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EML4551-2

Team 521: Housing/Chassis Design for Engine Electrical Accessories

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Abstract

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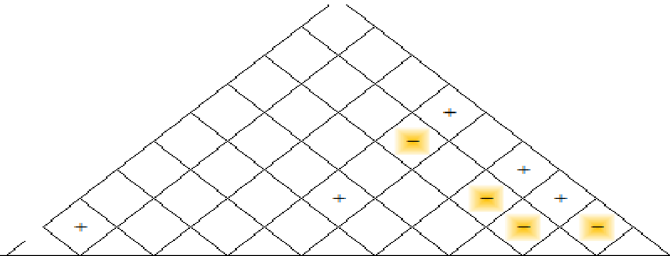
1.6 Concept Selection

Intro

In order to determine the final concept design for the project, a house of quality and a decision matrix were used. The engineering characteristics required to complete the project, and which engineering characteristics warranted a greater emphasis, were selected through the use of the house of quality. Using the determined engineering characteristics, decision matrixes were then constructed for each subsystem. The decision matrixes will serve to highlight each subsystem's strengths and weaknesses, and therefore allow for the elimination of concepts that will not allow for optimal combinations of engineering characteristics and customer requirements. Finally, a combination of the most ideal subsystems from each decision matrix will serve to determine the final concept design for the project.

HOQ

The house of quality is used to determine the most important ideas to focus on during the design process. To start the house of quality the customer requirements and engineering characteristics had to be determined. The customer requirements are a list of items that the customer is asking for in the project. The engineering characteristics are measurable goals for the project that relate to the customer requirements. Once the customer requirements and the engineering characteristics have been determined, the House of Quality can be graphed. On the left side column, going down, are the customer requirements, and on the top going across are the engineering characteristics. Then, each of the customer requirements is given a weight from 1-5(5 being the highest) to determine the importance of each of the requirements to the project. To fill in the table, ratings are given to the engineering characteristics to determine how relatable they are to the customer requirements. Ratings for the engineering characteristics are either 0, 1, 3 or 9; 0 meaning no relation while 9 means they are highly related to the customer requirements. After ratings have been given for each of the engineering characteristics, the ratings are then multiplied by the weight given to the customer requirements. For each of the engineering characteristics, the sum of the weight multiplied by the rating is determined to be the raw score. After determining the raw score for each of the engineering characteristics, the total raw score is found. Then to determine the relative weight to the project, the raw score for each engineering characteristic is divided by the total raw score (sum of all the raw scores from each engineering characteristic) this will give a fraction value that is multiplied by 100 to get a percentage. Last is to rate the engineering characteristics to determine which ones are the most important to the design. Ratings are given by the highest relative weight. The house of quality used is shown below.



Row #	Relative Weight	Customer Importance	Customer Requirements \ Engineering Characteristics	Decrease Assembly Time	Decrease Disassembly Time	Weight	Material Strength	Material Conductivity	Stability under vibration	Material Ductility	Number of Parts Damaged	Reliabilty
			Column #	1	2	3	4	5	6	7	8	9
			Units	min	min	kg	Gpa		N/A	N/A	N/A	N/A
			Direction of Improvement	▲	▼	◇	▲	▲	▲	▲	▼	▲
1	14%	5	Not Using Adhesive	9	9	1			3		1	
2	14%	5	Air tight Seal	3	3	1			1		3	9
3	11%	4	Easily Servicable	1	9	1					9	1
4	9%	3	Lower Labor Costs	9	9	1					9	3
5	14%	5	Operate In Required Temparture Range				1	3		1	3	3
6	9%	3	Life Cycles				3	1	9	3	9	9
7	6%	2	Maintain Current Housing Shape			1						1
8	14%	5	Simplicity	9	9	1					1	1
9	9%	3	Lower Material Costs	1	1	1	3	1	1	3	1	3
			Raw Score	139	171	27	23	21	30	23	133	116
			Relative Weight	20.35	25.04	3.953	3.367	3.075	4.392	3.367	19.47	16.98
			Rank Order	2	1	6	8	9	5	7	3	4

Figure 1: House of Quality

Pugh Chart

After establishing which engineering characteristics were most important using the house of quality, a Pugh matrix was created to help further narrow down the list of possible design concepts. The top five designs developed from concept generations were voted to be placed within the Pugh matrix. These five designs were then compared to a datum design that was shown to provide a simplistic solution to the project. Other than choosing another competitors product, the group decided to select one of its own conceptual designs as the datum for comparison. After selecting the datum design that was felt to accomplish most of the engineering characteristics; each of the other designs were then rank against it. If it was decided that one of the other concepts did a better job at meeting certain criteria, then a plus sign was given to that design within that area. On the other hand if a concept didn't satisfy the engineering characteristics as well as the datum it was then given a minus sign for that particular section. If both the datum and competing concept were about the same when it came to a design criteria, then the concept was awarded a zero. The Pugh matrix created is shown below in figure 2.

		Concepts				
Criteria		**1**	**3**	**5**	**7**	**10**
Decrease Disassembly Time	**Datum**	0	+	–	–	+
Decrease Assembly Time		0	+	–	–	+
Number of Parts Damaged		–	–	–	0	–
Reliability		0	–	+	0	–
Stability Under Vibration		–	–	0	–	–
Weight		+	+	–	+	+
	Number of Pluses	1	3	1	1	3
	Number of Minus	2	3	4	3	3

+	Better than baseline	1
0	About the same	0
–	Worse than baseline	-1
Symbols	**Relationship**	**Value**

Figure 2: Pugh Matrix of top five designs.

As can be seen from the chart, concept 5 and 7 were both only given one plus therefore they were both eliminated from being possible design selections. The Pugh matrix is only meant to narrow down the large list of concepts. To make it were the final decision isn't made solely off of a comparison of one datum, designs 1, 3, and 10 were chose to be put through an analytical hierarchy process for a more unbiased design selection.

Analytical Hierarchy Process (AHP)

The "Analytical Hierarchy Process" provided an organized, mathematical approach to determine which concept should be used to complete the project. The AHP was completed in a series of steps that allowed for each engineering characteristic (EC) to be evaluated by one another in a pairwise comparison matrix titled, "Criteria Comparison Matrix". This matrix produced the sum for each EC. The following table displays the Criteria Comparison Matrix.

Table 1: Criteria Comparison Matrix

Criteria Comparison Matrix						
	Decrease Disassembly Time	Decrease Assembly Time	Number of Parts Damaged	Reliability	Stability Under Vibration	Weight
Decrease Disassembly Time	1.00	0.33	0.14	0.11	0.11	7.00
Decrease Assembly Time	3.00	1.00	0.14	0.14	0.14	7.00
Number of Parts Damaged	7.00	7.00	1.00	3.00	3.00	9.00
Reliability	9.00	7.00	0.33	1.00	3.00	9.00
Stability Under Vibration	9.00	7.00	0.33	0.33	1.00	9.00
Weight	0.14	0.14	0.11	0.11	0.11	1.00
Sum	**29.14**	**22.48**	**2.06**	**4.70**	**7.37**	**42.00**

Each EC in the column was compared against the EC in that row based on its importance and significance in satisfying the overall goal of the project. The sum was calculated for each EC, this value was used in the next section to determine the values for the "Normalized Comparison Matrix". The table below displaces the normalized comparison matrix.

Table 2 Normalized Comparison Matrix

Normalized Comparison Matrix							
	Decrease Disassembly Time	Decrease Assembly Time	Number of Parts Damaged	Reliability	Stability Under Vibration	Weight	Criteria Weights
Decrease Disassembly Time	0.03	0.01	0.07	0.02	0.02	0.17	**0.05**
Decrease Assembly Time	0.10	0.04	0.07	0.03	0.02	0.17	**0.07**
Number of Parts Damaged	0.24	0.31	0.48	0.64	0.41	0.21	**0.38**
Reliability	0.31	0.31	0.16	0.21	0.41	0.21	**0.27**
Stability Under Vibration	0.31	0.31	0.16	0.07	0.14	0.21	**0.20**
Weight	0.00	0.01	0.05	0.02	0.02	0.02	**0.02**
Sum	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

The normalized comparison matrix was created to bring the values back to a common scale. This allowed for a more accurate reading of data. The criteria weight was calculated by averaging each value horizontally and summing those averaged values up at the end. Each sum was equal to one at the end which proved normality. The next step of the process was to determine the most suitable concept for each EC. This was also done with the pairwise matrix method comparing concepts one, three and ten. The following tables display each concept comparison table based on a particular EC.

Table 3: Decrease Disassembly Time Comparison Matrix

Comparison Matrix			
Decrease Disassembly Time			
Concepts	**1**	**3**	**10**
1	1.00	5.00	0.33
3	0.20	1.00	0.33
10	3.00	3.00	1.00
Sum	**4.20**	**9.00**	**1.67**

Table 4: Decrease Assembly Time Comparison Matrix

Comparison Matrix			
Decrease Assembly Time			
Concepts	**1**	**3**	**10**
1	1.00	5.00	0.33
3	0.20	1.00	0.33
10	3.00	3.00	1.00
Sum	**4.20**	**9.00**	**1.67**

Table 5: Number of Parts Damaged Comparison Matrix

Comparison Matrix			
Number of Parts Damaged			
Concepts	**1**	**3**	**10**
1	1.00	3.00	5.00
3	0.33	1.00	5.00
10	0.20	0.20	1.00
Sum	**1.53**	**4.20**	**11.00**

Table 6: Reliability Comparison Matrix

Comparison Matrix			
Reliability			
Concepts	**1**	**3**	**10**
1	1.00	0.33	0.33
3	3.00	1.00	3.00
10	3.00	0.33	1.00
Sum	**7.00**	**1.67**	**4.33**

Table 7: Sustainability Under Vibration Comparison Matrix

Comparison Matrix			
Sustainability Under Vibration			
Concepts	**1**	**3**	**10**
1	1.00	0.20	5.00
3	5.00	1.00	3.00
10	0.20	0.33	1.00
Sum	**6.20**	**1.53**	**9.00**

Table 8: Weight Comparison Matrix

Comparison Matrix			
Weight			
Concepts	**1**	**3**	**10**
1	1.00	0.33	0.20
3	3.00	1.00	0.20
10	5.00	5.00	1.00
Sum	**9.00**	**6.33**	**1.40**

A normalized comparison table was created for each of the EC concept comparison tables to create a common scale for each of the concepts. Each value resulted in a sum of one which proved the concepts were normalized. The table below displays the normalized comparison matrix for the top three concepts based on the EC's

Table 9: Decrease Disassembly Time Normalized Comparison Matrix

Normalized Comparison Matrix				
Decrease Disassembly Time				
Concepts	**1**	**3**	**10**	**Criteria Weights**
1	0.24	0.56	0.20	**0.33**
3	0.05	0.11	0.20	**0.12**
10	0.71	0.33	0.60	**0.55**
Sum	**1.00**	**1.00**	**1.00**	**1.00**

Table 10: Decrease Assembly Time Normalized Comparison Matrix

Normalized Comparison Matrix				
Decrease Assembly Time				
Concepts	1	3	10	Criteria Weights
1	0.24	0.56	0.20	0.33
3	0.05	0.11	0.20	0.12
10	0.71	0.33	0.60	0.55
Sum	1.00	1.00	1.00	1.00

Table 11: Number of Parts Damaged Normalized Comparison Matrix

Normalized Comparison Matrix				
Number of Parts Damaged				
Concepts	1	3	10	Criteria Weights
1	0.65	0.71	0.45	0.61
3	0.22	0.24	0.45	0.30
10	0.13	0.05	0.09	0.09
Sum	1.00	1.00	1.00	1.00

Table 12: Reliability Normalized Comparison Matrix

Normalized Comparison Matrix				
Reliability				
Concepts	1	3	10	Criteria Weights
1	0.14	0.20	0.08	0.14
3	0.43	0.60	0.69	0.57
10	0.43	0.20	0.23	0.29
Sum	1.00	1.00	1.00	1.00

Table 13: Sustainability Under Vibration Normalized Comparison Matrix

Normalized Comparison Matrix				
Sustainability Under Vibration				
Concepts	1	3	10	Criteria Weights
1	0.16	0.13	0.56	0.28
3	0.81	0.65	0.33	0.60
10	0.03	0.22	0.11	0.12
Sum	1.00	1.00	1.00	1.00

Table 14: Weight Normalized Comparison Matrix

Normalize the Comparison Matrix				
Weight				
Concepts	1	3	10	Criteria Weights
1	0.11	0.05	0.14	0.10
3	0.33	0.16	0.14	0.21
10	0.56	0.79	0.71	0.69
Sum	1.00	1.00	1.00	1.00

The AHP was very helpful in determine the most appropriate design based on the given criteria. However, the resulting concept will not be kept the same if the team feels that an improvement can be made throughout the process of the project.

Final Decision

After all the calculation and verification of data, concept three was presented as the final design. The following table displays the results.

Table 15: Final Results

Final Results	
Concept 1	0.37
Concept 3	**0.41**
Concept 10	0.22

Concept three was the press fitting components in place design that consist of a top and bottom plate with specifically marked locations for each component. This design satisfied all of the engineering characteristics because of its overall simplicity. The biggest benefit of using this design would be the assembly time, disassembly time, and the serviceability. This design does not require any adhesive application which will allow for a quick removal and instillation of the components without obstructing wire connections.