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A Scholarly Review of the Critical Works and Aa Future Global View of RAM Approaches for Complex Systems in Different Process Industries

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Abstract

It is necessary for industrial systems to function effectively for extended periods of time. Although system performance is crucial for failure-free operation, no manufacturing system can operate completely fault-free in real life. A thorough critical assessment of the literature covering the last 33 years on RAM approaches—Reliability, Maintainability, and Availability—has been done. This review can help to enhance the performance of complex systems. A complete overview of the historical and present state of RAM procedures in the scientific field and industry was obtained through the review of a few studies. Both qualitative and quantitative study of the complex systems may benefit from the various RAM tools and approaches that were taken from the review. The author attempted to concentrate on a few key facets of RAM methods in this study.

Keywords: *Reliability, Availability, Maintainability, Safety, Markov, Petri Nets, Dependability.*

Introduction

In an ideal world, all assets would be designed with low failure rates, cheap maintenance costs, and ease of use in mind. An asset's productivity and its acquisition and maintenance costs should be fairly balanced. RAM analysis is typically performed by a group of experts in systems, design, and reliability at the design stage. The analysis can be repeated over the asset's life by maintenance and service reliability engineers, who possess essential data regarding the asset's health and performance.

Reliability, availability, and maintainability are the three equally important components that typically work best together. A machine is considered operational when it is readily available, reliable when it is expected to operate as intended, and maintained when any problems can be easily fixed.

The likelihood that a system will finish the mission and function flawlessly in a particular environment for a predetermined amount of time is known as reliability. Reliability engineering uses risk management, prevention, and prediction to meet high levels of "lifetime" technical uncertainty and failure hazards. While statistics and mathematics play a significant role in determining dependability, they are not the only means to get it.

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System safety, safety engineering, and quality engineering are all strongly related to reliability engineering.

A unique metric called availability combines reliability and serviceability standards. It shows the likelihood that an asset will function—that is, not require maintenance or repairs—at any particular moment. In order to account for potential downtime during which the service may (and will) become unavailable during its anticipated useful life, availability is measured in steady state. If a component is entirely functioning in its original state, the failure rate is considered the projected strength of failure in reliability engineering calculations.

Maintainability talks about how easy an asset is to maintain and how many resources are needed. This approach can also be used to determine the likelihood that an asset will return to its intended state following a maintenance task. One popular metric to assess it is Mean Time to Repair (MTTR).

Three aspects of a system that are of significant significance to system engineers, logisticians, and users are its RAM (Reliability, Maintainability, and Availability). Together, these attributes affect the life-cycle costs and utility of a system or product. Research on Reliability, Availability, and Maintainability (RAM) is a decision-making tool that is used to reduce cycle costs and boost overall profitability by increasing system availability. "Reliability, Availability, Maintainability and Safety" is a term commonly used in engineering to characterize a feature of a system or product.

Critical Literature Review

Ciardo *et al.* (1990) used semi-markov reward procedures to analyze processing systems. An method by Beaudry, which was published for the computation of accumulated reward in a semi-markov process, is extended in the semi-markov reward process [1].

In 1991, Viswanadham *et al.* developed a fault-tolerant manufacturing system's performability. The authors attempt to illustrate the significance of performability in automated manufacturing system design with examples. The production lead time and throughput are the two main performance metrics that affect a plant's competitiveness [2]. The analytic behavior of availability and dependability of the crystallizer system in sugar plants was investigated by Kumar *et al.* (1992). Chapman-Kolmogrov equations served as the model's foundation. Different state probability and steady-state availability were obtained using the Laplace transform. Research has been done on the impact of failure and repair rates on availability [3]. The Markov approach was used by Sharma and Bazovsky (1993) to analyze big and complex systems. The differential problem was solved using the Laplace transform method. Design engineers were able to assess their own designs to improve system reliability following the modeling [4]. Behera *et al.* (1994) studied the flexible production system using deterministic and stochastic petri nets. A system performance evaluation has also been completed. Flexibility in industrial processes was also modeled using a generalized stochastic petri net. The performance metrics acquired were nearly identical for both the generalized stochastic petri net and the deterministic petri net [5]. The optimization of a manufacturing plant's availability and maintenance costs was studied by Murty and Naikan (1995). It has been determined that it is prudent to thoroughly consider the economic sustainability of overspending on maintenance in order to boost plant availability before making any significant decisions about the formation of the maintenance budget [6].

From a behavioral standpoint, Kumar *et al.* (1996) evaluated the carbon recovery and shell gasification procedures in a urea fertilizer factory. The problem was formulated by the author of this study using simple probability considerations. Based on the results of the analyses, the steady-state availability equations were derived and the behavior of the equipment was presented. Give the maintenance manager advice based on the failure results, including instructions on how to execute the repair schedule [7]. Thermal power plants' ability to generate steam and electricity was assessed by Arora and Mehta (1997). The formulas for mean time between failures and steady-state availability were created by the authors. Graphs show the relationship between system availability and failure and repair rates. The modeling strategy made use of a probabilistic approach and the Chapman-Kolmogorov birth-death process. Based on the results, the critical system and subsystem decided to reduce the number of failures, and the plant staff was notified of the results so they could prepare for the failure-free functioning of the system [8]. Pellegrini *et al.* (1998) evaluated the availability and performance of electrical complex systems using a statistical method based on the semi-Markov technique. The results were utilized to identify the resolution model of a semi-Markov process for the electronic system, and the asymptotic availability value was computed using the mean Laplace transform [9]. Singh and Mahajan (1999) assessed the dependability and availability of a utensil production facility. Laplace transformation is used to solve differential equations. The Markovian approach was employed to examine the impact of varying parameter accessibility. The results showed that disruptions in repair and failure rates had an impact on availability [10].

In 2000, Borgnovo *et al.* suggested modeling using Monte Carlo. Monte Carlo modeling provided guidance on the management and operation of the plant's tools. The operating and maintenance strategy is examined in the paper's study [11]. Zhang and Horigome (2001) examined how the system's failure and repair rates changed over time in terms of availability and dependability. The solution displays the availability and reliability of the system together with different failure and repair rates [12]. Using M cold stable units, Wang and Loman (2002) conducted a critical analysis of the availability and reliability of the K-out-of-N system. After looking into the design process for these power systems, it was discovered that this type of design may get rid of the highest chance of human error, Common Mode Failure (CMF), and Single Point Failure (SFP) [13]. In an effort to get deeper insight into the dependability and availability of distributed system services, Dai *et al.* (2003) created a model of a centralized heterogeneous distributed system. The study examined the sensitivity of the model parameter. It has been determined that the service reliability function can help with resource allocation for testing in an acceptable manner [14]. Six methods for determining the time-dependent probability of Markov models were outlined by Rauzy [2004]. Following a comprehensive analysis of methods including Euler approach, Runge-Kutta method, Adams-Bash ford multi-steps methods of order 2 and 4, full matrix exponentiation, and others, it was demonstrated that modern computers could theoretically handle Markov networks with millions of transitions [15].

Multi-objective optimization, which is mostly based on evolutionary algorithms and accounts for parameter uncertainty, was examined by Marseguerra *et al.* in 2004. After applying the process to increasingly complicated systems, this method provides a high degree of certainty in the actual system performance and provides the decision-maker with a tool to employ in order to identify a solution that is also optimal in terms of expected safety behavior [16]. Gupta *et al.* (2005) proposed a numerical examination of the process' availability and dependability in the bute-oil processing plant using the model's mathematical formulation. method can be used to manage complex systems that are subject to significant differential equations [17]. Majeed and Sadiq (2006) developed a model for the Dokan hydropower facility using the Markovian technique. After the problem was discussed and modeled, it was determined that power plant dependability declined yearly. It has been determined that a subpar maintenance program and the inexperience of engineers and technicians had a negative impact on availability [18].

In 2007, Chuan Ke and Kuangkhu compared the availability of redundancy systems that could be repaired. Confidence ranges for steady-state availability were compared using four bootstrap techniques [19]. The Markovian approach of getting system behavior using RAM analysis in critical engineering systems was introduced by Sharma and Kumar *et al.* (2008). The differential equations were created using the transition diagram. The managerial team has been told, based on the results, that features such as MTBF and MTTR are critical for the planning and maintenance of the system [20].

An availability analysis of a portion of the Rubber Tube Production System was conducted by Goyal *et al.* (2009) as part of a preemptive resume priority repair. Markov modeling was employed as the methodology.

The article aimed to increase operational availability. The impact of failure and repair rates on availability was discovered based on the findings. The system's overall availability and dependability are enhanced by maintenance management with the use of this data [21]. Adhikary *et al.* (2010) examined the RAM of a coal-fired power station. The distribution of failure and repair data is checked using trend and serial correlation tests before the data are best fitted with a probability distribution. Pareto analysis has been used to determine the major subsystem.

The results showed that the power plant's availability increases with an increase in MTBF and a drop in MTTR [22]. Vora *et al.* (2011) used a probabilistic technique to assess the thermal plant's turbo generator system's performance. The Markov technique has been applied to the formulation of problems using transition diagrams. Failure and repair graphs for maximum availability have been examined based on result availability [23]. Garg and Sharma (2012) examined the synthesis unit's performance at a fertilizer factory. The behavioral sensitivity of the system has also been studied. Utilizing the Lamda Tau-Technique, the behavior of a complicated system with room for improvement was examined. As fuzzy membership functions, eight important dependability metrics were also registered [24]. In 2013, Wolde *et al.* examined the topic of railway carrier maintenance and inspections. This study links failure and repair rates to system performance using mathematical modeling. By evaluating inspection plans for any system, this modeling helped to further optimize its cost [25].

The topic of Suleiman K *et al.* (2013)'s study was using a probabilistic approach to assess thermal power plant performance by analyzing stochastic data. The analysis's conclusions show that availability rises when the repair rate rises and vice versa, but availability falls when the failure rate rises. System availability analysis can be performed by the plant management using the result-based system [26]. Dewangan *et al.* (2014) looked at the steam turbine dependability of thermal power plants.

An analysis has been conducted using a five-year failure database. Critical components are categorized using Failure Modes and Effect Analysis (FMEA). Investigations have led to the conclusion that well-planned maintenance schedules and frequent scheduled maintenance can increase plant reliability [27]. In order to calculate RAM, dependability, MTBF, and MTTR, Aggarwal *et al.* (2015) devised a performance model based on the Markov birth-death process. Chapman-Kolmogorov differential equations and probabilistic factors have been used in mathematical modeling. The most important subsystem indicated and advised management to exercise extreme caution [28]. Talebborouane *et al.* (2016) investigated the availability of safety-critical systems using advanced fault tree and stochastic Petri Net formalisms. To overcome the limitations of the Markov process and Petri Nets, generalized stochastic Petri Nets and fault tree driven Markov processes were employed for analysis. It was determined that Petri Net modeling performs better than flaw tree-based Markov procedure [29]. Particle Swarm Optimization (PSO) was used by Kumar and Tewari (2017) to analyze and improve the performance of a beverage factory system.

The repair and failure rate are analyzed using the exponential distribution, and the Markov technique is employed for mathematical modeling. The plant management has discussed the results in order to enhance system performance [30].

Malik and Tewari (2018) modeled and prioritized maintenance for the water flow system of a coal-fired thermal power plant. Using the Markov technique, Chapman-Kolmogorov equations were constructed to obtain performance modeling. Through the case study, the authors illustrated the suggested methodology for supporting this type of decision-making process [31]. Singhal and Sharma (2018) examined the availability of industrial systems using the Markov process and generalized fuzzy numbers. Fuzzy generalized numbers have been used to handle data uncertainty.

Several arithmetic operations have been used to analyze availability analysis. The system analyst noted how the system was affected by failure and repair rates [32]. Velmurugan *et al.* (2019) examined the forming industry's availability, maintainability, and dependability using the Markov process. Mathematical functions were solved using MATLAB software. The most important subsystem was established in light of the findings. For effective maintenance, the maintenance manager has also been given the best maintenance policy [33]. Elusakin and Shafiee (2020) used stochastic Petri Nets with several failure modes as an advanced analysis tool to determine the reliability of subsea blowout preventers. Terms for MTBF, availability, and dependability were gathered and examined. Sensitivity analysis was used to evaluate how the fault coverage factor and redundancy design affect system performance. Based on the findings, it was determined that fault coverage and redundancy had a considerable impact on both MTBF and system availability [34]. Using Particle Swarm Optimization (PSO), Jagtap *et al.* (2020) maximized the boiler furnace system's availability in a coal-fired thermal power plant. The system was analyzed using the Markov approach. Plant management has been given maintenance priority based on the results [35].

RAMD (Reliability, Availability, Maintainability, and Dependability) analysis was used by Maihulla *et al.* (2021) to assess the effectiveness of the intricate system of reverse osmosis water purification apparatus. The economy's optimization was the main goal. Sensitivity analysis was used to find the constituent parts. Following the discovery, it was discovered that the RAM of a subsystem (the high-pressure pump) significantly impacts the system's overall availability [36].

The performance of a complex manufacturing system was examined by Kumar *et al.* (2021) using the Petri Nets modeling method in order to affect the real behavioral patterns of the numerous subsystems installed in the plant. The results have identified the subsystem that availability has negatively impacted [37]. In order to design the Decision Support System (DSS) for assembly line maintenance, Parkash and Tewari (2022) used a probabilistic approach in conjunction with the Markovian way of modeling. By solving differential equations and utilizing a transition diagram, the steady state probabilities were ascertained. Subsystem repair priorities were established and the most significant subsystem was identified [38]. Using Petri Nets-based methods, Kumar and Tewari (2022) assessed the ash handling system's performance characteristics in a coal-based thermal power plant. The influence of failure and repair rates has been identified. Modeling with stochastic Petri Nets (SPN). A crucial component of the system has been identified based on the findings. It was discovered that Petri Nets not only ensured better outcomes but also cut down on the time-consuming computing efforts needed for Markov and other modeling methods. [39] A continuous Markov process-based reliability analysis of wireless power transfer for electric car charging was given by Behnamfar *et al.* in 2023. Five subsystems were examined separately based on their respective reliability in order to calculate the total system reliability. With 66.31% availability during a twenty-year lifespan, the system proved to be very reliable, according to the findings [40]. Malik *et al.* (2023) employed a stochastic approach to assess the veneer cutting system's performability at the plywood plant, and Particle Swarm Optimization (PSO) was utilized to optimize the outcomes. Maintenance engineers receive assistance in optimizing both overall production costs and overall maintenance costs based on the analysis [41-44].

Research Gaps

The RAM technique has been utilized in this part to discuss the key conclusions from a study of the literature that was done over the previous three decades.

1. According to the study, researchers mostly concentrated on RAM methods; however, very little research on RAMD (Reliability, Availability, Maintainability, and Dependability) and RAMS (Reliability, Availability, Maintainability, and Safety) has been published. The significance of dependability and safety's impact on reliability was overlooked by researchers. Working in a safe environment is important, and safety makes team members more motivated to work in any hazardous situation. However, dependability is another crucial factor that positively affects reliability by helping it complete its assigned tasks or provide services.
2. A number of researchers talked about their initiatives to improve plant availability by implementing appropriate policies, procedures, and operating schedules. However, relatively few scholars have documented the relationship between operations schedule, cost, and maintenance strategies. Pay attention to the factors that also affected the cost.
3. The literature research shows that a variety of methods have been used, such as fault tree analysis, Markov models, and Lambda tau technologies. These methods all have different advantages and disadvantages. However, a technology called Markovian Petri Nets can effectively strike a balance between modeling and decision-making authority. There is very little use of this type of instrument in the literature review.

Concluding Remarks

A thorough review of the literature demonstrates the different RAM problems, instruments, and methods used in different processing industries and plants. The writers of the literature review mostly addressed maintenance plans, reducing production and maintenance costs, and boosting productivity and performability, among other topics. An array of RAM tools and techniques can be applied during the design and operating phases of the plant to further enhance its performance.

Every plant is separated into several systems or subsystems for efficient maintenance planning in order to guarantee that the systems continue to function for a long time.

Various techniques were employed for the analysis and modeling, including Markov Analysis, Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis, Reliability Growth Analysis, Fuzzy Model, Monte Carlo technique, Chapman Kolmogorov birth-death process, Stochastic Petri Nets, Particle Swarm Optimization (PSO), and others. The benefits and drawbacks of each of these methods are also covered in the study.

References

[1] Ciardo, G., Marie, R. A., Sericola, B., and Trivedi, K.S., (1990). Performability Analysis Using Semi-Markov Reward Processes . *IEEE Transactions on Computers*, 1251–1264.

[2] Viswanadham, N., Narahari, Y., and Ram, R., (1991). Performability of Automated Manufacturing Systems. *Control and Dynamic Systems*, 77–120.

[3] Kumar, D., Singh, J., and Pandey, P.C., (1992). Availability of the Crystallization System in the Sugar Industry under Common-Cause Failure. *IEEE Transactions on Reliability,* 85–91.

[4] Sharma, T.C., and Bazovsky, I., (1993). Reliability analysis of large system by Markov techniques. *Annual Reliability and Maintainability Symposium*, 260–267.

[5] Behera, T.K., Mishra, B.S., Patnaik, L.M., and Girault, C., (1994). Modelling and performance evaluation of flexible manufacturing systems using deterministic and stochastic timed Petri nets. *IEE Conf. Publ.,* 362–368.

[6] Murty, A.S.R., and Naikan, V.N.A., (1995). Availability and maintenance cost optimization of a production plant. *International Journal of Quality and Reliability Management,* 28–35.

[7] Kumar, Sunand., Kumar, Dinesh., and Mehta, N.P., (1996). Behavioral analysis of shell gasification and carbon recovery process in a urea fertilizer plant. *Microelectronics Reliability*, 671- 673.

[8] Arora, Navneet., and Kumar, Dinesh., (1997). Availability analysis of steam and power generation systems in the thermal power plant. *Microelectronics Reliability*, 795-799.

[9] Pellegrini, G. G., Catelani, M., and Iuculano, G., (1998). Measurement of the availability performance for electronic complex systems. *IEEE Instrumentation and Measurement Technology Conference, IEEE,* 51–54.

[10] Singh, J., Mahajan, P. (1999). Reliability of Utensils Manufacturing Plant. *A Case Study, Operational Research Society of India*, 260-269.

[11] Borgonovo, E., M. Marseguerra, M., and E. Zio, E., (2000). A Monte Carlo methodological approach to plant availability modeling with maintenance. *Reliability Engineering and System Safety*, 61-73.

[12] Zhang, T., and Horigome, M., (2001). Availability and reliability of system with dependent components and time-varying failure and repair rates. *IEEE Transactions on Reliability,* 151-158.

[13] Wang, Wendai., and Loman, James., (2002). Reliability/availability of K-out-of-N system with M cold standby units. *Annual Reliability and Maintainability Symposium,* 450-455.

[14] Dai, Y.S., Xie, M., Poh, K.L.,and Liu, G.Q., (2003). A study of service reliability and availability for distributed systems. Reliability Engineering and System Safety, 103-112

[15] A. Rauzy., (2004) "An experimental study on iterative methods to compute transient solutions of large Markov models, 1-25.

[16] Marseguerra, M., Zio, E., and Podofillini, L., (2004). Optimal reliability/availability of uncertain systems via multi-objective genetic algorithms. *IEEE Transactions on Reliability,* 424–434.

[17] Gupta, P., Singh, J.,and Singh, I.P., (2005). Mission Reliability and Availability Prediction of Flexible Polymer Powder Production System, *Operational Research Society of India*, 152-167.

[18] Majeed, A. R., and Sadiq, N. M., (2006). Availability & Reliability evaluation of Dokan hydro power station. *IEEE/PES Transmission & Distribution Conference and Exposition*, 1-6.

[19] Ke, J.C., and Chu, Y.K., (2007). Comparative analysis of availability for a redundant repairable system. *Applied Mathematics and Computation*, 332–338.

[20] Sharma, R. K., & Kumar, S., (2008). Performance modeling in critical engineering systems using RAM analysis. *Reliability Engineering & System Safety,* 913-919.

[21] Goyal, A., Sharma, S. K., and Gupta, P., (2009). Availability analysis of a part of rubber tube production system under preemptive resume priority repair. *International Journal of Industrial Engineering,* 260-269.

[22] Adhikary, D.D., Bose, G., Mitra, S., and Bose, D.,(2010). Reliability, Maintainability & Availability analysis of a coal fired power plant in eastern region of India. *2nd International Conference on Production and Industrial Engineering,* 1505–1513.

[23] Vora, Y., Patel, M.B., and Tewari, P., (2011). Simulation Model for Stochastic Analysis and Performance Evaluation of Steam Generator System of a Thermal Power Plant. *International Journal of Engineering Science and Technology*, 5141-5149.

[24] H. Garg, H., and S. P. Sharma, S.P., (2012) Behavior analysis of synthesis unit in fertilizer plant. *International Journal of Quality and Reliability Management*,217–232.

[25] Wolde, M. Ten., and Ghobbar, A.A., (2013). Optimizing inspection intervals – Reliability and availability in terms of a cost model: A case study on railway carriers. *Reliability Engineering and System Safety*, 137–147.

[26] Suleiman, K., Ali, U.A., and Yusuf, I., (2013) Stochastic Analysis and Performance Evaluation of a Complex Thermal Power Plant. *Innovative Systems Design and Engineering,* 21–32.

[27] Dewangan, D.N., Jha, M.K., and Banjare, Y.P., (2014) Reliability Investigation of Steam Turbine Used in Thermal Power Plant. *International Journal of Innovative Research in Science, Engineering and Technology,* 14915–14923.

[28] Aggarwal, A., Kumar, S., and Singh, V., (2015). Performance modeling of the skim milk powder production system of a dairy plant using RAMD analysis, *International Journal of Quality and Reliability Management*,167–181.

[29] Talebberrouane, M., Khan, F., and Lounis, Z., (2016). Availability analysis of safety critical systems using advanced fault tree and stochastic Petri net formalisms. *Journal of Loss Prevention in the Process Industries*, 193–203.

[30] Kumar, P., and Tewari, P.C., (2017) Performance analysis and optimization for CSDGB filling system of a beverage plant using particle swarm optimization. *International Journal of Industrial Engineering Computations*, 303–314.

[31] Malik, S., and Tewari, P.C., (2018) Performance modeling and maintenance priorities decision for the water flow system of a coal-based thermal power plant. *International Journal of Quality and Reliability Management*, 996–1010.

[32] Singhal, N., and Sharma, S.P., (2019). Availability Analysis of Industrial Systems Using Markov Process and Generalized Fuzzy Numbers. *Journal of Metrology Society of India,* 79–91.

[33] Velmurugan, K., Venkumar, P., & Sudhakarapandian, R. (2019). Reliability availability maintainability analysis in forming industry. *International Journal of Engineering and Advanced Technology*, 822-828.

[34] Elusakin, T., and Shafiee, M., (2020). Reliability analysis of subsea blowout preventers with condition-based maintenance using stochastic Petri nets. *Journal of Loss Prevention in the Process Industries*, 1-16.
[35] Jagtap, H., Bewoor, A., Kumar, R., Ahmadi, M.H., and Lorenzini, G., (2020). Markovbased performance evaluation and availability optimization of the boiler–furnace system in coalfired thermal power plant using PSO, *Energy Reports,* 1124–1134.
[36] Maihulla, A.S., Yusuf, I., and Bala, S.I., (2021). Performance evaluation of a complex reverse osmosis machine system in water purification using reliability, availability, maintainability and dependability analysis, *Reliability: Theory & Application*, 115-131.
[37] Kumar, A., Kumar, V., Modgil, V., Kumar, A., and Sharma, A., (2021). Performance Analysis of Complex Manufacturing System using Petri Nets Modeling Method. *In Journal of Physics: Conference Series, IOP Publishing Ltd*, 1-9.
[38] Parkash, S., and Tewari, P.C., (2022). Performance modeling and dss for assembly line system of leaf spring manufacturing plant. *Reliability: Theory & Application*, 403–412.
[39] Kumar, S., and Tewari, P.C., (2022) Performability Analysis of Multistate Ash Handling System of Thermal Power Plant With Hot Redundancy Using Stochastic Petrinets. *Reliability: Theory & Application*, 190–201.
[40] Behnamfar, M., Taher, M.A., Polowsky, A., Roy, S., Tariq, M., and Sarwat, A., (2023) Reliability Analysis of Wireless Power Transfer for Electric Vehicle Charging based on Continuous Markov Process. *Fourth International Symposium on 3D Power Electronics Integration and Manufacturing (3D-PEIM),* 1–5.
[41] Malik, S., Kumar, N., and Kumar, S., (2023) Process Modeling and Numerical Investigation of Veneer Cutting System of a Plywood Plant With Stochastic Approach, *Reliability: Theory & Application*, 141–153.
[42] Kumar, S., Tewari, P.C. and Sachdeva, A.K. (2024) 'Decision support system for maintenance order priority of multistate coal handling system with hot redundancy', Int. J. Intelligent Enterprise, Vol. 11, No. 2, pp.103–119.
[43] Kumar, S. and Tewari, P.C., (2023) 'Performance optimisation of the feed water system of thermal power plant using stochastic Petri nets with comparative analysis using PSO, Int. J. Simulation and Process Modelling, Vol. 20, No. 1, pp.1–9.
[44] Kumar, S., and Tewari, P.C., (2023) Performability Optimisation Of Multistate Coal Handling System Of A Thermal Power Plant Having Subsystems Dependencies Using Pso And Comparative Study By Petri Nets. *Reliability: Theory & Applications*, *March 1(72):* 250-263.