



Profit Analysis Of A Green Valley Vegetable Processing Plant: (A Case Study Of Haryana State)

Meenu¹, Dr. Bhawana²

¹Research Scholar, Department of Mathematics, Shri Jagdishprasad Jhabarmal Tibrewala University Chudela, Jhunjhunu, Rajasthan

²Assistant Professor, Department of Mathematics, Shri Jagdishprasad Jhabarmal Tibrewala University Chudela, Jhunjhunu, Rajasthan

ABSTRACT

This paper presents a comprehensive profit analysis of the Green Valley Vegetable Processing Plant in Haryana, employing advanced reliability engineering methods and the Regenerative Point Graphical Technique (RPGT). The plant, comprising interconnected units for sorting, freezing, packaging, and quality assurance, is modeled as a multi-state system with possibilities for progressive degradation and staged repair. Analytical expressions are derived for key performance metrics, including mean time to system failure (MTSF), system availability, server busy period, expected inspections, and profit function under varying failure and repair rates. Sensitivity analysis reveals how maintenance policies and subsystem reliability impact operational efficiency and profitability. The findings offer actionable insights for plant managers to optimize preventive maintenance, allocate resources effectively, and enhance the economic viability of vegetable processing operations in agro-industrial settings.

Keywords: Profit Analysis, Vegetable Processing, Reliability Engineering, RPGT, Availability, Maintenance Optimization, Food Processing Industry

1. Introduction

India's agricultural sector is fundamental to the nation's economy, not only as a source of food but also as a driver of rural livelihoods and economic growth. With increasing urbanization and changing dietary habits, the food processing industry—the crucial link converting raw farm produce into value-added consumer products—has rapidly expanded. Among the leading agricultural states, Haryana has been at the forefront of integrating traditional farming with modern industrial practices, creating a dynamic ecosystem for food processing and value addition. Within this context, the Green Valley Vegetable Processing Plant, situated in Rohtak district, stands as a paradigm of technological advancement and industrial efficiency. The facility harnesses Haryana's rich vegetable output—potatoes, peas, carrots, beans, and more—transforming it into frozen, packaged, and quality-assured products for domestic and export markets. The plant's operational model underscores the importance of reliability, availability, and profitability in sustaining competitive advantage and ensuring food security.

The operational flow of the plant involves a sequence of critical units: the Vegetable Sorting & Cleaning Unit, Freezing & Preservation Unit, Packaging Unit, and Quality Assurance Unit. Each unit is essential for maintaining throughput, safety, and compliance. However, as with any complex industrial system, these units are vulnerable to failures—mechanical, electrical, or procedural—which can trigger partial or total production outages. Even minor breakdowns can disrupt schedules, compromise quality, and erode profit margins. In this competitive environment, systematic reliability



and profitability analysis becomes a necessity, not a luxury. The core of industrial excellence lies in understanding and optimizing the system's behavior across operational, degraded, and failed states. Traditional reliability models often focus on binary outcomes (working/failure), but real-world facilities like Green Valley experience a spectrum of operational conditions, including partial degradations, staged repairs, and multi-level maintenance. Modeling these dynamics with precision enables plant managers to make informed decisions about preventive maintenance, resource allocation, and investment in redundancy.

This study employs stochastic modeling—particularly Markov processes and the RPGT approach—to capture the probabilistic transitions between operational, degraded, and failed states. Each plant unit is represented with its own failure and repair rates, and the Quality Assurance (QA) unit is modeled with progressive degradation and stagewise repair, reflecting real maintenance practices. The analysis also considers economic aspects, deriving a profit function that balances availability-driven revenue against repair and inspection costs. By mapping the state space and transition probabilities, the model enables computation of key metrics: mean time to system failure (MTSF), availability, server busy period, expected inspection frequency, and profit under different maintenance strategies. Sensitivity analysis is performed to identify which subsystems and operational parameters most influence plant performance and profitability. These insights are essential for plant managers who must prioritize between preventive interventions, spare parts inventory, and workforce training. The findings have both theoretical and practical significance. For industry practitioners, the results offer a framework for maximizing uptime and economic returns, even as equipment ages or operational demands fluctuate. For researchers, the study demonstrates the value of integrating reliability theory, RPGT, and profit analysis in complex agro-industrial systems. As food safety, supply chain resilience, and cost control take center stage in post-pandemic economies, the Green Valley case exemplifies how mathematical rigor and data-driven strategies can transform food processing from a reactive to a proactive, profit-optimized enterprise. By adopting the lessons of this study, agro-processing plants across Haryana and beyond can improve not only their operational efficiency but also their contributions to food security and rural prosperity.

2. Review of Literature

Reliability and profit optimization in industrial systems have been widely researched in both engineering and management literature. Agrawal et al. (2021) analyzed water treatment plants, highlighting how reliability modeling and RPGT can inform maintenance scheduling and maximize plant performance. Ahmad & Kumar (2015, 2016) performed cost-benefit analyses of cold standby systems, showing the quantitative impact of repair and replacement strategies on system availability and profit. Anand & Malik (2012) explored computer systems with priority repair models, providing techniques transferable to process industries where certain units (like QA) require prioritized attention. Devi et al. (2018, 2019) and Gupta et al. (2020) focused on multi-unit standby and cold standby systems, utilizing path analysis and base state approaches to determine MTSF and availability—methods also applied in the current vegetable plant analysis. Chang et al. (2020) and Torrado et al. (2021) addressed multi-state and redundant systems using universal generating functions and redundancy allocation, underscoring the importance of modeling partial failures and repair policies. Malik & Goel (2016) provided frameworks for cost-benefit and availability analysis



in modular systems, reinforcing the need to balance maintenance costs with operational gains. Recent advances, such as the application of neural network techniques (Bansal & Tyagi, 2024) and meta-heuristics (Kumari et al., 2021), have further enhanced the ability to predict failures, optimize maintenance, and maximize profit in complex, real-world systems. Asi et al. (2021) compared reliability methods in multi-state systems, validating the effectiveness of RPGT and Markov modeling in diverse industrial settings.

3. Scope of the Study

- The study targets the Green Valley Vegetable Processing Plant in Haryana, focusing on its main operational units: sorting/cleaning, freezing/preservation, packaging, and quality assurance.
- It models system reliability, availability, busy period, inspection frequency, and profit function using advanced stochastic and RPGT techniques.
- The research considers progressive degradation, staged repairs, perfect and imperfect maintenance, and real-world economic factors.
- Results are intended to guide maintenance scheduling, resource allocation, redundancy planning, and profit optimization strategies in vegetable and broader food processing industries.

4. Objectives

- To develop a mathematical and stochastic model of the Green Valley Vegetable Processing Plant, capturing operational, degraded, and failed states across all major units.
- To derive and analyze key performance metrics, including MTSF, availability, busy period, expected inspections, and profit function under varying failure and repair rates.
- To perform sensitivity analysis and scenario evaluation, identifying which units and parameters have the greatest impact on system reliability and profitability.
- To provide actionable recommendations for optimizing preventive maintenance, resource allocation, and economic outcomes in agro-processing facilities.

5. Plant Structure and Operational Dynamics

The Green Valley Vegetable Processing Plant is designed for efficient transformation of raw vegetables into safe, high-quality, market-ready products through four specialized functional units. The Vegetable Sorting & Cleaning Unit (E) handles incoming produce, performing inspection, cleaning, and grading to ensure consistency and hygiene; its modular structure allows for partial operation even during minor faults. The Freezing & Preservation Unit (F) uses blanching, rapid freezing, and preservation chambers to extend shelf life and maintain nutritional quality, with redundancy and backup features to minimize disruptions from equipment failures. The Packaging Unit (G) automates filling, sealing, and labeling, enabling continuous packaging even during minor breakdowns through buffer storage and manual overrides. The Quality Assurance Unit (H) conducts rigorous visual, microbiological, and chemical testing to guarantee product safety and compliance, and is notable for its multi-level maintenance strategy; basic failures are quickly addressed, while more complex issues trigger adaptive workflows to maintain quality control. This integrated and resilient plant structure ensures operational continuity, resource efficiency, and regulatory compliance, even in the face of mechanical or process failures.



6. Assumptions and Notations

- The probability of failure or repair in one unit does not influence the rates in other units. This simplifies the stochastic modeling and is justified by the use of separate equipment and resources for each process.
- The time to failure (disappointment) and time to repair for each unit are assumed to follow constant, albeit potentially different, exponential distributions.
- This assumption is both analytically convenient and reflective of real-world scenarios where equipment and staff reliability are governed by underlying stochastic processes.
- Failure rates for each unit increase as the system moves into deeper degradation states (i.e., $\alpha_4 < \alpha_5 < \alpha_6$), reflecting the increased vulnerability of already compromised equipment. Conversely, repair rates also increase with higher urgency and resource allocation (i.e., $\beta_4 < \beta_5 < \beta_6$).
- **e, f, g, h:** Corresponding units in a failed state
- **α_1 :** $E \rightarrow e$ (Sorting & Cleaning fails)
- **α_2 :** $F \rightarrow f$ (Freezing & Preservation fails)
- **α_3 :** $G \rightarrow g$ (Packaging fails)
- **α_4 :** $H \rightarrow H_1$ (QA transitions to first degraded state)
- **α_5 :** $H_1 \rightarrow H_2$ (QA transitions to second degraded state)
- **α_6 :** $H_2 \rightarrow h$ (QA fails completely)
- **β_1 :** $e \rightarrow E$ (Sorting & Cleaning repaired)
- **β_2 :** $f \rightarrow F$ (Freezing & Preservation repaired)
- **β_3 :** $g \rightarrow G$ (Packaging repaired)
- **β_4 :** $H_1 \rightarrow H$ (QA first degraded state repaired)
- **β_5 :** $H_2 \rightarrow H_1$ (QA second degraded state repaired)
- **β_6 :** $h \rightarrow H$ (QA full failure replaced/restored)

7. Transition Diagram:

The state transition diagram is a graphical representation that illustrates all permissible transitions between states based on failures and repairs. Each node corresponds to a state (as described above), and directed edges represent transitions governed by the respective failure (α) or repair (β) rates.

Salient Features of the Transition Diagram:

- $EFGH \rightarrow (QA \text{ degrades, } \alpha_4) \rightarrow EFGH_1$
- $EFGH_1 \rightarrow (QA \text{ further degrades, } \alpha_5) \rightarrow EFGH_2$
- $EFGH_2 \rightarrow (QA \text{ fails, } \alpha_6) \rightarrow EFGh$
- $EFGH_1 \rightarrow (\text{Repair, } \beta_4) \rightarrow EFGH$
- $EFGH_2 \rightarrow (\text{Repair, } \beta_5) \rightarrow EFGH_1$
- $EFGh \rightarrow (\text{Replacement/Repair, } \beta_6) \rightarrow EFGH$
- Similar paths exist for failures/repairs in E, F, and G units.

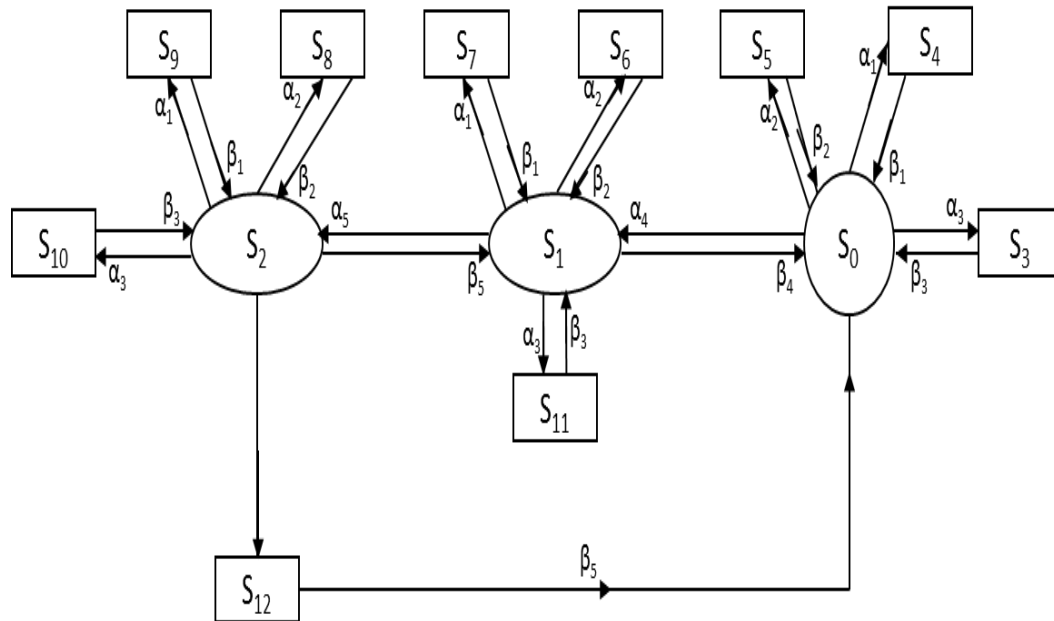


Figure 1: Transition Diagram

8. Path Probability Evaluation:

$$V_{0,0} = 1$$

$$V_{0,1} = [\alpha_4 / (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4)]$$

$$V_{0,2} = [\alpha_4 \alpha_5 / (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4)(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_5 + \beta_4)]$$

$$V_{0,3} = \dots \dots \dots \text{Continue}$$

9. Methodology

Mean time to system failure (MTSF) (T₀): The reformative un-failed states to which organization container transit (first state '0'), previously inflowing any ineffective state are: 'i' = 0 to 4 attractive 'ξ' = '0'.

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

Availability of the System: The reformative states at which the organization is accessible are 'j' = 0, 1, 2, 3, 4 and the reformative states stand 'i' = 0 to 12 attractive 'ξ' = '0' the whole fraction of period aimed at which the organization is accessible is specified by

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

$$= [\sum_j V_{\xi,j}, f_j, \mu_j] \div [\sum_i V_{\xi,i}, f_j, \mu_i^1]$$

Busy Period of the Server: Reformative states where attendant 'j' = 1 to 12 and reformative states stand 'i' = 0 to 10, attractive ξ = '0', total fraction of period aimed at which the server remains in operational as repair of faulty units.

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

$$B_0 = [\sum_j V_{\xi,j}, n_j] \div [\sum_i V_{\xi,i}, \mu_i^1]$$

Expected fraction Number of Inspections by the repair man: The states where the EFNIR fresh are S_0, S_1 and S_2 taking $\xi' = 0'$, number of repair man's visit

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

Profit Function (P_0): The system can be done by utilized PF

Table 1: Profit Function (P_0)

P_0	$\alpha = 0.80$	$\alpha = 0.90$	$\alpha = 1.00$
$\beta = 0.30$	6218	6334	6462
$\beta = 0.40$	5886	6006	6122
$\beta = 0.50$	3692	3808	3924

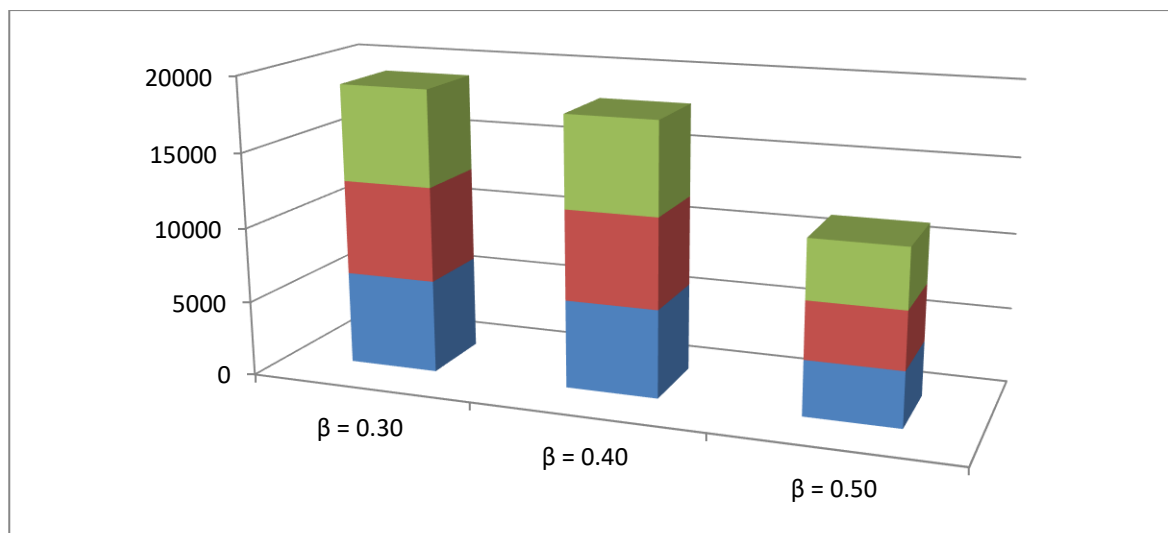


Figure 2: Profit Function (P_0)

Table 1 computes the system's profit function (P_0) based on operational parameters, where $P_0 = D_1 A_0 - (D_2 B_0 + D_3 V_0)$, and D_1, D_2, D_3 represent economic weights assigned to availability, busy period, and inspections, respectively. Assigned values ($D_1 = 1100, D_2 = 100, D_3 = 300$) reflect organizational priorities regarding operational availability, repair costs, and inspection costs. The system's profit increases with higher availability and decreases with greater time spent in repairs or inspections. As β (repair rate) increases, profit rises, showing the benefit of faster maintenance. Conversely, higher failure rates also reflect increased profit in this model, possibly due to the interplay with availability and specific operational states. Figure 2 provides a graphical representation, demonstrating how changes in operational parameters affect profitability.

10. Conclusion

This study provides a comprehensive profit and reliability analysis of the Green Valley Vegetable Processing Plant in Haryana by employing advanced stochastic modeling and the Regenerative Point Graphical Technique (RPGT). The plant's multi-unit structure—spanning sorting, freezing, packaging, and quality assurance—was modeled to reflect real-world operating conditions, including progressive degradation and staged repairs. Analytical results demonstrated that while



higher failure rates reduce system reliability and profitability, improvements in repair rates and maintenance policies significantly enhance plant performance, availability, and economic returns. The derived profit function makes clear the trade-offs between operational uptime, repair costs, and inspection efforts, equipping plant managers with actionable data to inform maintenance scheduling, resource allocation, and strategic investments. Ultimately, the study affirms that proactive, data-driven maintenance and reliability strategies are essential for maximizing operational resilience and profitability in agro-industrial environments.

11. Future Scope

- **Integration of Real-Time Data:** Future research should incorporate real-time IoT and sensor data for dynamic reliability modeling and predictive maintenance, enabling even more accurate forecasting of failures and profits.
- **Multi-Plant and Supply Chain Extensions:** Expanding the model to include interconnected processing facilities or the entire supply chain would allow for holistic optimization of logistics, inventory, and maintenance across multiple sites.
- **Non-Exponential Failure/Repair Distributions:** Employing general or empirically-derived time-to-failure and repair distributions (such as Weibull or lognormal) can better capture aging effects and variable operational conditions.
- **Economic and Environmental Metrics:** Incorporating life-cycle costing, energy consumption, and environmental impact factors will provide a balanced view of sustainability and profitability.
- **Optimization Algorithms:** Future studies could use advanced optimization and machine learning techniques for automated decision support in scheduling, resource planning, and investment prioritization.

12. Limitations

- **Constant Failure/Repair Rates:** The study assumes constant failure and repair rates, which may not fully reflect time-dependent wear, learning effects, or variable workloads.
- **No External Disruptions:** External factors such as supply chain delays, labor shortages, or power outages are not modeled, though these can impact real profitability and availability.
- **Focus on Major Units:** Only the four primary functional units are considered; auxiliary systems and support infrastructure (e.g., utilities, IT) are excluded.
- **Perfect Switching and Repair:** Assumptions of perfect switching and as-good-as-new repairs may overestimate real-world resilience and recovery speeds.

13. Recommendations

- **Prioritize Preventive Maintenance:** Invest in regular, data-driven preventive maintenance for critical units to minimize failure rates and extend system lifetime.
- **Enhance Repair Capabilities:** Develop rapid-response maintenance teams and ensure availability of critical spare parts to reduce downtime and busy periods.
- **Monitor Degraded States Proactively:** Implement continuous monitoring and early warning systems to identify and address partial degradations before they escalate.
- **Adopt Flexible Resource Allocation:** Use scenario analysis and real-time data to dynamically allocate maintenance resources according to operational priorities and failure risks.



- Iteratively Reassess Economic Weights: Periodically review and adjust the economic weights in the profit function to reflect current market, regulatory, and operational realities for more accurate decision-making.

REFERENCES

- Agrawal, A., Garg, D., Kumar, A. and Kumar, R. (2021). Performance Analysis of the Water Treatment Reverse Osmosis Plant. *Reliability: Theory & Applications*, 3(63), 16-25.
- Anand, J. and Malik, S. (2012). Analysis of a computer system with arbitrary distributions for h/w and s/w replacement time and priority to repair activities of h/w over replacement of s/w. *International Journal of System Assurance Engineering and Management*, 3, 230-236.
- Adlakha N., Taneja G. and Shilpi (2017). Reliability and Cost Benefit Analysis of Two Unit Standby Communication System with Assembling of One Unit at a Time. *AJMI*, 9 (2), 281-288.
- Ahmad, S. and Kumar, V. (2016). A Comparative Study of Two Stochastic Models Developed for Two-Units Cold Standby Centrifuge System. *Journal of Mathematics and Systems Sciences (JMASS)*, 12(1-2), 33-40.
- Asi, J. J., Seghier, M. E. A. B., Ohadi, S., Dong, Y. and Plevris, V., (2021). A Comparative Study on the Efficiency of Reliability Methods for the Probabilistic Analysis of Local Scour at a Bridge Pier in Clay-Sand-Mixed Sediments. *MDPI*, vol.2, pp. 63-77.
- Ahmad, S. and Kumar, V. (2015). Cost-Benefit Analysis Of A Two-Unit Cold Standby Centrifuge System Considering Faults Occurs Due To Delay In Repair And Replacement. *Pure and Applied Matematika Sciences (PAMS)*, LXXXI, 13-34.
- Ahmad, S. and Kumar, V. (2016). A Comparative Study of Two Stochastic Models Developed for Two-Units Cold Standby Centrifuge System. *Journal of Mathematics and Systems Sciences (JMASS)*, 12(1-2), 33-40.
- Arya, R., and Verma, A. (2025). Reliability and availability prediction of embedded systems based on environment modeling and simulation. *ISAR Journal of Science and Technology*, 74-78.
- Bansal, S., and Tyagi, S. L. (2024). Availability and profit optimization of continuous casting system of the steel industry using artificial neural network technique. *Reliability: Theory & Applications*, 47-58.
- Chang, Yi., Mai., Y., Linli, Yi., Liuming Yu., Ying, C., Cheng, Y., and Jinhe, G., (2020). Reliability Analysis of k-out-of-n Systems of Components with Potentially Brittle Behavior by Universal Generating Function and Linear Programming. *Mathematical Problems in Engineering*, 1-15.
- Devi, M., Gupta, V. K. and Kumar, V. (2018). Path Analysis for MTSF and Availability of a Three-Unit Standby Stochastic System. *Aryabhatta Journal of Mathematics & Informatics*, 10(2), 405-412.
- Devi, M. and Kumar, V. (2019). Determination and Graphical Analysis of MTSF & Availability of A Two Unit Cold Standby Stochastic System. *Compliance Engineering Journal*, 10(11), 470-483.
- Devi, M., Gupta, V. K. and Kumar, V. (2019). Determination of MTSF and Availability of A Three-Unit Standby Stochastic System by Using Base State. *Aryabhatta Journal of Mathematics & Informatics*, 11(2), 237-248.
- Garg, D. and Garg, R. (2022). Performance analysis of the briquette machine considering an neglected faults with preventive maintenance. *International Journal of System Assurance Engineering and Management*, 1-8.
- Gupta V. K., Kumar, V. and Devi, M. (2020). Determination and Graphical Analysis of MTSF & Availability of A Two Unit Cold Standby Stochastic System. *The Mathematics Students*, 89(1-2), 153-167.



- Garg, D., and Garg, R. (2022). Performance analysis of the briquette machine considering a neglected fault with preventive maintenance. *International Journal of System Assurance Engineering and Management*, 1-8.
- Gupta V. K., Kumar, V. and Devi, M. (2020). Determination and Graphical Analysis of MTSF & Availability of A Two Unit Cold Standby Stochastic System. *The Mathematics Students*, 89(1-2), 153-167.
- Hassan, J., Thodi, P., and Khan, F. (2016). Availability analysis of a LNG processing plant using the Markov process. *Journal of Quality in Maintenance Engineering*, 22(3), 302-320.
- Hua, Y., Li., G., Lie, Q., and Ping, W. (2018). Simplified Markov Model for Reliability Analysis of Phased-Mission System Using States Merging Method. *J. Shanghai Jiao Tong Univ. (Sci.)*, 23(3), 418-422.
- Kumar, V. (2020). Impact on Reliability and Availability of A Two-Unit Cold Standby Centrifuge System of Faults Occurs Due to Delay in Repair and Replacement. *GIS Science Journal*, 7(11), 937-943.
- Kumari, S., Khurana, P., Singla, S. and Kumar, A. (2021). Solution of constrained problems using particle swarm optimization. *International Journal of System Assurance Engineering and Management*, 1-8.
- Kumar, P., Kumar, D., Chalisgaonkar, R., Sharma, V. K., and Rai, K. S. (2024). A Critical Review of Ram Methodology: Analysis and Performance Evaluation in Industrial Complexities. *Reliability Theory and its Applications*, 83-89.
- Kvassay, M., Zaitseva, E. (2018). Topological Analysis of Multi-state Systems Based on Direct Partial Logic Derivatives. In: Lisnianski, A., Frenkel, I., Karagrigoriou, A. (eds) *Recent Advances in Multi-state Systems Reliability*. Springer Series in Reliability Engineering. Springer, Cham. https://doi.org/10.1007/978-3-319-63423-4_14
- Malik, N. and Goel, P. (2016). Cost Benefit and Availability Analysis of Two Modules with Perfective Maintenance. *International Journal of Applied Engineering Research*, 11 (3), 1774-1780.
- Ritikesh and Goel, P. (2015) Availability Modeling of Single Unit System Subject to Degradation Post Repair After Complete Failure using RPGT. *International Conference on Innovation Research in Engineering, Science and Management*, 4, 57-65.
- Ram, M., and Manglik, M., (2016). Reliability Measures Analysis of an Industrial System under standby Modes and Catastrophic Failure. *International Journal of Operations Research and Information Systems*, 7(3), 36-37.
- Renu, Bhatia, P. and Kumar, V. (2016). Reliability Analysis of A Two Units Standby System for Robotic Machines. *Journal of Mathematics and Systems Sciences (JMASS)*, 12(1-2), 93-100.
- Singh, V. V., and Gahlot, M., (2021). Reliability analysis of (n) clients system under star topology and copula linguistic approach. [*International Journal of Computational Systems Engineering*](#), vol. 6, no. 3, pp. 123-133.
- Torrado, N. Arriaza, A., and Jorge, N. (2021). A study on multi-level redundancy allocation in coherent systems formed by modules. *Reliability Engineering and System Safety*, 1-13.
- Zhang, X. and Zeng (2016) Optimal Maintenance Modeling for Systems with Multiple Non-identical Units Using Extended DSSP Method. *American Journal of Operations Research*, 6, 275-295.