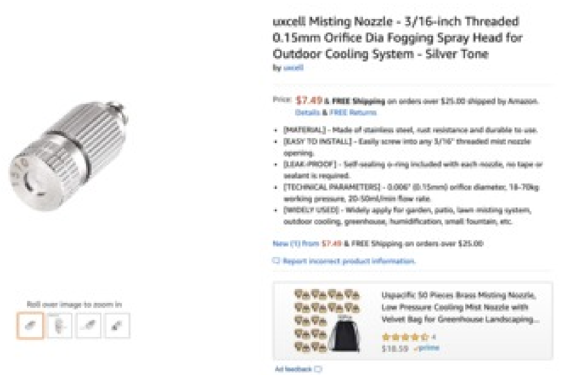
Design Items

▪ ANGELICA LOPEZ ▪ Dec 10, 2019 @04:39 PM CST



Screen_Shot_2019-12-10_at_4.34.15_PM.png(607.9 KB) - download

▪ ANGELICA LOPEZ ▪ Dec 10, 2019 @04:38 PM CST

Title: Items for design - future

Date: 12/10/19

Content by: Angelica

Present: Xu, Caleb

Goals: Outline some items for product

Content:

uxcell Misting Nozzle - 3/16-inch Threaded 0.15mm Orifice Dia Fogging Spray Head for Outdoor Cooling System - Silver Tone

https://www.amazon.com/gp/product/B07WLMQZ4K/ref=ppx_od_dt_b_asin_image_s00?ie=UTF8&psc=1

Conclusions/action items: We could incorporate this nozzle into our current design for future work. We are currently using a nozzle from a cologne sample which is made of plastic. A metal or stainless steel nozzle would be more sanitary and would also not erode/deteriorate as easily over long term use.

Cast Saw Burns: Evaluation of skin, cast and blade temperature

▪ CALEB RAVN ▪ Dec 03, 2019 @06:46 PM CST

Shuler, F.D., Grisafi, F. 2008. Cast saw burns: evaluation of skin, cast, and blade temperatures generated during cast removal. J Bone Joint Surgery Am. 90:2626-2630.

Title: Cast saw Burns
Date: 23 September 2019
Content by: Caleb Ravn
Present: Caleb Ravn
Goals: To better understand problem
Content:
Tested using 2mm cast thickness of both plaster and fiberglass casts
Stryker 940 cast cutter saw was used
Highest blade temps were 55.7 C when cutting fiberglass

Conclusions/action items:
Cool Blade to prevent burns

▪ CALEB RAVN ▪ Dec 03, 2019 @06:47 PM CST

Burn Centre Care - General Data about Burns, http://burncentrecare.co.uk/about_burned_skin.html.

Title: Burning of skin
Date: 23 September 2019
Content by: Caleb Ravn
Present: Caleb Ravn
Goals: To determine max safe blade temp
Content:
Skin begins to burn as low as 44 C if exposed for duration.
Burns very rapidly at about 80 C
Conclusions/action items:
Cool Blade to 44C

▪ CALEB RAVN ▪ Dec 10, 2019 @06:14 PM CST

Halanski, Matthew, and Kenneth J. Noonan. “Cast and Splint Immobilization: Complications.” Journal of the American Academy of Orthopaedic Surgeons, vol. 16, no. 1, Jan. 2008, pp. 30–40., https://journals.lww.com/jaaos/Fulltext/2008/01000/Cast_and_Splint_Immobilization__Complications.5.aspx.

Title: Cast and Splint Immobilization: Complications
Date: 25 September 2019
Content by: Caleb Ravn
Present: Caleb Ravn
Goals: To better understand cause of problem
Content:
a 0.72% incidence of cast saw burns resulting from removal of casting material
increased cast thickness and increased blade use result in higher blade temperatures
sliding the oscillating saw along the cast; doing so increases the chance of a cut or a burn
Conclusions/action items:
Changes in procedure may solve problem.

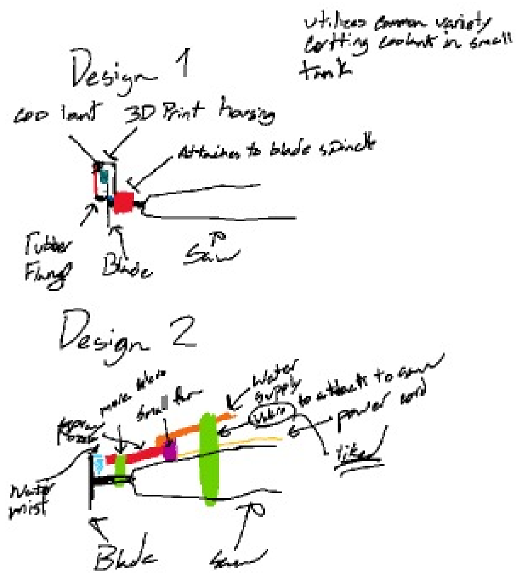
Design ideas

▪ CALEB RAVN ▪ Dec 03, 2019 @06:48 PM CST

Title: Idea Sketches
Date: 30 September 2019
Content by: Caleb Ravn
Present: Caleb Ravn
Goals: To visual Prelim Ideas
Content:see images

Conclusions/action items:

▪ CALEB RAVN ▪ Oct 09, 2019 @01:03 PM CDT



Design_Ideas_1_2.docx(518.8 KB) - download

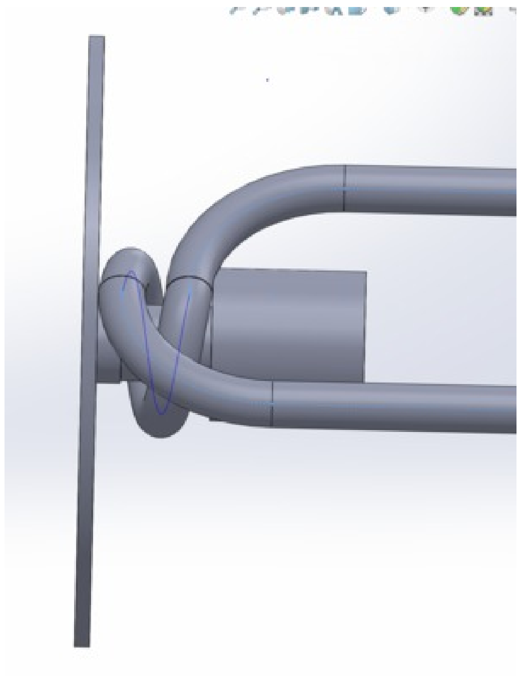
Solid Works

▪ CALEB RAVN ▪ Dec 03, 2019 @06:43 PM CST

Title: Solid Works models
Date: 3 December 2019
Content by: Caleb Ravn
Present: Caleb Ravn
Goals: To Model Prelim designs
Content:see images

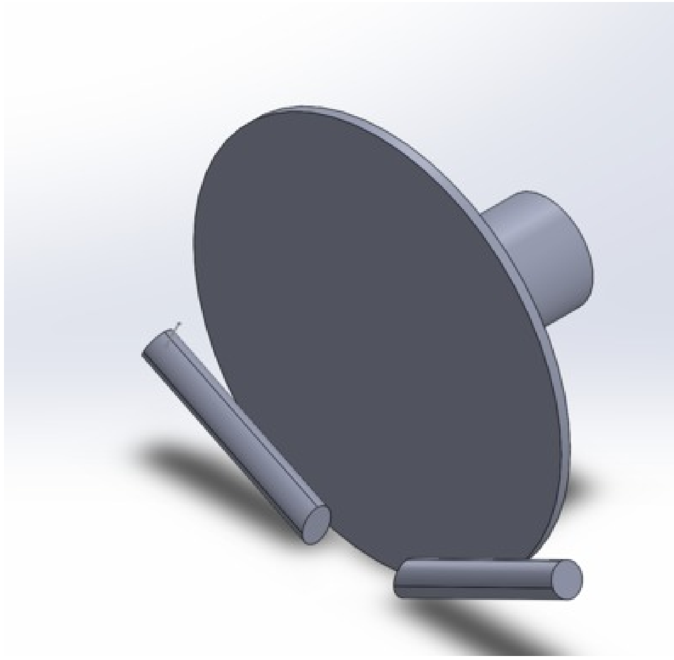
Conclusions/action items:

▪ CALEB RAVN ▪ Dec 03, 2019 @06:43 PM CST



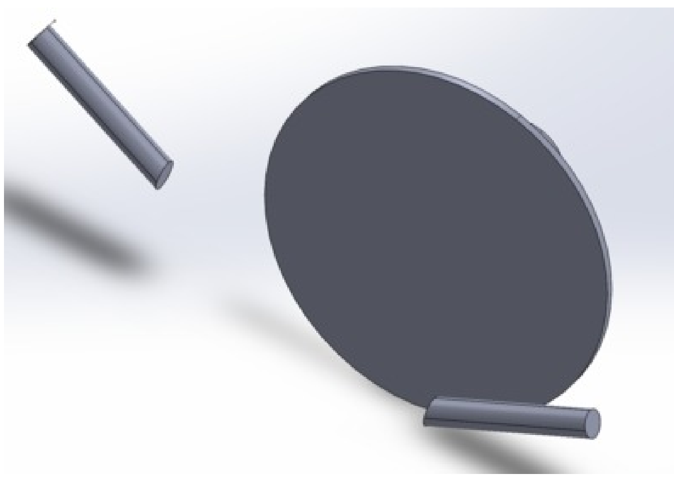
1.PNG(226.1 KB) - download

▪ CALEB RAVN ▪ Dec 03, 2019 @06:43 PM CST



2.PNG(199.8 KB) - download

▪ CALEB RAVN ▪ Dec 03, 2019 @06:43 PM CST



3.PNG(228.2 KB) - download

Cast-Saw burns 9/9/19

▪ NOAH Nicol ▪ Sep 10, 2019 @12:10 PM CDT

Title: Cast-Saw Burns: Evaluation of Skin, Cast, and Blade Temperatures Generated During Cast Removal

Date: 9/9/19

Content by: Noah Nicol

Present: Noah Nicol

Goals: Learn about the causes and effects

Content:

- Examined cast material (fiberglass vs plaster), cutting technique, and padding thicknesses.

Results

- Increased cast padding thickness was found to significantly reduce skin temperature.
- Saw blade temperatures can get high enough to create 2nd and 3rd degree burns while cutting.
- Plaster Casts generally yielded lower temperatures
- Fiberglass temps reached 55.7 C while plaster peaked at 40.6 C with good technique
- Lowest skin temperatures averaged 29.8C

Conclusions/action items:

A cadaver was used for skin temperature readings. I wonder how the temperatures would have differed if a living 37 C person experienced the additional thermal energy.

Shuler, F. and Grisafi, F. (2008). Cast-Saw Burns: Evaluation of Skin, Cast, and Blade Temperatures Generated During Cast Removal. *The Journal of Bone and Joint Surgery-American Volume*, 90(12), pp.2626-2630.

https://mds.marshall.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1017&context=sm_orthopaedics

11/15/19 Burn Micro environment

▪ NOAH Nicol ▪ Dec 09, 2019 @12:57 PM CST

Title: Burn Micro environment paper

Date: 11/15/19

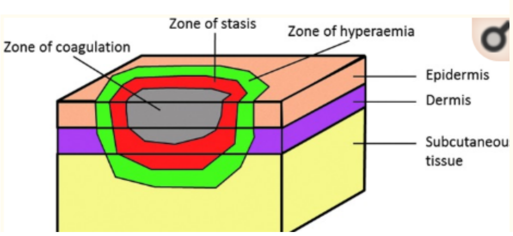
Content by: Noah

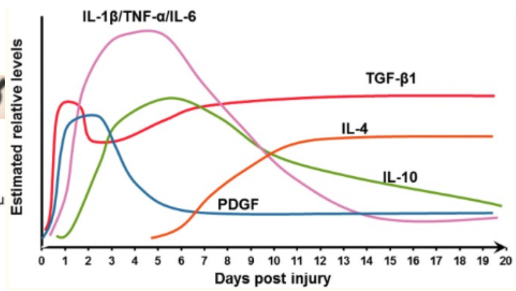
Present: Noah

Goals: Learn about the molecular/cellular process of burning skin/flesh

Content:

- The attached paper examines the connection between inflammation and fibrosis
- Numerous studies suggest that the expression of cytokines, chemokines, and growth factors in the wound environment determine the outcome of healing.
- "Inadequately debrided tissue can act as a nidus of inflammation as well as prevent proper vascularization of skin grafts placed over the necrotic tissue."
- Burn wounds are characterized by a region of coagulative necrosis (region called "zone of coagulation"). Here tissues are not sufficiently oxygenated to support survival or rapid healing. This is the main difference between healing from burns and other wounds.
- The "zone of stasis" surrounds the burned region and is less severely damaged. These tissues can recover depending on wound environment. This region is associated with vessel damage and leaking. Apparently this is another way burns are unique; local inflammatory reactions can lead to "persistent, progressive vasodilaiton and edema."
- The resolution of inflammation coincides with apoptosis of neutrophils and transdifferentiation of inflammatory macrophages into tissue remodeling macrophages expressing TGF-β1, fibroblast growth factor (FGF), and epidermal growth factor (EGF).





- Proliferative phase is followed by the inflammatory phase (fibroblasts migrate in and lay down more ECM)
- Collagen levels rise for several weeks (first type I then replaced by type III) -Tensile strength corrolates with amount of collagen
- Interestingly, the maximum strength of new tissue plateaus at 80% of undamaged tissue.
- Angiogenesis is responsible for wound closure and is stimulated by platelets and macrophages
- Mentions stem cell skin burn treatments -I heard a talk from the UW Madison researcher who pioneered this process!!

Conclusions/action items:

While this won't particularly help with our design itself, it is good to understand the burning process for explanation of background and clinical need for a cast cooling device.

Rose, L. and Chan, R. (2016). The Burn Wound Microenvironment. *Advances in Wound Care*, 5(3), pp.106-118.

Material and Saw alternatives

▪ NOAH Nicol ▪ Sep 11, 2019 @11:30 AM CDT

Title: Cast-Saw Burns: Comparison of Technique Versus Material Versus Saws

Date: 9/11/19

Content by: Noah Nicol

Present: Noah

Goals: Learn of solutions that have been attempted in the past to not repeat them and build off of them

Content:

Summary: Tested cast cutting with fiberglass and plaster casts on polyvinyl chloride pipes. Staff members used 3 saw models (DePuy, Swisstech, Stryker) at their usual speed while the edge of the saw blade's temperature was measured.

- 20-40F increase after blades had been used on 3-5 casts

To keep blade temperatures < 120degF, the following modifications were attempted:

- rotating cast-saw blade 90 degrees after its temperature exceeded 120F
- Use of a heat sink: copper plating .005in from both sides of the blade
  - copper wore away due to vibrating against cast material
- high-pressure air compressor
  - <140F for 60 seconds only, dust debris was a nuisance
- substituting stainless steel blade for one of aluminum oxide and silicon carbide (which is used to cut stone and metal
  - synthetic materials quickly deteriorated. Only DePuy could be retrofitted with modified blade. 210F in 30s
- DePuy cast saw model temperatures ranged 132-215F cutting fiberglass!
- Blade oscillation speed doesn't appear to correlate with temperature

Conclusions:

- >3/8 of an inch casts result in higher temperautes
- Stryker vacuum sometimes must be removed which elevates temperatures.

Conclusions/action items:

Perhaps look into alternative heat sink options.

[2]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].

Cast Saws on market

▪ NOAH Nicol ▪ Sep 11, 2019 @11:59 AM CDT

Title: Cast Saw designs currently on the market

Date: 9/11/19

Content by: Noah Nicol

Present: Noah

Goals: find a saw to modify/use for our design

Content:

M-PACT

- 2.5" titanium nitride blade
- $68 -cheap

Stryker 940

- $1,995
- specifications+features: https://cdn.shopify.com/s/files/1/1046/1086/files/Stryker-940-Cast-Removal-System.pdf
- Has vacuum
- compatible with Ion Nitrided, Stainless steel, and Titanium Nitrided blades

BAOSHISHAN Electric Cast Cutter Plaster

- $517

Conclusions/action items:

If there is a saw that is the most common and try to use that one for our design. The circular-bladed ones seem fairly common.

▪ NOAH Nicol ▪ Sep 11, 2019 @11:44 AM CDT

Stryker-940-Cast-Removal-System.pdf(247.6 KB) - download

Will our selected pumps work?

▪ NOAH Nicol ▪ Oct 31, 2019 @02:26 PM CDT

Title: Will our desired pump design work?

Date: 10/31/19

Content by:

Present:

Goals: Determine from online sources if the cheapest small pump we found online will have high enough water pressure.

Content:

Misting System basics: thttps://www.alloutcool.com/misting-system-basics.html says that very large droplets can be formed with as little as 15psi. Other sources (https://www.cool-off.com/faqs) report 35psi (city water pressure) is the lowest necessary to create mist.

The D1 size tube of the 12V peristaltic pump has an inner diameter of 1mm. This corresponds to a cross-sectional area of 7.854x10^-7m^2. With a given flow rate of 2-17ml/min, the velocity can be calculated by 2) in the equation below. For these conditions, the velocity of water is 2.1645 cm/min.

1) $\text{Pipe Diameter} = \sqrt{\frac{4 \cdot \text{flow rate}}{\pi \cdot \text{velocity}}}$

2) $\text{Velocity} = \frac{4 \cdot \text{flow rate}}{\pi \cdot (\text{pipe diameter})^2}$

3) $\text{Flow Rate} = \frac{1}{4} \cdot \pi \cdot (\text{pipe diameter})^2 \cdot \text{velocity}$

I realized this is not what I need to determine the pressure exerted by the pump however. Bernoulli's Equation, however, is used to determine fluid velocities through pressure measurements. It starts with qualifications of non-viscous, steady, incompressible flow at a constant temperature[1].

P + ½ρv2 + ρgy = constant

P = pressure

v = velocity

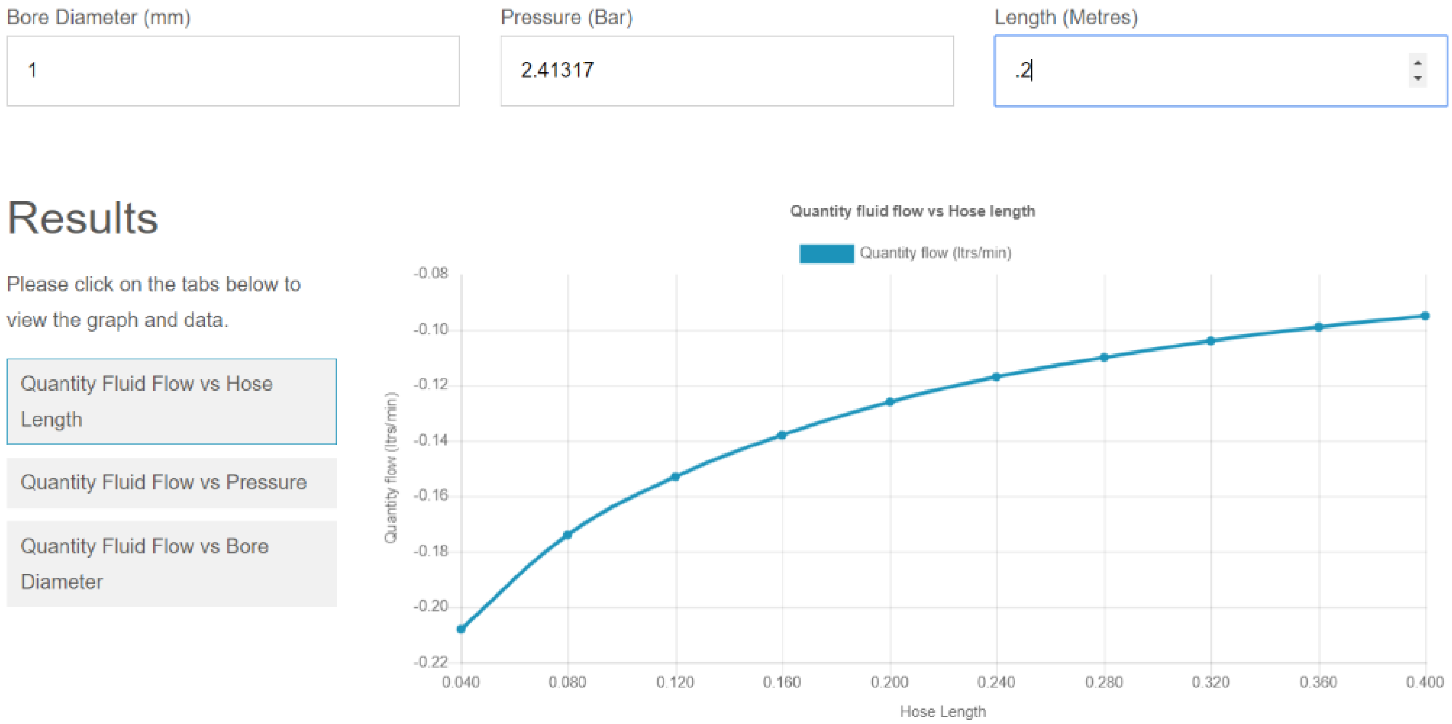
ρ = density of the fluid

g = gravity

y = height

The relationship between flow rate and pressure is also given by the Hagen–Poiseuille equation: Flow rate=πr4(P−P0)8ηlFlow rate=πr4(P−P0)8ηl where r is the radius of the pipe or tube, P0P0 is the fluid pressure at one end of the pipe, PP is the fluid pressure at the other end of the pipe, η is the fluid's viscosity, and ll is the length of the pipe or tube. This could be useful to find the nozzle pressure once the initial pressure P_0 created by the pump is determined.

The following graph[2] seems to also show a relationship in hose length and flow rate that I wouldn't have expected. It seems to indicate that flow rate increases with length, but perhaps we cannot assume constant pressure throughout the tube (2.41 Bar = 35psi).



Conclusions/action items:

References/Resources:

12V peristaltic pump: https://www.banggood.com/12V-DC-Large-Flow-Peristaltic-Pump-Corrosion-Resistant-Peristaltic-Metering-Pump-p-1568760.html?rmmds=buy&ID=514178&cur_warehouse=CN

[1]"Engineering Resources," *All Sensors*. [Online]. Available: https://allsensors.com/engineering-resources/white-papers/pressure-point-11-calculating-flow-rate-from-pressure-measurements. [Accessed: 31-Oct-2019].

[2]"Flow Rate Calculator - Pressure and Diameter," *Copely*. [Online]. Available: https://www.copely.com/tools/flow-rate-calculator/. [Accessed: 31-Oct-2019].

Impact of cast saw cooling device

▪ NOAH Nicol ▪ Dec 02, 2019 @09:50 PM CST

Title: Cast Saw cooling device potential impacts

Date: 11/15/19

Content by: Noah

Present: Noah

Goals: Examine all potential far reaching impacts of a cast saw cooling device on the medical world and beyond

Content:

- A cast saw cooling device, if effective, will obviously reduce the frequency of cast saw related burns. If implemented correctly, this may:
    - Reduce fear associated with cast removal process
    - Decrease opportunities for malpractice associated lawsuits <----very important to hospitals!
- Additionally, the small system tubing-mist unit could be applied to other cooling necessities not only in medicine, but any field that requires pinpoint cooling of a transportable device/system. I'm not familiar with it, but perhaps other portable saws can benefit from this system when excess heat could possibly damage the material being cut. Wood, for instance, hardens with heat so I could see it being desirable in this application.
- As syringes are widely used and accessible, I could imagine scenarios where ease of liquid uptake into a syringe and subsequent controlled expulsion would be useful not only in medicine, but culinary or agricultural purposes as well.

Conclusions/action items:

Continue to consider possible applications for the device.

Design idea 1

• NOAH Nicol • Sep 18, 2019 @08:10 PM CDT

Title: Design Idea 1

Date: 9/16/2019

Content by: Noah Nicol

Present: Noah

Goals: Create a unique design that brings ideas that haven't yet been discussed in group

Content:

While we have talked about possible solutions that cool the blade (misting the blade, solid heat sinks, vacuums), we have put little thought into designs that simply prevent heat from reaching the skin without modifying the cast/padding. I propose that an inexpensive bio-compatible liquid coolant be poured/injected into the cast as the saw cuts. My thought is that the coolant can flow through the crack in the cast left by the saw. As liquids tend to have a higher heat capacitances than solids (cast) or gasses (air trapped in padding), it stands to reason that a fluid, able to retain heat as both translational KE and vibrational KE, may be a good choice. Moreover, a higher specific heat (measured in J / (g °C))means that more energy is required to raise the temperature of the substance. Therefore, the same amount of heat (kinetic energy) created by the cast saw would generally result in a lower temperature when that energy is transferred to a liquid compared to a solid of the same mass.

heat required to change an object's temperature : $Q = mc\Delta T$

Plaster of Paris (PoP) is one of the most common medical casting plasters[1]. The specific heat of PoP is 930 J / (kg °C) for the 20 to 50°C range[2] while water's specific heat is 4186 J/(kg°C) (72.540J/(mol K)), about 4.5 times higher. Not only is this evidence in support of misting of the blade with water, but a biocompatible liquid with higher specific heat than that of water could potentially be extremely beneficial.

Liquids with High Specific Heat:

To my surprise, the only liquids with a higher specific heat than water were varying concentrations of ammonia[3,4]. While the body can deal with filtering out small amounts of ammonia and it is fairly inexpensive, I thought that due to ammonia's potentially deleterious effects and reputation[5], water should be used if this design is pursued. Whether water or a liquid like ethanol that would evaporate faster (thus taking heat with it) would be better for a spray technique is still up for investigation.

Possible modes of distribution:

- Patient operated squeeze bulb -gives the patient control and may distract them from the saw vibrating next to their recently inured appendage.
- Staff operated trigger system -may be difficult to cut and squirt simultaneously
- automatic pump
- Use vibration of saw on cast to encourage flow from device attached to cast saw

[1]M. Bullen, J. Kinealy, R. Blanchard, C. Rodda and P. Pivonka, "Comparison of the moulding ability of Plaster of Paris and polyester cast material in the healthy adult forearm", *Injury*, vol. 48, no. 11, pp. 2586-2589, 2017. Available: 10.1016/j.injury.2017.08.010 [Accessed 16 September 2019].

[2]. Dweck, M. Viana, A. Da Cunha, M. Melchert, A. Neves Junior and F. Cartledge, *Plaster of Paris Specific Heat Determination By Modulated DSC*. Rio de Janiero, Brazil: Simpósio de Análise Térmica, 2015, pp. 279-283.

[3]F. PAGE, "Liquids having a Specific Heat Higher than Water", *Nature*, vol. 17, no. 434, pp. 320-321, 1878. Available: 10.1038/017320b0 [Accessed 19 September 2019].

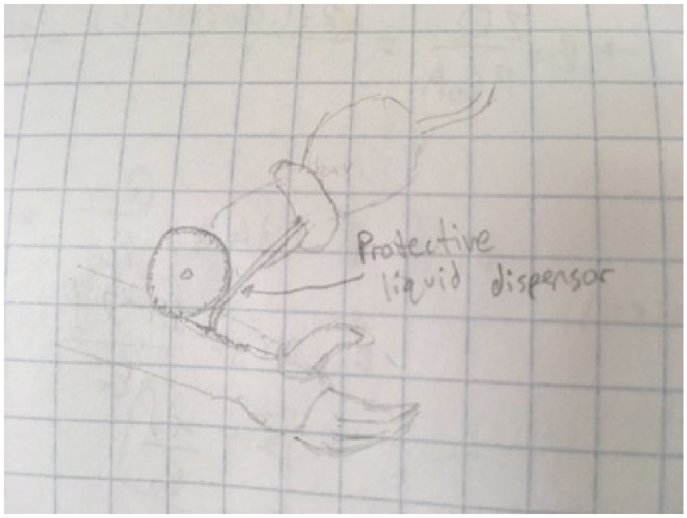
[4]"Specific Heat of Liquids and Fluids", *Engineeringtoolbox.com*, 2019. [Online]. Available: https://www.engineeringtoolbox.com/specific-heat-fluids-d_151.html. [Accessed: 19- Sep- 2019].

[5]"The Facts About Ammonia", *Health.ny.gov*, 2011. [Online]. Available: https://www.health.ny.gov/environmental/emergency/chemical_terrorism/ammonia_general.htm. [Accessed: 19- Sep- 2019].

Conclusions/action items:

Find out if there are non-toxic inexpensive liquids with a higher heat capacity than that of water.

▪ NOAH Nicol ▪ Oct 09, 2019 @12:20 PM CDT



581639F5-5572-417A-B716-038A389E866E.jpg(47.8 KB) - download

Market Design Pieces

Title: Market Design Pieces

Date: 10/7/2019

Content by: Noah N

Present: Noah N, Xu

Goals: Find a composite of existing products (adjustable nozzles, bendy tubes, misters) that can be used in our design to avoid 3D printing intricate interlocking pieces.

Content:

- Adjustable caulk nozzle: https://www.diy.com/departments/plastic-cartridge-nozzle-pack-of-2/492817_BQ.prd
- <$4 Bendy lighter: https://www.walmart.com/ip/Bic-Flex-Wand-Lighter/32469521?wmlspartner=wlpa&selectedSellerId=0&wl13=3857&adid=22222222227021269761&wl0=&wl1=g&wl2=c 78767842592&wl5=9018948&wl6=&wl7=&wl8=&wl9=pla&wl10=8175035&wl11=local&wl12=32469521&veh=sem&gclid=CjwKCAjwxOvsBRAjEiwAuY7L8tAnjUZz2VRHYgMr3T09lKDW2
- Spray nozzle company with "thousands of nozzle products and sizes" https://www.spray.com/contact/local_rep.aspx?Language=English
- spray bottle nozzle $0.92: https://www.berlinpackaging.com/3010c04blu-28-400-blue-pp-plastic-trigger-sprayers/?promo=shopping&gclid=CjwKCAjwxOvsBRAjEiwAuY7L8jCHQMFKL6dT7UueQRTAuB6q44X7czNfh2BaL6bAcLonuLWkRfyvNxoCJqwQAvD_BwE
-

Conclusions/action items:

Talk with team/confirm with BPEG and start purchasing! Client has yet to give us a budget even though we've asked, but the cost for most of above is quite low.

• NOAH Nicol • Oct 07, 2019 @09:24 PM CDT

spray_bottle_nozzle.PNG(291.4 KB) - download

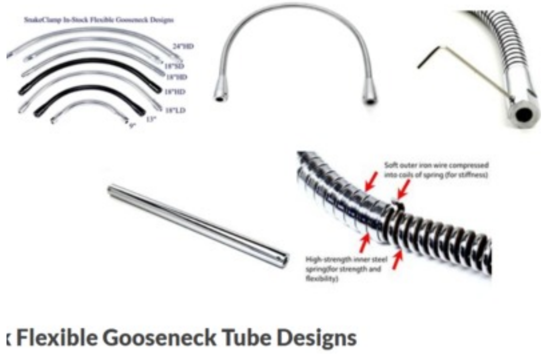
• NOAH Nicol • Oct 07, 2019 @09:18 PM CDT

Bendy_Lighter_BIC.PNG(54.2 KB) - download

• NOAH Nicol • Oct 07, 2019 @09:18 PM CDT

caulk_nozzle_BIC.PNG(101.4 KB) - download

▪ NOAH Nicol ▪ Oct 07, 2019 @09:28 PM CDT



Gooseneck_tubing.PNG(288.2 KB) - download

Attachment pieces

Title: Tube attachment pieces

Date: 11/14/19

Content by: Noah

Present: Noah

Goals: Document some methods of attaching the spray tubing to the cast saw.

Content:

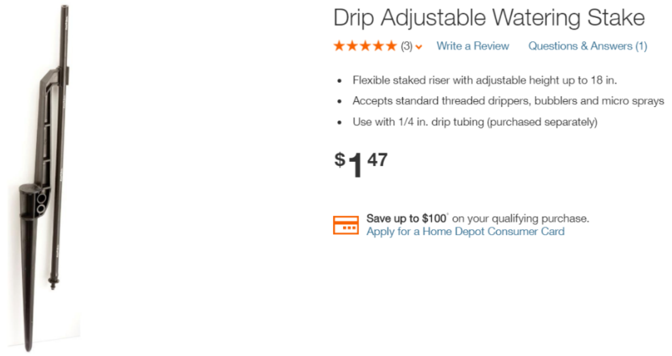
Medline tubing clip -this may be helpful as it is already used in medical environments. It also appeared cheap, however registration was required for a quote.

https://www.medline.com/product/Sterile-Adjustable-Tubing-Anchor/Z05-PF38961

The following tubing could be used in conjunction with the clip above: https://www.grainger.com/product/3P816?gclid=Cj0KCQiAk7TuBRDQARIsAMRrfUZ0UAuJhRvh4JzDLbLXDfvTDhEUAM1ogL4PVAyE2NA1JmB4ICBegdgaAjjyEALw_wcB&cm_mmc=PPC:+Google+PLA&ef_id=Cj0KCQiAk7TuBRDQAF

This tubing seems almost perfect as it was designed for mist cooling however it is strangely expensive.

The below cheap watering stake can be attached to tubing. I thought a nozzle could be stuck on the end but I don't recommend this device.



Conclusions/action items:

Confer with team to decide if the medical clip is something we'd like to use. The cheapest adjustable tubing would be an additional option.

Syringe backpack attachment

▪ NOAH Nicol ▪ Dec 02, 2019 @09:52 PM CST

Title: Liquid securing reservoir

Date: 12/2/2019

Content by: Noah

Present: Noah

Goals: Record idea for liquid securing reservoir

Content:

I was considering disassembling a squirt gun to see how its water reservoir functioned with its squirting mechanism, however I had the idea to turn the syringe instead as it is easily filled. Syringes were also available to us so this is also a choice that demonstrates resourcefulness. Of course, the only problem was that the vacuum created within the chamber would be too much for the pump to pull from, so I thought we could turn the syringe upside down and have it fixed to the back of the stuffed animal/circuit box. The opening of the syringe provides an air intake rout to equalize pressure. The caveat are that the syringe must be easily fixed upside-down, and when the user fills it up with water, they must pinch the tube simultaneously. I tried this and it was not inconveniently challenging. The image below depicts my proposed securing mechanism. Hook/clamp made of semi-flexible plastic that fits securely around the syringe body to be snapped into and out of place would be most convenient.

Conclusions/action items:

See how we will fix the syringe to the stuffed animal on 12/3 when we meet as a team.

Green Pass

▪ NOAH Nicol ▪ Dec 02, 2019 @08:50 PM CST

Title: Green Pass Permit

Date: 12/2/2019

Content by: Noah

Present: Noah

Goals: Record possession of appropriate training documentation for fabrication

Content:

Conclusions/action items:

▪ NOAH Nicol ▪ Dec 02, 2019 @08:51 PM CST

E3F4E646-AD62-4636-A90E-C6C738E5369D.jpg(24 KB) - download

2014/11/03-Entry guidelines

▪ John Puccinelli ▪ Sep 05, 2016 @01:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

▪ John Puccinelli ▪ Nov 03, 2014 @03:20 PM CST

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items: