PELLET PRODUCTION MACHINE DESIGN USING THE AXIOMATIC HOUSE OF QUALITY (AHOQ) METHOD AT NABOLAK FISHERY

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ABSTRAK

Pada proses peternakan ikan, biaya operasional yang paling besar terdapat biaya pakan atau pelet. Nabolak Fishery merupakan salah satu peternakan ikan yang ada di Kabupaten Toba. Nabolak Fishery sudah mampu mengolah hasil panen ikan secara langsung menjadi produk turunan kemasan seperti daging ikan diolah menjadi nugget, tulang ikan diolah menjadi kerupuk dan ampas dari sisa pengolahan digunakan sebagai pakan ikan lele. Nabolak Fishery memiliki potensi untuk menciptakan pellet ikan guna mengurangi biaya operasional dan menambah pendapatan. Dengan adanya mesin produksi pellet sendiri, peternak ikan di Nabolak Fishery dapat memproduksi pakan sendiri dan juga menambah produk turunan. Desain mesin produksi pellet yang efektif, efisien dan sesuai dengan kebutuhan peternak ikan sangat dibutuhkan agar dapat meningkatkan produktivitas peternak. Metode Axiomatic House of Quality (AHOQ) merupakan salah satu metode yang efektif dalam memecahkan permasalahan desain mesin produksi pellet. Metode ini dapat digunakan untuk mengetahui bagaimana spesifikasi mesin yang benar-benar dibutuhkan Nabolak Fishery dengan melibatkan customer attributes, functional requirement dan elemen-elemen lainnya. Setelah didapatkan desain dan spesifikasinya, maka dilakukan pemodelan dengan software Solidwork. Solidwork akan memperlihatkan desain tiga dimensi. Desain tiga dimensi yang dihasilkan oleh solidwork selanjutnya diberikan kepada penempa untuk membuat mesin produksi pellet.

Kata kunci: *AHOQ, Customer Requirement, Pellet Ikan, Mesin Produksi Pellet*

ABSTRACT

In fish farming, the most significant operational cost is the cost of feed or pellets. Nabolak Fisheries is one of the fish farms in Toba Regency. Nabolak Fisheries can process fish harvests directly into packaged derivative products such as fish meat processed into nuggets, fish bones processed into crackers, and dregs from processing residues used as catfish feed. Nabolak fisheries have the potential to produce fish pellets to reduce operational costs and increase revenue. With their own pellet production machine, fish farmers in the Nabolak Fishery can produce their feed and add derivative products. The design of pellet production machines that are effective, efficient, and follow the needs of fish farmers in order to increase farmer productivity. The Axiomatic House of Quality (AHOQ) method is an effective method for solving pellet machine design problems. This method determines what machine specifications are needed by involving customer requirements, functional requirements, and other elements. After obtaining the design and specifications, modeling was carried out using Solidwork software. Solidwork will feature a three-dimensional design. The three-dimensional design produced by SolidWorks is then given to the blacksmith to make the pellet production machine.

Keywords: *AHOQ, Customer Requirement, Fish Pellets, Pellet Production Machine*

INTRODUCTION

Livestock farming in Indonesia experiences very rapid changes from year to year. Improvements in science and technology have had a significant impact, both directly and indirectly related to human habits. The human needs in the field of technology increase every year, and technological developments can help the work in human life. Technology has become a need that society must fulfill in its daily activities. The livestock sector already uses sophisticated tools or technology to help workers. However, many farmers still need to generate income that could have been greater.

Procurement of feed/pellets for fish cultivation is an essential support for fish farmers' productivity [1]. The fish farming process will require significant costs. In the operational costs of fish farming, the most extensive costs incurred are feed costs. In fish farming, costs for fish food can reach 75% of the total costs incurred. The quality and quantity of animal feed is an obstacle that often occurs in meeting the basic needs of life, growth, production, and livestock reproduction. The quality and quantity of fish feed must be considered properly because it has a significant influence.

Much research has been carried out regarding pellet production machine design. Pellet production machines can be made using electric or conventional machines [2]. Small-capacity machines can significantly impact farmer productivity [3]. Pellet production machines have been designed using CATIA V5 software [4]. The design results using CATIA V5 cannot fulfill three-dimensional elements. The pellet machine design must also meet aspects of efficiency and reliability [5]. Conventional machines are considered more reliable than electric ones (Erlin et al., 2022). Machine design can also meet customer needs; using the AHOQ method, customer needs can be met [6]. The AHOQ method uses an integrated system approach starting from functional requirements, process variables, and design parameters [7]. In pellet production machines, tools should be added to change the size of the pellets so that they can reach all sizes of livestock [8]. Pellet production machines can be modified and developed to increase productivity [9]. Design that can be easily upgraded to be better.

District, Toba Regency, Nabolak Fishery has 12 ponds with a land area of ±4000 m^2. This farm can distribute as much as 150 kg per week at IDR 26,000/kg. Meanwhile, the need for pellets on this farm can reach 1 ton in one month, where one sack costs IDR 360,000 and weighs 30 kg. If accumulated, the expenditure for pellets is ± IDR 12,000,000, so the income from Nabolak Fishery is ± IDR 3,600,000. The cost of feed is expensive for farmers because they use feed sourced from factories, which impacts daily costs so high that the profits are not commensurate with the operational costs that have been incurred.

RESEARCH METHOD

Nabolak Fishery is a fish farm in Nagatimbul Village, Bonatua Lunasi. Axiomatic design focuses on developing a theoretical framework and solving problems still lacking. The use of this method is used to minimize difficulties in applying the QFD method. The Axiomatic House of Quality (AHOQ) method designs products based on the functional requirements of the wants and needs of potential users. A modified version of House of Quality (HOQ) was used to reduce the time required to create product designs and reduce product specification errors due to the difficulty of translating user statements into required product specifications. This method consists of four domains, namely customer attributes, functional requirements, design parameters, and process variables. Besides consisting of 4 domains, the design also consists of two axioms, namely independent axioms and information axioms.

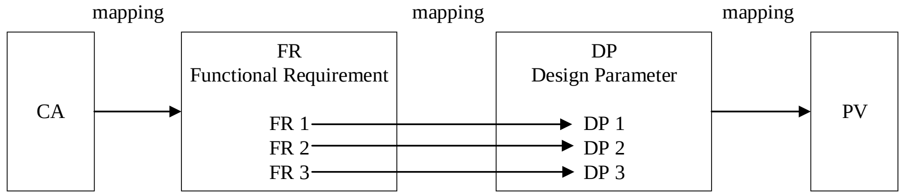

Figure 1. Axiomatic Conceptual Design [6]

Determining criteria for customer attributes begins with determining the required criteria for the product being designed and involving potential users directly, then Functional Requirements functions to translate the criteria into design language [10]. This process determines the specifications of the physical design. A zigzagging process aims to become design parameters until the attributes are designed in detail to answer the customer's specifications. In contrast, process variables are used to explain how the specifications of the design parameters are made. Some of the terms used in understanding the Axiomatic House of Quality method include: 1) Customer Attribute (CA): a domain that accommodates the wants and needs of potential users; 2) Functional Requirements (FR): a domain that accommodates the function of a targeted design or product; 3) Design Parameter (DP): is a domain that manifests FR regarding the realization of the function of the FR domain; 4) Process Variable (PV): This is the domain of the production process from the design stage before becoming a product.

The preparation of the AHOQ integration model begins by formulating a matrix between FR and DP, correlating each existing DP by adding constraints and linking them to the DP, and evaluating the assembled AHOQ model. The steps taken in the AHOQ method are as follows: 1) List of customer attributes (CA); 2) Convert CAs into FRs/Convert CAs into FRs; 3) Identify Limitations/Identify Constraints; 4) Formulate design parameters; 5) Formulate the Design Matrix and Initial Design; 6) Correlation of Design Parameters; 7) Comparison of competing products with the market/Comparisons of Competing Products; 8) Make a list of constraints; 9) Formulation of Process Variables; 10) Evaluation of Final Model Results. In this study, AHOQ steps will be carried out in stages to ensure satisfactory results.

DISCUSSION AND RESULT

The process of making a pellet machine starts from the stages of implementing AHOQ, machine design, and machine testing, which will be discussed one by one as follows.

AHOQ Implementation

The first step for the Axiomatic House of Quality method is to create a customer attribute (CA). Based on interviews and distributing questionnaires that have been analyzed regarding the pellet machine needs that customers want, a list of customer attributes is obtained in Table 1. Followed by converting CAs into FRs. The eight FRs are expected to meet the needs of the customer. These FRs are used as a technical requirement to achieve success in designing pellet production machines. CAs that have been converted to FRs are shown in Table 1.

Table 1. Conversion of CAs into FRs

List of customer requirements			List of Technical Requirements	
C1	Pellets have a size that fish can consume.	→	FR1	The machine can produce pellets of various sizes
C2	The machine has a capacity of 30 to 50 kg/hour.	→	FR2	The driving machine is capable of producing pellets with a capacity of 30 to 50 kg/hour.
C3	It has a feature for mixing ingredients to make pellets.	→	FR3	The machine has components that can mix the ingredients to make pellets.
C4	Using fossil fuel propulsion.	→	FR4	The driving engine uses fossil fuels as an energy source.
C5	Has additional features or functions	→	FR5	The machine can be used as a corn sheller.
			FR51	The machine has safety features as protection when in use.
C6	The machine material is solid and durable.	→	FR6	Machines using materials can be used for long periods.
C7	The machine is easy to move.	→	FR7	It has a drive mechanism on the machine for easy moving.

The next step is to identify constraints. This stage is very influential in product development. At this stage, the constraints that have been identified will influence the method that will be implemented and are also involved in using the constraints that exist in the method. The limitation in product development is the design specifications: 1) Capacity of pellets that can be produced; 2) Able to produce the expected pellet size; 3) Has additional functions (multifunction); 4) The material used must be strong and durable; 5) The tool is easy to use and move.

The design Parameter is a domain that becomes a display of functional requirements and how the function of the FR is applied. The next step is to formulate the design parameters where this activity is the essence of making a product. At this stage, creative thinking is needed to find the best physical solution. The purpose of the DP is to represent the physical elements or design variables that satisfy a certain FR. The conversion of functional requirements into design parameters that have been obtained can be seen in Table 2.

Table 2. Conversion of FRs into DPs

List of Technical Requirements			Design Parameters	
FR1	The machine can produce pellets of various sizes.	→	DP1	Filters that can be replaced according to the desired size.
FR2	The driving machine is capable of producing pellets with a capacity of 30 to 50 kg/hour.	→	DP2	Use of a engine with engine power equal to 6.5 hp.
FR3	The machine has components that can mix the ingredients to make pellets.	→	DP3	The pellet machine has a mixing feature to mix the ingredients to make pellets.
FR4	The driving engine uses fossil fuels as an energy source.	→	DP4	The engine uses gasoline.
FR5	The machine can be used as a corn sheller.	→	DP5	It has a mixing feature that can be used as a corn sheller.
FR51	Machines using materials can be used for long periods.	→	DP51	Use rubber on each elbow.
FR6	Machines using materials can be used for long periods.	→	DP6	Pellet production machines are dominated by hard materials such as iron.
FR7	It has a drive mechanism on the machine for easy moving.	→	DP7	Using drive wheels.

Once the relationship between FRs and DPs has been identified, the next step is to analyze the matrix results. The analysis carried out is to look at each DP relationship and re-check that each relationship between FRs and DP is related. If FRs are connected to two DPs or vice versa, then the connection and design must be adjusted in order to avoid problems causing excessive design time. The formulation of the design matrix can be seen in the Table 3.

Table 3. Design Matrix

	DP1	DP2	DP3	DP4	DP5	DP51	DP6	DP7
FR1	1	0	0	0	0	0	0	0
FR2	0	1	0	0	0	0	0	0
FR3	0	0	1	0	0	0	0	0
FR4	0	0	0	1	0	0	0	0
FR5	0	0	0	0	1	0	0	0
FR51	0	0	0	0	0	1	0	0
FR6	0	0	1	0	1	0	1	0
FR7	0	0	0	0	0	0	0	1

In the AHOQ method, this stage explains how to overcome dependencies on design and physical/virtual visual design matrices. If the design matrix has been completed and has produced a combined design, it is necessary to separate the FR so that each axiom gets independence. However, this step is optional if the design matrix has been completed and the ideal design has been achieved. Then, the researcher can proceed to the next stage, namely, the correlation of design parameters/correlation of design parameters. The correlation matrix describes the relationship between technical requirements in a model. At this stage, the matrix formed may have a positive or negative correlation with the design parameters that have been determined. This Correlation of Design Parameters is shown in Figure 2.

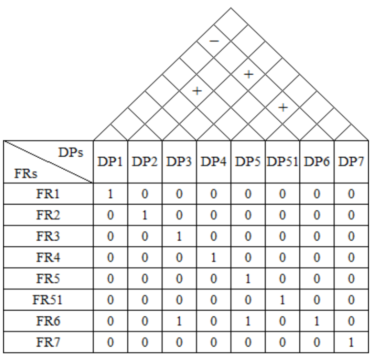

Figure 2. Correlation of Design Parameters

Machine Design and Specifications

After conducting a correlation analysis, a design or technical drawing of a pellet production machine has been obtained and designed based on customer voices or requests. The machine was designed using SolidWorks software, as shown in Figure 3.

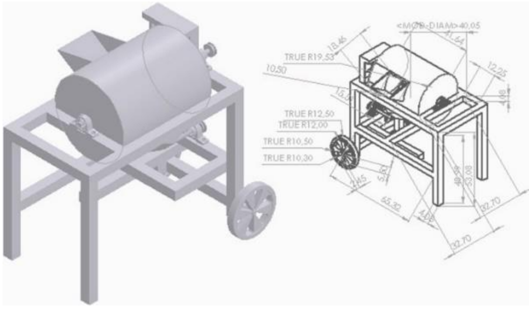

Figure 3. Final Design of Pellet Production Machine

The vendor will provide this design to be made into a pellet machine product as shown in Figure 4. This pellet production machine is designed using five parts: machine frame, drive wheel, mixer, mixing tube, and pellet machine.

Figure 4. The Final Machine of Pellet Production

The machine is designed with components that function to maintain safety when using this machine. The first component designed is the cover on the pellet mixing tube, which functions to insert the pellet-making ingredients that can be opened and closed. The mixing process can be used without fear of the release of these ingredients. With this cover, the accident rate for operators who use it will be reduced. The second component designed to increase safety is found in the corner of the machine, which is coated with rubber. The rubber-coated corners serve to protect the operator if he stumbles into a corner of the machine. There are four corners covered with rubber. The next component is in the connector for the mixing and pellet printer features, where the connector has a handle that makes it easier to pull the connector without touching the mixing tube with your hands or fingers.

Machine Testing

The final stage in the AHOQ method is evaluating the results of the final model by collecting data in designing a pellet production machine. Evaluation is carried out to find out whether the response regarding the design that has been made is following the customer's wishes. If the concept that has been created receives an evaluation, then this can be a consideration for researchers in making improvements to the concept that has been created. It is necessary to test the function of the machine. The tests carried out are as follows:

Pellet Material Mixer Testing

Pellet material mixing tests are carried out to determine whether the material can be mixed well. The results of this test were carried out to answer the third design parameter (DP3), namely that the driving machine has a mixing feature for mixing the ingredients for making pellets. Based on the results of the tests carried out, it can be seen that the machine can perform the mixing function, but shortcomings still need to be considered in further research. In this test, the mixing process carried out with 10 kg of pellet material can be mixed, but small portions still clump.

Corn Sheller Testing

Corn sheller testing is carried out to ensure that the corn shelling feature functions correctly. The results of this test were carried out to answer the fifth design parameter (DP5), namely that the pellet machine has a mixing feature that can also be used as a corn sheller. Based on the results of the tests carried out, it can be seen that the machine can shell, but the size results produced are still the results of shelled corn of various sizes. The following are the results of experiments using the mixing feature, which can be used as a sheller.

Pellet Printer Experiment

Pellet printer testing is carried out to determine the amount of capacity that can be produced by the machine. Testing was carried out three times. The results of this test were carried out to answer the second design parameter, namely the use of a driving engine with engine power equal to 6.5 HP to obtain a total capacity of 30 kg to 50 kg/hour.

Final Capacity

A test is carried out on the pellet production machine's capacity. The result pellet capacity is 30 kg/hour to 50 kg/hour.

Table 4. Pellet Production Machine Capacity Test Results

Number of Test	Testing Time (minute)	Testing Time (hour)	Total Capacity Testing (kg)	End Capacity (kg/hour)
1	17	$\frac{17}{60}$	10	35,2
2	8	$\frac{8}{60}$	5	37,5
3	7	$\frac{7}{60}$	5	42,8
Mean				**38,5**

Based on the table 4, it is known that the first experiment obtained a capacity of 35.2 kg/hour, the second experiment was 37.5 kg/hour, and the third experiment was 42.8 kg/hour. The capacity produced from each test meets consumer needs, namely above 30 kg/hour to 50 kg/hour. Based on the results of the tests carried out, it can be seen that the machine can produce pellets. The experiment was carried out using a sieve with a diameter of 4 mm. The machine produces pellets according to the expected size of 4 mm. The capacity produced with three trials exceeded 30 kg/hour to 50 kg/hour. So it is concluded that the machine can meet customer needs.

CONCLUSION

Based on the results of the analysis carried out from data processing using the Axiomatic House of Quality method in designing pellet production machines, it can be concluded as follows: 1) There are 7 Customer Attributes with 8 Functional Requirements, which are used as a reference in designing pellet production machine products; 2) The pellet production machine functions as a pellet maker by going through the stages of mixing and molding pellets; apart from that, this machine has other functions: it can be used to shell corn.

ACKNOWLEDGE

The Chairman and Members expressed their gratitude for the support of DIKTI along with BIMA and the Leadership of the Del Institute of Technology and LPPM for the opportunity given to carry out community service in the Lake Toba area, especially Laguboti. By carrying out this community service, we hope that what has been carried out will provide maximum benefits for the community economy and the development of science in Indonesia. That is what we can convey for the assistance and cooperation from DIKTI and the Del Technology Institute.

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