Optimization of Cloth Drying Rack Design Through Integrated QFD and AHP Concept

Hung, Yu-Ching[1], Lee, Yann-Long[2], Kamarul Bin Amir Mohamed[1]

[1]Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2]Department of Industrial Design, Chao Yung University and Technology, Taiwan(R.O.C.)

*Corresponding author's email: kamarulamir@utem.edu.my

ABSTRACT: The instability of the climate and the annual rainfall do not follow the cycle anymore. It's concerning for those who prefer to dry their clothes outdoor and people who can't effort a washing machine that includes a dryer. In this study, Quality Function Deployment (QFD) method is a method that helps to collect opinions from customers and translate the respondent's requirements into technical characteristics. Here through a questionnaire survey to carried out to define the customer's requirements, and use HoQ to translate the user needs into the technical characteristics to find the main solving direction. And using AHP analysis method based on ranked of customer's requirements to select the suitable design. According to the result of design validation, there are 70~80% of respondents satisfied(a rating of 4) with function and aesthetics; 40% of the respondents suggest that the Foldability function should be added in the future. Overall, the integrated QFD and AHP method helps define the customer's requirements and select final concepts more accurately.

Keywords: *Quality Function Deployment; Analytic Hierarchy Process; Cloth drying rack design*

1. INTRODUCTION

Product design is a knowledge-intensive process[1]. In this research, most of the respondents are female at the age of 40 to 44 years old who works as a housewife with a Diploma certificate in their hand. Second, the respondents are having problems drying their cloth during the rainy season. If to use the cloth dryer in daily life indeed makes their life easier and time-saving. Unfortunately, the results of the survey also show that the current cloth dryer product in the market is not affordable for most people. So, it is very important to develop a cloth dryer product that is affordable for most people to use. This shows that this project has the potential to achieve its main objectives.

2. METHOD

The QFD methodology is an analytical approach to collecting customer expectations data. QFD is a preparation mechanism for translating the needs of the customer (customer's voice) into acceptable technical specifications for all phases of the product life cycle. The definition of the QFD approach is divided into two basic activities: the development of product quality and the development of quality features. QFD was first proposed by Yoji Akão, Professor of Management Engineering at Tamagawa University[2]. The House of Quality is the key method of QFD. The HOQ tool helps the management to carry out a market evaluation from the consumer's view[3]. This involves the collection of data of the User's requirements and analysis of Voice of the Customer (VOC). The HOQ is described as a design matrix meant to prove how customer requirements relate directly to the methods and techniques that manufacturers can use to meet those requirements. HP is used to define the weight of customer need connected to the New Product Development (NPD) process. AHP best-practice states that the low-consistency customer respondent is considered untrustworthy.

This research proposes an approach for using QFD and AHP to integrated Peltier chips on drying rack innovation design to meet the user's need.

2.1 Identify the Customer and Design Requirement

The customer's requirement can be identified through the user's need survey that has been conducted earlier. In this research, 9 criteria have been chosen. The 9 criteria are Function, Performance, Efficiency, Durability, Capacity, Size, Style, Weight, and Materials. There are 8 criteria of the design requirements that have been expressed based on the results of the customer's requirements analysis. The 8 criteria are Weight (kg), Power (Watt), Manufacturing Cost (RM), Dimension of Product (mm), Shape (appearance), Material, Strength (MPa), and Expected Lifespan (years). After the design requirement is defined, each design requirement then will be given a technical goal based on the result of the user need survey.

2.2 Determination of Weights (using AHP)

After the customer's requirements are determined, the weight of each customer's requirement is calculated by using the AHP method. From the result obtained, the rank of the weight of each criterion are Capacity (0.20) > Durability (0.19) > Function (0.18) > Weight (0.10) > Efficiency (0.09) > Style (0.08) > Performance (0.04) > Size (0.04) > Materials (0.04). From the ranking shown, most of the experts think that capacity is the most important criteria that should be prioritized compared to the other criteria.

2.3 Development of Relationship Matrix

The relationship between the criteria of 'HOWs' and 'WHATs' are recorded using the variable ◎ (Strong Relationship), ○ (Moderate Relationship) and

▲ (Weak Relationship). Each variable also represents 9, 3, and 1, respectively. In this project, the Function have a strong relationship with the Dimension and the Expected Lifespan but it have a moderate relationship with the Power. However, the Function have a weak relationship with the Maufacturing Cost and the Strength.

2.4 Determine the Weight

From the relationship between 'WHATs' and 'HOWs' , the weight of the design requirement is calculated. For each customer's requirement weight will be multiply with the relationship score to determine the importance rating of each design requirement.

2.5 Ranking the Design Requirement

Based on the result of the analysis, the ranking of the design requirement is Dimension (0.18) > Power (0.14) > Expected Lifespan (0.14) > Strength (0.13) > Weight (0.12) > Materials (0.11) > Manufacturing Cost (0.09) > Shape (0.09). from the ranking shown, dimensions are the most important criteria while designing the electric cloth drying rack compare to other criteria.
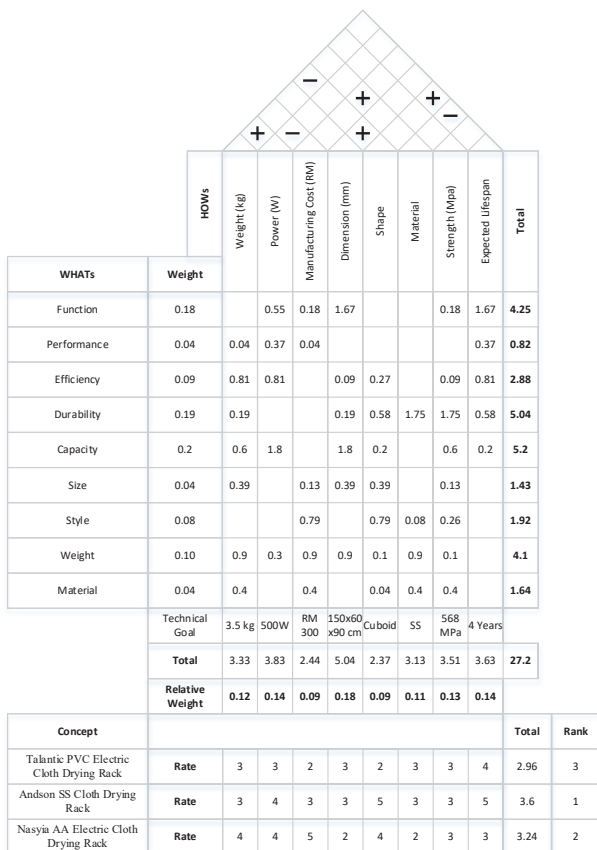
WHATs	Weight	Weight (kg)	Power (W)	Manufacturing Cost (RM)	Dimension (mm)	Shape	Material	Strength (Mpa)	Expected Lifespan	Total
Function	0.18		0.55	0.18	1.67			0.18	1.67	**4.25**
Performance	0.04	0.04	0.37	0.04					0.37	**0.82**
Efficiency	0.09	0.81	0.81		0.09	0.27		0.09	0.81	**2.88**
Durability	0.19	0.19			0.19	0.58	1.75	1.75	0.58	**5.04**
Capacity	0.2	0.6	1.8		1.8	0.2		0.6	0.2	**5.2**
Size	0.04	0.39		0.13	0.39	0.39		0.13		**1.43**
Style	0.08			0.79		0.79	0.08	0.26		**1.92**
Weight	0.10	0.9	0.3	0.9	0.9	0.1	0.9	0.1		**4.1**
Material	0.04	0.4		0.4		0.04	0.4	0.4		**1.64**
Technical Goal		3.5 kg	500W	RM 300	150x60 x90 cm	Cuboid	SS	568 MPa	4 Years	
Total		3.33	3.83	2.44	5.04	2.37	3.13	3.51	3.63	**27.2**
Relative Weight		**0.12**	**0.14**	**0.09**	**0.18**	**0.09**	**0.11**	**0.13**	**0.14**	

Concept										Total	Rank
Talantic PVC Electric Cloth Drying Rack	Rate	3	3	2	3	2	3	3	4	2.96	3
Andson SS Cloth Drying Rack	Rate	3	4	3	3	5	3	3	5	3.6	1
Nasyia AA Electric Cloth Drying Rack	Rate	4	4	5	2	4	2	3	3	3.24	2

Figure 1 Final Design Selection

3. RESULT AND DISCUSSION

3.1 Using the Morphological Analysis to Generate the Design Concepts

Morphological Analysis is a method of finding all possible solutions to a multi-dimensional problem that is not quantified. In this research, the morphological analysis will be used to create 3 concepts of the electric cloth drying rack. First, the electric cloth drying rack will be break into 5 keys criteria. The criteria that have been chosen are materials that will be used, the type of cloth rack feet, joining materials, size, and finish. Then, lists all different ideas based on creativity and logic for each 5 keys criteria. There will be 3 options for each 5 keys criteria. Lastly, after all the different ideas have been generated, look for an unusual combination of ideas that will spark the 3 concepts of the electric cloth drying rack.

3.2 Final Design Selection

Final Design selection is carried out to rank and select the final design concept idea that will be developed later. As shown in Figure 1, the rank of the concept is Andson SS Cloth Drying Rack (3.6) > Nasyia AA Electric Cloth Drying Rack (3.24) > Talantic PVC Electric Cloth Drying Rack (2.96). The final product rendering is as shown in Figure 2.

Figure 2 Final Product 3D Modelling

4. CONCLUSION

This research has shown how integrated the QFD and AHP to develop the electric cloth drying rack by using the Peltier element. Based on the result, function, performance, and efficiency are important criteria to be considered when designing and developing the electric cloth drying rack through the result of the analysis. And most of the experts are think that capacity is the most important criterion followed by durability and function. New concepts and prototypes for electric cloth drying racks are tested to meets the needs of customers. The recommendation should enhance the design appearance to attract the user's preference.

REFERENCES

[1] S. K.Chandrasegaran *et al.*, "The evolution, challenges, and future of knowledge representation in product design systems," in *CAD Computer Aided Design*, Feb. 2013, vol. 45, no. 2, pp. 204–228, doi: 10.1016/j.cad.2012.08.006.

[2] R.Wolniak, "The history of the QFD method," *Sci. Pap. Silesian Univ. Technol. Organ. Manag. Ser.*, vol. 2017, no. 100, pp. 553–564, 2017, doi: 10.29119/1641-3466.2017.100.42.

[3] D.Neira-Rodado, M.Ortíz-Barrios, S.dela Hoz-Escorcia, C.Paggetti, L.Noffrini, andN.Fratea, "Smart product design process through the implementation of a fuzzy Kano-AHP-DEMATEL-QFD approach," *Appl. Sci.*, vol. 10, no. 5, 2020, doi: 10.3390/app10051792.