DESIGNING FOOD DELIVERY MACHINE FOR POULTRY IN CHICKEN FARM TO REDUCE EMPLOYEE UNERGONOMIC MOTION AT MIJEN'S CHICKEN FARM

By

Anisa Nurul Hikmah

ID No. 00420180039

A Final Project presented to the Faculty of Engineering President University in partial fulfilment of the requirements of bachelor's degree in engineering Major in Industrial Engineering

2022

Adi Saptari
25 Agustus 2022

Anastasia L. Maukar
25 Agustus 2022

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STATEMENT OF ORIGINALITY

In my capacity as an active student of President University and as the author of the final project stated below:

Name	: Anisa Nurul Hikmah
Student ID number	: 004201800039
Study Program	: Industrial Engineering
Faculty	: Engineering

I hereby declare that my final project plan entitled "**Designing Food Delivery Machine for Poultry in Chicken Farm to Reduce Employee Unergonomic Motion at Mijen's Chicken Farm**" is to the best of my knowledge and belief, an original piece of work based on sound academic principles. If there is any plagiarism detected in this final project, I am willing to be personally responsible for the consequences of these acts of plagiarism, and will accept the sanctions against these acts in accordance with the rules and policies of President University. I also declare that this work, either in whole or in part, has not been submitted to another university to obtain a degree.

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Cikarang, Indonesia, August 2022

Ir. Adi Saptari, M.Sc., Ph.D.

STATEMENT OF ORIGINALITY

In my capacity as an active student of President University and as the author of the final project stated below:

Name	: Anisa Nurul Hikmah
Student ID number	: 004201800039
Study Program	: Industrial Engineering
Faculty	: Engineering

I hereby declare that my final project plan entitled "**Designing Food Delivery Machine for Poultry in Chicken Farm to Reduce Employee Unergonomic Motion at Mijen's Chicken Farm**" is to the best of my knowledge and belief, an original piece of work based on sound academic principles. If there is any plagiarism detected in this final project, I am willing to be personally responsible for the consequences of these acts of plagiarism, and will accept the sanctions against these acts in accordance with the rules and policies of President University. I also declare that this work, either in whole or in part, has not been submitted to another university to obtain a degree.

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By

Anisa Nurul Hikmah

004201800039

Approved by

Ir. Adi Saptari, M.Sc., Ph.D.
Final Project Advisor

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Study Head of Industrial Engineering Program

ABSTRACT

At Mijen's Chicken Farm, feeding is still performed manually. There were four workers performing the jobs in the three level of stall, and carries a sack of chicken food for 50 Kg, two hours daily. The manual process resulted ergonomically an unsafe working position with a REBA score between 11 and 15 and high level of risk, indicating that immediate action is necessary. To eliminate or reduce the unsafe working condition, a food delivery machine capable of rectifying the situation was proposed. This machine's design incorporates QFD to accommodate user requirements and value engineering to produce the most cost-effective tool. The results of the identification revealed a number of usability, security, comfort, strength, accuracy, efficiency, anti-rust, and durability characteristics. In addition, value engineering is utilized in the development of the tool's 12 material concepts. The selection of a concept is determined by considering its function and cost. Concept 8 was selected with a value of 1.8730, its total cost was Rp 3,707,347, and its function was 3,194. The results of the design can reduce the number of workers from four to two and reduce the REBA score from 11-15 into 4 and 5 indicating medium risk, as humans are replaced by machines, saving Rp 5,670,042 in labor costs and incurring an operating cost of Rp.130,023 per month for 3000 watts of electricity for this machine.

Keywords: Ergonomic, REBA, FAST Diagram, Quality Function Deployment, Value Engineering,

ACKNOWLEDGEMENT

This final project is hardly to be done without a big support. Therefore, I would like to express my gratitude to Allah SWT, the source of everything. Thank you for the chance and endless love that You give to me. And also, to:

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9) For all my friends in Industrial Engineering 2018 thank you for the togetherness even though it was short and separated by the pandemic. let's graduate together in this year.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TERMINOLOGIES

Plasma	: Individual owned business but in cooperation with a limited liability company (PT).
Poultry	: Is a type of livestock group of birds used for meat and eggs or feathers.
Farm	: Animal husbandry is the activity of breeding and cultivating livestock to obtain the benefits and results of these activities.
BoM	: Bill of Material that provide the structure of the product component.
FAST diagram	: Diagram that broken down the customer desire to find the solutions for the proposed product.
Value Engineering	: Creative and structured method to identified the cost-effective ways to build a product.
QFD	: Quality Function Deployment, a method for developing design from ideas or concept from consumer demand.
Bill of Material	: to elaborate the subsystem of a product.

CHAPTER I

INTRODUCTION

1.1 Problem Background

This study was completed in one of the chicken farms, Mijen's Chicken Farm or broiler farm, Central Java. This business has advantages of relatively short production period, which can be harvested in 32-40 days, high productivity, relatively affordable prices, and increasing public interest in chicken consumption.

As a broiler provider, Mijen's Chicken Farm has contributed to the supply of broilers from 2016 to the present and has made Mijen's Chicken Farm one of the plasma broiler farms in the city of Semarang, Central Java. The demand for chicken consumption from PT. XYZ continues to increase every period. In 2021 Mijen's Chicken Farm harvested six times the highest yield in February – March 2021 with 29,116 chickens, the lowest yield in September – October 2021 with 23,230 chickens, and the average yield is 27,431 chickens in 2021 production.

As a supplier of broilers, Mijen's Chicken Farm must meet several requirements proposed by the customer (PT.XYZ) to maintain the quality and credibility of the company to end customers. The main requirement is that the weight of the chickens must increase every day by 28.35 grams per chicken. To meet this target, feeding is done once a day and vitamin one per week.

The problems arise when the chicken cannot meet directly with humans because it will experience shock and fall. When it falls, the chicken cannot return to its standing position, resulting in death. During six-month periods in 2021, the highest number of dead chickens were 1,926 chickens from May to June 2021, and the lowest was 629 chickens from November to December 2021. The average amount of dead chickens is 1,058 chickens per month in 2021.

The feeding process is carried out by four workers at Mijen Chicken Farm and still uses the manual method, namely in the pelvis and distributed to the feed place that has been provided. Carrying a load weighing 50 kg per person with repetitions as much as 2-3 times per floor per day, it makes the position not ergonomic and dangerous and unsafe which causes some complaints on the worker's body (Hikmah, 2022).

This project is to find an improvement that can be made for working method of feeding chickens, so that may reduce or eliminate the unsafe conditions. Improving working methods in feeding chickens can be done by designing better feed distribution aids. Quality function deployment (QFD) and value engineering methods will be used in designing this machine. Quality Function Deployment (QFD) accommodates consumer needs and collects as many consumer needs as possible. Meanwhile, Value Engineering will be used to choose alternative products with the highest value, and FAST Diagram will be use as the analysis to determine cause-effect of the research in the value engineering analysis stage. With this machine, a chicken feeding process will be obtained that is more ergonomic, safe, and can reduce physical complaints suffered by workers at Mijen's Chicken Farm. This designed machine will also provide more efficient and fast feed distribution results.

1.2 Problem Statement

1. How safe is the working conditions at Mijen’s Chicken Farm particularly on feeding chicken.
2. How to reduce the unsafe working conditions.

1.3 Objectives

1. To analyse the working condition at Mijen’s Chicken Farm on feeding chicken using ergonomic approach.
2. To reduce the unsafe conditions in feeding chicken using a food chicken delivery machine

1.4 Scope

Due to time and resource constraints in conducting this research, some scope will be set in conducting the observation:

a. The data for this study were collected between March 19th and March 26th, 2022.
b. The research focuses primarily on the process of feeding chickens.
c. The food delivery machine in this study was merely in the planning stage.

1.5 Assumption

The following assumptions were utilized in this study:

a. It is assumed that the working day is 40 days per period
b. It is assumed the working hour is 2 hours per day for feeding

1.6 Research Outline

Chapter I Introduction

This chapter discusses the context of the problem, the problem statement, the objective, the scope, and the research outline. In addition, this chapter provides an overview of the phenomena surrounding the research, why the researcher chose the particular subject, the research objectives, the research limitations, and the assumptions used to conduct the analysis.

Chapter II Literature Study

This chapter contains prior research investigations relating to the research. These discoveries contribute to delivering more knowledge and understanding to establish general principles of the prevailing problem.

Chapter III Research Methodology

This chapter covers the theoretical framework of the research and further discusses the flow of performing the research, beginning with the initial observation, problem identification, literature study, data collection, data analysis, and ending with the conclusion and recommendation.

Chapter IV Data Analysis

This chapter begins by providing a quick overview of the observed company and the food delivery procedure in general. The original system is then assessed utilizing pertinent data collected. Next, the problem's root cause is identified to discover the best solution for the system. Finally, the original and new systems will be compared to demonstrate the improvement.

Chapter V Conclusion and Recommendation

This chapter concludes with a recommendation and a conclusion. The conclusion outlines the problem, the method employed, the findings, and the data analysis that answers the research purpose. Furthermore, several recommendations for future research are suggested.

CHAPTER II

LITERATURE STUDY

2.1 Product Development Planning

Product development is all activities that include analysis of perceptions and opportunities for the market and ends with the production stage and then delivery of goods to consumers (Irwan & Purna, 2017). The resulting products can be finished goods, semi-finished goods, components, subassembly, assembling, and raw materials (Irwan & Purna, 2017).

In product designing, the are several stages which already structured in five stages as in Figure 2.1. These stages are: planning, concept development, system-level design, detail design, testing and refinement, and product ramp up (Ulrich & Eppringer, 2007)

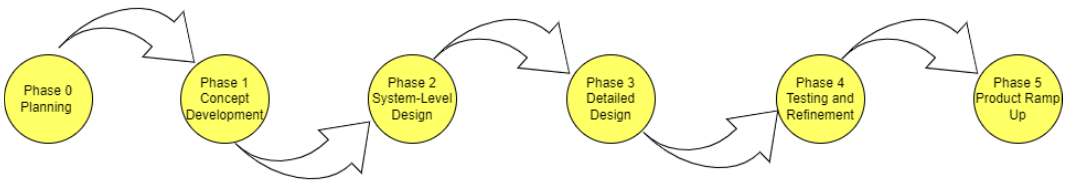


Figure 2. 1 Product Design and Development Phase *(Ulrich & Eppringer, 2007)*

Product development can be done with two events, namely to make something more advanced or modern than its previous form, something inspired by an existing product or feature, and the second is to create something new and unprecedented *(Wenwen & Zhibin, 2012)*. The following are explanations of each phase of product design and development:

2.1.1 Phase 0: Planning

The project approval process to the process of launching a real product development all begin with planning activities. Starting with identifying opportunities, then conducting market research to determine the purpose of this business and who the target market is (Ulrich & Eppringer, 2011).

2.1.2 Phase 1: Concept Development

Market needs have been identified in the development concept, and several product alternatives already exist and are being evaluated. At this stage, the selection of one or two concepts to be developed and tested is made. A concept is a detailed description of a product's form, function, and appearance, complete with specifications, competitor analysis, and cost considerations (Ulrich & Eppringer, 2011).

2.1.3 Phase 2: System-Level Design

This stage includes the product architecture definition, product composition into subsystems and components, and several main designs. This phase's output relates to the specification and shape of the product functionally on each subsystem of the product to be executed (Ulrich & Eppringer, 2011)**.**

2.1.4 Phase 3: Detailed Design

This phase includes the discussion of products that have reached the smallest or most detailed stage; the details in question include the specifications of the shape, material, and tolerance limits of all components in the product. This phase's output is the recording of the product's quality control, including the shape of each component and the equipment that will be used for production, detailed specifications on the raw materials to be purchased, and planning for product assembly production (Ulrich & Eppringer, 2011).

2.1.5 Phase 4: Testing and Refinement

This phase will involve the evaluation and construction of several versions of the pre-production results. The initial prototype is usually referred to as an alpha prototype, and it is made with the original components that will be used for the actual product, but the fabrication process does not have to coincide with the actual production. The purpose of this alpha prototype test will be to determine whether the product has function compatibility with what was planned. The following prototype is a beta prototype in which the components used are in accordance with production needs, but the assembly process is not. Product performance and durability are determined through beta prototype testing (Ulrich & Eppringer, 2011).

2.1.6 Phase 5: Production Ramp-Up

This is the first stage of producing new products. The first batch of products will be made in accordance with the actual production flow. The product to be manufactured will be tailored to the needs of the customer and will be inspected for flaws (Ulrich & Eppringer, 2011) .

Figure 2.2 depicts the concept development stage, which consists of several Front-End Activities.

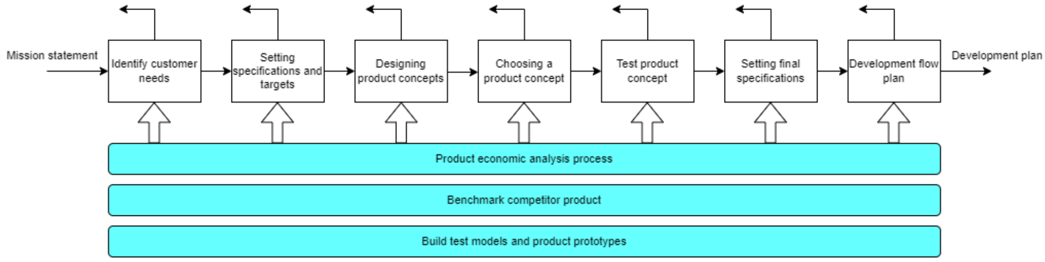


Figure 2. 2 Front-End Concept Development Phase *(Ulrich & Eppringer, 2011)*

At the Front-End Activities stage depicted in Figure 2.2, it is composed of interconnected activities. The arrow pointing to the left in Figure 2.2 indicates that, as a result of the new information, it is possible to return to the previous stage.

2.2 Quality Function Deployment (QFD)

Quality Function Deployment is a concept developed by Dr. Shigeru Mizumo and Akao Yoji in 1996 in Japan. QFD is a method for developing designs from ideas or concepts that aim to satisfy consumer desires, which are then translated from consumer demand into the target of the design and the prioritization of quality assurance throughout all stages of production (Akao, 2004). In another definition Quality Function Deployment is described as a process that presents the structure of the development cycle. The uniqueness of QFD lies in customer needs being the main focus, elements defined by consumers are very important then a framework is made that binds all activities in the cycle which is formed in a structure in one complete package (Bossert, 2021).

In the use of QFD there are four stages that should be carried out, these phases are described as figure 2.3

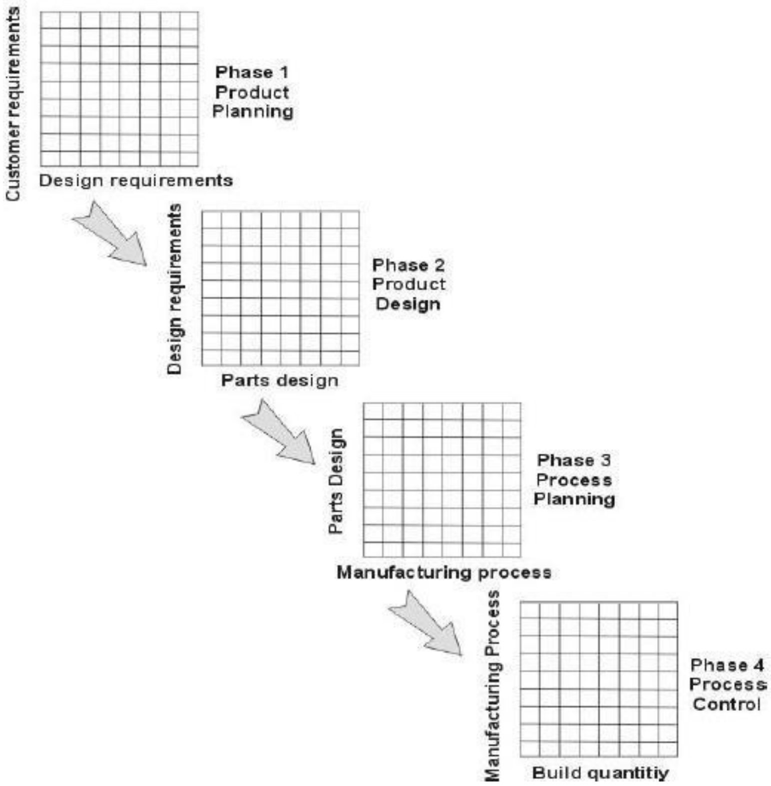


Figure 2. 3 Phase in QFD *(Akao, 2004)*

2.2.1 Phase 1 Product Planning (House of Quality)

During this phase, customer requirements will be translated into product specifications to meet consumer demands. At this stage, House of Quality and Voice of Customer are created.

2.2.2 Product Design

At this stage, the customer's desires will be specified in greater detail as components of the concept product.

2.2.3 Product Planning

In this phase, based on the desired outcome, the target value and manufacturing procedure will be determined.

2.2.4 Production Planning (Process Control)

Indicators for monitoring the production process will be determined at this stage of production planning.

2.2.5 REBA

REBA is an abbreviation for Rapid Entire Body Assessment, which is an assessment that measures the importance of worker posture for the safety of workers performing daily activities. Observations are made using a REBA table, which includes assessing the neck, back, arms, wrists, and feet. a manager or supervisor (Ansari & Sheikh, 2014).

2.3 Voice of Customer (VOC)

QFD requires the identification of consumer needs as one of its steps. Voice of Customer is derived from the expression of consumer desires or expectations that describe what they expect from a product. Typically, these expectations are very abstract and general, so Quality Function Deployment is used to translate it into a structure that is easier to comprehend in this instance (Mulay & Khanna, 2017).

2.4 House of Quality (HOQ)

The House of Quality is the initial step in implementing the Quality Function Deployment methodology and it describes the fundamental processes underlying the Quality Function Deployment (Yuliani, Kholil, & Setianingrum, 2021).

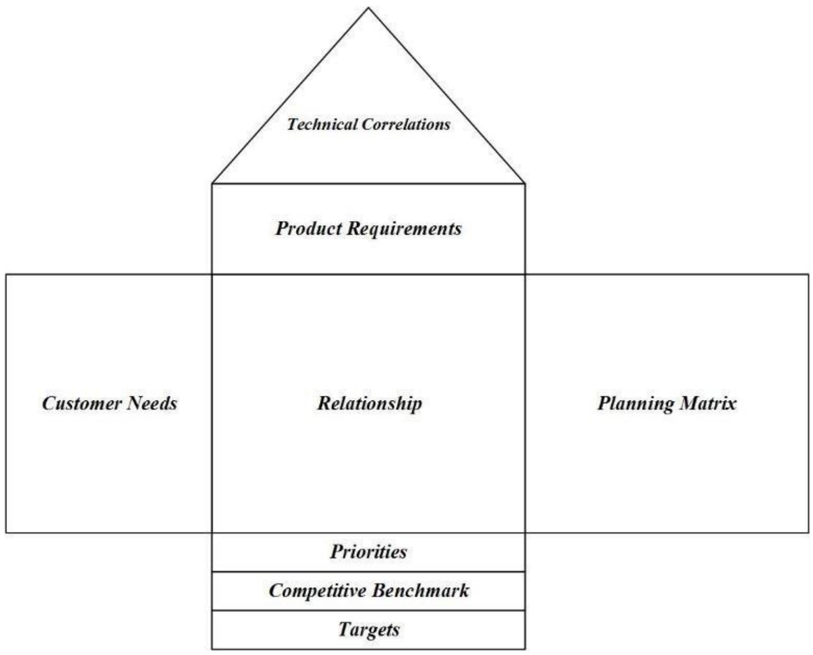


Figure 2. 4 House of Quality *(Ficalora, 2012)*

There are seven steps in the preparation of the HOQ *(Ficalora, 2012)*. These can be described as:

a. Determination of customer needs

Voice of the Customer, which was conducted in a previous stage, is used to determine customer needs. From these outcomes, attributes will be derived and poured into the House of Quality.

b. Formation of planning matrix

The importance of each attribute is obtained from the market analysis results which are then written in the form of a matrix. The result of the planning matrix is the initial value for each attribute.

$$IR = \frac{Target\ Value}{Evaluation\ Score} \quad (2.1)$$

$$Weight = IR\ x\ RII \quad (2.2)$$

c. Making product requirements

The matrix containing the desired product's technical specifications is the product requirements.

d. Determination of relationship

The so-called relationship is the relationship that is bound between customer needs and product requirements. The primary priority is then established based on the product requirements.

e. Determination of Technical Correlation

At this stage, the relationship between the technical details of the matrix and product requirements is determined.

f. Get Competitive Benchmark

Collecting value from products owned by competitors is carried out at this stage.

g. Determine the target

Based on the results of the evaluation of the competitive benchmark, a target for the product's technical aspects or requirements is established.

2.5 Function System Analysis Technique (FAST)

The Function System Analysis Technique (FAST) diagram depicts the project's cause and effect *(Aghajany, Amerian, & Simkooei, 2022)*. In FAST, a systematic analysis is performed on the functions of very important parts or aspects of products and services; this function is defined based on the use and value of the product or service *(Aghajany, Amerian, & Simkooei, 2022)*.

During the development of FAST, a concise explanation of the product's functions, from the highest to the lowest, is provided. As illustrated in figure 2.5 below.

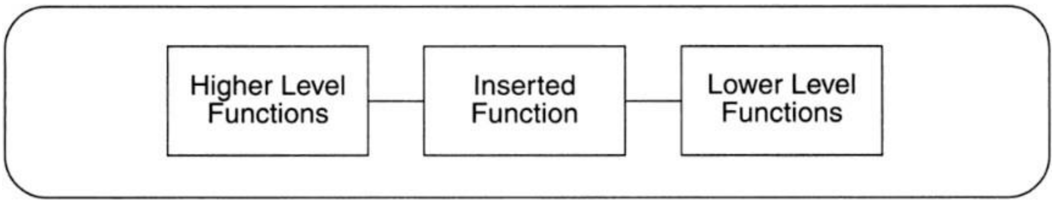


Figure 2. 5 Description of Functions from High to Low Level

From the highest level to the lowest, the description function is based on how-why questions. As depicted in the following function figure 2.6.

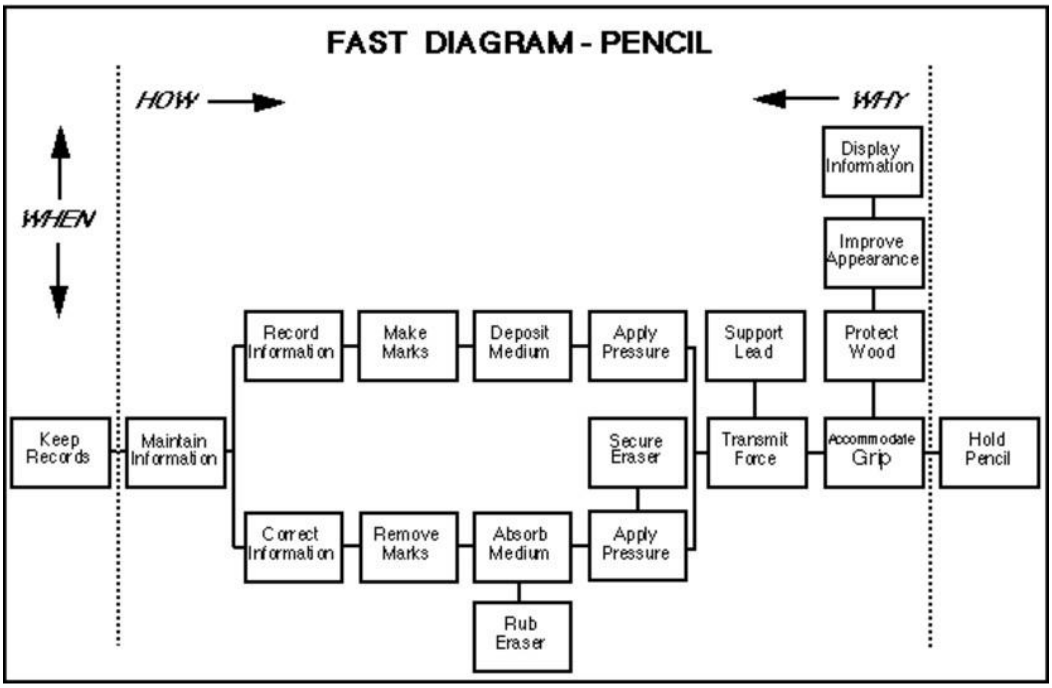


Figure 2. 6 FAST diagram drawing (npd-solutions, 2016)

2.6 Value Engineering

Value engineering is a creative, structured method that identifies cost-effective ways to manufacture a product (Cooper & Slagmulder, 2017). Value is defined as the equivalent value in return of goods, services, or money and comparable items (Cooper & Slagmulder, 2017). However, all experts concur that the ratio of function to cost is the foundation of value.

$$Value = \frac{function}{cost} \quad (2.3)$$

In value engineering, function is defined as something that is required or anticipated for the transaction that has occurred (Manoj, Choudhury, & Alzaylaie, 2020).

Cost is a quantity with units, whereas value is a quantity without units when determining value. To change the value of a function in one currency, use the following formula.

$$V_0 = \frac{F_0}{C_0} = 1$$

$$V_0 = V_n$$

$$\frac{F_0}{C_0} = \frac{F_n}{C_n}$$

$$C'n = \frac{Fn.Co}{Fo} \quad (2.4)$$

Description:

V_0 : Initial value

V_n : Product alternative value

F_0 : Initial design function

F_n : Product alternative function

C_0 : Initial design fee

C_n : Product alternative costs

C'n : Function value in rupiah

$$Function = \sum(Ai\ x\ \%\ Wi) \quad (2.5)$$

There are six stages of value engineering as follows (Cooper & Slagmulder, 2017).

a. Information Stage

At this stage, the introduction of the product will be explored as well as the collection of product-related information related to consumer needs.

b. Analysis Stage

At this stage, the analysis will be conducted to provide an explanation of the product's functions and descriptions.

c. Creative Stage

This stage is for developing as many ideas and alternatives that can be used as comparisons for the product being developed.

d. Evaluation Stage

At this stage, several alternative products will be eliminated in order to select the best concept, which will be carried forward to the next phase of the process.

e. Development Stage

This stage consists of selecting the best alternative that has been determined by the previous process, developing the best results, and analysing their deficiencies.

f. Presentation

At the presentation stage, the engineer will explain to the customer whether or not the designed product meets their requirements; if not, the product will be revised.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Methodology

This study employs quantitative methods. Descriptive quantitative research is a type of detailed, constructed, and procedural research. where numbers are at the core of this research method Tables, graphs, and diagrams are also used to present the findings (Muzaki & Nugroho, 2021). Almost all aspects of research methodology are covered, beginning with initial observations: initial observation problems; identification of problems; literature review; data collection; data analysis; conclusions and recommendations.

3.2 Research Framework

Figure 3.1 shows the research framework, depicts step by step of research. The study starts with initial observation.

3.1.1 Initial Observation

The first step is to observe how the conditions of the field or workplace will be researched. Through observation, the researcher can gain a thorough understanding of the problem. In these cases, researchers observed the entire process of feeding chickens. Researchers added interview procedures to gather information from workers about the problems they encountered to support the change. This information was originally naturalized and obtained from Mijen's Chicken Farm workers.

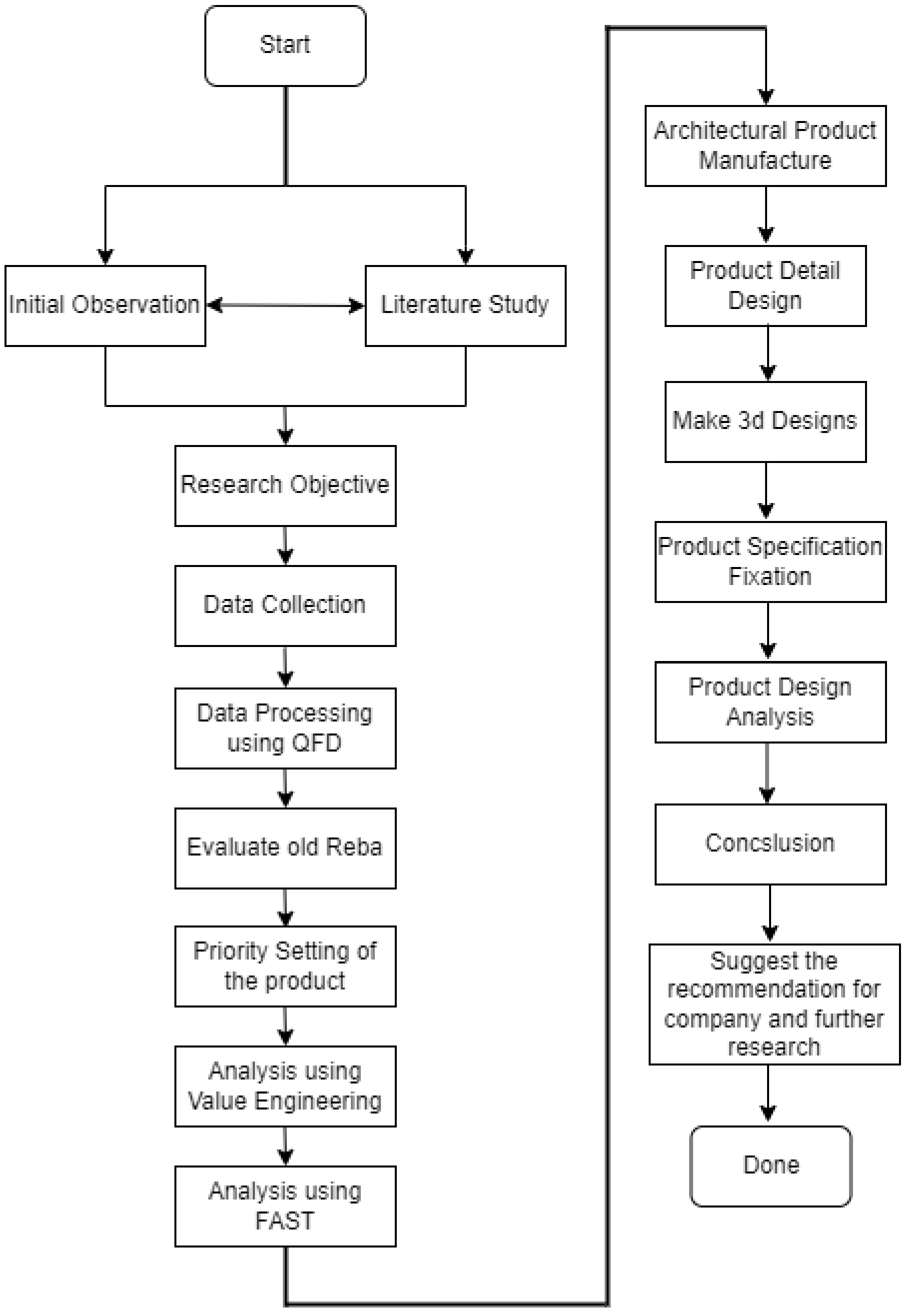


Figure 3. 1 Research Framework

3.1.2 Problem Identification

Following observation, the problem was discovered. And the problem is that the workers complain during the feeding process, which is still done manually. The perceived complaints are the result of actions that are not ergonomic. As a result, this problem must be identified further from the core of the problem in order to facilitate the repair process. After determining the problem and study objectives, the next step is to define the scope and assumptions.

3.1.3 Literature Study

To gather theories and methodologies related to the issues that occurred, a literature review was conducted. Researchers will seek out literature sources that can be used as principles for conducting analysis, ensuring that the research has a solid foundation for problem solving. Theories are derived from a variety of sources, including journals, books, and other publications. The following literature was used to assist researchers with their analysis:

- Product Development Planning
- Quality Function Deployment (QFD)
- Function System Analysis Technique (FAST)
- Value Engineering

3.1.4 Data Collection

Data collection techniques were used in this study in a variety of ways. Here is an explanation of the data obtained:
For data to obtain primary data, the techniques carried out are:

- Observation

  In this case, the study was conducted through direct observation on Mijen's Chicken Farm between March 19th and March 26th, 2022. The observation technique used is direct observation of occurrences at Mijen's Chicken Farm.

  The study observes how the workers do the feeding process about 2 hours with carry out 50kgs chicken food sack in their shoulder with repetitive 2-3 times per row of each person. After problems can be identified and recommendations for future improvements made through observation.
- Interview

  In this case, an interview was conducted with the four workers who provided feed at Mijen's Chicken Farm. Following the interview, the author obtained a different perspective on the problems encountered in the field.

- Questionnaire

  A number of questionnaires were distributed to chicken feeder workers. The questionnaires were in the form of several questions that could be answered with three choices (a, b, and c), and then there were types of questions that only needed to be answered by putting a tick on the columns "very important", "important", "less important", and "not important". This is related to the level of interest required by the workers in the improvement that will be implemented. The following are the values of the importance criteria that were used:

  - Very important worth 4
  - Important worth 3
  - Less important worth 2
  - Not important worth 1

3.1.5 Data Analysis

All collected data and information will be analysed to answer the problem formulation, which is to determine what improvements are appropriate for correcting work postures that are less safe in the long run using the Quality Function Deployment (QFD) include REBA as a work posture score to evaluate the level of importance of improvement action needed, using observation while feeding process and get the score through REBA table and Value Engineering methods. The following steps must be taken in order to achieve the research objectives:

- **Phase 0: Planning**

In phase 0 of planning, the first step is to identify problems with the process of feeding chickens. Observing the chicken feed workers' complaints allowed for the identification of the issue. Observational evidence indicates that the feeding of chickens at Mijen's Chicken Farm continues to be performed manually, resulting in worker complaints. The complaint was caused by the too-bent feeding position and the weight of 50 kg on the hips of workers performing repetitive motions. Based on these issues, the desired outcome is the creation of a modern and human-friendly feeder to reduce the employee unergonomic motion. For one-week, direct observation was conducted in the percussion area to support this procedure.

Literature studies on product development design, *Quality Function Deployment* (QFD), *Function Analysis Technique* (FAST), and *Value Engineering* are used to support the comprehensive data of the writing. Following the initial phase, the subsequent phase will consist of data collection and data processing.

- **Phase 1: Concept Development**

Several stages of concept development are carried out during this phase, as will be explained below:

1) Quality Function Deployment (QFD)

At the QFD stage, needs will be identified in order to prioritize the technical needs and characteristics of the to-be-manufactured product. To meet user requirements, direct interviews were conducted with chicken feed workers. Based on the interview results, it was determined that the user's needs for chicken feed tools served as attributes or characteristics. The subsequent step is to distribute questionnaires to workers in the chicken feed industry to determine the relative importance of each of these attributes or characteristics. The survey results will be incorporated into the design of the House of Quality.

The planning matrix will then be implemented. In constructing the planning matrix, the percentage of significance of each attribute or characteristic of the manufactured product or instrument is determined. As a benchmark for the planning matrix, competitive products are considered. Following the technical description of the product's attributes, the relationship between the technical response and the product's attributes is determined. The relationship between the attributes is computed to determine the relative weight of each technical response.

2) Value Engineering

Several stages of concept development using value engineering are completed in phase 1. These phases include the information, analysis, creative, evaluation, and development phases. At the information stage, information on user priorities is compiled through data collection. This information is derived from the results of the previous process's QFD.

Based on this data, the subsequent stage of analysis is conducted. The purpose of this analysis is to describe the essential function of the upcoming tool. This function is characterized using the Function Analysis System Technique (FAST). In the development stage of the chicken feeding machine, solutions are obtained by describing the function with a how-why statement in accordance with the FAST method.

After determining the critical function in the Analysis phase, the following phase is the creative phase. According to the FAST diagram, the creative stage consists of generating as many alternatives to the chicken feed machine as possible. After obtaining multiple options, the evaluation phase comes next.

During the evaluation phase, the value of each alternative is determined. The calculation of this value is based on a comparison between the function's value and its cost. Using a Likert scale, the value of the function is determined by comparing alternative products. The value of the function is determined by adding the results of multiplication between the alternative values for each attribute and the attribute's weight. Table 3.1 displays the calculation of the function value for each alternative.

Table 3. 1 Calculation of function score for each alternative

Attribute	Weight	Score		
		Alternative 1	Alternative 2	Alternative 3
Attribute 1	………%	A1		
Attribute 2	………%	A2		
Attribute 3	………%	A3		
Function		$\sum (Ai\ x\ \%\ Wi)$		

Following this, the cost of each alternative will be determined. In calculating the cost, manufacturing expenses are taken into account. After determining the value of function and cost, calculate the value of each alternative by comparing the function and cost values.

Each alternative will be assigned values during the evaluation phase. During the development phase, the alternative with the highest value will be selected for implementation. This stage of development involves creating a chicken feeder based on the selected alternative.

- **Phase 2: System-Level Design**

In phase 2, the chicken feed machine is disassembled into subsystems. The description is presented in a *Bill of Materials (BOM) Tree* format. The architecture and components of the chicken feed machine are obtained by creating the BOM *Tree*.

- **Phase 3: Detailed Design**

In phase 3, the product's specifics are described through detailed design. This detailed design includes comprehensive specifications for the chicken feeder's constituent parts.

- **Phase 4: Testing and Refinement**

Using the Rapid Entire Body Assessment (REBA), an assessment of work posture is performed at this stage. This evaluation is used to determine the value of the work posture of workers employing the manual feeding technique. With the REBA assessment, the level of risk associated with the old worker posture will be determined. The deficiencies identified will be factored into the design of a new machine for generating chicken feed.

3.1.6 Conclusion and Recommendation

The concluding phase of this research consists of making conclusions from the issues outlined in the research objectives. Then, provide recommendations to Mijen's Chicken Farm and for future investigations.

CHAPTER IV

DATA COLLECTION AND ANALYSIS

4.1 Data Collection

Mijen Farm is one of the farms that produces chickens for processing in the city of Semarang, Central Java. To be able to produce good quality chickens, the Mijen farm gives feed to the chickens it has once a day and vitamins once a week.

This process of feeding chickens is carried out manually. Chicken food was packed in sacks weighing 50 kg. This feed is then taken from the storage area manually by the worker. Workers then pour this chicken food into a feeding place totaling 175 large buckets with a capacity of 7 kg. This feeding is carried out for two hours to thousands of chickens. Workers need to carry sacks from the 1st floor, 2nd floor, to the 3rd floor. The process of picking up sacks and putting feed into containers can be seen in Figure 4.1 below.

Figure 4. 1 Feeding Process

Data collection was carried out to all employees of the Mijen Farm, which amounted to five people. Workers who carry out feeding consist of an age range of 22 to 29 years with an average length of work of 5.25 years. The profile of the chicken feed worker can be seen in Table 4.1.

Table 4. 1 Chicken Feeding Worker Profile

No	**Name**	**Age**	**Length of Work**
1	Slamet	29	6
2	Budi	22	4
3	Rejo	23	5
4	Agung	25	6
Average		24.75	5.25

The daily feeding of chickens is performed seven days a week. The chickens are fed for a maximum of two hours after the Ashar prayer. Six times of data collection for the duration of data provision were performed. The duration in question is the time between the sack being opened and the individual transfers to the feed location. This duration does not include the time required to deliver it to each floor, disassemble the feed, and calculate the daily consumption.

Figure 4.2 depicts the distribution of the length of feeding time during each visit.

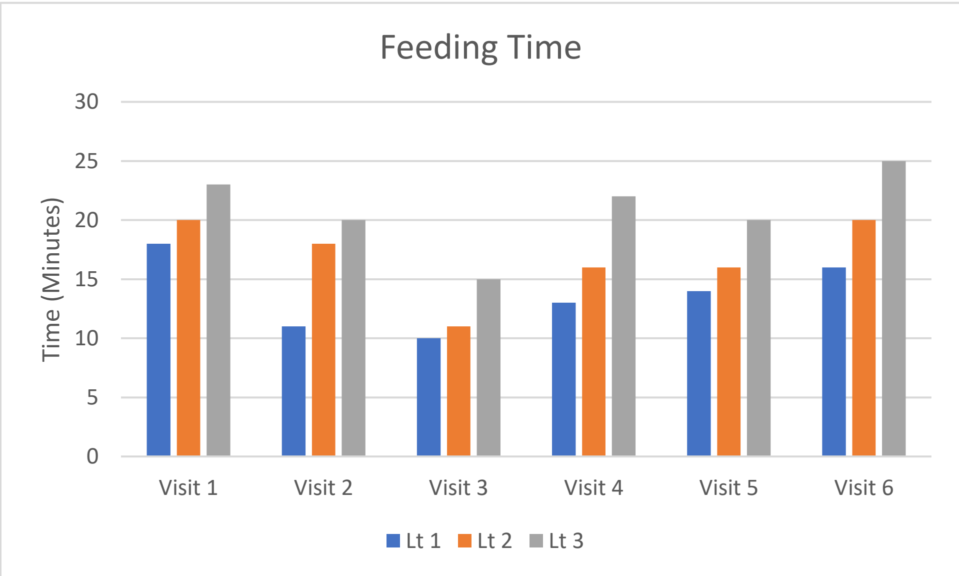


Figure 4. 2 Duration of Feeding

The duration of feeding differs between visits. The shortest duration for feeding is 36 minutes, while the longest duration is 61 minutes. Workers spend varying amounts of time on each floor. The third floor is where employees spend the most time feeding animals. The duration of this feeding is displayed in Table 4.2.

Table 4. 2 Average duration of Feeding

No	**Floor**	**Visit 1**	**Visit 2**	**Visit 3**	**Visit 4**	**Visit 5**	**Visit 6**	**Average**
1	Lt 1	18	11	10	13	14	16	13.7
2	Lt 2	20	18	11	16	16	20	16.8
3	Lt 3	23	20	15	22	20	25	20.8
Total		61	49	36	51	50	61	51.3

4.2 Data Analysis

Following the collection of all data, the next step is to analyse the data and the case. Several techniques, including Quality Function Deployment, Function System Analysis Technique (FAST), and Value Engineering, are employed to address the existing issues.

4.2.1 Quality Function Deployment

Product concept development with quality function deployment is accomplished by evaluating the results of REBA (Rapid Entire Assessment), identifying the needs of chicken feeder users, and generating HOQ (House of Quality). Here is an interpretation of each QFD step.

- **Evaluation of REBA**

Using the REBA, the neck, trunk, legs, upper arms, forearms, and ankles were evaluated to determine the worker's posture. The REBA evaluation is performed on all feeding workers based on the figure 4.1.

__Table 4. 3 REBA Assessment Result__

<table>
<tr><th>No</th><th>Activity Name</th><th>Workers</th><th>Final Score</th><th>Action Level</th><th>Risk Level</th><th>Action</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Lifting the sack</td><td>Worker 1</td><td>11</td><td rowspan="8">4</td><td rowspan="8">Very High</td><td rowspan="8">Needed Action as soon as maybe</td></tr>
<tr><td>Worker 2</td><td>13</td></tr>
<tr><td>Worker 3</td><td>11</td></tr>
<tr><td>Worker 4</td><td>14</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">Transferring feed to containers</td><td>Worker 1</td><td>15</td></tr>
<tr><td>Worker 2</td><td>13</td></tr>
<tr><td>Worker 3</td><td>12</td></tr>
<tr><td>Worker 4</td><td>13</td></tr>
</table>

The expert assessment of work posture yielded a REBA score between 11 and 15 as shown in Table 4.3, the detailed calculation will be attached into appendix 3. The score indicates a very high level of risk, and immediate action is required. Therefore, in the development of the product concept, consideration is also given to the user's posture when using the tool, so that the REBA value can be reduced and complaints can be reduced.

- **Identify Customer Needs (Voice of Customer)**

Through an interview, the user's requirements for the solution to the problem are determined. The worker responsible for feeding chickens, as the owner of the problematic property, was questioned. This interview was conducted to determine the feeding device requirements of the chicken feeders. The result of the statement was interpreted as the user's needs during the interview. The user's requirements are interpreted in Table 4. 4 below.

__Table 4. 4 Interpretation of User Needs__

No	Customer Statement	Interpretation of Needs
1	Difficulties when raising the sack to the shoulder	Easy-to-use products
2	Sacks often slip	The product is not dangerous for its users

Table 4. 4 Interpretation of User Needs (Continued)

No	Customer Statement	Interpretation of Needs
3	Shoulder and neck pain if you carry the sack on the shoulder for too long	Products convenient to use
4	Legs often slip if moving feed to the container	The product is strong to withstand loads and is not prone to breakage
5	Difficulties when pouring feed into containers so that they spill	Products can feed the chickens with an appropriate amount
6	Need to go back and forth to pick up sacks to each floor	Efficient tools
7	Durable tools	Products that are resistant to rust
		Products that have a long service life

The results of the interpretation of user requirements are used to determine the product's characteristics. Product characteristics are innate to the product. The following product attributes were derived from the interpretation of customer needs:

1) Ease of Use
2) Security
3) Comfort
4) Strength
5) Accuracy
6) Price
7) Time Efficiency
8) Anti-rust
9) Durable

➢ **House of Quality**

It is also necessary to distribute the questionnaire in order to determine the user's requirements and preferences. The questionnaire can be seen in Appendix 1. The purpose of the questionnaire is to determine the significance of each product attribute. The result of such significance is used in the construction of the house quality.

a) Planning Matrix

The planning matrix is used to determine the relative importance of each attribute. The planning matrix is determined by determining the relative importance of each attribute, benchmarking against competitors, and calculating weights.

Through the distribution of questionnaires to employees, the importance of each attribute is determined. Workers evaluate the significance of each of these characteristics. Appendix 2 contains a summary of the evaluation of attribute importance's results. From each attribute, the relative importance index (RII) is derived (Relative Important Index). Table 4.5 displays the relative importance index (RII) for each attribute.

Table 4. 5 RII Attribute

No	Attribute	RII
1	Ease of Use	**3**
2	Security	**4**
3	Comfort	**3**
4	Strength	**3**
5	Accuracy	**4**
6	Price	**3**
7	Efficiency	**3**
8	Anti-rust	**2**
9	Durable	**2**

After determining the importance of each attribute, the following step involves benchmarking against competitors. Manual feeder and table feeding tools are used as competitors as a comparison. In this instance, the researcher selected the Hanging Feeder product as a comparable alternative to the existing conditions. Each competitor's image is depicted in the image below.

Table 4. 6 Competitors product

No	Competitor Products	Picture	Information	Disadvantages
1	*Feeder Pan*		Automatic channeling of feed. It only needs to be in the content of the main source.	Possible for food to clump during the distribution through pipe
2	*Chain feeder*		Automatic channeling of feed.	Allows chicken to climb onto the chain conveyor, causing the chicken to pinch and die
3	*Hanging feeder*		It needs to be manually filled in one by one.	Worker still has to perform manually

The evaluation score of the benchmark product is compared to the target value for each attribute when conducting benchmarking. After obtaining the two numbers, a calculation of the improvement ratio is performed.

Table 4.7 displays the planning matrix's outcomes. In the planning matrix, the value of the first competitor, the second competitor, and the product is shown. In addition, the evaluation score, target value, RII, IR, weight, and percentage of weight are displayed.

Table 4. 7 Planning Matrix

	Benchmarking 1	2	3	4	5	Evaluation score	Target Value	IR	RII	Weight	%Weight
Ease of Use				Kompetitor 1		3	4	1,3	3	3,9	7,5%
					Kompetitor 2						
			Produk								
Security				Kompetitor 1		2	5	2,5	4	10,0	18,8%
				Kompetitor 2							
		Produk									
Comfort			Kompetitor 1			2	4	2,0	3	6,0	11,3%
				Kompetitor 2							
		Produk									
Strength				Kompetitor 1		3	4	1,3	3	4,0	7,5%
			Kompetitor 2								
			Produk								
Accuracy			Kompetitor 1			2	5	2,5	4	10,0	18,8%
					Kompetitor 2						
		Produk									
Price		Kompetitor 1				5	4	0,8	3	2,4	4,5%
	Kompetitor 2										
					Produk						
Time Efficiency			Kompetitor 1			1	4	4,0	3	12,0	22,5%
				Kompetitor 2							
	Produk										
Anti-rust				Kompetitor 1		5	4	0,8	2	1,6	3,0%
			Kompetitor 2								
					Produk						
Durable				Kompetitor 1		3	5	1,7	2	3,3	6,3%
			Kompetitor 2								
				Produk							

Kompetitor 1
Kompetitor 2
Produk

The assessment of the benchmark is based on each criterion proposed by the consumer, if the researcher believes that the product to be developed is superior to competitors, then the product to be developed is given a high rating. However, if the competitor feels superior in one criterion, the competitor's product will be rated higher.

The calculation of *the improvement ratio* is carried out using the formula 2.1 and Weight using formula 2.2.

$$IR = \frac{Target\ Value}{Evaluation\ Score} = 4/3 = 1.3$$

$$Weight = IR \times RII = 1.3 \times 3 = 3.9$$

$$\%Weight = \frac{3.9}{53.2} x\ 100\% = 7.33082 \approx 7{,}5\ \%$$

RII was come from questionnaire result modus and in table 4.7 the RII score is 3, while target value is our higher standard based on RII value, and in table 4.7 target value score is 4. Evaluation Score come from our product benchmark; we value our product against competitor’s product in those each requirement.

b) Product Requirements

Product specifications are the product's technical requirements. In defining product requirements, each attribute is described using a technical response. The technical response for each attribute is detailed in Table 4.8.

Table 4. 8 Product Requirements

No	*Customer Requirement*	*Engineering Characteristics*	Unit	Code
1	Product are safety	Product dimensions	m3	EC1
2	The product is not dangerous for its users	The number of angles on the product	pcs	EC2
3	Products are easy to learn and use	Number of components of the product	pcs	EC3
4	The product is strong to withstand loads and is not prone to breakage	Ultimate tensile strength	MPa	EC4

Table 4. 8 Product Requirements (Continued)

No	Customer Requirement	Engineering Characteristics	Unit	*Code*
5	Products make work faster	Long set up tool	sec	EC5
6	Products have an affordable price	Price	Rp	EC6
7	Products can feed the chickens with an appropriate amount	Discharge of feed coming out of the tool	m^3	EC7
8	Products that are resistant to rust	Corrosion rate material	MPY	EC8
9	Products that have a long service life	Material resistance	D/m^2	EC9

Table 4.8 displays the engineering characteristics and their units, if they have been translated, as well as the code created to facilitate and shorten the process in the future.

c) Relationship Determination

The relationship between technical response and attributes is denoted by the term Relationship. How the relationship between technical responses and attributes is determined is determined by this relationship. Marking is performed based on the level of relationship, as shown in Table 4.9 below.

Table 4. 9 Relationship Score

Sign	Relationship	Score
●	Strong	9
□	Keep	3
Δ	Weak	1

The following are the results of the relationship matrix.

Attribute	Responds Technical								
	Product dimensions	The number of angles on the product	Number of components of the product	Ultimate tensile strength	Long set up tool	Price	Discharge of feed coming out of the tool	Corrosion rate material	Material resistance
Comfort	● 1. 0125	□ 0.3375						Δ 0.1125	Δ 0.1125
Security		● 1.6875	□ 0.5625	□ 0.5625				Δ 0.1875	□ 0.5625
Ease of Use	□ 0.225		● 0.675		□ 0.225				
Strength				● 0.675					□ 0.225
Time efficiency					● 2.025	●	□ 0.225		
Price	□ 0.135		□ 0.135			● 0.405			Δ 0.045
Accuracy							● 1.6875		
Anti-rust						Δ 0.03		● 0.27	Δ 0.03
Durable								□ 0.1875	● 0.5625

Figure 4. 3 Relationship Matrix

To determine the value of the relationship matrix, multiply the percentage of each interest in the benchmark by 100, then divide by the score of each interest.

Multiplying the score of the sign of the relationship with the weight or weight of each attribute yields the value of the relationship between the technical response and the attribute.

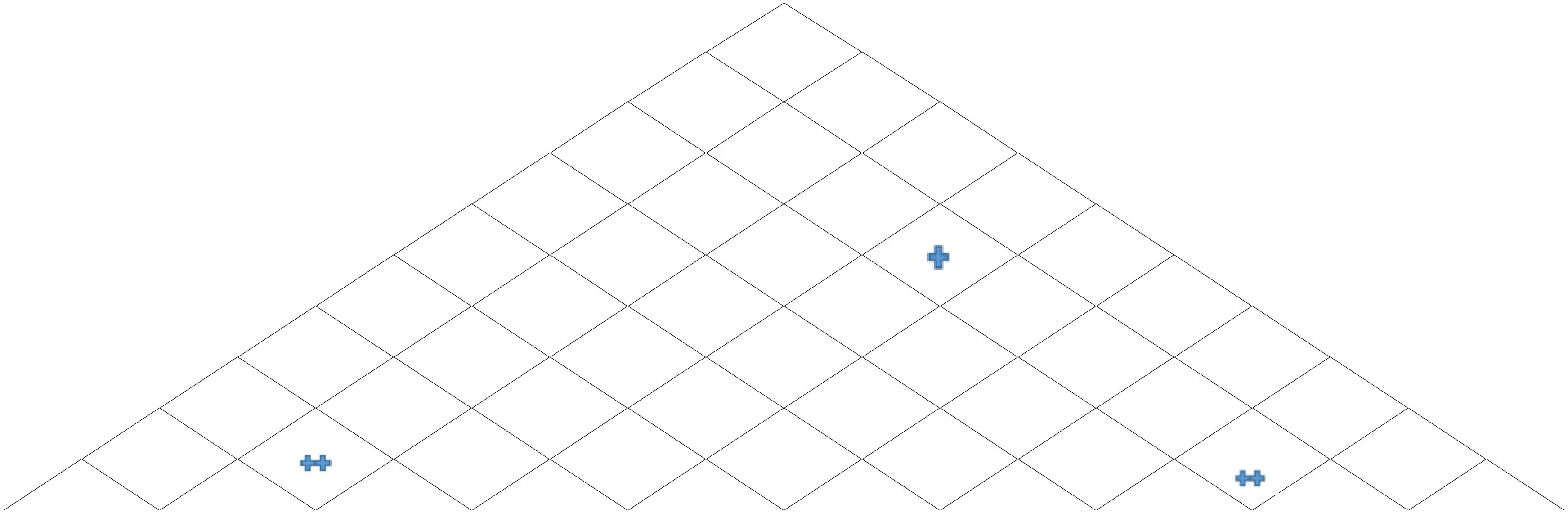
d) Technical Correlations

Technical correlation represents the relationship between each technical attribute. The table below demonstrates the technical correlation between poultry feeding tools.

Number of angles and number of components have a strong correlation, as there must be a connector as the number of components increases. The connector will create a right angle. Therefore, every two components contain one corner. There are more angles the more components there are.

Corrosion rate material - material resistance: high correlation, because corroded material has a lower resistance or, in other words, corrosion affects the resistance of the material. A material with a high corrosion rate is not resistant to corrosion.

Ultimate tensile strength - material resistance: UTS refers to the amount by which the material breaks, whereas material resistance is defined as the material's resistance to the environment. Therefore, they are related because they both represent the material's resistance to something. The greater the UTS, the more durable the material. The detail shape is shown in figure 4.4 below



Attribute Technical									
Product Dimension	**The number of angles on the product**	**Number of components of the product**	**Ultimate tensile strength**	**Long set up tool**	**Price**	**Flow the chicken food**	**Corrosion rate material**	**Material resistance**	**-**

Figure 4. 4 Technical Correlations

The following is a description of the sign on the technical correlation.

: *Strong correlation*

: *Partitive correlation*

: *Negative correlation*

: *Strong negative correlation*

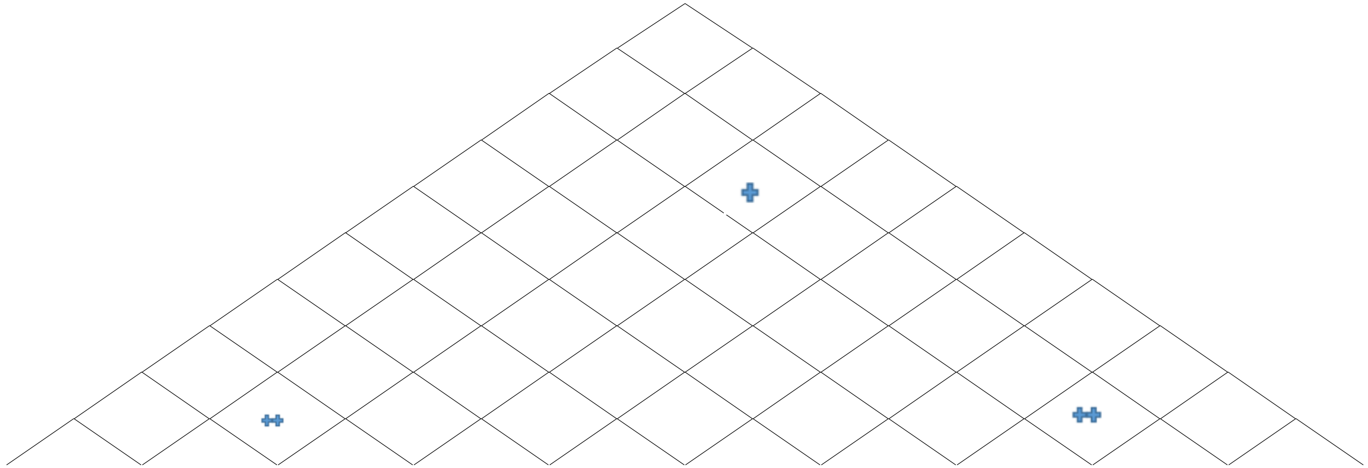
e) Determinations of Priority and Targets

Priority is expressed as a proportion of the total number of values for each technical response. This value is the value derived from the relationship matrix's results. Targets are the desired outcomes of each technical response. Prioritization and objectives are displayed figure 4.5 below.

Attribute	Responds Technical									
	Product dimensions	The number of angles on the product	Number of components of the product	Ultimate tensile strength	Long set up tool	Price	Discharge of feed coming out of the tool	Corrosion rate material	Material resistance	Weight%
Comfort	● 1.0125	□ 0.3375						Δ 0.1125	Δ 0.1125	7.5%
Security		● 1.6875	□ 0.5625	□ 0.5625				Δ 0.1875	□ 0.5625	18.8%
Ease of Use	□ 0.225		● 0.675		□ 0.225					11.3%
Strength				● 0.675					□ 0.225	7.5%
Time efficiency					● 2.025	●	□ 0.225			18.8%
Price	□ 0.135		□ 0.135			● 0.405			Δ 0.045	4.5%
Accuracy							● 1.6875			22.5%
Anti-rust						Δ 0.03		● 0.27	Δ 0.03	3.0%
Durable								□ 0.1875	● 0.5625	6.3%
Sum Scores	1.3725	2.025	1.3725	1.2375	2.25	0.435	1.9125	0.7575	1.5375	
Priority (%)	10.64%	15.70%	10.64%	9.59%	17.44%	3.37%	14.83%	5.87%	11.92%	
Target value	Max length 4m	2	10	515 MPa	10s	IDR 2,250,000	250gr/s	0.05-2mm/year	5 years	

Figure 4. 5 Prioritization objectives

The HOQ of the feeder is derived as follows from the results of calculating HOQ using these steps.



Attribute	Responds Technical									
	Product dimensions	The number of angles on the product	Number of components of the product	Ultimate tensile strength	Long set up tool	Price	Discharge of feed coming out of the tool	Corrosion rate material	Material resistance	Weight%
Comfort	● 1.0125	□ 0.3375						Δ 0.1125	Δ 0.1125	7.5%
Security		● 1.6875	□ 0.5625	□ 0.5625				Δ 0.1875	□ 0.5625	18.8%
Ease of Use	□ 0.225		● 0.675		□ 0.225					11.3%
Strength				● 0.675					□ 0.225	7.5%
Time efficiency					● 2.025	●	□ 0.225			18.8%
Price	□ 0.135		□ 0.135			● 0.405			Δ 0.045	4.5%
Accuracy							● 1.6875			22.5%
Anti-rust						Δ 0.03		● 0.27	Δ 0.03	3.0%
Durable								□ 0.1875	● 0.5625	6.3%
Sum Scores	1.3725	2.025	1.3725	1.2375	2.25	0.435	1.9125	0.7575	1.5375	
Priority (%)	10.64%	15.70%	10.64%	9.59%	17.44%	3.37%	14.83%	5.87%	11.92%	
Target value	Max length 4m	2	10	515 MPa	10s	IDR 2,250,000	250gr/s	0.05-2mm/year	5 years	

Figure 4. 6 House of Quality

4.2.2 Value Engineering

Value engineering is a stage that is carried out after the quality function deployment. The purpose of Value Engineering is to obtain a product or building that is balanced between the functions owned and the costs incurred by eliminating unnecessary costs, without having to sacrifice the quality, reliability, performance of a product or building. in the product development stage, additional analysis methods are needed, in product development it only includes the planning stage not to cost evaluation, then the use of value engineering is considered very appropriate to determine the value of a concept at the appropriate cost. The explanation of the steps is provided below.

- **Information Stage**

The information stage is the stage of gathering information about the user's needs and the order of importance of those needs. The QFD phase that has been completed in the past yield’s information about user requirements. The following are the user needs determined by QFD.

Table 4. 10 Product Attribute Properties

Attribute	Weight
Ease of Use	7.5%
Safety	18.8%
Comfort	11.3%
Strength	7.5%
Accuracy	18.8%
Price	4.5%
Time efficiency	22.5%
Anti-rust	3.0%
Durable	6.3%

The next is table priority of technical product that has been mention is House of Quality previously. The result shown in table 4.11 below.

Table 4. 11 Priority of Technical Response of the Product

Technical Attributes	Weight
Product dimensions	10.6%
The number of angles on the product	15.7%
Number of components of the product	10.6%
Ultimate tensile strength	9.6%
Long set up tool	17.4%
Price	3.4%
Discharge of feed coming out of the tool	14.8%
Corrosion rate material	5.9%
Material resistance	11.9%

In the analysis phase, attributes and technical responses with a weight greater than 10 percent are considered. Safety, comfort, accuracy, and time efficiency are product attributes with a weight value of greater than 10 percent. Moreover, product dimensions, number of product angles, number of product components, length of tool set-up, feed discharge emanating from the tool, and material resistance are among the technical responses with a weight of over 10 percent.

- **Analysis Stage**

After completing the QFD section, the essential functions of the chicken feed tool are described in value engineering. This crucial function is described using the FAST language (Function Analysis System and Technique). The FAST diagram depicts the chicken feeder's essential functions. The function's description also takes into account the information gathered in the preceding phase. The drawing of the FAST diagram takes into account technical responses with a weight greater than 10%, namely safety, comfort, precision, and time efficiency. In addition, the depiction of the FAST diagram takes into account product attributes, such as product dimensions, the number of product angles, the number of product components, the length of tool setup, the feed discharge exiting the tool, and the material's resistance. The image below is a FAST representation of a chicken feeder.

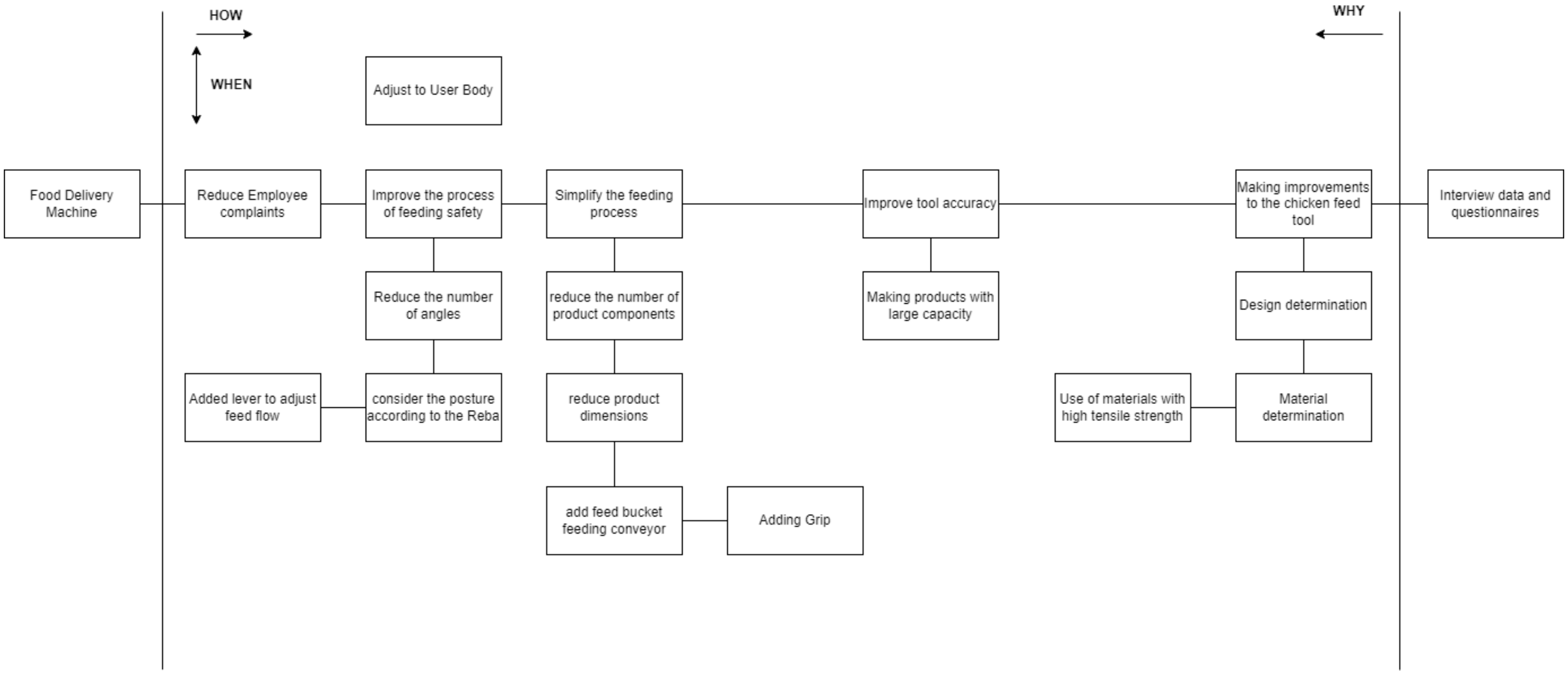


Figure 4. 7 FAST Diagram

As a result of the development of critical functions using FAST diagrams, user requirements were met. These solutions consist of the use of supports, the improvement of the feeder's shape, the reduction of the number of corners owned, the reduction of the number of product components, the use of durable materials, and the addition of connectors. The support will replace the central input so the user will not have to lift the sack again. This support will be embedded into the ground to reinforce the buffer structure. The shape of the feeder is a circle to prevent the user from being injured by sharp corners. Reduce the number of product components that the user must interact with to make the product more user-friendly. To be durable, the material must have a high tensile strength, but it must also be resistant to rust. The connector between the feeders is utilized so that users do not have to repeatedly fill each feeder. This system requires air pressure assistance from a pump or engine.

- **Creative Stage**

During this phase, developed alternatives for the product are created. The creation of this alternative is based on the results of QFD and the development of critical functions using pre-made FAST diagrams. The production of this alternative depends on the selection of the physical initial design of each component and the tool components' constituent materials. These alternatives will be displayed in the morphology chart, as shown in Table 4.12 below.

Table 4. 12 Morphology Chart

Component	Alternative	
Buffer material	 Iron	 Stainless Steel

Table 4. 13 Morphology Chart (continued)

Component	Alternative	
Feed Input Material	 Iron	 Stainless Steel
Feed input form	 Circle	 hopper
Connecting material	 Stainless Steel	 Iron
Feeding methods	 Vacuum	 Hook

As depicted in the preceding morphology chart, development is subdivided into a variety of options based on the physical initial design of each component and the material used to construct the tool's components. The proposed alternatives are as follows.

Table 4. 14 Morphology Table

	1	2	3	4	5
	Buffer Material	**Feed Input Material**	**Feed input form**	**Connecting material**	**Feeding methods**
1	Iron	Iron	Circle	Stainless Steel	Vacuum
2	Stainless steel	Stainless steel	Hopper	Iron	Hook/Grip

Table 4.14 outlines the selection of the material for the food delivery machine that will be created.

There are numerous possible material combinations for the food delivery machine, to determine which is the superior concept combination, it is necessary to randomly arrange a number of concepts as a comparison to determine the superior product concept. The combination information is displayed in table 4.15.

Table 4. 15 Material Concept Alternative of Food Delivery Machine

	1	2	3	4	5
Combination 1	1	1	1	1	1
Combination 2	1	2	1	1	1
Combination 3	1	1	1	1	2
Combination 4	2	1	1	1	2
Combination 5	1	2	1	1	2
Combination 6	1	1	1	2	1
Combination 7	2	1	1	2	1
Combination 8	1	2	1	2	1
Combination 9	2	2	1	2	1
Combination 10	1	1	2	2	1
Combination 11	2	1	2	2	1
Combination 12	1	2	2	2	1

Table 4.15 shown some alternatives to the materials that can be used to create the structure of this food delivery machine. Following the formation of multiple possible combinations, an evaluation will be conducted at the next stage.

➢ **Evaluation Stage**

Each concept's evaluation phase is the value assessment phase. This evaluation is conducted by evaluating the function and cost of each concept. The evaluation is based on the worker's evaluation of the importance of each concept for each characteristic. The evaluation is shown in the table 4.16 below.

Table 4. 16 Concept Score

		Concept Score											
Attribute	Weight	1	2	3	4	5	6	7	8	9	10	11	12
Ease of Use	7.50%	3	3	4	4	4	3	3	3	3	3	3	3
Security	18.80%	3	3	3	3	3	4	4	4	4	2	2	2
Comfort	11.30%	3	3	3	3	3	3	3	3	3	3	3	3
Strength	7.50%	4	3	4	3	3	4	3	3	1	4	3	3
Accuracy	18.80%	3	3	3	3	3	3	3	3	3	4	4	4
Price	4.50%	2	2	1	2	2	2	3	3	4	3	2	3
Time efficiency	22.50%	3	3	3	3	3	3	3	3	3	3	3	3
Anti-karat	3.00%	2	3	1	2	2	3	3	3	4	3	3	3
Durable	6.30%	4	2	4	3	2	3	2	3	2	3	2	4
Function		3.069	2.898	3.069	3.006	2.943	3.224	3.131	3.194	3.056	3.081	2.898	3.069

To calculate the function, use the formula 2.5 provided below.

$$Function \quad = \sum(Ai\ x\ \%\ Wi)$$

$$= (3\ x\ 0.075) + (3\ x\ 0.188) + (3\ x\ 0.113) + (4\ x\ 0.075) + (3x\ 0.188) + (2\ x\ 0.045) + (3\ x\ 0.225) + (2\ x\ 0.03) + (4\ x\ 0.063) = 3.069$$

After evaluating the function, the next step is to evaluate the cost of each concept. The costs assessed for each concept include the material, labor, and overhead expenses required to implement the concept. Material expenses are the expenses incurred to acquire materials. The material costs for each material are detailed in the table below.

Table 4. 17 Estimated Material Cost

Part	Material	Material Price (Rupiah)
Buffer	*Stainless steel*	36,000
	Iron	102,250
Place of feed input	*Stainless steel*	160,000
	Iron	103,950
Connectors	Stainless steel	3,458,900
	Iron	550,000
Machine cost	Vacuum	600,000
	Grip	3,100,000
	Dinamo motor BS-4525A	1,750,000

In the construction of a Food Delivery Machine, in addition to the conceptual components, there are additional components that come together to form a single tool. Table 4.18 displays the section along with the material and cost of the material.

Table 4. 18 Other material costs

Part	Material	Specifications	Necessity		Price	Unit	Total
			Sum	Size			
Assembly	Mur builds	M6 25	70		304,00	Pcs	21. 280
	Glue	Vineland	4		54,000	Pcs	54,000
Feeder	Plastic	Thickness 1 cm		35	6,000	Pcs	210,000

Calculating labour costs is based on the cost of transforming these materials into tool components. According to Regulation 28/PRT/M/2016 of the Minister of Public Works and Public Housing, the time required to transform raw materials into tool parts is determined by the labour coefficient.

Table 4. 19 Standard Time Efficiency

Material	Workmanship	Size	Information	Time (hours)
Wood	Cutting + mounting	1000000	Cm^3	21
	Painting	10000	Cm^2	0.325
Plywood	Creation + installation	10000	Cm^2	3
	Painting	10000	Cm^2	0.325
Iron plate	Cutting	10000	Cm^2	1.05
	Installation	10000	Cm^2	0.35
	Welding	10	Cm	0.02
	Refinement	10000	Cm^2	0.15
	Painting	10000	Cm^2	0.25
Iron frame	Cutting	10000	Cm^2	0.65
	Installation	10000	Cm^2	0.35
	Welding	10	Cm	0.02
	Refinement	10000	Cm^2	0.15
	Painting	10000	Cm^2	0.25
Wall & Builds	Installation	1	pcs	0.2

Source: Regulation of the Minister of Public Works and Public Housing, 2016

Calculation of each material's processing time is based on the labor coefficient. The processing times for each material are detailed in Table 4.20.

Table 4. 20 Material processing time

Part	Material	Size	Information	Sum	Time
Buffer	*Stainless steel*	60	Cm	1	0.1308
	Iron	60	Cm	1	0.1308
Place of feed input	*Stainless steel*	200	Cm2	1	0.436
	Iron	200	Cm2	1	0.436
Connectors	Stainless steel	4000	Cm	1	1.4
	Iron	4000	Cm	1	1.4
Machine cost	Vacuum	0		1	0
	Grip	0		1	0
	Dinamo motor BS-4525A	0		1	0
Assembly	*Mur*	70	pcs	1	14

The time that mentioned in table 4.20 above is estimated time based on regulations from the Minister of Public Works and Public Housing, time adjusted base on the size of the material that would be in process.

The table 4.20 is used to determine the cost of manufacturing tool parts with the material based on the amount of time required to process the material. Calculating the cost of manufacturing tools based on the time and wages of hourly workers. People's monthly wages are adjusted to the UMR (Regional Minimum Wage) of Rp 2,835,021, that is in Semarang.

$$\text{Hourly rate} = \frac{2{,}835{,}021}{22 \, x \, 7}$$

$$= \text{Rp. } 18.409$$

The need for working hours and the hourly wages of people determines labour costs. The need for labour costs to transform raw materials into tool components is outlined in the table below.

Table 4. 21 Labour Cost

Part	Material	Time	Cost
Buffer	Stainless steel	0.1308	2407.93
	Iron	0.1308	2407.93
Place of feed input	Stainless steel	0.436	8026.42
	Iron	0.436	8026.42
Connectors	Stainless steel	1.4	25772.92
	Iron	1.4	0.00
Machine cost	Vacuum	0	25772.92
	Grip	0	0.00
Assembly	Mur	14	0.00

Material and labour costs are applied to the total of each concept. In the calculation of total costs, overhead expenses are also included. The additional overhead costs account for 30% of labour costs.

Table 4. 22 Cost of each concept

Concept	Material Costs Variable	Material Costs Total	Labour costs	Overhead Costs	Total cost of the concept
Combination 1	4,254,900	6,290,180	293,936.5	88180.94443	6,672,297
Combination 2	4,198,850	6,234,130	293,936.5	88180.94443	6,616,247
Combination 3	6,754,900	8,790,180	293,936.5	88180.94443	9,172,297
Combination 4	6,821,150	8,856,430	293,936.5	88180.94443	9,238,547
Combination 5	6,698,850	8,734,130	293,936.5	88180.94443	9,116,247
Combination 6	4,254,900	6,290,180	293,936.5	88180.94443	6,672,297
Combination 7	1,412,250	3,447,530	293,936.5	88180.94443	3,829,647

Table 4. 22 Cost of each concept (Continued)

Concept	Material Costs Variable	Material Costs Total	Labour costs	Overhead Costs	Total cost of the concept
Combination 8	1,289,950	3,325,230	293,936.5	88180.94443	3,707,347
Combination 9	1,356,200	3,391,480	293,936.5	88180.94443	3,773,597
Combination 10	1,346,000	3,381,280	293,936.5	88180.94443	3,763,397
Combination 11	1,412,250	3,447,530	293,936.5	88180.94443	3,829,647
Combination 12	1,289,950	3,325,230	293,936.5	88180.94443	3,707,347

The calculated concept cost from table 4.22 is used to calculate the value by comparing it to the previously determined function value. In its determination, value is a non-united quantity, whereas cost is a quantity with units. Therefore, the function's value is converted into the same unit as the cost. To change the value of the function, use the benchmark concept's assumption value, concept 1 with value 1. Below is an illustration of how to calculate the value of a concept 2 example value.

Concept function value 2 = 2,898

Benchmark concept function 1 value = 3,069

Benchmark concept cost = Rp. 6,672,297

Nilai function $= \frac{F1.Co}{Fo}$

$= \frac{2{,}898\ x\ 6{,}672{,}297}{3{,}069}$

= 6,300,526

Concept Cost 2 = 6,616,247

Value concept 2 $= \frac{Function}{Cost}$

$= \frac{6{,}300{,}526}{6{,}616{,}247}$

Value concept 2 = 0.952281072

The outcomes of each value calculation for concepts one through twelve are detailed in Table 4.23.

Table 4. 23 Value of each Concept

Concept	Function	Function in rupiah	Cost of Concept	Value
1	3.069	6,672,297.426	6,672,297	1
2	2.898	6,300,527.188	6,616,247	0.952281072
3	3.069	6,672,297.426	9,172,297	0.727440151
4	3.006	6,535,329.444	9,238,547	0.707397943
5	2.943	6,398,361.461	9,116,247	0.701863515
6	3.224	7,009,282.144	6,672,297	1.050505051
7	3.131	6,807,091.313	3,829,647	1.777472064
8	3.194	6,944,059.296	3,707,347	1.873053291
9	3.056	6,644,034.191	3,773,597	1.760663219
10	3.081	6,698,386.565	3,763,397	1.779877543
11	2.898	6,300,527.188	3,829,647	1.645197713
12	3.069	6,672,297.426	3,707,347	1.799749702

- Operational Cost

  Labour cost to operate machine = Rp 2,835,021 x 2 = Rp 5,670,042

  Electricity cost = 3000: 1000

  = 3 kwh

  = 3 Kwh x Rp. 1,444,70 x 30

  = Rp 130.023

  The cost is reduced from the previous labour cost Rp 11,340,084, the machine can replace the number of workers with the total monthly operational Rp 5,800,065 include electricity.

- **Development Stage**

  During the development stage, an alternative concept is selected for further development through this procedure. Based on the results of the calculation in table 4.23, the alternative concept selection process selects the concept with the highest value, which is the eighth concept with a value of 1.87305 and a concept cost of Rp 3,707,347.

4.2.3 System Level Planning

The second step in the process of planning and developing a product is system level planning. During this phase, the food delivery machine is broken down into subsystems that form a bill of materials tree for the tools. The results of the BoM Tree are depicted in the following figure.

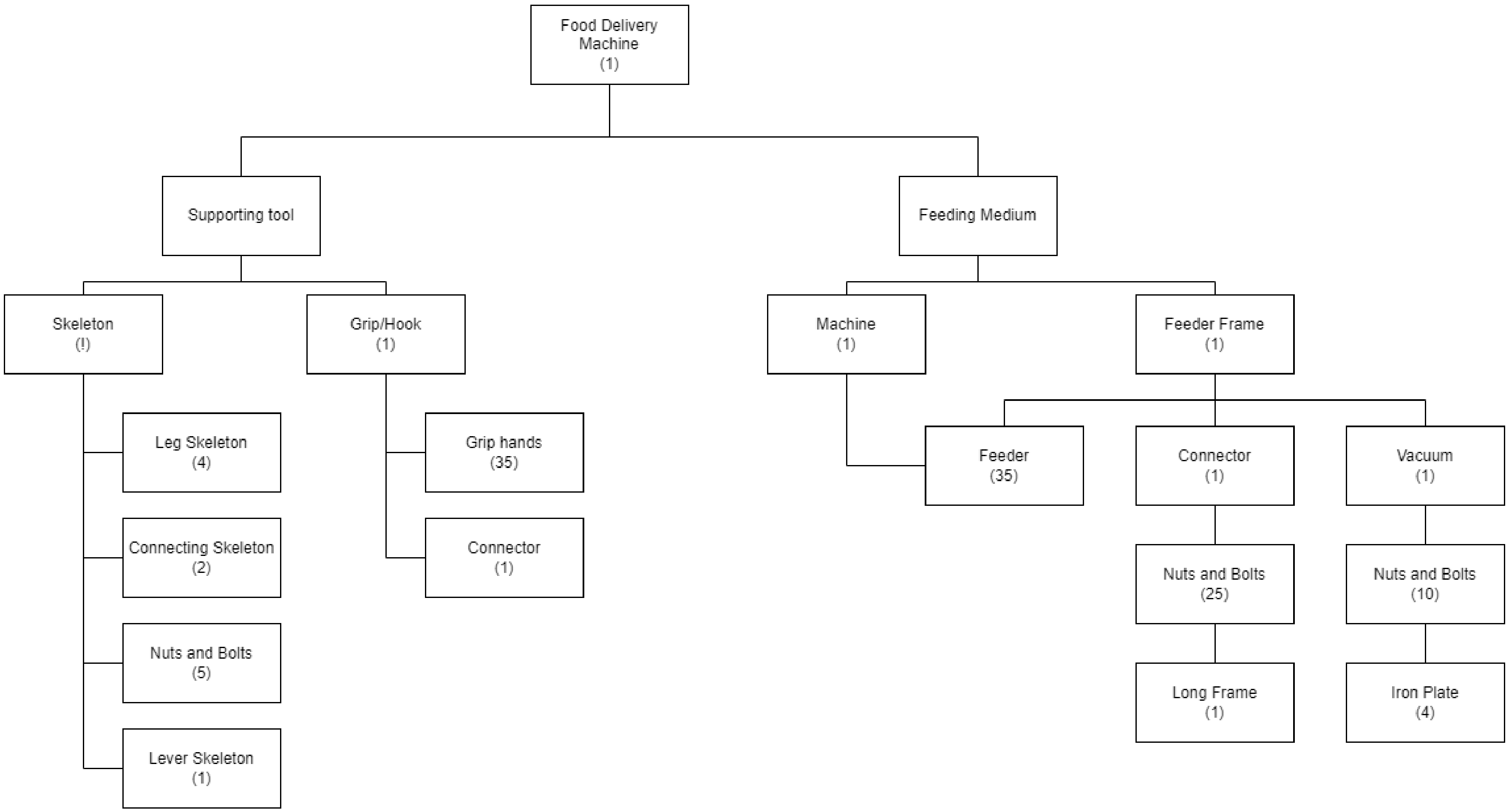


Figure 4. 8 Bill of Material Tree

4.2.4 Detailed Design

The food delivery machine design is specified in the detailed design. The components that comprise a chicken feeding device are specified in great detail in the detailed design. In addition, the determination of manufactured or purchased components is carried out.

Table 4. 24 Bill of Material

No	Component	Material	Total	Information	Dimension
1	Buffer tools	Iron	1	Create	69 x 60 x 54 cm
1.1	Skeleton		1	Create	69 x 60 x 54 cm
1.1.1	Table leg frame	Iron	4	Create	4x4x90 cm, thickness 2mm
1.1.2	Connecting frame	Iron	4	Create	4x4x20 cm, 2mm thick
1.1.3	Lever frame	Iron	1	Create	2x4x60 cm, 2mm thick
1.1.4	Nuts and Bolts		5	Buy	M6 25
1.2	Grip/Hook	Stainless steel	1	Create	69 x 60 cm, 1.2 cm thick
1.2.1	Table leg frame	Iron	4	Create	3x3x40 cm, thick 2mm
1.2.2	Connector	Iron	1	Create	20x20x30 cm, 3mm thick
2	Feeding tools		1	Create	
2.1	Machine		1	Buy	Motor reels
2.2	Frame of feeding device		1	Create	
2.2.1	Feeder	Plastic	35	Buy	20 x 20 cm
2.2.2	Connectors	Iron	1	Create	20 cm, 40m
2.3.1.1	Long frame	Stainless Steel	1	Buy	6” inch
2.3.1.1	Nuts and Bolts		25	Buy	M6 25
2.2. 3	Feed input tool	Iron	1		D 30 cm

Table 4. 25 Bill of Material (Continued)

No	Component	Material	Total	Information	Dimension
2.3.1.1	Skeleton	Iron	1	Create	D 30 cm
2.3.1.2	Nuts and Bolts		10	Buy	M6 25
2.3.1.3	Iron plate connector		4	Create	4x4x20 cm, 2mm thick

The bill of materials in table 4.24 describes in detail the components of the food delivery machine. The BoM Tree differs from the BoM Table in that the BoM Tree only includes the number and parts, whereas the BoM Table includes the ingredients and approximate dimensions for each component.

4.2.5 Analysis Planning Stage

At the planning stage, which is the initial stage of the beginning of the research, a preliminary identification of the issues that arise for the workers at Mijen's Chicken Farm, particularly in the daily feeding process, is conducted. Identification includes the process of observing workers during feeding who still rely on manual methods and whose work position is not very ergonomic, as indicated by the REBA scores of 11 to 15.

At this stage, workers were also given interviews and questionnaires. According to the interviews, the workers were between 20 and 30 years old. This age can be used as a benchmark for the severity of the risk. Feeding time for workers is 2 hours per day.

4.2.6 Analysis Quality Function Deployment

The identification of user needs that will be utilized in QFD is obtained through worker interviews. From the results of the interview, it was determined that the user's statement was then translated into user needs, which included easy-to-use products, safe products for users, comfortable products to use, strong products that can withstand loads and are not easily broken, products that can feed the appropriate amount, effective tools, rust-resistant products, and long-lasting products.

The results of interpreting the needs of workers are then translated into nine characteristics: usability, safety, comfort, strength, accuracy, price, time efficiency, anti-rust, and durability. The evaluation was conducted by twenty-one respondents, including workers, owners, and several local chicken farmers. From the results of the six attributes, the percentage of time efficiency with the highest percentage is 22.5 percent, followed by accuracy and security with a balanced weight of 18.8 percent, convenience with a weight of 11.3 percent, strength and ease of use with a figure of 7.5 percent, durability with a percentage of 6.3 percent, and price with a percentage of 4.5 percent in the second lowest position.

The assessment of technical responses is based on the relationship between technical responses and attributes. Six of the six attributes have technical responses with a weight greater than 10 percent. Among them are product dimensions, the number of product angles, the number of product components, the time required for product assembly, the rate of feed flow, and the material's resistance.

4.2.7 Analysis Value Engineering

In value engineering, critical functions are described using a FAST diagram; the results of the description are then incorporated into the design solution. These solutions include the use of supports, the improvement of the feeder's shape, the reduction of the number of product components, the use of durable materials, and the addition of connectors.

The development of materials used in the manufacture of food delivery machines involves twelve concepts. Utilizing concepts with the highest value, concept cost, and function, variations of the possible materials to be used are created using concepts with the highest value, concept cost, and function. Concept 4 has the highest concept cost, at Rp 9,238,547, with function 3,006 and value 0.7073. The concepts with the lowest concept costs are the eighth and twelfth concepts, which have a total concept cost of Rp 3,707,347. However, the concept 8 has a function value of 3,194 while the concept 12 has a function value of 3,069. The concept value of 8 is 1.8730 while the concept value of 12 is 1.7997, a difference of.

The concept selected for development at this concept stage is the eighth concept, which has the highest value which is 1.8730 with 3,194 functions and a total concept cost of Rp 3,707,347.

4.3 Proposed Improvement

At this stage, an improvement design based on the problems mentioned in the background problem will be displayed, the design below is a suggestion for improving work methods in an effort to reduce the complaints of workers who still use manual methods in the process, with the displayed angles following the cube's orientation.

- **Front View**

Design of front view will be shown in the figure 4.9 below.

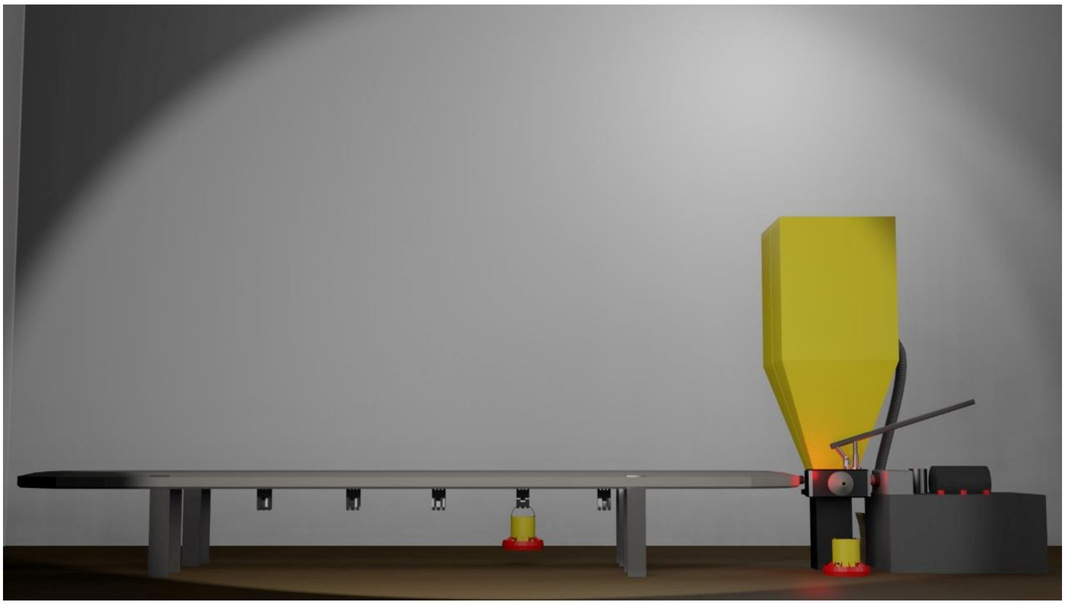


Figure 4. 9 Front View

In addition to a hopper and a conveyor, this food delivery machine also includes a chicken feed device. 50 cm is added to the height of the conveyor from the surface, 30 cm is added to the height of the feed, and 10 cm is added to both the length of the grip/hook and the distance of the feed from the ground for the hanging position.

- **Top View**

Design of top view will be shown in the figure 4.10 below.

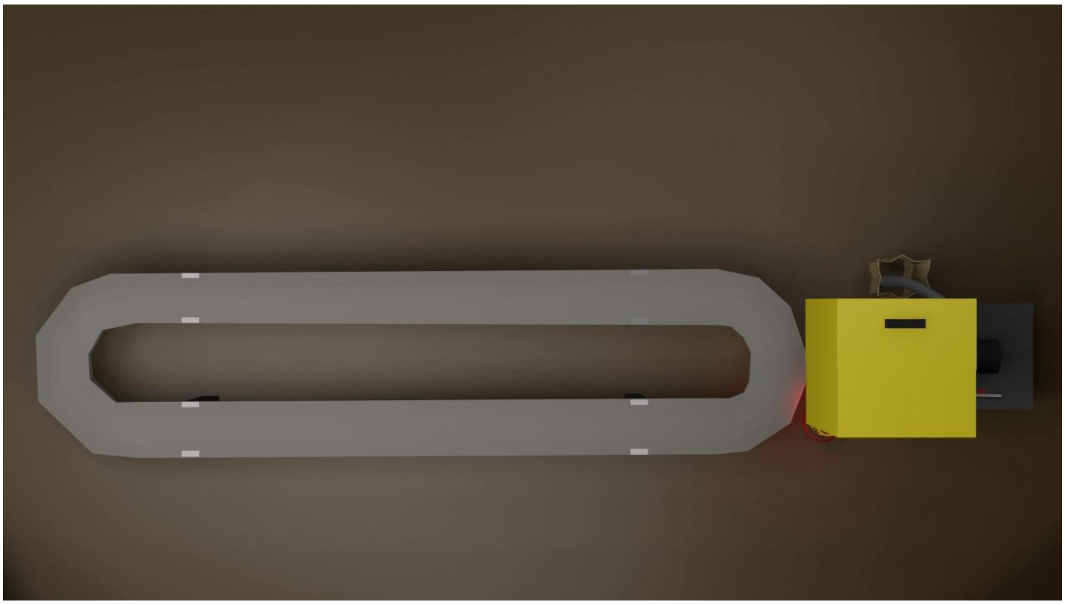


Figure 4. 10 Top View

The top view of this machine will display the intended route of the conveyor, and there is a hopper lid opener to make it easier to determine whether the conditions inside the hopper are safe, whether there is clumping, and for other hopper-related inspection needs.

- **Right View**

Design of right view will be shown in the figure 4.11 below.

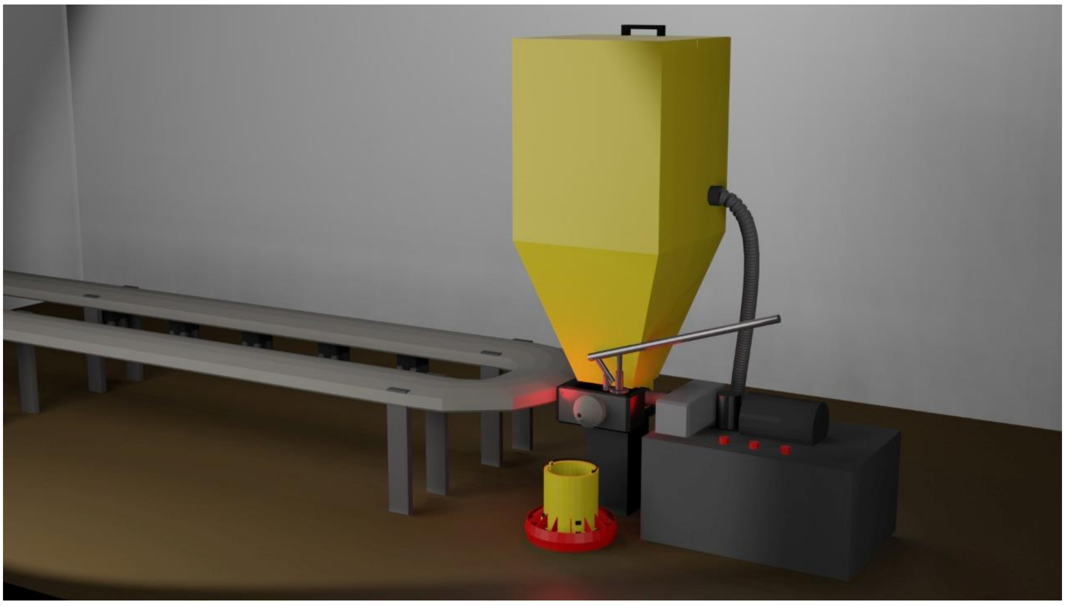


Figure 4. 11 Right View

From the right side, the hose resembles an elephant's trunk, which aims to eliminate the process of lifting the sack to fill it into the hopper. To use the vacuum, simply press the on/off button located near the machine, point the hose at the sack, and it will automatically feed. shall be drawn into the hopper.

- **Left View**

Design of left view will be shown in the figure 4.12 below.

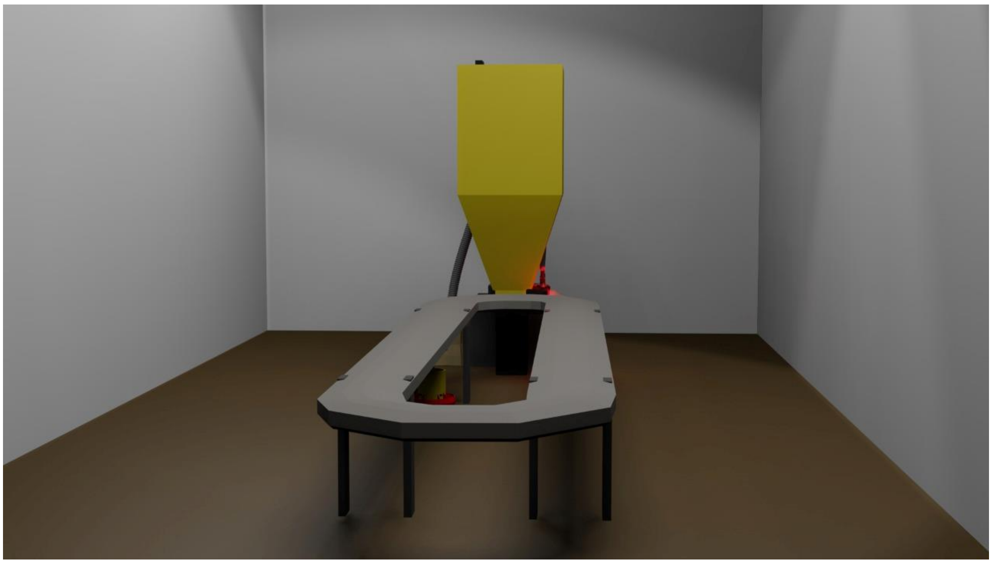


Figure 4. 12 Left View

On the left side, there are two conveyor supports that are useful for bolstering the conveyor when dozens of buckets of chicken feed are being transported.

- **Bottom View**

Design of bottom view will be shown in the figure 4.13 below.

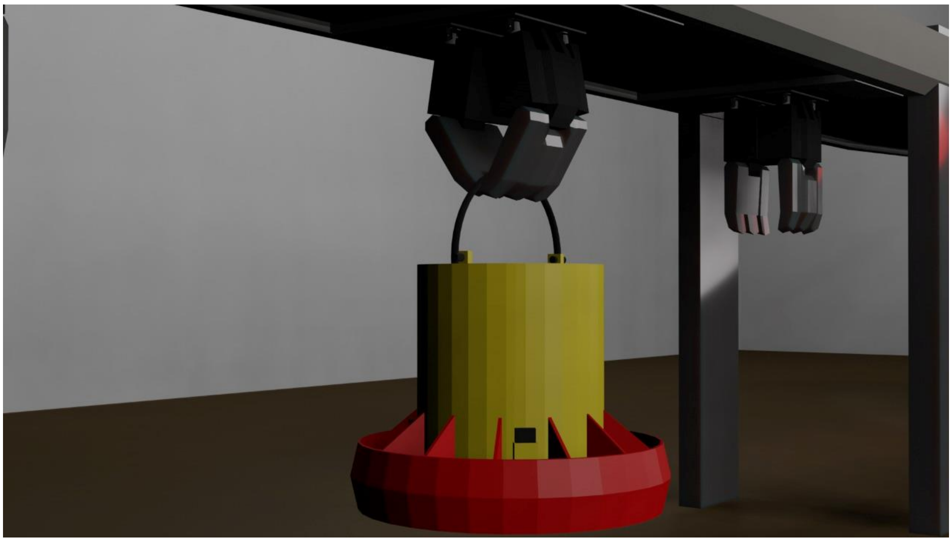


Figure 4. 13 Bottom View

On the underside is a hand grip whose purpose is to clamp the feed bucket and then distribute it to the appropriate location. When the feed has reached its destination, the claw will open, and there are on/off buttons for conveyor movement.

- **Detailed Front Corner View**

Design of front corner view will be shown in the figure 4.14 below.

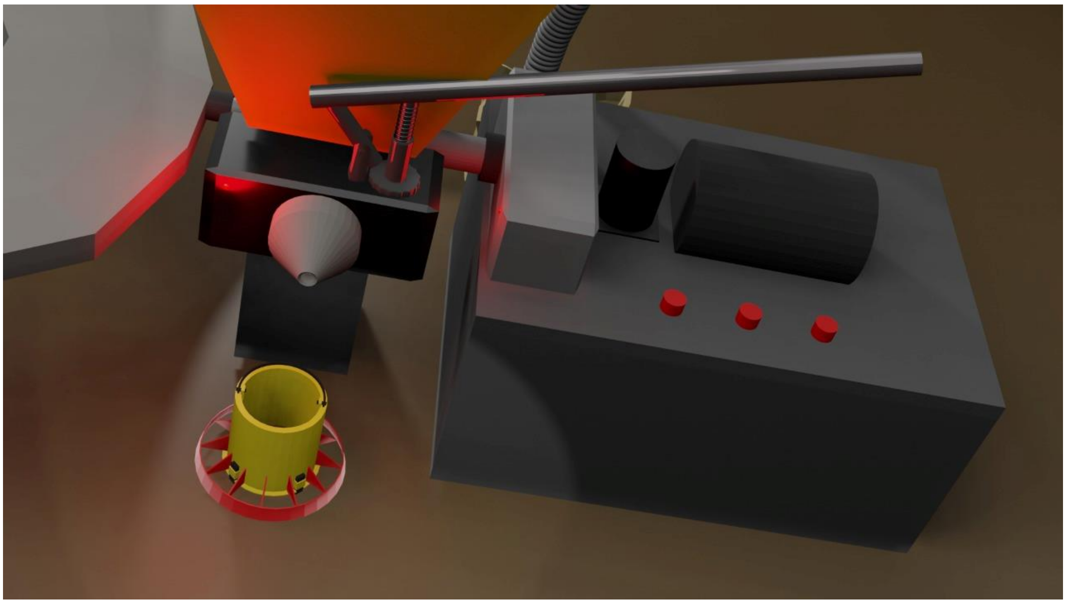


Figure 4. 14 Detailed Corner View

On the side of the hopper, as depicted in Figure 4.14, there is a lever and a spout that are used to regulate feeding. The spout serves to drain feed from inside the hopper, while the lever controls the feed flow in the hopper. If the feed bucket is full, press the lever down to shut off the flow; if want to fill the bucket, lift the lever up to open the flow.

- **Detailed Front View**

On the inside of the hopper is a stirrer that prevents chicken feed from clumping. Since chicken feed is composed of fine grains that are prone to clumping, the addition of this stirrer takes into account the textured nature of chicken feed. If the feed becomes lumped, it cannot be distributed.

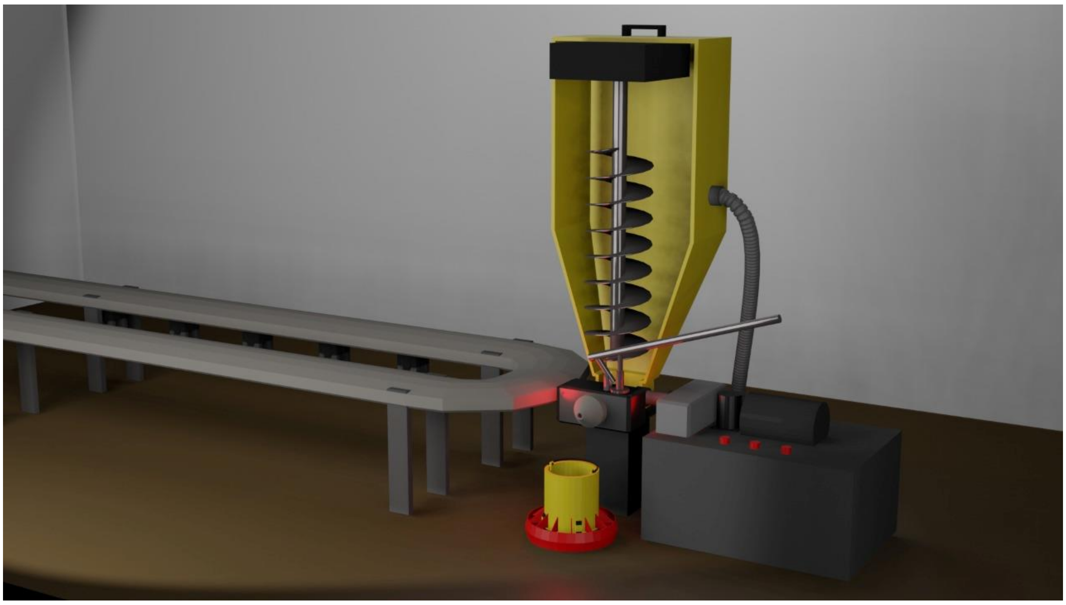


Figure 4. 15 Detailed Front View

This machine operates by utilizing the motor on the right for power, then to reduce the movement of lifting the sack, a vacuum is provided in the form of a long hose to suck feed from the sack into the hopper, then in the hopper there is a stirring machine to prevent clumping of feed, then The feed will be taken down from the front side using a lever as a regulator of the outflow of feed, then the feed is hooked to the conveyor claws, then the feed will There are four control buttons for on/off machine operation, vacuum on/off control, feed mixer on/off operation, and on/off conveyor operation. This machine was design to distributed 175 of buckets in 10 minutes and it can be less based how operator operates speed flow of this machine. This tool only requires two workers to operate, saving more labour than its predecessor, which required four people. The link of the video simulation is https://drive.google.com/drive/folders/1REqDf1DHY9VBbH8bEG5tfoYbVdTdLy7o

4.4 Analysis of work posture after tool implementation

Workers evaluate the to-be-used tool experimentally through 3D design as part of the tool's implementation. In this trial, the worker's body position while performing feeding operations with the new machine was also evaluated. Based on the REBA examination, the final REBA scores for worker 1 and worker 2 are 5 and 4, respectively. The REBA score suggests a medium or moderate risk level. The REBA score is already superior to the REBA score when employees utilize the manual approach, which ranges from 11 to 15 or an average of 12.5. Figure 5. and Figure 4. depict differences in working position using manual versus modern tools.

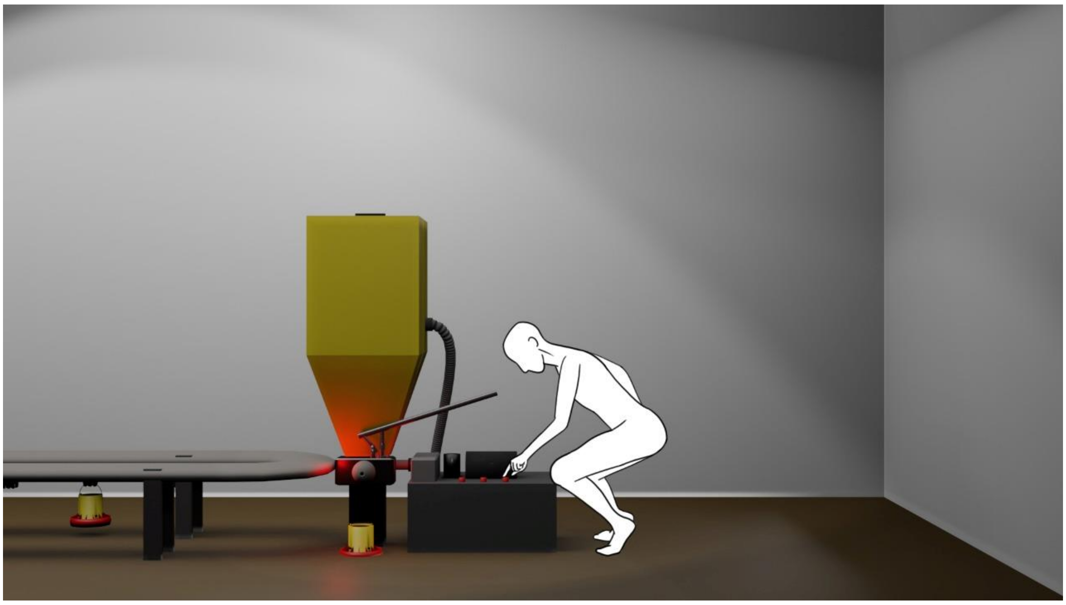


Figure 4. 16 Workers Press Button Process

This process just requires a few seconds, which is less than five seconds to click the button. And the resulting score is relatively low, 5, with specifics provided in Appendix 3.

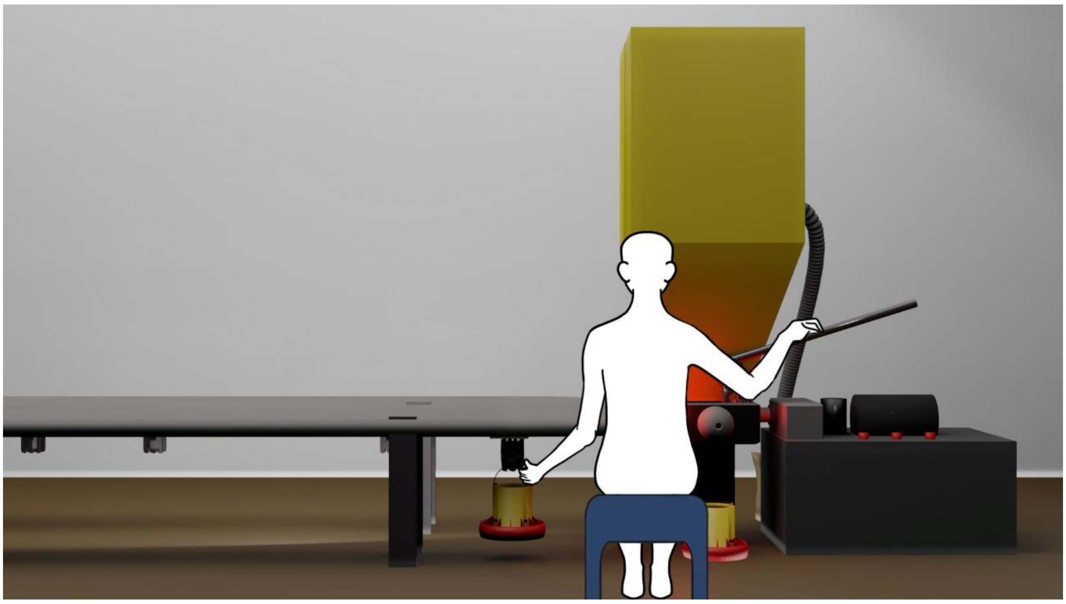


Figure 4. 17 workers fulfilment process

The second position is fulfillment process after improvement the REBA score at number 4 in the final result, this is better than the previous position which was all above number 11 which indicates a serious complaint and must immediately make changes.

Figure 4. 18 Manual process of feeding

In figure 4.18 the Reba score is 11 and 12 which indicate high risk and have to change immediately, some pain is experienced by the worker after the feeding process done. The detailed calculation is attached in appendix 5 for lifting sack and appendix 6 for pouring the food into the buckets.

4.5 Analysis cost after implementation

The amount listed below is the overall cost that must be invested to construct a food delivery machine, which substitutes the jobs of multiple workers.

Table 4. 26 Investment cost

Investment Cost	Total (Rp)
Material Cost	3,325,230
Labor Cost	293,936,5
Overhead Cost	88,180
Total	3,707,346.5

The benefits received from this machine include savings on monthly labour expenditures that must be incurred by the owner, as detailed below.

Employee salary per person : Rp 2,835,021

Number of employees : 4

Total monthly expenses : 2,835,021 x 4

: Rp. 11,340,084

Compare to the estimated cost to build the food delivery machine is approximately Rp 3,707,436, 5 once and only need two persons to operate, the detail is

Employee monthly expenses	: 2,835,021 x 2
	: Rp 5,670,042
Electricity cost	:3000: 1000
	:3 kwh
	:3 Kwh x Rp. 1,444,70 x 30
	: Rp 130.023

And currently, the total monthly expenses that the owner must pay are significantly is Rp 5,800,065 save up to Rp 5,540,019.

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The following are some conclusions that can be drawn from the final research of this project:

From the analysis using REBA method it was found that the current activities of workers in feeding chicken were not safe. The activities have REBA score from 11 to 15 which was categorized as unsafe. These conditions need immediate solution.

To improve the working condition of feeding activities, it was proposed a machine which design to help reduce the unsafe condition. The process of design the tool was using: the Quality Function Deployment method. Nine attributes were identified: usability, security, comfort, strength, accuracy, price, time efficiency, anti-rust, and durability. The attribute under consideration has a weight greater than 10 percent, indicating that it is highly desired by the user.

The evaluation of design using the value engineering method. Among 12 designs proposed, it was analysed that design with concept 8 was chosen. It has the highest value of 1.8730 and a function value of 3.194, the total cost of the concept was Rp. 3,707,347.

The proposed food delivery machines have removed some unsafe steps in manual feeding. That is the step of lifting 50kgs of feed repeatedly and bending down to fill the feed one by one into the bucket. The design of a new machine, was reanalysed, the REBA score reduces from 11-15 to 4 - 5 which is medium risk than the previous condition.

5.2 Recommendations

The author makes the following suggestions and recommendations to various parties, based on the research conducted:

Serious injuries may occur in the future if the risks faced by employees during the feeding process are not taken into consideration by the owners. By implementing this food delivery machine, several ergonomic issues would be resolved and operational expenses will be reduced. However, this design needs further assessment before implementation.

For further research, there are several recommendations for future research, including: the design of the tool can be made more modern and environmentally friendly, such as by employing solar panels as the primary source of energy.

The function is evaluated by specialists in their respective fields, namely those with experience in the development of animal feed and academics who can recommend the best materials for the production process.

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APPENDICES

Appendix 1
Questionnaire

QUESTIONNAIRE

Perkenalkan nama saya Anisa Nurul Hikmah, mahasiswa tingkat akhir prodi Teknik Industri Universitas Presiden. Saya sedang melakukan penelitian mengenai "Pengembangan Alat Pakan Ayam Guna Mengurangi Gerakan Pekerja Yang Tidak Ergonomis". Oleh karena itu saya memohon kesediaan Bapak untuk mengisi beberapa pertanyaan yang saya ajukan.

Nama :
Jenis Kelamin : L/P
Umur :
Pekerjaan :
Lama Kerja :

Kuisioner

1. Berapa lama anda memberi makan ayam dalam satu hari ?
   a. 1-2 jam b. 3-4 jam c. 5-6 jam
2. Berapa banyak ayam yang anda beri pakan setiap harinya?
   a. 10-15 ribu b. 16-20 ribu c. 25-30 ribu
3. Apakah anda melakukan pemberian pakan dalam satu waktu ?
   a. Ya b. Tidak
4. Jika tidak, berapa kali anda melakukan pemberian pakan dalam satu hari ?
   a. 2 kali b. 3 kali c. Lainnya ....
5. Apakah anda mengalami kendala dalam pemberian makan secara manual ?
   a. Ya b. Tidak
6. Jika Ya, apa yang membuat anda mengalami kendala ?
   a. Beban terlalu berat
   b. Pemberian dalam waktu lama menyebabkan sakit pada bagian tubuh
   c. Lainnya ...
7. Apakah anda menginginkan inovasi pada kendang ayam ini ?
   a. Ya b. Tidak

Tingkat Kepentingan

No	Atribut	Sangat penting	Penting	Kurang penting	Tidak penting
1	Keamanan				
2	Kemudahan Penggunaan				
3	Kenyamanan				
4	Kekuatan				
5	Harga				
6	Performa Kecepatan				

Karakteristik Alat

1. Apakah anda setuju jika alat dibuat untuk digunakan dalam posisi berdiri pada saat pengisian pakan ke Hopper ?
   a. Ya b. Tidak
2. Material apa yang sebaiknya digunakan untuk chicken feeder ini ? rel (aluminium + stainless steel)

Feeder pan	Hopper	Rel
a. Besi	a. Baja	a. aluminium
b. Plastic	b. Stainess Steelb. Besi	
c. Lainnya ...	c. Lainnya...	c. Lainnya

3. Bagaimana posisi alat yang diinginkan ?
   a. Horizontal b. Vertical
4. Untuk posisi peletakan pakan ke hopper bagaimana posisi yang diingkan ?
   a. Dituangkan dengan di angkat ke hopper
   b. Disedot menggunakan vakum
   c. Lainnya ....

Semarang, Maret 2022

Appendix 1 Research Questionnaire

Appendix 2

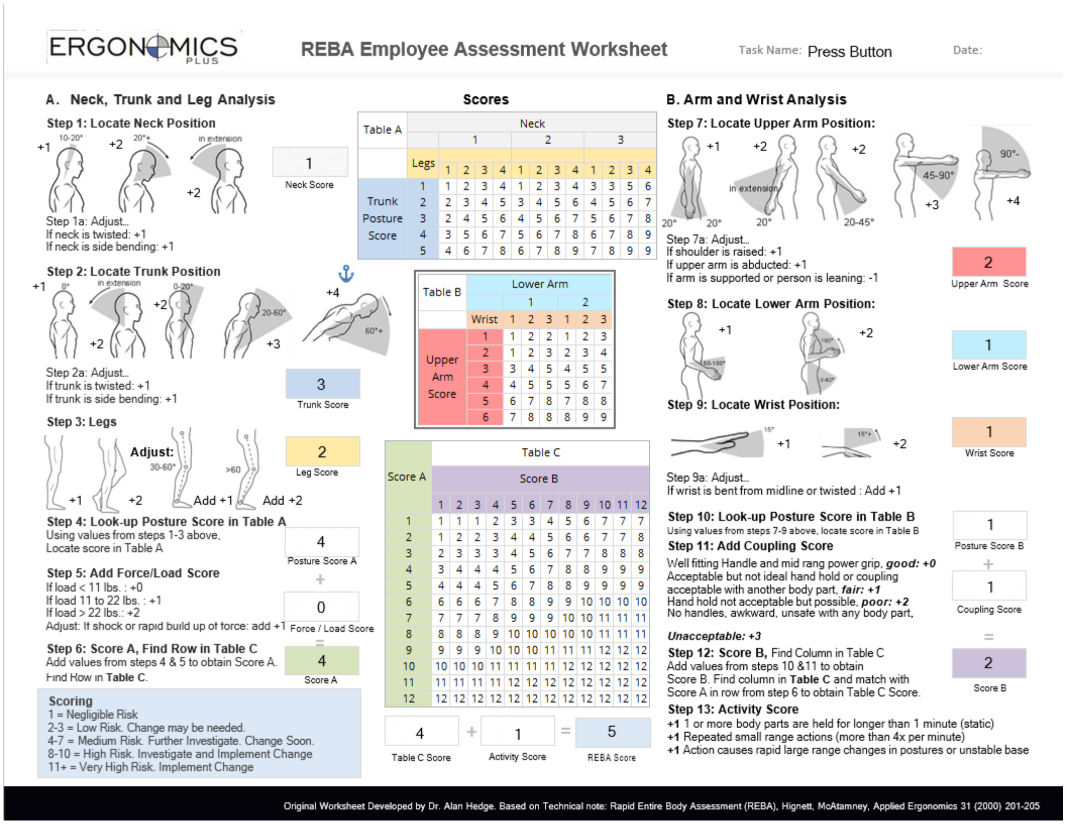
Result of Attribute Interest Level Questionnaire Recap

Attribute	Score																					Mode
Ease of Use	4	3	4	2	4	4	2	3	3	3	4	3	2	2	3	3	3	4	3	4	3	3
Security	2	3	2	4	3	2	3	2	4	4	2	4	3	4	2	2	4	3	4	2	2	4
Comfort	2	3	4	2	4	3	4	2	2	3	2	2	3	3	4	2	3	2	4	3	2	3
Strength	2	4	2	3	2	4	3	3	4	3	4	3	2	3	3	4	4	4	4	3	4	3
Accuracy	2	3	3	3	3	3	4	4	3	3	2	4	2	3	3	2	3	4	2	2	3	4
Price	2	4	3	4	3	3	4	3	3	3	4	3	3	4	4	2	3	2	2	2	3	3
Efficiency	4	3	2	4	2	2	4	4	4	2	3	4	3	4	2	3	2	4	4	4	4	3
Anti-rust	4	3	4	3	4	4	4	4	4	2	3	3	2	2	3	2	4	3	2	4	3	2
Durable	3	2	4	4	2	4	3	2	4	3	2	4	4	3	3	3	2	4	2	2	3	2

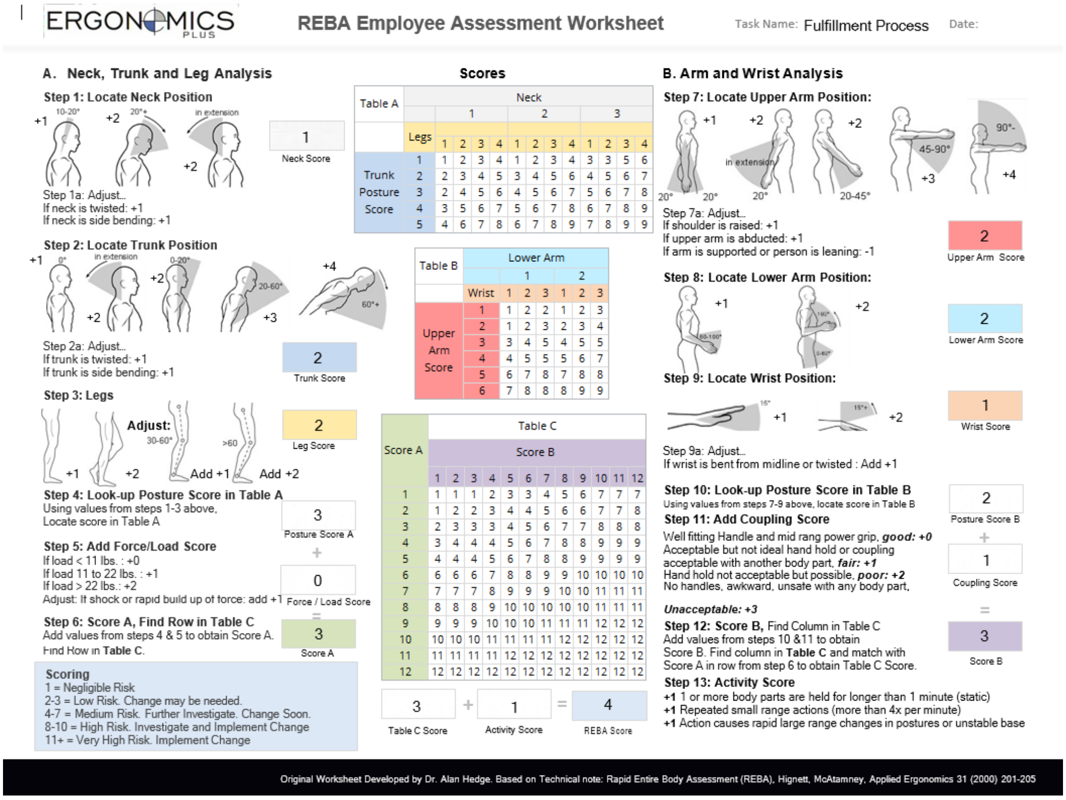
Appendix 2 Table of Questionnaire Recap

Appendix After

Calculation of after REBA



Appendix 3 REBA Press Button process



ERGONOMICS PLUS

REBA Employee Assessment Worksheet

Task Name: Fulfillment Process Date:

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

+1 10-20° +2 20°+ in extension +2

1 Neck Score

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 2: Locate Trunk Position

+1 0° in extension +2 +2 0-20° 20-60° +3 +4 60°+

Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

2 Trunk Score

Step 3: Legs

+1 +2 Adjust: 30-60° Add +1 >60 Add +2

2 Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above,
Locate score in Table A

3 Posture Score A

Step 5: Add Force/Load Score
If load < 11 lbs. : +0
If load 11 to 22 lbs. : +1
If load > 22 lbs.: +2
Adjust: If shock or rapid build up of force: add +1

+ 0 Force / Load Score

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

= 3 Score A

Scoring
1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further Investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

Scores

Table A	Neck	1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B	Lower Arm	1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table C

Score A \ Score B	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

3 Table C Score + 1 Activity Score = 4 REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

+1 20° 20° +2 in extension 20° +2 20-45° 45-90° +3 90°- +4

Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

2 Upper Arm Score

Step 8: Locate Lower Arm Position:

+1 60-100° +2 100°+ 0-60°

2 Lower Arm Score

Step 9: Locate Wrist Position:

15° +1 15°+ +2

1 Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

2 Posture Score B

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, ***good: +0***
Acceptable but not ideal hand hold or coupling acceptable with another body part, ***fair: +1***
Hand hold not acceptable but possible, ***poor: +2***
No handles, awkward, unsafe with any body part,
Unacceptable: +3

+ 1 Coupling Score

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

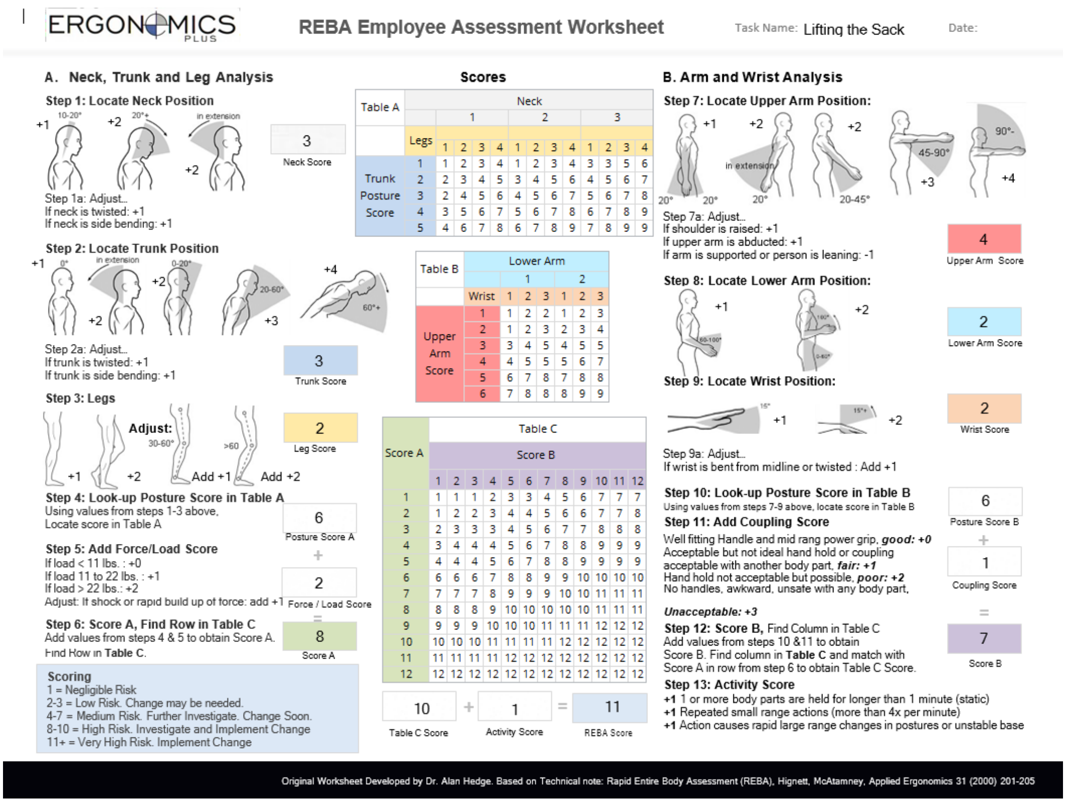
= 3 Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

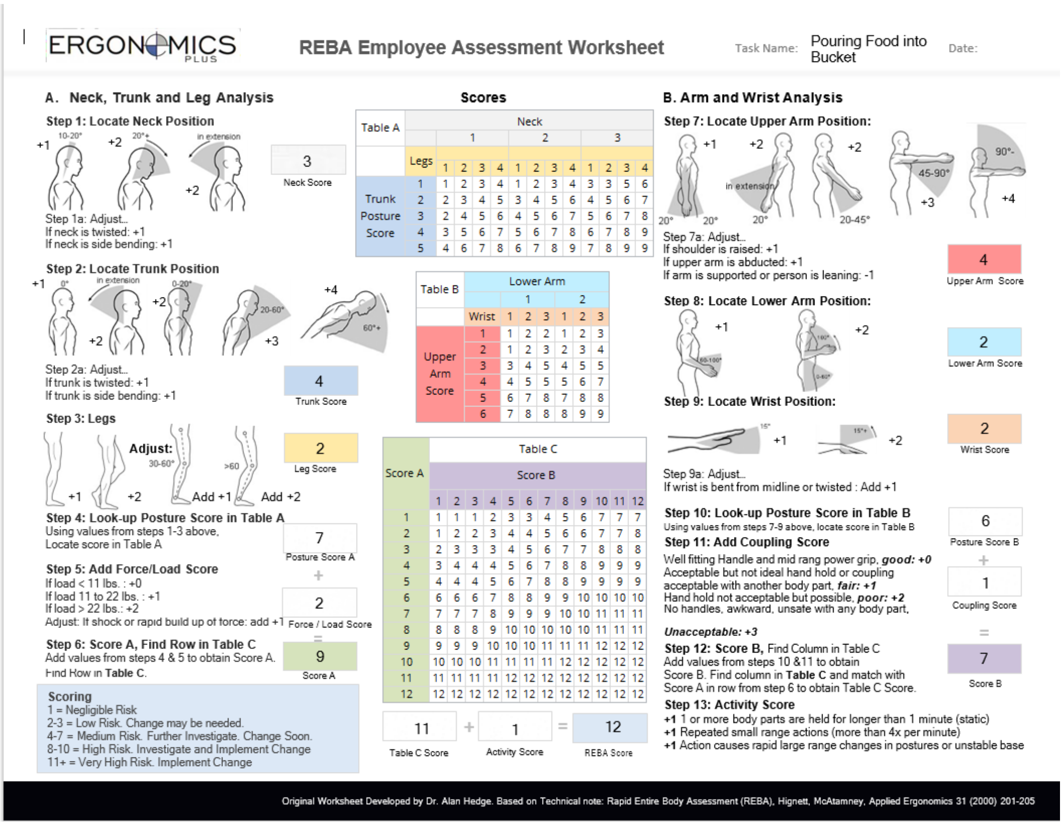
Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

Appendix 4 Fulfilment Process into the bucket

Appendix Before



Appendix 5 Lifting Sack process



Appendix 6 Pouring food into the bucket process