

# Design, Structural Validation And Performance Evaluation Of A Pedal-Operated Groundnut Shelling Machine For Small-Scale Agricultural Processing

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**Abstract-** Groundnut shelling is an essential post-harvest operation that converts dried pods into marketable kernels, but small farmers commonly depend on hand shelling or costly powered machines. This study presents the design, fabrication, structural validation and experimental evaluation of a revised pedal-operated groundnut shelling machine developed as a low-cost intermediate technology for rural and small-scale users. The machine consists of a hopper-fed rotary drum, stationary perforated concave, chain-and-sprocket transmission, 25 mm main shaft, welded mild-steel frame, pedal crank, fan-assisted separation unit and collection arrangement. Human power is transmitted through the pedal crank to the shelling shaft; the drum-concave pair cracks pods by rubbing and compression, while the outlet and fan arrangement separate lighter shells from heavier kernels. Design calculations were performed for pedal torque, power, chain drive ratio, shaft stress and drum peripheral speed. Structural safety was verified through finite-element/static simulation of the frame, shaft, shelling drum, pedal crank, bearing bracket and complete assembly. The maximum equivalent stress in the full assembly was 93.6 MPa, which is below the 250 MPa yield reference, and the corresponding factor of safety was 2.67. Experimental trials for 1-10 kg batches showed shelling efficiency between 89.2% and 91.3%, cleaning efficiency between 84.5% and 86.2%, and mechanical damage between 4.3% and 5.4%. The results confirm that the pedal-operated configuration can reduce drudgery, avoid electricity dependence and deliver acceptable shelling performance when speed, feed rate and concave clearance are controlled.

**Keywords:** groundnut shelling; pedal-operated machine; agricultural mechanization; finite element analysis; chain drive; shelling efficiency; small-scale processing.

## Highlights

- A revised pedal-operated sheller was developed for electricity-free groundnut processing.
- The drum-concave shelling unit was integrated with chain drive and fan-assisted separation.

- Frame, shaft, drum, pedal crank and bearing bracket were checked through structural analysis.
- The complete assembly remained safe with maximum stress of 93.6 MPa and factor of safety of 2.67.
- Experimental trials showed up to 91.3% shelling efficiency and mechanical damage below 5.4%.

## I. INTRODUCTION

In today's highly competitive and technology-driven business environment, organizations must continuously improve employee skills and performance to achieve organizational goals. Performance appraisal systems are critical components of human resource management, serving as a structured method for evaluating employee performance within organizations. These systems provide a framework through which employee contributions, strengths, and areas for improvement are systematically assessed.

The importance of performance appraisals extends beyond individual assessment; they play a pivotal role in aligning employee goals with organizational objectives, enhancing motivation, and promoting overall organizational effectiveness. The study of performance appraisal systems encompasses various dimensions, including their design, implementation, and impact on employee performance and organizational culture.

Performance appraisal, as defined by Flippo, is "the systematic, periodic and an impartial rating of an employee's excellence in matters pertaining to his present job and his potential for a better job." It involves analyzing different appraisal methods — such as traditional rating scales, 360-degree feedback, and continuous performance management approaches — while also addressing the psychological and social factors influencing the appraisal process, including biases, ratings accuracy, and the recipient's reaction to feedback.

The present study focuses on EEE Infra Equipments Pvt. Ltd., Chennai — a leading player in the infrastructure equipment sector — and aims to critically examine the effectiveness of its performance appraisal system and its impact on employee motivation.

### 1.1 Statement of the Problem

In most manufacturing and infrastructure companies, the performance appraisal system plays a vital role in guiding employee development and organizational direction. However, leadership behaviour challenges arise when motivational styles are negative, causing low morale and conflict. Employees are left unformed, insecure, and reluctant to exercise initiative. Participation in appraisal processes becomes ineffective when subordinates do not thoroughly understand organizational objectives, resulting in minimum interaction between employees and their supervisors during appraisal cycles.

### 1.2 Objectives of the Study

- To critically examine the performance appraisal system at EEE Infra Equipments Pvt. Ltd.
- To find out how performance appraisal is carried out in the organization.
- To assess employees' perception about the concept of performance appraisal.
- To determine the attitude of employees towards performance appraisal and their satisfaction with management's response to their suggestions.

## II. REVIEW OF LITERATURE

An extensive review of existing literature was undertaken to understand the relationship between performance appraisal systems and employee motivation across industries.

### 2.1 Performance Appraisal and Motivation

Rajesh Kumar & Anita Sharma (2021) examined the relationship between job performance evaluation and employee performance in manufacturing industries. The findings showed that workload pressure, role conflict, and lack of organizational support were major causes of reduced motivation. The study suggested that structured feedback and flexible work arrangements help reduce stress and improve performance.

Michael Tetrick & Paul Spector (2021) concluded that prolonged performance uncertainty negatively affects job

satisfaction and organizational commitment. Employees experiencing limited recognition showed lower efficiency and motivation, with the authors recommending performance recognition training and supportive leadership practices to enhance employee outcomes.

Ayesha Khan & Imran Ali (2022) investigated how fair appraisal processes influence employee performance in private organizations. The findings revealed that time pressure and perceived bias during evaluations significantly affect work quality, emphasizing the importance of work-life balance and transparent appraisal initiatives.

### 2.2 Organizational Commitment and Appraisal Systems

John P. Meyer (2022) explored the relationship between performance feedback, organizational commitment, and performance. The study concluded that inadequate performance feedback reduces employees' emotional attachment to the organization, leading to decreased performance. Effective communication and employee recognition were suggested as strategies to enhance engagement.

S. Lakshmi & R. Karthik (2022) found that structured appraisal management programs including regular training, engagement activities, and performance recognition significantly improved employee efficiency and reduced turnover intentions in industrial sectors.

### 2.3 Recent Developments (2023–2025)

Sarah Johnson & David Lee (2023) analysed the effect of performance feedback quality on corporate employees, demonstrating that constructive appraisal processes reduce decision-making uncertainty and improve performance outcomes. Priya Menon (2023) further found that infrastructure companies adopting transparent performance evaluation strategies observed measurably improved productivity levels.

Rajesh E., Komal Phagna & Parag Kalkar (2024) concluded that organizations implementing structured performance appraisal programs and supportive HR practices improve employee performance and job satisfaction. Muktifani & Hazmi (2024) further confirmed that strong peer support and collaborative appraisal reduced the negative impact of evaluation anxiety on overall work performance.

Victoria Israel Munisi (2025) and Mussa, Harahap & Widhistuti (2025) collectively emphasized that supportive appraisal environments and organizational social support

significantly improve job satisfaction and performance levels in both public and private sector organizations.

### III. RESEARCH METHODOLOGY

#### 3.1 Research Design

The research design adopted for the study is descriptive in nature. A descriptive research design was employed as it allows the researcher to describe the present situation and understand the behaviour of employees regarding the performance appraisal system. This approach only reports what has happened and what is currently happening, making it suitable for the study's objectives.

#### 3.2 Population, Sampling, and Data Collection

The study was conducted at EEE Infra Equipments Pvt. Ltd., Chennai. The population covers all employees subject to the performance appraisal process within the organization. A convenience sampling technique was used to select 110 respondents across various departments including Software Development, Quality Assurance, Product Management, and Project Management, among others.

Primary data was collected through a structured questionnaire covering aspects such as employee satisfaction, appraisal fairness, motivation levels, career growth perceptions, feedback quality, and compensation linkage. Secondary data was gathered from company reports, published journals, and HR documentation.

#### 3.3 Statistical Tools Used

- Chi-Square Test: To examine the association between demographic variables and appraisal perceptions.
- Correlation Analysis (Pearson and Spearman's rho): To assess the relationship between promotion-linked salary and expected benefits.
- Percentage Analysis: For frequency distribution of survey responses.
- Descriptive Statistics: Mean and standard deviation for key appraisal variables.

### IV. INDUSTRY AND COMPANY PROFILE

#### 4.1 Infrastructure Equipment Industry Overview

The infrastructure industry is considered the backbone of economic development. It encompasses the development and maintenance of essential facilities such as roads, bridges, railways, airports, power plants, and urban

development projects. In India, the sector has gained significant importance due to rapid urbanization, population growth, and increasing demand for transportation and energy facilities.

The infrastructure equipment industry — which includes earthmoving equipment, cranes, material handling machines, and road construction equipment — supports construction, mining, power generation, oil and gas, and industrial development. The National Infrastructure Pipeline (NIP) and related government initiatives have created long-term growth opportunities for infrastructure equipment manufacturers.

#### 4.2 Company Profile: EEE Infra Equipments Pvt. Ltd.

EEE Infra Equipments Pvt. Ltd. is a Chennai-based infrastructure equipment company engaged in the supply, maintenance, and operation of heavy machinery for construction and development projects. The company serves multiple sectors and operates with a workforce spanning engineering, operations, sales, and administration departments. The organization's HR department manages performance appraisal cycles that are designed to be comprehensive, transparent, and development-focused.

The appraisal methodology at EEE Infra Equipments includes collaborative goal setting at the start of each cycle, continuous feedback throughout the year, 360-degree feedback from peers and supervisors, self-assessment components, and a final performance rating that informs HR decisions on promotions, salary increments, and training allocation.

### V. DATA ANALYSIS AND INTERPRETATION

#### 5.1 Descriptive Profile of Respondents

The survey covered 110 respondents across multiple departments. The departmental distribution included Software Development (12.5%), Quality Assurance (15%), Product Management (12.5%), and Project Management (10%), along with other functional areas. The sample included respondents at varying seniority levels and experience ranges, providing a representative cross-section of organizational opinion.

#### 5.2 Employee Perception of Appraisal System

When asked about the overall impact of the performance appraisal system on motivation, 50% of respondents indicated that they were moderately motivated by the existing system. A strong majority (50%) strongly agreed that the appraisal system has a positive impact on their

organization, while 37.5% agreed that their performance is accurately reflected through the appraisal process. Additionally, 46.9% agreed that the appraisal system effectively identifies their growth potential.

### 5.3 Chi-Square Analysis

The chi-square test was applied to examine associations between demographic variables (age, gender, designation, work experience) and employee perceptions of the appraisal process. The results indicated statistically significant associations between work experience and perceived fairness of the appraisal system, suggesting that more experienced employees hold more nuanced views of the appraisal process. Similarly, a significant association was found between designation level and satisfaction with feedback quality.

### 5.4 Correlation Analysis

The correlation analysis revealed a significant positive relationship between promotion and salary linkage for respondents and their expected benefits. Both Pearson and Spearman's rho coefficients indicated a moderate positive correlation of approximately 0.4 for promotion-linked salary and expected benefits, suggesting that employees who perceive a clear link between their appraisal outcomes and salary increments demonstrate higher motivation and commitment. This finding highlights the critical role of compensation transparency in appraisal effectiveness.

## VI. KEY FINDINGS

- 50% of respondents reported being moderately motivated by the organization's appraisal system.
- 50% of respondents strongly agreed that the appraisal system has a positive impact on the organization.
- 37.5% of respondents agreed that the appraisal process accurately reflects their performance.
- 46.9% of respondents agreed that the system effectively identifies their growth potential.
- A moderate positive correlation ( $r \approx 0.4$ ) was found between promotion-linked salary increments and employee expected benefits.
- Chi-square analysis confirmed significant associations between work experience and perceived appraisal fairness.
- Feedback satisfaction and performance rating accuracy were identified as areas requiring improvement.

- Employees in senior designations reported higher satisfaction with the appraisal system compared to junior-level employees.

## VII. SUGGESTIONS AND RECOMMENDATIONS

### 7.1 Enhance Transparency and Fairness

The organization should address concerns about transparency and bias by organizing workshops and training sessions for both appraisers and appraisees. Creating an inclusive work environment through proactive measures that promote fairness will improve the perceived legitimacy of the appraisal process. Clear communication of appraisal criteria and outcomes is essential.

### 7.2 Promote Career Development

The organization should provide clear pathways for career advancement directly tied to performance and merit. Regularly communicating promotion opportunities and associated salary increments will motivate employees to align their performance with organizational expectations. Transparent succession planning will further support employee commitment and reduce turnover.

### 7.3 Improve Feedback Mechanisms

The feedback process should be enhanced by conducting more frequent and constructive review sessions. Managers should be trained on effective feedback delivery techniques, and technology platforms should be leveraged to enable real-time feedback. Moving from annual to continuous feedback cycles will better support employee development and performance correction.

### 7.4 Recognize and Reward Contributions

Implementing formal recognition programs that acknowledge employee contributions through awards, certificates, and public appreciation will reinforce positive performance behaviours. Informal recognition through praise from supervisors and peers should also be encouraged as a regular practice. Recognition that is directly tied to appraisal outcomes strengthens the motivational impact of the appraisal system.

## VIII. CONCLUSION

This study provides valuable insights into various aspects of employee perception and experience within EEE Infra Equipments Pvt. Ltd. The analysis underscores the

critical importance of transparency, fairness, career development opportunities, feedback mechanisms, and recognition in fostering a positive work environment and enhancing employee motivation and satisfaction.

While the majority of respondents perceive the organization positively in terms of appraisal transparency, fairness, and motivation effectiveness, areas for improvement remain — particularly in feedback satisfaction and performance rating accuracy. The significant positive correlation between promotion-linked salary and expected benefits confirms that employees are motivated when they perceive a direct and equitable connection between their performance and career rewards.

The performance appraisal system at EEE Infra Equipments Pvt. Ltd. represents a strategic HR initiative that, when strengthened with the recommended improvements, can significantly enhance employee motivation and drive organizational success. Through a comprehensive approach encompassing goal setting, continuous feedback, 360-degree evaluations, and self-assessments, the system not only evaluates workforce performance but also supports professional growth and development.

As the company continues to evolve in a dynamic industry, a robust and transparent performance appraisal system remains integral to cultivating a high-performing, motivated workforce that can adapt to future challenges and contribute to long-term organizational excellence.

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