Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Profit Optimization in Agro-Processing: A Case Study of a Lever–Flywheel Pounding Machine

Prof. Nagendrapratap Singh

CEO & Founder, PerpetualGravity Labs Pvt Ltd, Navi Mumbai, India
Email: n4nagendrap@gmail.com

Abstract

Agro-processing industries often face the challenge of high electricity costs in grain and spice pounding operations. This paper presents a case study on the design and evaluation of a lever–flywheel pounding machine that utilizes mechanical advantage to minimize power consumption while maximizing output efficiency. Two prototypes (2 HP and 0.5 HP) were tested. Results indicate that the 2 HP machine delivers greater throughput, whereas the 0.5 HP variant achieves superior profit efficiency per watt consumed. The study demonstrates how leveraging mechanical advantage can optimize profitability in small- and medium-scale agro-processing industries.

Keywords: lever–flywheel pounding machine, agro-processing, profit optimization, mechanical advantage, energy efficiency, cost per unit, ROI

1. Introduction

The pounding of grains and spices is an essential agro-processing activity in India and other developing economies. Traditional electrically powered pounding machines consume high amounts of energy, thereby reducing profit margins for small-scale processors. Lever–flywheel systems offer an alternative design by amplifying mechanical output without requiring proportional input energy. This case study evaluates two prototypes of lever–flywheel pounding machines—2 HP and 0.5 HP—designed at Thakur College and Fr. C. Rodrigues College (Vashi), focusing on power consumption, throughput capacity, and profitability.

2. Methodology

Two machines were constructed and tested. Their specifications are summarized in Table 1.

Machine	Capacity (HP)	Flywheel Diameter (D_2)	Load Arm (D_1)	MA (D_2/D_1)	Power (W)	Output (kg/hr)
Thakur College	2.0	80 cm	30 cm	2.67	1492	120
Fr. C. Rodrigues	0.5	30 cm	30 cm	1.0	373	40

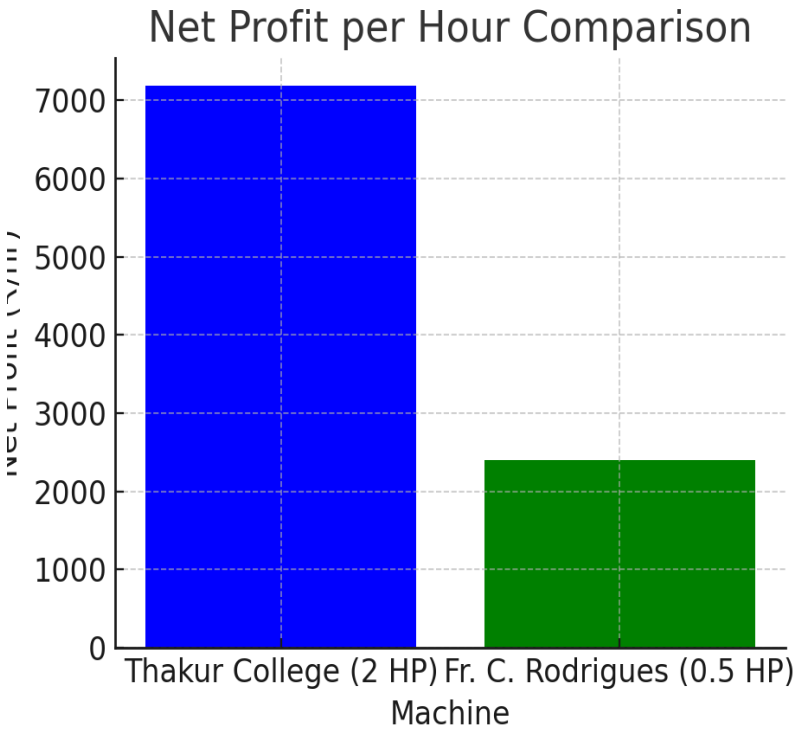
Table 1: Machine Specifications

3. Results

Machine	Output (kg/hr)	Revenue (₹/hr)	Energy Cost (₹/hr)	Net Profit (₹/hr)	Profit per Watt (₹/W)
Thakur College (2 HP)	120	7200	16.412	7183.588	4.815
Fr. C. Rodrigues (0.5 HP)	40	2400	4.103	2395.897	6.423

Table 2: Profitability Analysis

Figure 1: Net Profit per Hour comparison between the two pounding machine prototypes.



4. Discussion

The findings highlight a trade-off between total profit and profit efficiency per watt. The 2 HP pounding machine achieves higher throughput (120 kg/hr), ensuring maximum profitability per operational cycle, making it ideal for commercial-scale processing units. On the other hand, the 0.5 HP pounding machine demonstrates greater efficiency per unit of energy consumed, making it more suitable for small-scale farmers and rural entrepreneurs. This indicates that machine design must be aligned with scale of operation: smaller models for local use, larger models for industrial-scale applications.

5. Conclusion

This case study demonstrates that lever–flywheel pounding machines can significantly optimize profitability in agro-processing. By reducing energy cost per unit of output, these machines enhance both economic and environmental sustainability. For rural entrepreneurs, the 0.5 HP model offers a cost-effective solution, while the 2 HP model provides higher profit margins for industrial processing. Future research should explore renewable integration (solar-assisted motors) and life-cycle cost analysis.

References

1. Singh, N., Gravity Mechanics and Energy Efficiency, PG Labs Publications, 2024.
2. Rao, J.S., Mechanical Advantage in Lever Systems, Springer, 2018.
3. Cengel, Y., Thermodynamics and Energy Systems, McGraw-Hill, 2015.