Concept Selection

Team 314: Abbott Reusable RF Probes

Concept Selection

To select the winning concept for our project, a Pugh Chart was used to compare all the High Fidelity Concepts generated. To validate the selection criteria used in the Pugh Chart, we developed a House of Quality as well as an Analytical Hierarchy Process matrix to decide the weight of each criteria. After making use of the concept selection tools, the concept selected was to use a PSU (Polysulfone) polymer for the hub and 304 stainless steel for the shaft.

House of Quality

The House of Quality (HoQ) was created by comparing the requirements to the customer's needs. As seen in figure 3, our HoQ used arrow notations (↑ or ↓) to show the relationship between the requirements and needs and how the requirements should be rank-ordered. The results from this process revealed that, in descending order of importance, the rank of our requirements are as follows: biocompatibility of the selected materials, ability to propagate RF signals, measure the temperature at the tip of the probe, withstand repeated sterilizations, obtain FDA approval, and maintain a final production cost of less than $200. Using these results from the HoQ, we were then able to determine the particular importance of the needs in the AHP chart.

Analytical Hierarchy Process (AHP)

The analytical hierarchy process (AHP) chart in figure 4 shows the relationship of customer needs in a matrix. The result is a 6x6 matrix, based on our defined needs and requirements. The rows are compared against the columns, and their relative importance is quantified as a fraction. This method gives us each of the values for the upper half of the matrix. The values are then inverted and reflected to fill the lower half of the matrix.

For each row, the geometric mean is calculated using the following formula:

$$Geometric\ Mean = \sqrt[n]{\prod_{i=1}^{n} a_i}$$

Where $n = 6$, and a_i is each of the values of that row in the matrix.

Using the sum of all geometric means, the normalized weight is calculated with the following equation:

$$Normalized\ Weight = \frac{Geometric\ Mean}{Sum\ of\ all\ Means}$$

Afterwards, all the needs are ranked based on the weight value; the higher the weight, the more important the need is. The sorted customer needs can be found in figure 1.

Sorted results:		Weight
1	Biocompatible materials	0.29
2	Propagate RF Signals (2Hz - 465kHz)	0.24
3	Measure temperature	0.19
4	Withstand repeated sterilization	0.10
5	FDA approval	0.14
6	Final production cost of $200	0.05

Figure 1. Table of sorted customer needs with their weight

Pugh Chart

For the Pugh Concept Selection Chart (seen in figure 5), we used the customer needs, weighted by the AHP decision matrix, to determine the viability of each of our high-fidelity concepts. Since the baseline, Abbot's current reusable RF probe, meets nearly all customer needs, the only needs where the concepts can exceed the baseline are "withstand repeated sterilizations" and "final cost." The outcome of this process revealed that the best option for our final concept is utilizing a PSU (Polysulfone) hub in combination with a 304 stainless steel shaft.

Final Selection

The final concept selected for the reusable RF probe was a PSU (Polysulfone) polymer hub in combination with a 304 stainless steel shaft. This combination met all customer needs while retaining a good ratio between being cost-effective and reusable. The next closest concept was a PPSU (Polyphenylensulfone) hub material with a 304 Stainless Steel shaft, which possesses better reusability characteristics. However, it is not as cost-effective as the final concept selected.

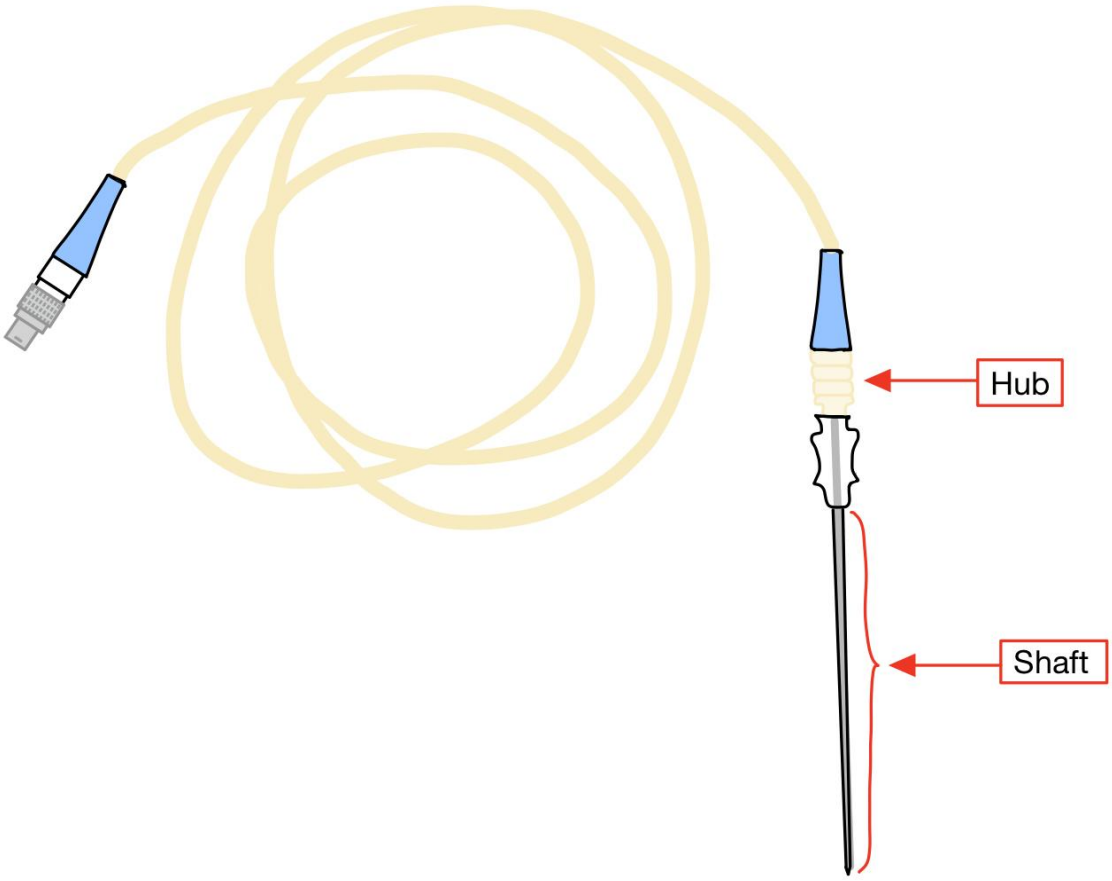
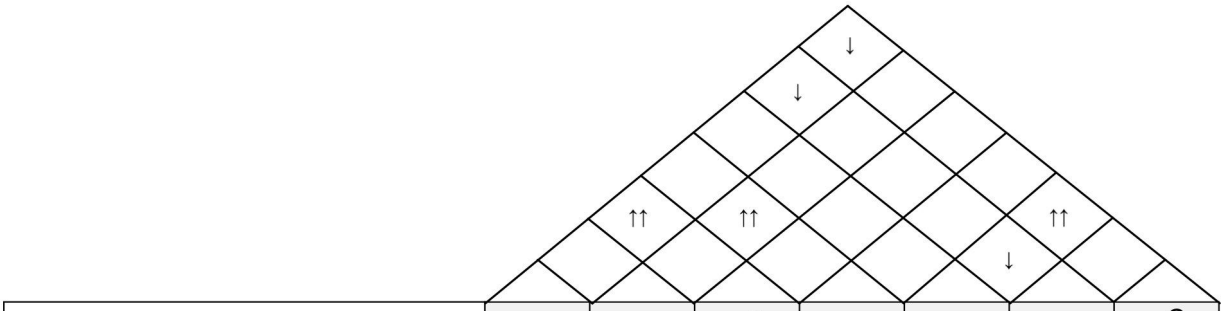


Figure 2. Drawing of the final concept selected. The material chosen for the hub is PSU (Polysulfone) polymer, and the material chosen for the shaft is 304 stainless steel.

Appendix



			Transmit RF Signal	Transmit Voltage	Converts RF signal into thermal energy	Read temperature	Durability of materials	Affordable cost	Compatible with medical sterilization techniques
			+	+	+	+	+	-	+
1	Biocompatible materials	+				↑	↑	↓	↑↑
2	Propagate RF Signals (2Hz - 465kHz)	+	↑↑	↑	↑↑				
3	Measure temperature	+		↑↑		↑↑			
4	Withstand repeated sterilization	+	↓	↓	↓		↑↑	↓↓	↑↑
5	Final production cost of $200	-					↓	↑↑	↑↑
6	FDA approval	+	↑	↑	↑	↑	↑↑		↑↑
Targets for requirements			2 Hz to 460 kHz	1.875 - 7.2 V	Thermal range between 50 C to 110 C	Temperature range between 50 C to 110 C	Reusable for at least 100 times	<$200	Sterallize at least 100 times

Figure 3. House of Quality

		Biocompatible materials	Propagate RF Signals (2Hz - 465kHz)	Measure temperature	Withstand repeated sterilization	Final production cost of $200	FDA approval	Geometric Mean	Normalized Weight
1	Biocompatible materials	1	6/5	3/2	3	6	2	2.004	0.29
2	Propagate RF Signals (2Hz - 465kHz)	5/6	1	5/4	5/2	5	5/3	1.670	0.24
3	Measure temperature	2/3	12/30	1	2	4	4/3	1.336	0.19
4	Withstand repeated sterilization	1/3	2/5	1/2	1	2	2/3	0.668	0.10
5	Final production cost of $200	1/6	1/5	1/4	1/2	1	1/3	0.334	0.05
6	FDA approval	1/2	3/5	3/4	3/2	3	1	1.002	0.14

Figure 4. Analytical Hierarchy Process (AHP)

	W	Baseline (PET With 304 Stanless Steel)	PESU (Polyethersulfone) With 304 Stainless Steel	PPSU (Polyphenylensulfone) With 304 Stainless Steel	PSU (Polysulfone) With Stainless Steel
Biocompatable Materials	6	-	0	0	0
Propogate RF Signals	5	-	0	0	0
Measure Temp	4	-	0	0	0
Withstand Repeated Sterilizations	2	-	+1	+1	+1
Final Cost ≤ $200	1	-	-1	+1	+1
FDA Approval	3	-	0	0	0
Score		-	0.05	0.15	0.15
Continue?		NO	NO	YES	YES

Figure 5. Pugh Chart