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DEVELOPMENT OF A 10 KG CAPACITY ROTARY DRIVEN POTATO GRATER PROTOTYPE

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Abstract.*This study presents the development of a prototype potato grater powered by a rotary drive system with a processing capacity of 10 kg. The design aims to improve the efficiency, uniformity, and safety of potato grating compared to conventional manual methods. The development process includes determining design specifications, selecting suitable materials, designing the cutting mechanism, and constructing the prototype. Performance testing was conducted to evaluate grating capacity, grating quality, operational stability, and energy consumption. The test results show that the prototype can process up to 10 kg of potatoes effectively within a short time, producing consistent grated output with smooth operation. The findings indicate that the prototype offers a practical and efficient solution for small-scale food processing applications, enhancing productivity while reducing labor intensity.*

Keywords: *Design Engineering; Food Processing Machine; Potato Grater; Prototype Development; Rotary Drive.*

1. INTRODUCTION

Potatoes are a food commodity widely used as a raw material for various processed products due to their nutritional content and processing flexibility. In households and small and medium-sized businesses, potatoes are generally processed through a grating stage as a semi-finished ingredient for various food products.(Cendrakasih et al., 2024)However, the grating process is still often done manually or using simple tools, resulting in relatively low productivity and less uniform quality of the grated results.

The use of conventional potato graters has several limitations, including limited working capacity, an unstable grating process, and safety aspects that are not yet optimal.(Permana & Nurwathi, 2021)This situation presents a challenge, especially for small and medium-sized businesses that require equipment with larger capacities, continuous processes, and consistent results. Furthermore, prolonged manual operation can lead to operator fatigue and reduce work efficiency.(Simanjuntak et al., 2021).

With the increasing need for efficiency in food processing, the development of potato grating machines that are more effective and safe is necessary. Rotary-driven grating systems offer the advantages of stable rotational motion, continuous operation, and the ability to produce more uniform shreds. However, designing a rotary-driven grating machine requires a precise design approach to ensure optimal capacity, stability, and safety.(Ali et al., 2025).

Based on these problems, this research developed a prototype of a rotary-driven potato grater machine with a capacity of 10 kg.(Feriadi Sidik et al., 2022)The objective of this research is to design and implement a prototype potato grater machine capable of meeting capacity requirements, improving the stability of the grating process, and supporting safety and ease of operation. The results of this research are expected to serve as a reference in the development of more efficient and reliable small-scale food processing equipment.

2. LITERATURE REVIEW

2.1 Potato Grating Process in Food Processing

Grating is a mechanical process that reduces the size of a material by abrading its surface using a grating element. In potato processing, the grating stage influences the quality of the final product because the size and uniformity of the grated product determine its textural characteristics and ease of subsequent processing. Therefore, a stable grating system is necessary to produce consistent output and minimize material loss during processing.(Defrian et al., 2024).

2.2 Disc-Based and Rotary Mechanism Grating Machines

A disc grater with a rotary mechanism is a commonly used system because it can produce a continuous process through the rotating motion of the grating element. The main advantage of the rotary mechanism is the stability of the rotation, which is relatively easy to control, which affects the grating rate and uniformity of the results. However, increasing capacity in a rotary system depends not only on the size of the disc but also on the flow of material from the hopper, the design of the grater blade, and the stability of the structure so that vibrations do not disrupt the process.(Wijoyo et al., 2022).

2.3 Performance Parameters (Capacity, Rotation Speed, and Quality of Shredded Results)

The performance of a shredding machine is generally assessed by its processing capacity (kg/hour or kg/process), rotational speed, operational stability, and shredded product quality. Disc rotational speed affects the rate of abrasion and the size of the shredded product, but excessively high speeds can increase vibration, noise, and component wear.(Anderson et al., 2024)Therefore, machine design needs to consider the balance between target capacity (in this study 10 kg), quality of results, and operator comfort through the selection of disc configuration, drive system, and frame stiffness.(Manguluang et al., 2021).

2.4 Prototype Design and Development Using CAD (SolidWorks)

Computer-Aided Design (CAD) software such as SolidWorks is widely used in machine design because it is able to visualize components in three-dimensional models, evaluate layouts, and reduce the potential for errors before fabrication.(Arief et al., 2023)i. In developing the potato grater prototype, CAD played a role in designing the frame, hopper, grater plate, shaft, and drive system to meet dimensional constraints and operational requirements. The use of SolidWorks helped accelerate design iterations and improve the design's readiness for manufacturing and testing.(Shulhany et al., 2022).

3. RESEARCH METHODS

This study uses a machine prototype design and development approach aimed at producing a rotary-driven potato grater with a capacity of 10 kg and evaluating its performance feasibility. The research methodology is systematically structured, starting from user needs identification, prototype design, performance testing, and results analysis based on quantitative parameters.

The research stages carried out include:

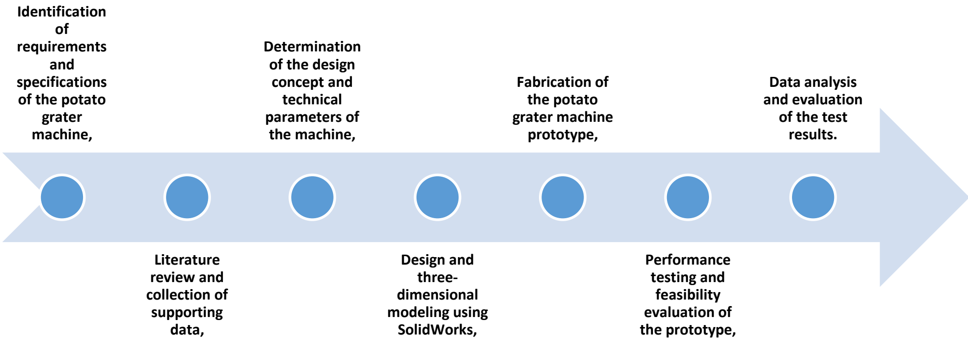

Figure 1. Flowchart

These stages are carried out to ensure that the prototype developed meets functional, technical and operational needs.

1. Identifying Machine Requirements and Specifications

The needs identification was conducted by considering the use of potato grating machines in households and small and medium-sized businesses. The primary requirements formulated included a grating capacity of 10 kg per process, stable grated results, ease of operation, user safety, and ease of maintenance.

Based on these needs, the initial specifications of the machine were determined, including a rotating disc-based grating mechanism, an electric motor drive system, a hopper as a place to enter materials, and a sturdy and stable support frame.

2. Determination of Concept and Technical Parameters

The potato grating machine concept uses a rotary drive mechanism with a disc-shaped grating element. The technical parameters specified include target capacity, disc rotation speed, shredding disc dimensions, hopper volume, and drive system layout.

Determination of technical parameters is carried out by considering the balance between grating capacity, quality of grated results, energy efficiency, and stability of machine operation.

3. Design and Modeling Using SolidWorks

The prototype engine design was carried out using SolidWorks software. This stage included creating a three-dimensional model of each major component, virtually assembling the components, and evaluating the suitability of dimensions and layout between components.

Three-dimensional modeling is used to visualize the final design of the prototype, minimize design errors, and ensure that the machine can be assembled and operated according to the established concept.

4. Testing Methods and Performance Parameters

Testing was conducted to evaluate the performance and feasibility of the potato grating machine prototype. Parameters tested included actual capacity, grating efficiency, energy consumption, operator productivity, and electricity operating costs.

a. Actual Machine Capacity

The actual capacity of the machine is calculated using the equation:

$$Q = \frac{m}{t}$$

with:

Q =machine capacity (kg/hour)

m =mass of processed potatoes (kg)

t =grating time (hours)

b. Shredding Efficiency

The shredding efficiency is calculated to determine the level of material loss during the process, with the equation:

$$\eta_m = \frac{m_{out}}{m_{in}} \times 100\%$$

with:
m_{in} = mass of potatoes entered (kg)
m_{out} = mass of grated product (kg)

c. Energy Consumption and Specific Energy

The electrical power of the machine is calculated based on:

$$P = V \times I \times cos\ \varphi$$

The electrical energy used during the grating process is calculated by:

$$E = P \times t$$

Meanwhile, the specific energy of grating is calculated using:

$$SEC = \frac{m}{E}$$

d. Operator Productivity

Operator productivity is calculated using the equation:

$$OP = \frac{m}{n \times t}$$

with:
OP= operator productivity (kg/hour/operator)
n = number of operators

e. Electricity Operating Costs

The electricity costs during the grating process are calculated using:

$$C_e = E \times T$$

with:
C_e= electricity costs (Rp)
T = electricity tariff (Rp/kWh)

The electricity cost per kilogram of product is calculated as:

$$C_e/kg = \frac{C_e}{m}$$

5. Prototype Feasibility Evaluation

Prototype feasibility evaluation is conducted by comparing performance test results against initial specifications and requirements. A prototype is deemed feasible if it can achieve the target capacity, has high shredding efficiency, relatively low energy consumption, and is safe and easy to operate. The evaluation results are used as a basis for discussing prototype performance and recommendations for further development.

4. RESULTS AND DISCUSSION

4.1 Results of Potato Grater Machine Prototype Development

The results of this study cover two main stages: the design of the potato grater machine and the realization of a prototype machine, which is then evaluated through a performance feasibility test. The design phase is carried out to ensure that the machine's configuration and dimensions meet capacity requirements, operational stability, and user safety. Next, the design results are realized into a physical prototype to verify the suitability between the design and the actual performance of the machine.

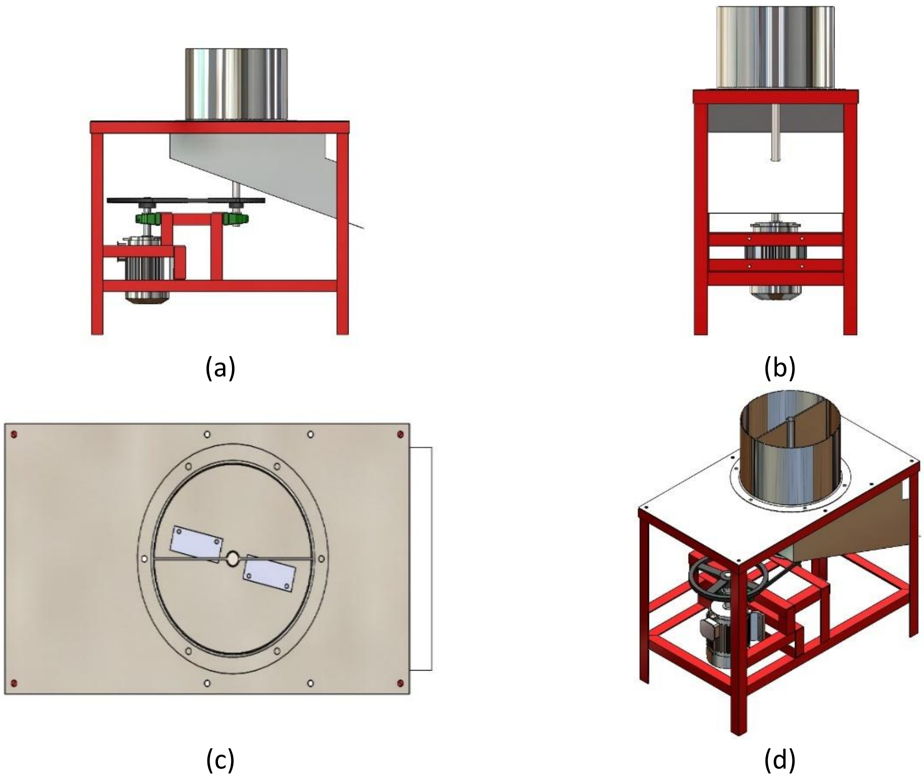

Figure 2. Design Results of Potato Grater Machine Design with Rotary Drive (A) Front View (B) Side View (C) Top View and (D) Isometric View

The machine design results are shown in the three-dimensional model in Figure 2, which depicts the frame structure, rotating disc-based grating system, hopper, and drive system. Meanwhile, the finished tool in Figure 3 is a prototype machine that has been assembled and is ready for functional testing. The relationship between the design results and the finished tool forms the basis for discussing the prototype's performance and feasibility testing conducted in this study.

Figure 3. Potato Grater Machine Prototype

4.2 Prototype Performance Feasibility Test Results

Feasibility testing was conducted to evaluate the prototype's ability to meet capacity and operational efficiency targets. Parameters analyzed included actual capacity, shredding efficiency, energy consumption, operator productivity, and electricity operating costs.

a. Actual Machine Capacity

Based on the test results, the prototype is capable of processing 10 kg of potatoes in 6 minutes, so the actual capacity of the machine can be calculated as follows:

$$Q = \frac{m}{t} = \frac{10}{0,1} = 100\ kg/jam$$

These results demonstrate that the machine is capable of operating at a capacity significantly higher than the required per process, making it suitable for household and small-to-medium business applications. This capacity also indicates that the rotary grating system is capable of continuous and stable operation.

b. Shredding Efficiency

The grating efficiency is calculated based on the ratio of the input potato mass to the collected grated mass. The test yielded a grated mass of 9.6 kg from a 10 kg input, so the grating efficiency is:

$$\eta_m = \frac{9,6}{10} \times 100\%$$
$$= 96\%$$

This high efficiency value indicates relatively little material loss during the shredding process. This is due to the design of the hopper and shredding disc, which effectively direct material to the shredding area without much material being retained or spilled.

c. Energy Consumption and Specific Energy

The electrical power of the machine during operation is calculated based on voltage, current, and power factor, and the average power obtained is 467.5 W. The electrical energy used to process 10 kg of potatoes for 6 minutes is:

$$E = P \times t = 467,5 \times 0,1 = 0,04675\ kWh$$

The specific energy of grating is calculated as follows:

$$SEC = Em = \frac{0,04675}{10} = 0,004675\ kWh/kg$$

The relatively low specific energy value indicates that the machine has good energy efficiency, making it suitable for repeated operations on a small business scale.

d. Operator Productivity

Operator productivity is calculated based on the amount of material processed per unit time by one operator. With one operator processing 10 kg of potatoes in 6 minutes, the productivity is as follows:

$$OP = \frac{10}{0,1} = 100\ kg/jam/operator$$

These results show that the use of machines significantly increases productivity compared to manual methods, while reducing the physical workload of operators.

e. Simple Economic Feasibility

The electricity operating cost is calculated based on energy consumption and an electricity tariff of Rp 1,700/kWh. The electricity cost for one 10 kg shredding process is:

$$C_e = 0,04675 \times 1700 = Rp\ 79,48$$

Thus, the electricity cost per kilogram of potatoes processed is:

$$C_e/kg = \frac{79{,}48}{10} = Rp\ 7{,}95/kg$$

These low electricity operating costs indicate that the machine is economically viable for use on a household and small to medium business scale.

4.3 Discussion of Prototype Feasibility

Based on performance tests and feasibility calculations, the rotary-driven potato grater prototype demonstrated performance that met design targets. The machine achieved an actual capacity of 100 kg/hour, with a grating efficiency of 96% and relatively low specific energy consumption. Furthermore, operator productivity increased significantly, and the operating cost of electricity per kilogram of material was economical.

These results demonstrate that the prototype design is not only functionally feasible but also operationally feasible and economically feasible. Therefore, the developed machine has the potential to be a practical solution for potato grating needs in small and medium-sized businesses. Further development can focus on long-term testing, vibration and noise analysis, and hygiene improvements for broader food processing applications.

CONCLUSION

This study successfully developed a rotary driven potato grater prototype with a capacity of 10 kg designed for small-scale food processing applications. The design process resulted in an integrated machine configuration consisting of a rigid steel frame, a rotary disc grating system, a stainless steel hopper, and an electric motor-driven transmission system, which provides stable and continuous grating operation.

The feasibility evaluation demonstrated that the prototype is capable of processing 10 kg of potatoes within a short processing time, achieving a high grating efficiency and low material loss. The machine exhibited a low specific energy consumption and significantly improved operator productivity compared to manual grating methods. In addition, the operating cost per kilogram of processed material was found to be relatively low, indicating favorable economic feasibility for small and medium enterprises.

Overall, the results confirm that the developed prototype meets the functional and operational requirements. Further research is recommended to conduct long-term performance testing, noise and vibration analysis, and hygiene evaluation to enhance the machine's applicability in broader food processing environments.

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