

DESIGN OF A POTATO GRATING MACHINE WITH ROTARY DRIVE AND 10 KG CAPACITY USING SOLIDWORKS

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Abstract. *The potato grating process is an important stage in food processing that is still often done manually or using simple tools, making it less efficient and potentially causing safety issues and inconsistency in results. The main problems faced are limited capacity, uneven grated results, and low levels of operator safety and comfort. This study aims to design a potato grater machine with a rotary drive with a capacity of 10 kg that suits user needs. The Quality Function Deployment (QFD) method is used to translate user needs into technical characteristics through the preparation of a House of Quality (HOQ). Based on the results of the QFD analysis, the priority of the main technical characteristics is obtained, namely the rotational speed of the disc, frame stiffness, safety system, and diameter of the shredding disc. These characteristics are then used as the basis for machine design using SolidWorks software. The results of the study are a potato grater machine design that has a stable structural configuration, a controlled rotary drive system, and is equipped with safety guards, so it is expected to be able to improve efficiency, safety, and quality of the shredded results.*

Keywords: HOQ; Potato Grater Machine; QFD; Rotary Drive; SolidWorks.

1. INTRODUCTION

Potatoes are a food commodity widely used as a raw material for various processed products, both at the household level and in small and medium enterprises (SMEs). Potato processing generally involves a grating stage to produce semi-finished products that are then processed into various food products. In practice, the grating process is still often done manually or using simple tools, requiring a relatively large workforce and a relatively long processing time. (Simanjuntak et al., 2021).

The use of conventional potato graters often causes several problems, including limited production capacity, non-uniform grated results, and high levels of operator fatigue. (Permana & Nurwathi, 2021) Furthermore, occupational safety and hygiene are often neglected, potentially leading to workplace accidents and reduced product quality. This presents a challenge for SMEs seeking potato graters with larger capacities, stable processing, and safe and easy operation.

Along with the increasing need for efficiency and productivity in food processing, a potato grating machine is needed that is able to work more optimally. (Harius & Arief, 2025). The designed machine is not only required to have the appropriate capacity, but also must produce uniform gratings, be easy to clean, safe to use, and have efficient energy consumption. However, machine designs that only focus on technical aspects often do not pay attention to the user's needs as a whole, so the design results do not fully meet user expectations.

Therefore, a design approach is needed that can systematically integrate user needs into the machine's technical specifications. The Quality Function Deployment (QFD) method is one

approach that can be used to translate customer needs (voice of customer) into product technical characteristics through the preparation of a House of Quality (HOQ). With this method, design priorities can be determined objectively so that the resulting machine design is more effective and in accordance with user needs.(Shukla & Chauhan, 2016).

Based on these problems, this study proposes the design of a potato grater machine with a rotary drive with a capacity of 10 kg, modeled using SolidWorks software. The rotary drive system was chosen because it is capable of producing a continuous and stable grating process, so it is expected to increase the capacity and quality of the grated results. The application of the QFD method in this study is expected to direct the design process to be more structured and oriented to user needs.(Ali et al., 2025).

The purpose of this study is to design a potato grater with a rotary drive with a capacity of 10 kg that meets user needs in terms of capacity, stable results, safety, and ease of maintenance. Furthermore, this study aims to analyze the application of the QFD method through the House of Quality in determining the priority of technical characteristics and producing a machine design that is ready to be developed into the manufacturing stage.

2. LITERATURE REVIEW

2.1 Grating Machines in Food Processing

A grating machine is a mechanical device widely used in food processing, particularly for hard to medium-textured materials such as tubers. The primary function of a grating machine is to reduce the size of the material by scraping the surface using a rotating grating element. The use of a grating machine aims to increase process efficiency, speed up production times, and produce a more uniform grated product size compared to manual processing.(Thoriq & Sutejo, 2018).

In potato processing, the grating process plays a crucial role because it affects the quality of the final product. A grating machine designed with a well-designed mechanical system is capable of producing consistent gratings while minimizing material loss. Therefore, design aspects such as the shape of the grating disc, rotational speed, and structural stability are crucial factors in designing a potato grating machine.

2.2 Rotary Drive System in Food Processing Machines

Rotary drive systems are widely used in food processing machines because they produce stable and continuous rotating motion. In grating machines, the rotary system allows the grating element to work evenly across the entire surface of the material, resulting in more uniform shredded results. Furthermore, rotary systems are relatively simple, easy to maintain, and have good mechanical efficiency.

The rotational speed of a rotary system must be adjusted to the characteristics of the material being processed. Too low a speed can result in suboptimal shredding, while too high a speed can potentially cause excessive vibration and accelerate component wear. Therefore, the design of a rotary drive system requires a balance between capacity, quality, and operator comfort.(Putra et al., 2024).

2.3 Quality Function Deployment (QFD) and House of Quality (HOQ)

Quality Function Deployment (QFD) is a design method used to systematically translate customer needs (voice of customer) into technical product characteristics. QFD aims to ensure that the designed product truly meets user needs, not just based on the designer's assumptions.(Ginting et al., 2020). One of the main tools in the QFD method is the House of Quality (HOQ), which functions to map the relationship between customer needs and technical characteristics.(Vadila, 2023).

Through HOQ, technical characteristics can be prioritized based on their importance to

customer needs. Applying QFD to machine design allows the design process to be more structured, objective, and user-oriented. This method is widely used in engineering product development because it can reduce the risk of mismatch between design and actual user needs.(Longshore et al., 2023).

2.4 Product Design Using SolidWorks

SolidWorks is a computer-aided design (CAD) software widely used in engineering product design. This software allows designers to create three-dimensional models, perform initial simulations, and evaluate component layouts before manufacturing. Using SolidWorks in machine design offers the advantage of clearer and more accurate design visualization.(Pranata et al., 2025).

In designing the potato grater, SolidWorks was used to model all major components, such as the frame, hopper, grating disc, and drive system. Three-dimensional modeling minimizes potential design errors early on, ensuring the resulting design is more ready for production.

3. RESEARCH METHODS

This research uses a user-needs-based product design approach by applying the Quality Function Deployment (QFD) method. This method is used to produce a potato grater machine design with a rotary drive with a capacity of 10 kg that meets user needs and has systematically prioritized technical characteristics.

This research was conducted at the Mechanical Engineering Laboratory, Muhammadiyah University of West Sumatra, from November 2025 to January 2026. The research activities included collecting user requirements data, QFD analysis, preparing a House of Quality (HOQ), and designing a machine using SolidWorks software. The research was conducted through the stages as shown in Figure 1.

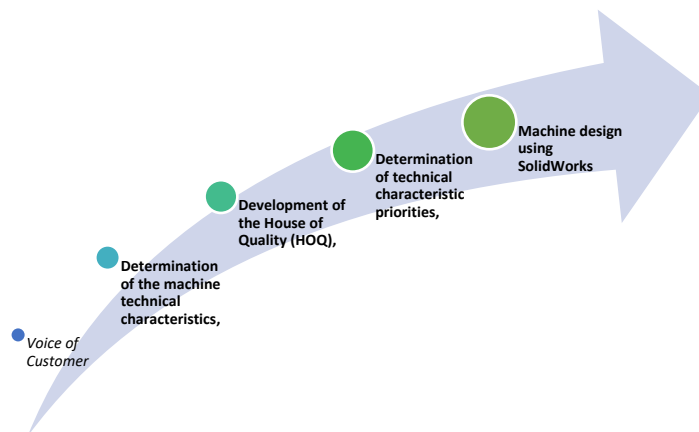


Figure 1. Flow chart

Stages to ensure that design results are based on user needs and structured technical analysis.

1. Identify Customer Needs

Customer needs were identified based on literature reviews, observations of similar equipment, and the characteristics of potato grater usage in households and small and medium-sized businesses. Each customer need was assigned a priority weight using a scale of 1–5. The results of the customer needs identification were used as the basis for developing the QFD.

2. Determination of Technical Characteristics

Technical characteristics are defined in response to identified customer needs. These

characteristics encompass controllable aspects of machine design, such as the dimensions of key components, drivetrain, rotational speed, frame stiffness, and safety systems. These technical characteristics are used as technical variables in the development of the House of Quality.

3. Preparation of House of Quality (HOQ)

The House of Quality (HOQ) is designed to map the relationship between customer needs (W_i) and technical characteristics (H_j). This relationship is assessed using the following numerical scale:

- a. Strong relationship (○) = 9
- b. Moderate relationship (▲) = 3
- c. Weak relationship (■) = 1
- d. No relationship = 0

The value of this relationship is expressed as R_{ij} , which is the value of the relationship between the i -th customer's needs and the j -th technical characteristics.

4. Calculation of Technical Interest Value

The technical importance value is used to prioritize technical characteristics in the machine design process. This value is obtained by multiplying the customer requirement weights by the relationship values in the HOQ matrix, then summing them for each technical characteristic.

Technical importance value formula:

$$TK_j = \sum_{i=1}^n (W_i \times R_{ji}) \quad \dots(1)$$

with:

TK_j :technical importance value of j -th characteristic

W_i :weight of importance of customer i 's needs

R_{ji} :the value of the relationship between the i -th customer requirement and the j -th technical characteristic

n :number of customer requirements

The technical importance value is obtained by multiplying the weight of customer requirements by the relationship value in the HOQ matrix. The technical characteristics with the highest importance value are set as the top priority in the machine design process.

5. Machine Design Using SolidWorks

Based on the QFD analysis results and the technical characteristic priorities obtained from the HOQ, a potato grater machine with a rotary drive system was designed using SolidWorks software. The design focused on meeting the working capacity of 10 kg, the stability of the grating process, operator safety, and ease of maintenance. A three-dimensional model was used to visualize the design and evaluate the component layout before the final design was determined.

4. RESULTS AND DISCUSSION

4.1 Identifying Customer Needs (Voice of Customer)

The initial stage in the potato grater design process involves identifying customer needs (voice of customer). This identification aims to ensure that the resulting machine design meets the needs of users, particularly households and small and medium-sized food processing enterprises (SMEs).

Based on the identification results, customer needs include grating capacity and throughput, grating stability, operational safety, ease of cleaning, ease of maintenance, energy efficiency, vibration and noise levels, frame structural strength, corrosion resistance, and manufacturing costs. Each customer need is assigned a weighted importance using a scale of 1–5 according to its priority level.

The identification results showed that the highest-ranking requirements were machine capacity, stable grater output, and operator safety. This indicates that users place a high value

on machines that can operate effectively, safely, and produce uniformly grated potatoes.

4.2 House of Quality (HOQ)

The House of Quality (HOQ) is used as the primary tool in the Quality Function Deployment (QFD) method to systematically translate customer needs into the technical characteristics of a potato grater machine. The HOQ developed in this study illustrates the relationship between customer needs, technical characteristics, and the correlation between technical characteristics, which serve as the basis for determining design priorities. The structure of the House of Quality (HOQ) for a rotary-driven potato grater machine is shown in Figure 2.

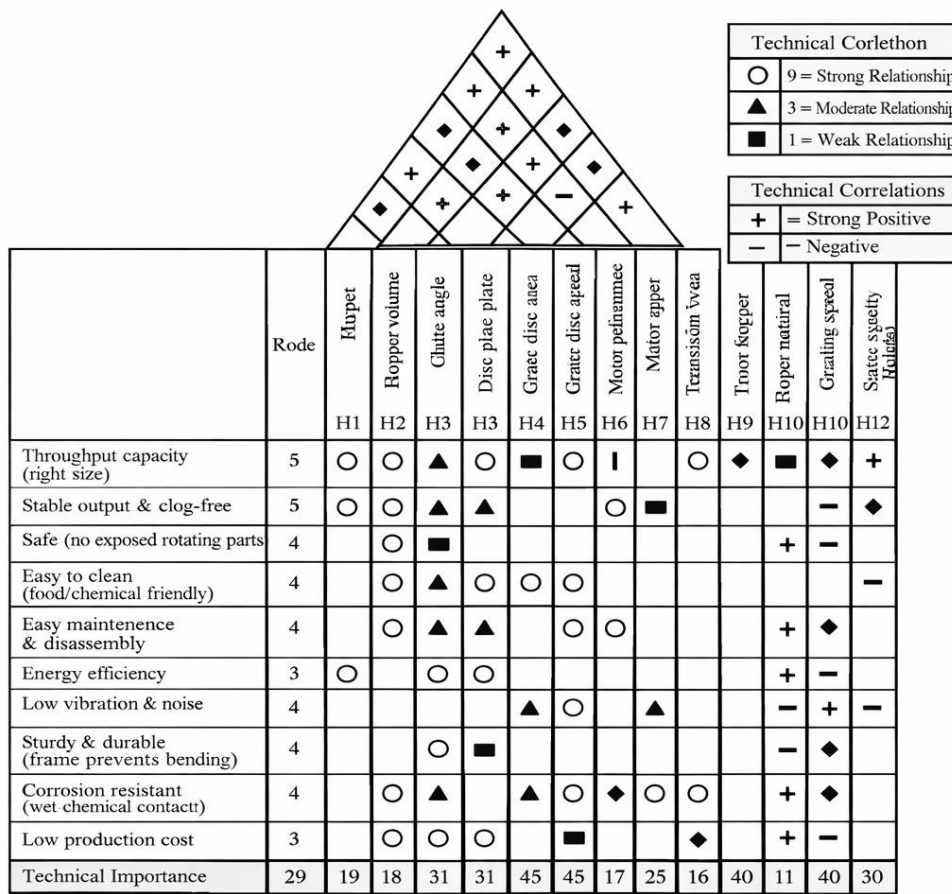


Figure 2. House of Quality (HOQ) of potato grater machine

Based on Figure 2 shows that customer requirements for shredding capacity and throughput are strongly related to the technical characteristics of hopper volume, shredding disc diameter, and disc rotational speed. This indicates that increasing machine capacity is not only determined by hopper size but also must be balanced with the rotary system's ability to process materials effectively. Furthermore, the need for stable, jam-free output is strongly linked to the disc rotational speed and the rigidity of the machine frame. A rigid frame plays a crucial role in maintaining the alignment of the shaft and disc, thus minimizing vibration and irregularities in the shredding results.

4.3 Correlation Analysis of Technical Characteristics

Correlation analysis between technical characteristics of the HOQ roof indicates positive and

negative relationships that need to be considered in the design process. A positive correlation was observed between hopper volume and shredding disc diameter, indicating that increasing the amount of incoming material must be balanced with adequate disc dimensions to maintain optimal shredding performance.

Conversely, there is a negative correlation between disc rotational speed and operator comfort, particularly with regard to increased vibration and noise. Therefore, disc rotational speed should not be increased excessively but should be optimized to produce uniform grating without causing discomfort during operation.

The calculation of the technical importance value in this study is based on the House of Quality (HOQ) shown in Figure 2, using the customer needs weights and relationship symbols found in the HOQ. The customer needs weights can be seen in Table 1.

Table 1. Customer Needs Weight

Code	Customer Needs	Weight (Wi)
W1	Work capacity according to needs	5
W2	The grater output is stable and does not jam.	5
W3	Operator security	5
W4	Easy to clean	4
W5	Easy maintenance	4
W6	Energy saving	3
W7	Low vibration and noise	3
W8	Strong and durable construction	4
W9	Corrosion resistant	4
W10	Affordable manufacturing costs	3

A. Technical Characteristics (HOWs)

The required technical characteristics of the machine are shown in Table 2.

Table 2. Technical Characteristics of the Machine

Code	Technical Characteristics
H1	Hopper volume
H2	Chute angles & geometry
H3	Disc diameter
H4	Disc diameter (working area)
H5	Disc rotation speed

H6	Motor and axle performance
H7	Transmission type
H8	Material hopper
H9	Frame stiffness
H10	Speed of the shredding process
H12	Safety system

B. WHAT–HOW Relationship Matrix (According to the HOQ Symbol)

Symbol conversion:

○ = 9

▲ = 3

■ = 1

Table 3. WHAT–HOW Relationship Matrix

Customer Needs (WHATs)	Weight	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H12
Capacity/throughput as needed	5	○	○	▲	○	■	○		○	◆	■	◆
Stable output & not easy to jam	5		○	▲	▲		▲	■			-	◆
Safe (no exposed rotating parts)	5	○	○	■							+	-
Easy to clean (food/chemical friendly)	4		○	▲	○	○	○					-
Easy maintenance & dismantling	4		○		▲		○	○			+	◆
Energy saving	3		○	▲	○						+	-
Low vibration & noise	3	○		○		▲	○		▲		-	+
Strong & durable (frame does not bend easily)	4			○	■						+	◆
Corrosion resistant (wet/chemical contact)	4	○	▲	▲		▲	○	◆	○	○	+	-
Affordable manufacturing costs	3		○	○	○		■			◆	+	-

The data above is calculated:

$$TK_j = \sum_{i=1}^n (W_i \times R_{ji})$$

Based on the results of the calculation of technical importance values in the House of Quality, the priority order of technical characteristics is obtained as shown in Table 4.

Table 4. Technical Interest Value Results

Code	Technical Characteristics	Technical Interest Value	Priority
H6	Motor and axle performance	52	1
H5	Disc rotation speed	45	2
H4	Disc diameter (working area)	45	3
H10	Speed of the shredding process	40	4
H12	Safety system	30	5
H3	Disc diameter	31	6
H1	Hopper volume	29	7
H9	Frame stiffness	25	8
H8	Material hopper	17	9
H2	Chute angles & geometry	18	10
H7	Transmission type	11	11
H11	(not dominant)	–	–

The results of this analysis are then used as a basis for determining the configuration and dimensions of the potato grating machine design, the implementation of which is summarized in Table 5.

Table 5. QFD Analysis Results

Priority Technical Characteristics	QFD Analysis Results	Implementation in Design
Motor and axle performance (H6)	Highest priority	Selection of an electric motor with sufficient torque and a stable grating shaft
Disc rotation speed (H5)	Very influential on output	The rotary system is designed with a stable rotation speed to prevent jamming.
Disc diameter (H4)	Affects capacity	The grating disc is designed with a diameter suitable for a capacity of 20 kg.
Process speed (H10)	Affect productivity	The component layout is arranged so that the flow of materials is smooth.
Safety system (H12)	Important for operators	Added protection to the disc and transmission area
Hopper volume (H1)	Capacity support	The cylindrical hopper is designed according to the material flow.
Frame stiffness (H9)	Affecting vibrations	The frame uses steel profiles to increase stability.

These technical characteristics are a top priority in the design process, as they have the most significant impact on meeting customer needs. Meanwhile, characteristics such as hopper volume, safety systems, and material contact areas are of medium importance, but are still considered to support the safety and hygiene aspects of the machine.

4.5 Potato Grater Machine Design Results

Based on the QFD analysis results and the technical characteristic priorities obtained from the House of Quality, a potato grater machine with a rotary drive system was designed using SolidWorks software. The design focused on meeting the 10 kg working capacity, ensuring the stability of the grating process, and ensuring operator safety during operation.

The design model of the potato grating machine design with rotary drive is shown in Figure 3.

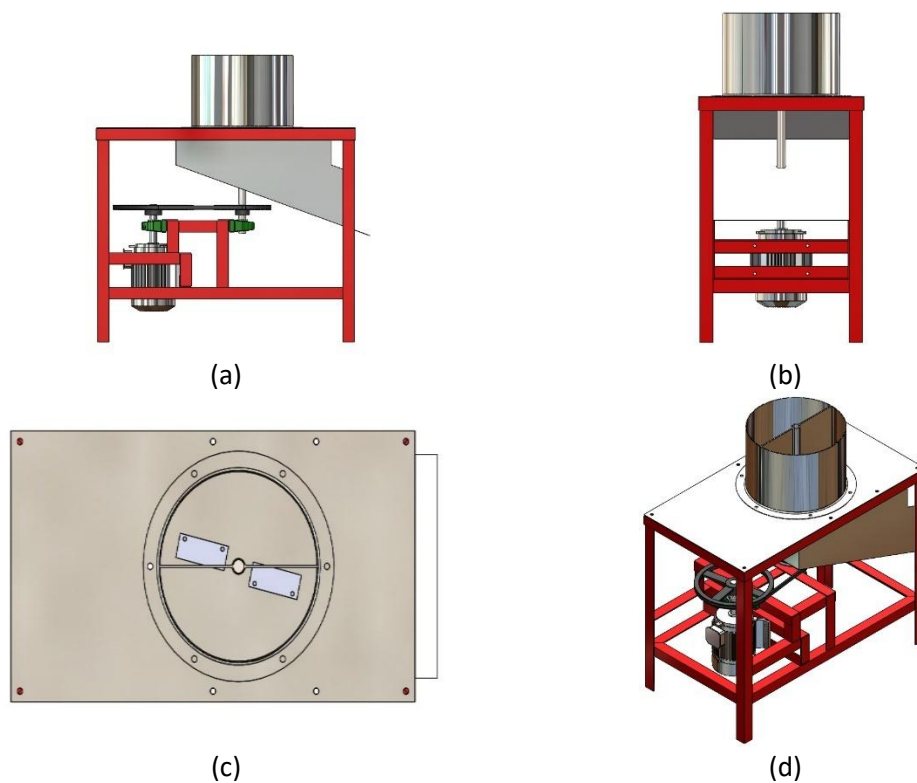


Figure 3. Design Results of Potato Grater Machine Design with Rotary Drive (a) Front View (b) Side View (c) Top View and (e) Isometric View

Based on Figure 3, the potato grater is designed with a cylindrical hopper at the top for the material input, a grating disc in the center, and an electric motor located at the bottom of the frame. Placing the motor at the bottom lowers the machine's center of gravity, thus increasing stability during operation.

The machine frame is designed using square-shaped steel profiles to increase structural rigidity and minimize vibration. The rotary drive system is designed to produce a stable rotational speed, allowing for continuous shredding with relatively uniform shredded results.

The design results show that the application of the QFD method through the House of Quality can systematically guide the potato grater design process based on user needs. The rotational speed of the disc and the design of the shredding disc are the main factors influencing the quality and stability of the grated potato results.

Furthermore, frame rigidity plays a crucial role in maintaining the stability of the rotary system and suppressing vibrations during operation. The selection of corrosion-resistant materials for parts in direct contact with the material supports hygiene and simplifies the machine's cleaning process. The resulting machine design not only meets functional requirements but also meets safety, comfort, and ease of maintenance, meeting customer needs.

CONCLUSION

Based on the design and analysis results, it can be concluded that the application of the Quality Function Deployment (QFD) method through the House of Quality (HOQ) is able to direct the potato grater machine design process systematically and based on user needs. The QFD results show that the technical characteristics with the highest priority are the rotational speed of the disc, frame stiffness, safety system, and the diameter of the grater disc.

These technical characteristics were then implemented into the design of a 20 kg rotary-drive potato grater using SolidWorks software. The resulting design features a stable structural configuration, a controlled drive system, and safety guards for operator safety and comfort.

The designed potato grater machine is expected to be able to increase the efficiency of the grating process, produce more uniform gratings, and meet the safety and ease of maintenance aspects according to user needs.

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