INTECHBIZ2025
International Conference on Industrial Technology and Business

Design and Development of a Rice Separator Machine from Empty Grains Using QFD (Quality Function Deployment) Approach for Farmers in Tanjung Belit Village, Bengkalis Regency

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Abstract

This study develops a rice separator machine using the Quality Function Deployment (QFD) approach to support farmers in Tanjung Belit Village, Bengkalis Regency. The issue faced by farmers is the presence of empty husks mixed with harvested rice after using combine harvesters. Manual cleaning by winnowing is still common but highly inefficient. This research identifies farmers' needs through field observations, questionnaires, and interviews, followed by QFD analysis to translate those needs into technical specifications. The results from the House of Quality (HOQ) emphasized five priorities: strong frame with vibration dampers (11%), low-carbon steel frame (10%), L-profile frame (10%), hopper thickness 1.5 mm (9.6%), and hopper capacity ≥250 cm³ (9.2%). The first design concept reached the highest score of 3.614 in concept scoring. The study concludes that the proposed machine design is simple, efficient, and affordable, thus providing a potential technology solution for local farmers to improve productivity and rice quality.

Keywords : Rice separator, QFD, Empty husk, Design, Agriculture

1. INTRODUCTION

Rice (Oryza sativa L.) is the primary staple food in Indonesia, making it vital to ensure food security. Indonesia has about 10 million hectares of rice fields with production reaching more than 50 million tons annually. In rural areas such as Desa Tanjung Belit, Bengkalis Regency, most farmers use combine harvesters for efficiency. However, the harvested rice still contains impurities such as empty husks, straw, and other waste, reducing its quality. Farmers traditionally clean rice by winnowing (manual separation), a process that is labor-intensive, time-consuming, andinefficient.

The challenge is how to provide simple, low-cost technology that supports farmers' productivity. The application of Quality Function Deployment (QFD) is relevant because it systematically translates farmers' needs into technical design requirements. By incorporating farmers' voices into the design, the resulting product is expected to be more acceptable, useful, and sustainable. This research contributes by developing a prototype rice separator machine that is affordable and practical for farmers in small villages, thereby supporting national food security policies.

2. REVIEW OF LITERATURE

Previous research has explored rice separator technologies with varying approaches. Suhendra et al. (2023) studied airflow-based separation and found that smaller outlet openings with higher airflow significantly increased rice cleanliness up to 98.6%. Ulfiyah et al. (2023) designed a cyclone-based separator to separate filled and empty grains, highlighting the importance of low-cost, farmer-friendly machines. Hajizi (2024) examined shaft and motor specifications in rice separator design, focusing on durability and safe operation. Other

researchers applied QFD in different agricultural tools. For example, Anggara (2024) used QFD to develop ergonomic ship seats, while Priyono & Yuamita (2022) redesigned tobacco leaf cutters with QFD. These studies demonstrate that QFD is a versatile method that can translate customer needs into technical solutions across fields.

QFD itself, developed in Japan in the late 1960s by Akao and Ishihara, has been widely adopted in industries such as automotive and manufacturing. Its central tool, the House of Quality (HOQ), provides a structured framework for linking customer demands with engineering characteristics. In this study, QFD is applied in the agricultural context to ensure that farmers' needs are central to machine design, a field where such structured approaches are still limited.

3. METHOD

The study adopted an applied research methodology combining engineering design with QFD analysis. The research took place in Desa Tanjung Belit, Bengkalis Regency, and the Mechanical Engineering Workshop of Politeknik Negeri Bengkalis. The subjects were 25 farmers, selected using Slovin's formula from a population of 45 farmers. Data collection methods included observation, structured interviews, and questionnaires. The questionnaire items were tested for validity (using Pearson correlation) and reliability (using Cronbach's Alpha >0.7).

The QFD process involved several stages:

1. identifying the Voice of Customer (VOC),
2. translating VOC into technical requirements,
3. building the HOQ matrix,
4. assigning weights to each customer requirement, and
5. evaluating alternative design concepts through concept scoring.

The flowchart of the research process began with literature review and field survey, followed by QFD construction, concept evaluation, and final design proposal.

4. RESULT & DISCUSSION

The QFD analysis produced five major priorities: strong frame with vibration dampers (11%), low carbon steel frame material (10%), L-profile frame (10%), hopper thickness 1.5 mm (9.6%), and hopper capacity ≥250 cm^3 (9.2%). Farmers emphasized the importance of durability, ease of use, and affordable cost. The HOQ matrix clearly demonstrated the alignment between farmers' needs and technical solutions.

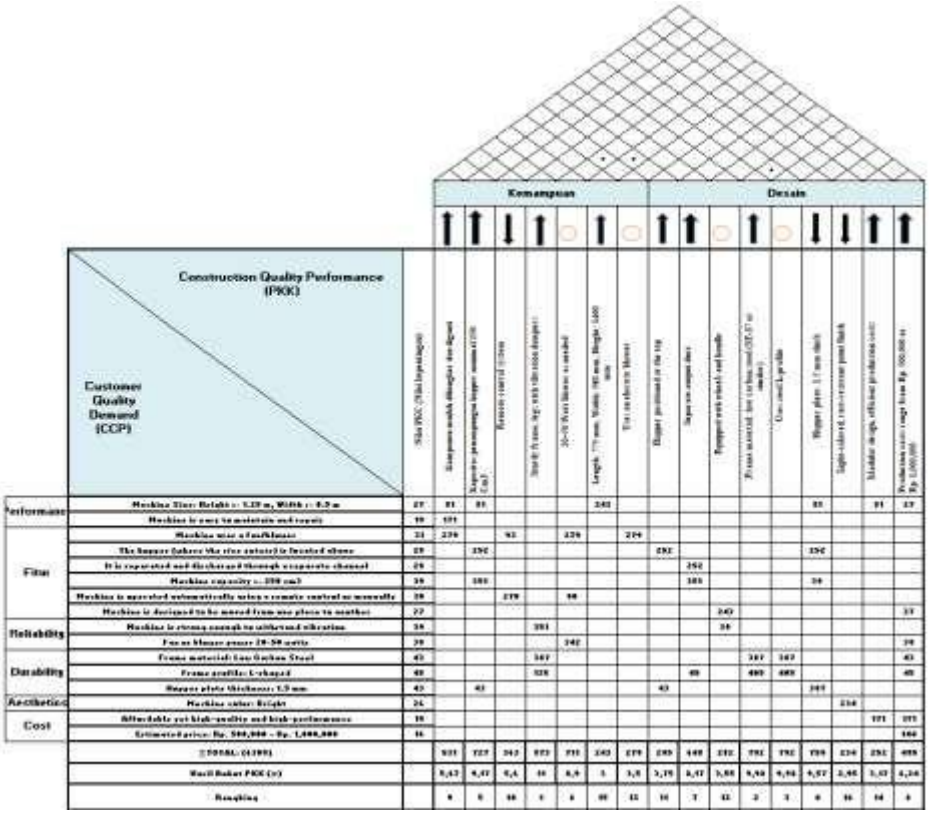


Figure 1, HOQ matrix

Concept scoring was applied to three alternative designs. The first concept achieved the highest score (3.614), meeting farmers' expectations in terms of strength, capacity, and ease of operation. The results confirmed that airflow-based separation is efficient for removing empty husks, consistent with Suhendra et al. (2023).

Concept Criteria	Weight %	Concep Desain					
		Alternative Concept 1		Alternative Concept 2		Alternative Concept 3	
		Rating	Weighted Value	Rating	Weighted Value	Rating	Weighted Value
Sturdy frame, vibration-damping legs	11	4	0,44	5	0,55	4	0,44
Low-carbon steel frame material (ST-37 or similar)	10	4	0,4	4	0,4	3	0,3
Uses steel L-profiles 1.5 mm	10	4	0,4	2	0,2	3	0,3
thick hopper plate Minimum 1,5 mm	9,6	2	0,192	4	0,384	3	0,288
hopper capacity of 250 cm3	9,2	3	0,276	5	0,46	3	0,276
20–50 Watt blower as needed	8,9	3	0,267	4	0,356	3	0,267
Separate output channel	8,2	2	0,164	2	0,164	3	0,246
Production costs in the price range of Rp. 500,000 - Rp. 1,000,000	6,2	2	0,124	2	0,124	2	0,124
Components are easy to disassemble and replace	5,7	2	0,114	2	0,114	2	0,114
Remote control system	5,6	2	0,112	2	0,112	3	0,168
Hopper positioned at the top	3,8	4	0,152	5	0,19	4	0,152
Equipped with wheels and handles	3,6	4	0,144	4	0,144	4	0,144
Uses electric blower Modular design	3,5	4	0,14	4	0,14	4	0,14
Modular design, efficient production costs	3,2	3	0,096	3	0,096	3	0,096
efficient production costs Length: 775 mm, Width: 560 mm, Height: 1400 mm Light-colored	3	3	0,09	3	0,09	3	0,09
rust-resistant paint finish	3	3	0,09	3	0,09	3	0,09
Total Score			3,201		3,614		3,235
Ranking			3		1		2
Continued?			NO		Yes		NO

Figure 2, Concep scoring Desain

Compared to traditional winnowing, the proposed machine reduces cleaning time by more than half and requires minimal labor. Additionally, farmers indicated that the machine should be portable, easy to maintain, and safe to operate. These findings validate the integration of QFD into agricultural product design.

Discussion: The study demonstrates that QFD is effective not only in industrial sectors but also in agriculture. The main challenge lies in balancing affordability with durability. By selecting low-carbon steel and ergonomic design, the proposed machine ensures both strength and cost-effectiveness. This innovation can serve as a model for other small-scale farming technologies, bridging the gap between academic research and rural needs.

5. CONCLUSION

This study successfully developed a rice separator machine design based on farmers needs using the QFD method. The prioritized specifications included a strong frame, low-carbon steel material, ergonomic hopper, and adequate capacity. The concept scoring indicated that the first design was most acceptable to farmers. The machine is expected to significantly reduce cleaning time, improve rice quality, and support local productivity. Future research should focus on prototype testing, performance evaluation in different environments, and potential commercialization strategies to ensure broader adoption among farmers.

6. ACKNOWLEDGEMENTS

This research was supported by internal funding from Politeknik Negeri Bengkalis (PNBP Scheme 2025). The authors thank the farmers of Desa Tanjung Belit for their collaboration and valuable feedback during the research process

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