

Quality Function Deployment (Qfd) Matrix Application in Re-Designing Extruder Machine

Andreas Tri Panudju⁽¹⁾, Rina Nopianti⁽²⁾, Leni Triana⁽³⁾

¹Industrial Engineering Department-Bina Bangsa University

²Accounting Department-Bina Bangsa University

³Management Department-Bina Bangsa University

Corresponding Author: Andreas Tri Panudju

ABSTRACT : The purpose of this study was to determine the characteristics of the pasta extruder machine desired by the user, the importance of the product attributes, the level of customer satisfaction and the strategy of developing the next pasta extruder machine. The Quality Function Deployment (QFD) method with 2 (two) stages of House of Quality (HoQ) was applied to translate what the pasta extruder machine user wants into the needs of a more detailed process. The results of the study found 13 attributes of product satisfaction desired by the user, which were translated into 11 technical parameters in HoQ stage 1, then in the HoQ stage 2 matrix, the 11 technical parameters were translated into 13 process requirements by the UMKM development bureau team along with the priority order later used as a basis for engine repairs. The improvement step that needs to be done to improve the quality of this machine is to use a reliable drive motor and equip the motor housing with axial fan and installation of automatic heat limiting indicator, designing the cutter to attach to the dies with 30° sharpness and choose the blade material from the High Speed Steel, redesigning the gap between the land screw and the base of the housing screw, adding speed regulators and variations in the size of gears for screws, adding dies to macaroni, rice, crackers and rice noodles, adding product containers and curly noodle maker casings, redesigning the gearbox and motor housing, redesigning the engine casing, making the input hopper wider, by removing the lid hopper, and using the drat system for locking lid hopper, dies, screw and mixer nuts.

KEYWORDS User Needs, Quality Function Deployment (QFD), Product Development, Pasta Extruder.

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I. INTRODUCTION

The Food Team of the UMKM Development Bureau has made a single screw extruder capacity of 25 kg / day intended for Food SMEs in Banten and Lampung. This machine processes local food flour (corn, sago and mocaf) which is made into pasta products in the form of analog rice, noodles and macaroni with cold extrusion technology. Extrusion is a food processing process that combines several processes continuously including mixing, cooking, kneading, compaction and forming [1]. Food is forced to flow under the influence of operating conditions through a mold designed to form the result of extrusion in a short time [2]. The basic principle of this tool is to insert material that will be processed and then pushed out by screw through a mold hole (die) in the expected shape [3]. This pasta extruder machine product is a new product whose consumer acceptance and desires for product quality characteristics are not yet known, both in terms of satisfaction and performance. Because of that, it is necessary to conduct a survey on the response of the users of the pasta extruder machine as an evaluation of the engine performance and future product development. Based on the above, it is necessary to review the design of the extruder pasta machine. A product is said to be good if it successfully meets consumer needs [4]. Therefore a review of the machine products will be better if it is adjusted to the needs and desires of the customers [5], so that the technology produced by UMKM Development Bureau can provide satisfaction to its users. The purpose of this study was to determine the characteristics of the pasta extruder machine desired by the user [6], the importance of the product attributes, the level of customer satisfaction and the strategy of developing the next pasta extruder machine.

II. RESEARCH METHODOLOGY

The study was conducted on the response of users of pasta extruder machines made by UMKM Development Bureau. The study sample was 15 respondents using a single screw extruder with a capacity of 25

kg / day in the area of Grobogan Regency, Central Java. This research is good in collecting and processing the data using the Quality Function Deployment (QFD) method approach. The research began with the identification of the current machine and the user's desire for a pasta extruder machine by conducting interviews and in-depth discussions with the UMKM Development Bureau Food Team as a machine maker, internal users (researchers in the UMKM development) and external users (Food SMEs).

The information obtained was used to compile the attributes of the pasta extruder machine in the questionnaire, where respondents were asked to assess the level of importance and satisfaction of this machine attribute. The results of questionnaire data that have been tested for validity and reliability are then processed into the House of Quality (HoQ) matrix to determine the priority of the development of pasta extruder machine improvements. The calculation of QFD used is chain QFD analysis, meaning that the House of quality (HOQ) matrix analysis uses more than one HOQ matrix. QFD analysis allows more than one HOQ matrix with the aim that the output of QFD is more technical and specific. In this study using two HOQ matrices to produce optimal results.

III. RESULTS AND DISCUSSION

From the research, there were 13 satisfaction attributes of pasta extruder machine products, where there were 9 satisfaction attributes of this machine product which had the highest value or what was really considered important by users of single screw extruder type pasta extruder machine with the same value of 3.8 of which were : a) easy material input, b) material pushed to the end of the mold, c) can be used for various types of carbohydrate raw material, d) the shape and size of the results as expected, e) the machine is not easy to heat, f) for use on high speed and heavy loading machine does not experience interference, g) easy engine operation, h) easy to clean, and i) available kit tools. Whereas in the second place that is considered important by the users are: a) easy to find spare parts and b) diversity of die shapes, then c) the shape of the engine is interesting and d) the appearance of the engine seems sturdy. Users consider these attributes to be very important compared to other attributes and show that the user places the 9 attribute as the first consideration when choosing a pasta extruder machine product. The attributes of engine performance and the reliability of the operation of the pasta extruder machine are considered more important by the user than the attributes of engine maintenance and repair, additional features offered and the aesthetics of the pasta extruder machine.



Figure 1. Current Extruder Paste Machine

Based on the demographic conditions and conditions of the user's community, this machine is very suitable for small production levels (max 30 kg / day). The average level of satisfaction with the performance of this pasta extruder machine in the eyes of users is already quite satisfied, with an average score of satisfaction of 2.94 (less satisfied - satisfied). In general, this machine can fulfill what is desired and expected by users in producing artificial rice, noodles and macaroni. However, considering that at the moment users are still looking for market opportunities and have not yet fully produced, so the UMKM development bureau team must continue to improve the performance of this machine in the future.

Complaints that most arise from users and are also the lowest attribute level of satisfaction from the performance of these machines are: a) fast heat engines and b) not easy to get spare parts especially if there is damage to the dynamo or electric motor. This is because in the user area the availability of electric motor components is still incomplete, so that if there is damage to the electric motor, especially the capacitor components, the user finds it difficult to get it.

From the results of data processing obtained Repair Ratio > 1, as a result all the attributes that exist in the pasta extruder machine must be improved in order to increase user satisfaction. This should receive special attention from the UMKM development bureau and as an evaluation material for further machine repairs. Based on this, to be easier in development and in accordance with the needs and expectation of users, development should be based on the priority scale produced by looking at the level of the UMKM development bureau's ability to fulfill it. For technical improvement steps aimed at UMKM development bureau, see Table 1.

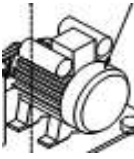

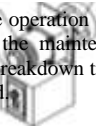

Table 1. Priority for Re-Design of Pasta Extruder Machines

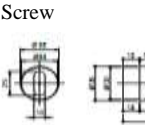

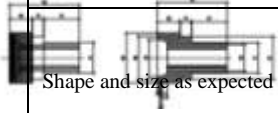


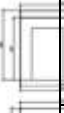




Customer Requirement	Technical Parameter	Process Requirement	Priority
The machine is not easy to heat	Reliable engine	Using a reliable engine (electric motor)	1
	Fan on the electric motor housing	Installing the axial fan on the electric motor housing	4
Results as expected (shape and size)	Blade material and the right blade design	The design of the knife is right attached to the dies; sharpness of the blade 30°	2
Can be used for various types of carbohydrate source raw materials		Knife made of high speed steel (HSS)	3
The material is pushed to the end of the mold (die)	The distance between the land screw and the base of the casing and the barrel base is minimized	Distance of land screw to the base of the casing using 3 mm	5
		Distance of land screw to barrel base ≤ 1 mm	6
For use at high speeds and heavy loading the engine does not experience interference	Screw speed regulator	Increases screw speed control	7
Diversity of die shapes	Varied shapes of dies	Adding dies to macaroni, rice, crackers and rice noodles.	8
Tools kit	Provide complete and appropriate tools kits	Add product storage containers and curly noodle maker casings	9
Attractive machine shape	Ergonomic and attractive machine design	Makes the machine ergonomic and attractive with selected ingredients	10
The appearance of the engine seems sturdy			
Easy to find spare parts	Provide sufficient spare parts	There is availability of spare parts in the region	11
Easy input	The input hopper is wider	Enlarge the hopper input, and the hopper lid can be removed	12
Easy machine operation	Housing, dies, screw and mixer nuts are easily removed	Locking housing, dies, screw and mixer nuts with drat system	13
Easy to clean			

The priority of developing pasta extruder machines is the analysis of the wishes of users, so that it is good for UMKM development bureau to conduct research on the development of pasta extruder machine products to consider the results of the output that researchers have as a reference. From this study, it is known that the level of user acceptance of the single screw extruder technology in the study area: (a) is influenced by the desire of the users of this technology to continue to use this technology; (b) strongly influenced by the opinions / perceptions of the local community who perceive that the use of this technology can benefit themselves; and (c) will increase if this technology is easier to use, and d) there is a broad market for the products produced.

The technical improvement details of the pasta extruder machine can be seen in table 2 below:

Table 2. Technical Improvement of the Pasta Extruder Machine

Improved parts Expected Final	Conditions based on customer requirement attributes	Recommended steps based on technical parameters
 electric motor	The machine does not heat up quickly	Using a reliable drive engine with due regard to the energy needed, and the availability of spare parts in the user's area.
	For use at high speeds and heavy loading the engine does not experience interference	
 cutter	Can be used for various types of carbohydrate source raw materials, Shape and size as expected	Blade material from HSS (High Speed Steel)
 cutter inverter	Machine operation can be carried out smoothly, not halting. Launch the maintenance process and production process, reduce breakdown time and waste time because the engine is damaged.	It is necessary to separate the inverter cutter from the cutter and the electric motor and add the buffer on the inverter cutter holder with the addition of nuts so that it does not move or tilt when used.
Fan	 The heat on the engine can be controlled so that abnormalities in the engine can be detected early and necessary actions are taken.	Addition of fan to the motor casing
		Screw housing is equipped with an automatic heat limiting indicator.

<p>Screw</p> 	<p>The material is pushed to the end of the mold (die) so that the material is not much left behind on the base of the casing and the base of the barrel of the pasta extruder machine</p>	<p>The distance tolerance between the land screw and the casing base is ≤ 3 mm and the tolerance of the distance between the land screw and the barrel base is ≤ 1 mm.</p>
<p>Housing screw</p> 	<p>Can be used for various types of carbohydrate source raw materials</p> <p>Shape and size as expected</p> 	<p>Careful design needs to be made so that there are speed regulators and variations in the size of the gears for the screw so that the screw can be adjusted to the speed with which the raw material is processed.</p> <p>The need to design streak grooves in the right screw housing, make the material will be well packed and crushed so that optimal results are obtained.</p>
<p>Dies</p> 	<p>The diversity of the shapes of dies, so that it can produce various types of pasta products which in turn can increase product competitiveness.</p>	<p>Adding dies to macaroni, rice, crackers and ricenoodles</p>
<p>Tool kits</p> 	<p>Provide complete and appropriate tools kits</p>	<p>Add product storage containers and curly noodle maker casings</p>
<p>Casing</p> 	<p>Attractive machine shape</p> <p>The appearance of the engine seems sturdy</p> 	<p>Redesigning the gearbox and motor housing with the corners of the housing is blunted for user safety and replaced with stainless steel.</p> <p>Need to redesign the engine casing with regard to ergonomic principles and product design</p>
<p>Hopper</p> 	<p>Entering the ingredients is easy, preventing raw materials from spilling out, increasing product yield.</p>	<p>Making input hopper is wider. Hopper redesign by paying attention to ergonomic principles to determine the optimal hopper magnitude</p>
<p>Hopper Lid</p> 		<p>The hopper lid can be removed</p>
<p>nuthousing</p> 	<p>The machine is easy to clean. Cleaning can be done immediately after the process so that the quality of processed products is maintained.</p>	<p>Locking nut housing, dies, screws and mixers with drain system</p>

Based on the recommended repair steps, it can be seen that the design of the pasta extruder machine after repairs is as follows:

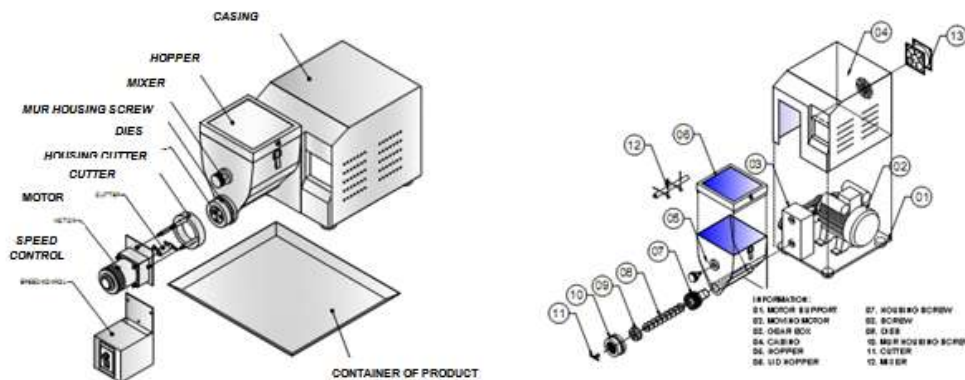


Figure 2. 3D Images and Isometric Paste Extruder Machines after Re-Design

Table 3. Specifications of Pasta Extruder Machine

NO.	COMPONENTS	CURRENT DIMENSION	RE-DESIGN DIMENSIONS
1.	Motor support and gear box	381 x 320 x 10 mm (metal plat)	381 x 320 x 10 mm (SS 304)
2.	Motor	1,5 Hp; 1 phase	1,5 Hp; 1 phase
3.	Gear box	1/40	1/30
4.	Fan	null	Yes, 4,5 Ampere
5.	Screw speed control	null	Yes
6.	Casing	385 x 325 x 390 mm (SS 304)	385 x 325 x 390 mm (SS 304)
7.	Hopper	180 x 199 x 240 mm (SS 304)	200 x 220 x 240 mm (SS 304)
8.	Lid Hopper	199 x 190 x 34 mm (SS 304)	200 x 220 x 34 mm (SS 304)
9.	Housing screw	Ø68 x 94 mm (SS 304)	Ø68 x 96 mm (SS 304)
10.	Screw	Ø26 x 200 mm (SS 304)	Ø35 x 240 mm (SS 304)
11.	Dies	Ø 60 x 30 mm (bronze)	Ø 60 x 30 mm (bronze)
12.	Nut housing screw	Ø85 x 40 mm (SS 304)	Ø88 x 41 mm (SS 304)
14.	Cutter	400 x 80 x 3 mm (SS)	400 x 80 x 3 mm (HSS)
15.	Inverter Cutter	combined with dynamo	separated from the dynamo
16.	Product Storage Container	null	Yes (SS 304)
17.	Sleeve for curly noodles	null	Yes (SS 304)

Due to the limited time, researchers were only able to obtain data from 75 respondents and were only aimed at users of single screw extruder machines in the area around Banten and Lampung. Even though there are still many potential pasta extruder machine users with far greater capacity outside this region, such as Central Java and East Java.

However, the results obtained are sufficient to illustrate the overall analysis of the user acceptance level of this pasta extruder machine as well as the feedback obtained which has been used as a basic priority for further development of this engine product.

The results of this study indicate that the QFD method can be used in the process of developing pasta extruder products and improving product quality based on user desires.

This research complements and supports previous studies that the method of Quality Function Deployment (QFD) can improve product quality based on the needs and desires of consumers so that this research can be used as a reference for further research with the same product or different products.

IV. CONCLUSION

The attributes of the pasta extruder machine desired by the user include: "easy input material", "the material is pushed to the end of the mold", "can be used for various types of carbohydrate source raw materials", "the shape and size of the results are as expected", "The engine is not easy to heat", "for use at high speeds and heavy loading of the engine does not experience interference", "easy engine operation", "easy to clean", "available tools kit", "easy to find spare parts", "diversity of die shapes", "interesting machine shapes" and "the appearance of the engine seems solid".

In general, this machine can fulfill what is desired and expected by users in producing analog rice, noodles and macaroni. However, considering that at the moment users are still looking for market opportunities and have not yet fully produced, the UMKM development bureau team must continue to improve the performance of this machine.

In the future, it is expected that UMKM development bureau's engineering products can attract the attention of industry partners so that they can be mass produced, thereby increasing the role of technology in this country.

The priority improvement steps for repairing the pasta extruder machine are:

1. Using a reliable electric motor by considering the convenience found on the market.
2. Designing a cutter (knife) is right attached to the dies with the sharpness angle of the blade 30° and selecting the blade material with good quality steel from High Speed Steel (HSS) so that the knife is always sharp.
3. Separating the cutter inverter from the cutter and the electric motor and adding a buffer to the inverter cutter holder with the addition of nuts so that it does not move or tilt when used.
4. Complete the motor housing with axial fan and installation of automatic heat limiting indicator.
5. Redesigning the size of the gap between the landscrew and the base of the casing and the landscrew with the base of the screw barrel housing by narrowing the sizes so that the entire material can be pushed to the end of the mold.
6. Add speed control devices and variations in the size of gears for screws so that they can adjust to the type of raw material handled.
7. Adding dies to macaroni, rice, crackers and rice noodles.
8. Add product storage containers and curly noodle casing to the kit components.
9. Redesigning the housing of the gearbox and motor bike with the corners of the housing blunted for user safety and replaced with stainless steel, redesigning the engine casing with regard to ergonomic principles and product design.
10. Make the in-put hopper wider, by means of the hopper lid can be removed so as to facilitate the entry of raw materials.
11. Locking nut, thirst, dies, screw and mixer with drat system, so the machine is easy to clean.

Suggestions for the UMKM Development Bureau are related to increasing the acceptance rate of pasta extruder technology in Indonesia as their role in technology diffusion, namely:

1. The UMKM Development Bureau is able to further explore the desire of the user community to provide technology in accordance with the requested specifications, so that the implementation of this pasta extruder technology is effective.
2. It should be considered so that the same machine can be upgraded to an intermediate production level (80-100 kg / day).
3. The related Bureau service can help find a market that can accommodate the production of users of this pasta extruder machine, so that the technology can be used optimally.
4. Providing integrated training on the technology of extrusion processing with this machine, both in terms of technical and managerial aspects in the food UKM group.

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