

Profit Analysis And Optimization Of Agro Biotech Processing: A Case Study Of Shree Shyam Agro Biotech Pvt. Ltd., Rajasthan Using Rpgt

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ABSTRACT: This paper presents a comprehensive profit analysis and optimization of agro biotech processing at Shree Shyam Agro Biotech Pvt. Ltd., Rajasthan, using the Reliability, Profitability, and Generalized Transition (RPGT) modeling framework. The study evaluates the performance of key processing units by modeling failure and repair dynamics, system transitions, and economic outcomes. By incorporating reliability indicators—such as mean time to system failure (MTSF), steady-state availability, busy period of repair personnel, and expected maintenance interventions—alongside a detailed profit function, the analysis identifies how operational strategies and maintenance policies impact plant profitability. The findings provide actionable insights for plant managers, enabling data-driven decisions that maximize efficiency, reduce downtime, and sustain competitive advantage in the agro biotech sector.

Keywords: Profit analysis, RPGT, Reliability optimization, Availability, Rajasthan

1. INTRODUCTION

In the rapidly evolving landscape of industrialization, the agro biotech sector serves as a foundation for agricultural value addition, rural livelihood support, and food security. Rajasthan, with its vast agricultural resources and robust infrastructure, has become a key center for agro-based industries. Shree Shyam Agro Biotech Pvt. Ltd. exemplifies this growth through its commitment to efficient processing, product quality, and sustainability. However, unique challenges—such as seasonal variability, stringent safety norms, and the critical need for uninterrupted operations—demand strategic optimization of plant processes and economic evaluation of outcomes. This case study applies advanced mathematical modeling, specifically the RPGT framework, to systematically analyze plant reliability and profitability. By integrating sensitivity analysis on failure and repair rates, the study equips management with clear guidance for maintenance investments and operational improvements, ultimately driving greater efficiency, profitability, and resilience in the competitive food processing industry.

Contemporary research in mathematical modeling, reliability optimization, and profit analysis has significantly advanced the operational efficiency of various industrial and biotechnological systems. Kumar and Mimansha (2025) utilized adaptive cuckoo optimization to address failure dependencies in complex systems, demonstrating the potential of dynamic metaheuristics in reliability optimization. In the agro-processing sector, Rani, Malik, and Kumar (2025) applied the Regenerative Point Graphical Technique (RPGT) to model and analyze the behavior of rice processing plants, illustrating RPGT’s versatility in agro-industrial reliability analysis. Further contributions include the mathematical formulation for optimal extraction processes within the bioactive compounds sector, as presented by Sunita, Basotia, and Kumar (2024). Their work highlights the intersection of biotechnology and process optimization. The industrial application of RPGT is further evidenced in Kumar’s (2023) sensitivity analysis of a polytube industry, which revealed crucial parametric impacts on plant performance and profitability. Profit analysis and reliability modeling extend beyond agro-processing, as seen in Kumar and Goel’s (2023) mathematical modeling of the soap industry and Rajbala, Kumar, and Khurana’s (2022) study on redundancy allocation in manufacturing. The breadth of mathematical modeling is further demonstrated in the healthcare domain by Mishra, Kumar, and Sharma (2022), who modeled disease progression in diabetes patients. Theoretical advancements, such as the unification of integrals involving generalized Mittag–Leffler functions by Mohit, Kumar, and Basotia (2022), provide foundational tools for advanced modeling across industries. Performance and reliability analyses in water treatment (Agrawal et al., 2021) and cold standby systems (Kumar, Garg, & Goel, 2019) have also been instrumental in translating mathematical models into actionable industrial strategies. Earlier work by Kumar, Garg, and Goel (2017, 2018, 2019, 2023) demonstrated the enduring value of mathematical modeling and profit analysis for bread-making systems and edible oil refineries, further cementing the significance of these techniques for both operational decision-making and economic evaluation.

2. SYSTEM DESCRIPTION

The processing system at Shree Shyam Agro Biotech Pvt. Ltd. is structured as a series of interlinked units: Raw Material Reception and Storage, Cleaning and Grading, Processing and Quality Control, and Packaging, Storage, and Dispatch. Each unit is designed for specialized tasks—from the careful intake and preservation of raw pulses, grains, and oilseeds, through rigorous cleaning, grading, and mechanical processing, to final packaging and coordinated distribution. All operations are digitally monitored for real-time performance and quality

control. The RPGT modeling framework captures the operational dynamics, including failure and repair events, throughput, and economic contributions of each unit, providing a holistic view for optimization and economic evaluation of the entire plant.

3. ASSUMPTION AND NOTATIONS: -

- 1) Switching is perfect.
- 2) Each unit (A, B, C, D) is either operational or failed. For the finishing unit, the system tracks which of the three machines (one online, two standby) is active at any time.

$n_i/ m_i (2 \leq i \leq 5)$: Constant Failure/Repair rates of units A, B, C, D respectively.

A/a: Unit in full working/failed state, in the same way for other units.

d_1 : Active online component of unit D is in failed state.

d_2 : One stand by and online component of unit D is in failed state.

4. TRANSITION DIAGRAM OF SYSTEM

In the context of the optimization and economic evaluation of agro biotech processing at Shree Shyam Agro Biotech Pvt. Ltd., Rajasthan using RPGT, the system’s transition diagram represents the various states and transitions of the interconnected units (A, B, C, D) throughout the processing plant. Each unit can exist in either an operational or failed state, with transitions between these states governed by statistically independent and constant failure and repair rates. Specifically, for Unit D (the finishing and dispatch unit), the model accounts for one machine operating online and two machines in standby, tracking which machine is active and the sequence of failures and repairs. The transition diagram thus comprehensively maps all possible operational and degraded configurations, illustrating how the system navigates between states based on failures, repairs, and the activation of standby components. This framework enables the calculation of key performance indicators such as system reliability, mean time to system failure (MTSF), steady-state availability, repairman workload, and overall profitability, providing the basis for data-driven optimization and economic analysis in the agro biotech processing environment.

$S_2 = ABCD,$	$S_3 = aBCD,$	$S_4 = AbCD,$	$S_5 = ABcD$
$S_6 = ABCd_1,$	$S_7 = aBCd_1,$	$S_8 = AbCd_1,$	$S_9 = ABcd_1$
$S_{10} = ABCd_2,$ $S_{14} = ABCd$	$S_{11} = aBCd_2,$	$S_{12} = AbCd_2,$	$S_{13} = ABcd_2$

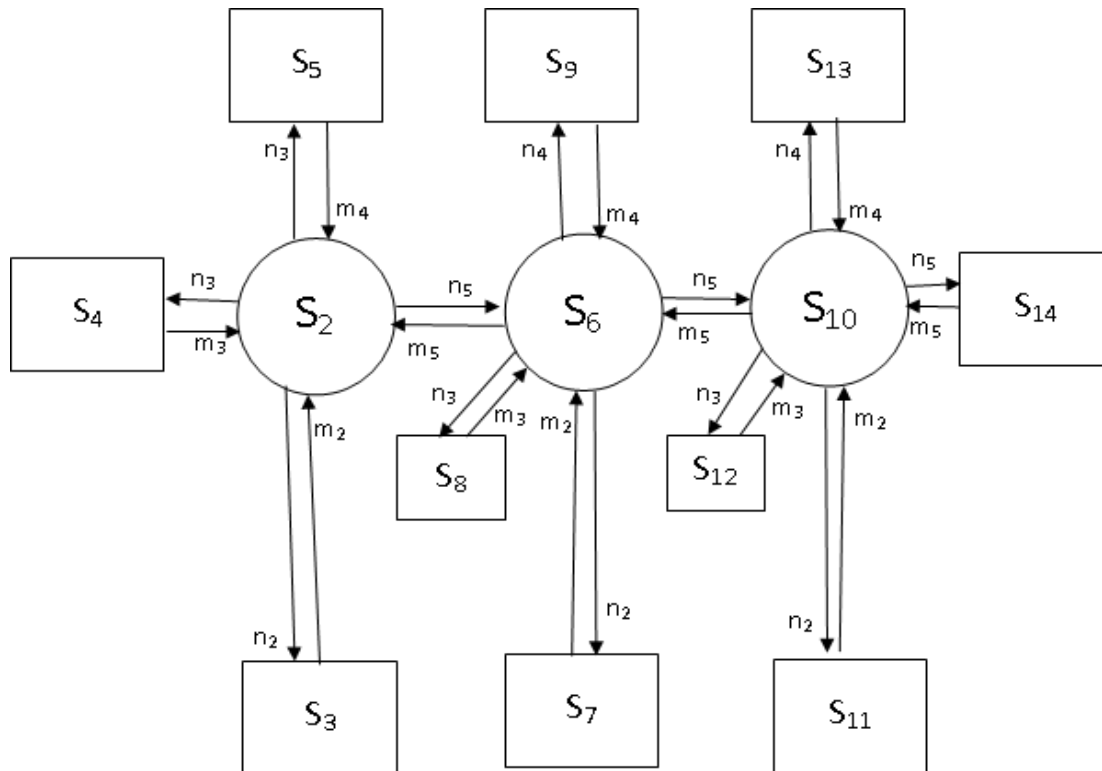


Figure 1: Transition Diagram of System

5. EVALUATION OF PARAMETERS

The transition path probabilities from base state $\xi = 10$ 'to reachable states are using RPGT are:

Probabilities in estate 10'to altered vertices and agreed for example

$$V_{10,2} = (10,6,2)/[\{1-(2,3,2)\}\{1-(2,4,2)\}\{1-(2,5,2)\}\{1-(6,8,6)\}\{1-(6,9,6)\}\{1-(6,7,6)\}]$$

$$= (p_{10,6}p_{6,2})/[(1-p_{2,3}p_{3,2})(1-p_{2,4}p_{4,2})(1-p_{2,5}p_{5,2})(1-p_{6,8}p_{8,6})(1-p_{6,9}p_{9,6})(1-p_{6,7}p_{7,6})]$$

$$V_{10,3} = (10,6,2,3)/[\{1-(6,9,6)\}\{1-(6,7,6)\}\{1-(6,8,6)\}\{1-(2,4,2)\}\{1-(2,5,2)\}]$$

$$= (p_{10,6}p_{6,2}p_{2,3})/[(1-p_{6,9}p_{9,6})(1-p_{6,7}p_{7,6})(1-p_{6,8}p_{8,6})(1-p_{2,4}p_{4,2})(1-p_{2,5}p_{5,2})]$$

$$V_{10,4} = \dots\text{Continues}$$

$$V_{2,2} = 1;$$

$$V_{2,3} = (2,3) = p_{2,3};$$

$$V_{2,4} = \dots\text{Continues}$$

6. METHODOLOGY

MTSF (T_0): Un-failed situations to which organization transits once initial state 2', before visiting first unsuccessful attractive $\xi = 10$ '.

$$MTSF (T_0) = \left[\sum_{i,sr} \left\{ \frac{\left\{ \text{pr} \left(\xi \xrightarrow{sr(sff)} i \right) \right\} \mu_i}{\Pi_{m_1 \neq \xi} \{1-V_{m_1 m_1}\}} \right\} \right] \div \left[1 - \sum_{sr} \left\{ \frac{\left\{ \text{pr} \left(\xi \xrightarrow{sr(sff)} \xi \right) \right\}}{\Pi_{m_2 \neq \xi} \{1-V_{m_2 m_2}\}} \right\} \right]$$

Availability of System (A₀): The situations at which arrangement works in full or partial states i.e. it is accessible are j' = 2, 6, 10 and enchanting ξ' = 10' convenience is specified by

$$A_0 = \left[\sum_{j,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow j}) \right\} f_j \mu_j}{\Pi_{m_1 \neq \xi} \{1-V_{m_1 m_1}\}} \right\} \right] \div \left[\sum_{i,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow i}) \right\} \mu_i^1}{\Pi_{m_2 \neq \xi} \{1-V_{m_2 m_2}\}} \right\} \right]$$

Busy Period of the Server: States when server is tiring doing maintenance stand; j=12, attractive ξ = 0', server's busy period is

$$B_0 = \left[\sum_{j,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow j}) \right\} n_j}{\Pi_{m_1 \neq \xi} \{1-V_{m_1 m_1}\}} \right\} \right] \div \left[\sum_{i,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow i}) \right\} \mu_i^1}{\Pi_{m_2 \neq \xi} \{1-V_{m_2 m_2}\}} \right\} \right]$$

Expected Fractional Number of Assessments thru the repair man: The states where repairman joins a fresh stand 3, 4, 5, 6, Taking ξ' = 2', this value using RPGT is given by

$$V_0 = \left[\sum_{j,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow j}) \right\}}{\Pi_{k_1 \neq \xi} \{1-V_{k_1 k_1}\}} \right\} \right] \div \left[\sum_{i,sr} \left\{ \frac{\left\{ \text{pr}(\xi^{sr \rightarrow i}) \right\} \mu_i^1}{\Pi_{k_2 \neq \xi} \{1-V_{k_2 k_2}\}} \right\} \right]$$

6.1 Particular Cases:

To further elucidate the optimization and economic evaluation of the agro biotech processing system at Shree Shyam Agro Biotech Pvt. Ltd., Rajasthan, this section presents particular cases based on the RPGT model. By examining the system's performance under varying failure and repair rates, detailed insights are drawn into reliability, availability, maintenance workload, and profitability. The following tables and figures summarize the results and trends for key performance metrics, enabling data-driven recommendations for operational improvement.

Behavior Analysis: Fix; α = n_i; β = m_i

PROFIT FUNCTION (P₀): The system can be done by utilized profit function

$$P_0 = D_1 A_0 - (D_2 B_0 + D_3 V_0) = D_1 A_0 - D_2 B_0 - D_3 V_0,$$

Taking D₁ = 1300; D₂ = 100; D₃ = 200,

we have

Table 1: Profit Function (P₀)

n \ m	0.75	0.85	0.95
0.25	2731.5	2875.0	2930.4

0.35	2396.1	2603.7	2807.9
0.45	2181.4	2292.1	2408.8

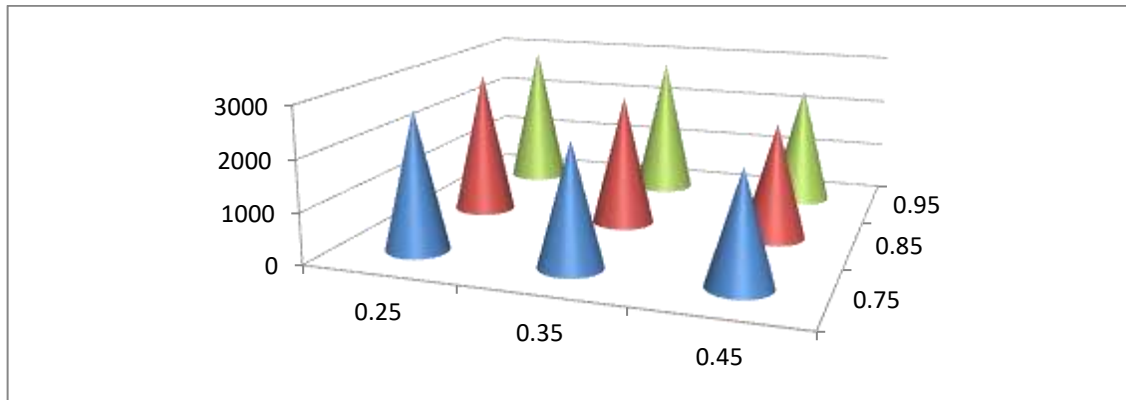


Figure 2: Profit Function (P₀)

Table 1 and Figure 2 detail the profit function as influenced by system availability, server busy periods, and repairman visits. The analysis demonstrates that overall profit increases with higher repair rates and decreases with higher failure rates. Efficient repair strategies and proactive maintenance are therefore essential for maximizing economic returns in the plant.

7. Conclusion:

In summary, this study demonstrates that optimizing reliability and maintenance strategies using the RPGT framework significantly enhances the operational efficiency and profitability of agro biotech processing plants. The analysis reveals that reducing failure rates and improving repair processes are critical for maximizing system availability and economic returns. By applying advanced mathematical modeling, plant managers gain actionable insights for data-driven decision-making. These findings provide a valuable roadmap for sustaining growth, quality, and competitiveness in Rajasthan’s agro biotech industry.

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