Rapid Fluid-Heating System For Surgeries

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Background

Problem:

Perioperative hypothermia, a drop in core body temperature below 37°C during surgery, is common under anesthesia due to impaired temperature regulation. This can lead to increases in infection risk, blood loss, and recovery time [1].

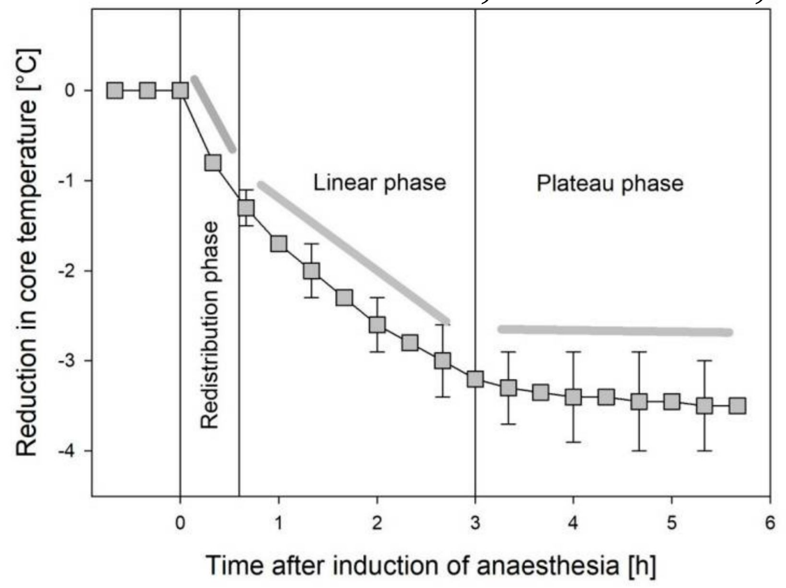

Figure 1: Reduction in core body temperature over time after anesthesia is induced in general surgeries. Effects can extend post operation [1]

Limitations With Current Solutions:

- Takes over 30 minutes to heat one IV bag
- Consumes over 1500 Watts
- Costs $1500 - $5000 depending on size

Figure 2: Pedigo Deluxe Fluid Warming Cabinet [2]

Mission Statement:

We aim to improve patient outcomes by making rapid fluid-warming technology accessible in all hospital settings.

Design Inputs

Customer Need	Metric
Adequate Saline Heating	8℃-10℃/10 Seconds
Power Usage	< 1500 Watts
Maintain Body Temperature	36℃ - 37℃
Reasonable Cost	< $1000 [3]
Sterility	10^{-4} SAL [4]

Table 1: Key design inputs from customer needs

Project Planning

Project Timeline **Product Architecture** **References**

Device Concept and Design

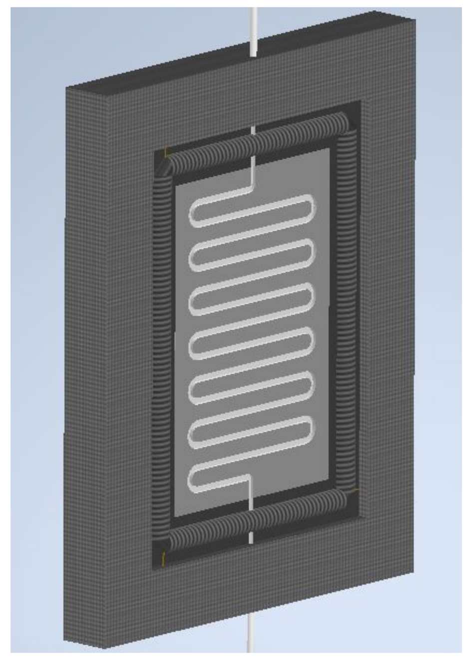

Figure 3: Isometric view of device concept:

1. Flow of saline out of IV bag into pump
2. Flow rate of pump is set and corresponding power to heating coils is controlled by microcontroller
3. Heat transfer from heating coils, to steel walls, to polyethylene tubing, to saline
4. Throttling of heated saline being output
5. Gravity fed flow of heated saline to warming bath
6. Warmed saline used in desired circumstance

Technical Modeling

The following models were derived from a cylindrical heat transfer with multiple resistances in a flowing fluid

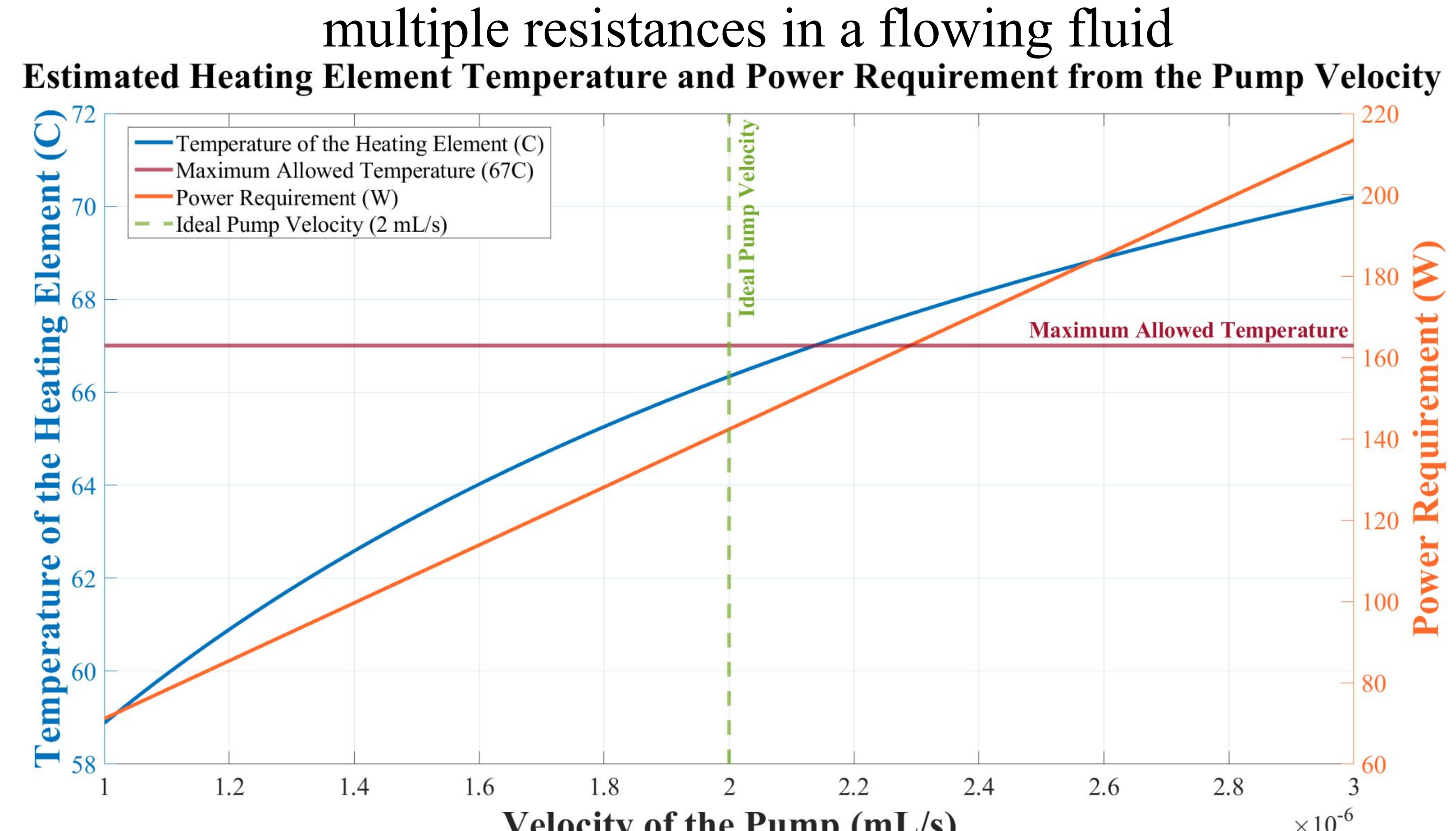

Figure 4: Estimated heating element temperature (66.3℃) and power requirement (140 W) based on an ideal pump velocity of 2 mL/s.

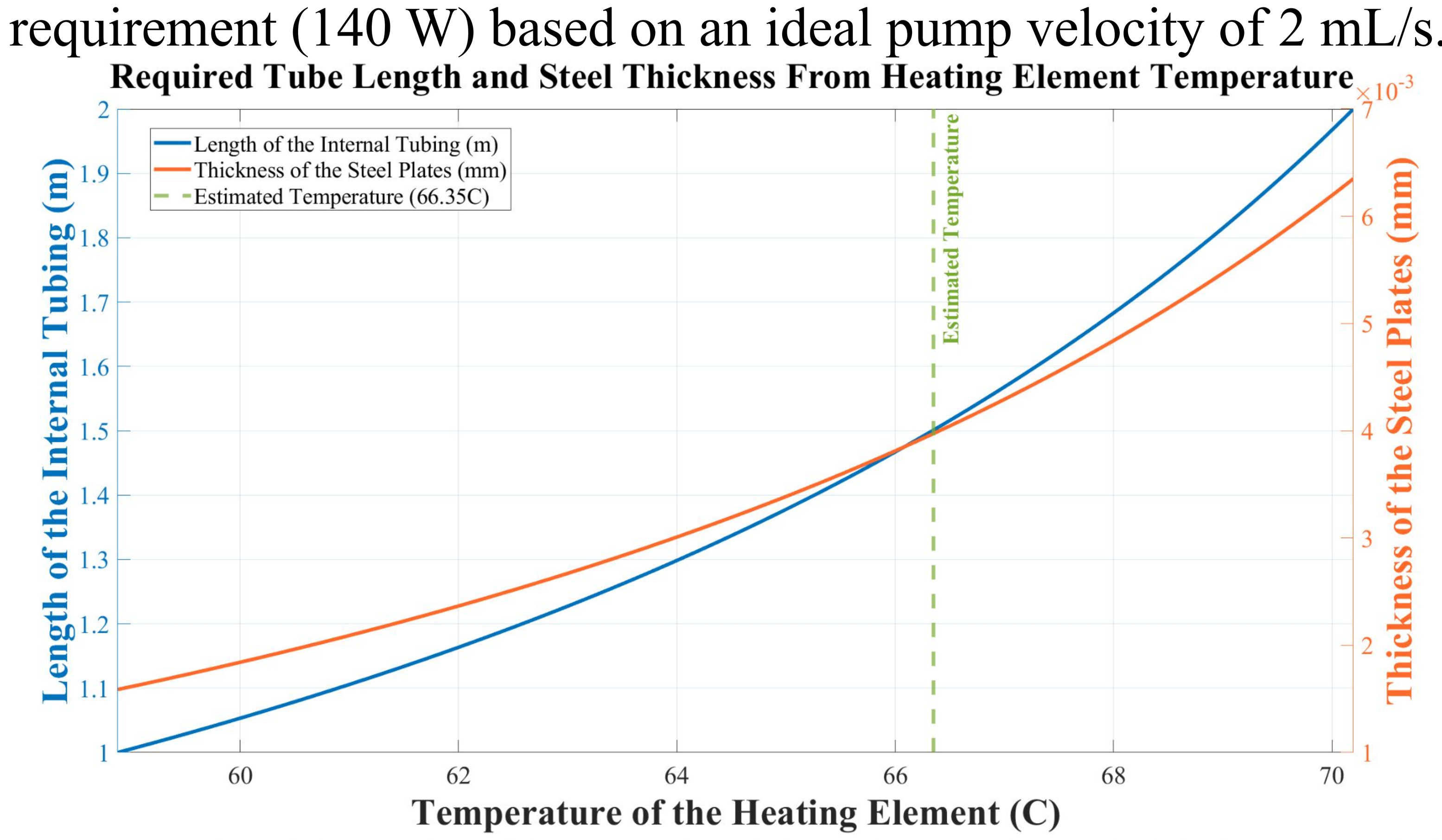

Figure 5: Required length of internal tubing (1.5 m) and thickness of the steel plates (4 mm) based on an estimated heating element temperature of 66.3℃.

Manufacturing Cost

Description	Annual Cost	Unit Cost
Direct Materials	$277,280	$346.60
Direct Labor	$100,000	$100
Overhead	$21,600	$21.60
Total # Units Produced	1000	-
Total Manufacturing Cost		$468.20
Profit Margin		20%
Final Market Cost		$561.84

Table 2: Manufacturing cost based on a 5 employee start-up making 1000 units annually in 800 SF lab space

Product Specifications

Parameter	Specification
Dimensions	30cm x 15cm x 5cm
Weight	1.25 kg
Materials	Polyethylene, Steel
Power Usage	250 Watts
Heating Speed	1 Liter in 10 Minutes
Accuracy	± 0.5℃
Heating Range	20℃ to 70℃

Table 3: Product specifications for current device concept

Future Directions

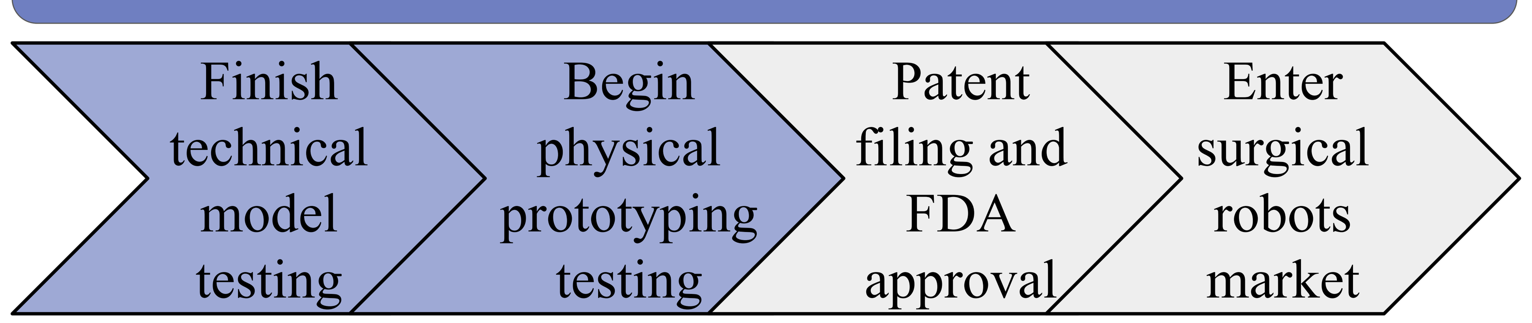

Figure 6: Current design state and future directions diagram

Acknowledgements

We would like to thank Professor Carlos Mendez-Arias, Mr. Amar Vamsi Krishna, Dr. Camilla Gomes, Dr. Bradley Greger, Dr. Brent Vernon, and Professor Michael Sobrado for providing mentorship throughout the design process.