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RELIABILITY OPTIMIZATION METHODS: A SYSTEMATIC LITERATURE REVIEW

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Abstract: The industry is a system that combines parallel, series, or combination of two to transform cheap raw materials into valuable goods. Occasionally, the system may also consist of subunits that can be arranged in various ways. The series arrangement is represented when the system fails completely because of the failure of every subunit (also called complete failure); conversely, when the system operates with low efficiency, i.e., this illustrates the arrangement in a parallel fashion in a reduced state (called partial failure). In order to learn about the advancements in the field of reliability theory and to determine which research methods are most frequently employed by researchers, a brief survey covering the years 1958 to 2024 was conducted for the paper. The overall impact of the functioning system's state on its dependability is further discussed in this study by reviewing 112 papers selected from the study of 220 papers taken from reputed journals. In this study, we've taken into account the reviews of numerous researchers and investigated the most popular approach for overcoming others' obstacles. Additionally, which variables influence the primary reliability metrics in their work and how? These are complemented by graphics and table.

High lights:

- A Review of literature is highlighted with important points of papers of researchers.
- Tables regarding relation of proportionality between different parameters is illustrated.
- Table and graph regarding the methodology used by different researchers.

Keywords: Reliability, availability, RPGT, maintenance, PSO, productivity.

MSC: 90B25.

1. INTRODUCTION

The **reliable** and **reliable** words introduced in 1816 and first attested to by the poet Samuel Taylor Coleridge are frequently used in the present environment. We are reliant on machines to use less of our physical strength and produce better results with less waste as technology becomes more prevalent. The traditional operations of the outdated systems have now been replaced by highly developed ones, guaranteeing faultless functioning. In addition, consumers demand trouble-free appliances like air conditioners, refrigerators, washing machines, and inverters, as well as timely and consistent offering services such as water and power supplies, as well as transportation that is scheduled. While customers may tolerate system failures in less crucial cases up to a certain point, there are hazardous systems (nuclear power plants, hospital services, etc.) where even a little malfunction can have catastrophic effects, including big economic loss, perils to human existence, or environmental devastation. Thus, such systems are unable to tolerate failures. Due to this fact, reliability theory has become a much more important theme in research and has gained attention. The machine or system's subsystems are organized in a variety of ways, such as series, parallel, mixed, and complex configurations. These arrangements together determine the system's overall reliability and, consequently, its outputs. A system's capacity to carry out its intended function for a predetermined amount of time under predetermined conditions is the most popular definition of reliability, however there are other definitions as well. System failures are natural implementing appropriate unavoidable; hence, they cannot be utterly deterred or overlooked. Nevertheless, their ramifications may be reduced by utilizing reliability theory strategies, such as incorporating repair plans or a wide assortment of redundancy measures. In any sarcastic system, the failure of a somewhat limited number of its subsystems results in a decrease in efficiency or, sometimes, the failure of a complete system, which results in a big loss of profit. Maintenance of broken systems through corrective and preventive measures is part of the appropriate repair policy. It is very beneficial to use reliability in a system to lessen the factors that lead to any system's failure. Thus, an industry can increase productivity to a greater degree by taking reliability technology into consideration. In this literature, On 112 papers' review has been conducted to examined the different methodology used by researchers and variation impact on reliability of a system due to some factors like failure rate and repair rate etc.

The paper includes the following section to communicate the whole study. Section 2 includes the notation used for study. Section 3 comprises the methodology to span the whole data. The literature including the 112 papers is described in section 4. Section 5 explained the reliability attributes behaviour with respect to various parameters. The different methods used by researchers are studied in section 6 and represented graphically. The conclusion, Future scope and limitations are described in section 7,8 and 9 respectively.

2. NOTATION

F/R rate: Failure and Repair rate
FR: Failure Rate
RR: Repair Rate
IR: Inspection Rate
PM: Preventive Maintenance
MTSF(MTTF): Mean to system failure
PSO: Particle Swarm Optimization
BPS: Busy Period of Server
WSB: Warm Stand By
CSB: Cold Stand By
IP: Inversely Proportional
DP: Directly Proportional
RPGT: Regenerative Point Graphical Technique
pr: Probability of transition from One state to another in a system model.
$\overline{\boldsymbol{cycle}}$**:** represents a cycle through failure free states in any transition diagram of system model
$\left(\boldsymbol{i} \xrightarrow{s_k} \boldsymbol{j}\right)$: is k-th directional path from state i to state j; k takes a positive integer values for possible paths from state i to state j.
$\left(\boldsymbol{\xi} \xrightarrow{sff} \boldsymbol{i}\right)$**:** is a directional failure free path from base state ξ to state i.
$\boldsymbol{V_{k,k}}$**:** represents transitional Probability Density Function of the state k reachable from the terminal state k of the k-cycle.
$V_{\overline{m,m}}$**:** Probability factor of reaching to the mth terminal state from the m-$\overline{\boldsymbol{cycle}}$.
$\boldsymbol{\eta_i}$**:** is expected waiting time that repairman spends while doing a given job, considering that the system has entered a regenerative state ‘i’ at t=0.
μ_i**:** Mean sojourn time spent in state i, before visiting any other states and is determined by Laplace transformation of $R_i(t)$: $\mu_i = \int_0^\infty R_i(t)dt$
$\mathbf{R_i(t)}$**:** Probability density function (p.d.f.) of the system that at time t, the system stay in regenerative state i..
f_j**:** is fuzziness value of the j-state. f_j=1 for working state and =0 for failed state.

3. METHODOLOGY

The extensive literature review of 112 papers is studied in this paper which can be understand with the explained methodology. It took three steps to conduct a comprehensive and exhaustive analysis of the domain: (a) gathering relevant literature; (b) screening the literature collected; and (c) analysing the final work that was chosen. In order to search for relevant conference and journal papers from scientific databases and scientific indexing services such as Web of science, Scopus and IEEE Explore the first step involved selecting appropriate keywords. Words like “genetic algorithm”, “regenerative point technique”, “system availability”, “Machine learning” and "particle swarm optimization" were among the search terms. The collection consisted of 220 papers, which were studied, and the papers having close relevance to the domain were selected. It was discovered that while the papers in the collection contained related information, they could also be further divided into distinct subdomains that were pertinent to the research topic. The steps followed to carry out the intended literature review are displayed in Figure 1.

Following the above-mentioned categories, the papers were filtered to identify the majority of those that studied the regenerative point technique and software analysis tool, which quantifies the effect of various system factors on reliability and other agronomic practices on solving differential equations using various methods such as the Laplace Transformation Method, the Runga-Kutta Fourth Order Method, and others. and roughly ten to fifteen papers that use soft tool algorithms like PSO, GA, etc. to analyse system reliability parameters, but due to demand of accuracy and time issue the software tool analysis becoming more prominent in upcoming researches. Among the final selection of papers, the majority come from journals that are indexed by Scopus, and the remaining papers also come from reputable journals.

The following queries were investigated in depth through a careful examination of the final selected papers:

- Which methodologies have been applied to measure the impact of different system components on system reliability?
- What effects does the state of a system component have on dependability metrics like availability, MTSF, and busy period duration?
- How effective is one approach in comparison to another? And how work hard analysis and soft algorithm analysis?
- What type of data sets have been used by the authors?

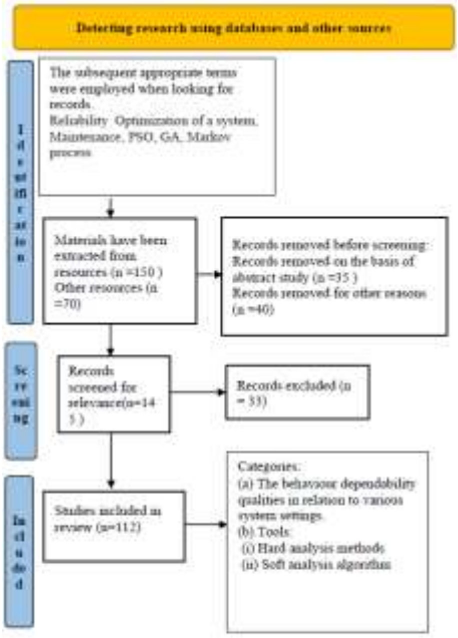

Figure 1: Methodology for Systematic Review

4. REVIEW OF LITERATURE

The poet Samuel Taylor Coleridge coined the term "reliability" in **1816**. Prior to World War II, i.e., dependability stood for repeatability prior to **1939.** If the results of a scientific trial were consistently positive over time, then we could say that the trial was "reliable" in that regard.

1920 saw a greater emphasis on output improvement, which can be strengthened by applying statistical process control—a notion advanced by Dr. Walter A. Shewhart. At that time, Waloddi Weibull was conducting his trial using statistical models, and he concentrated on the decreased efficiency caused by fatigue. At this point, a machine or system's dependability accelerated to raise the standard of the entire output.

The output that would be available on demand for any given period of time was defined by the U.S. military in **1940** as the modern definition of reliability.

Because the industries were not mechanized between 1939 and 1942, downtime was not as important as it is today. This indicated that preventing equipment failure was not a top concern. A Navy survey carried out during the war revealed that less than one-third of all appliances were inefficient due to malfunctions in the electrical appliances used during World War II. This was the crucial element in introducing those appliances' increased dependability. Additionally, the Vanguard satellite was underperforming by over a third in terms of efficiency. In order to achieve maximum success during the design phase of the Apollo Man-On-the-Moon project, reliability became increasingly important. Due to the unexpectedly high rates of fatigue and electronic tube failure during the war, the field of equipment reliability has come under increased scrutiny.

The paper titled "Cumulative Damage in Fatigue" in an “ASME journal” by Miner focused on the results of damage issue of automotive axels due to torsion fatigue which enhances the concept of reliability in 1945. Reliability of the vacuum tube as used in radar systems and other electronics used in military was a main application. But the use of this become very troublesome and financially tough.

A reliability society was formed by IEEE in 1948 which lighted up the advancement of technology. It is group of volunteer of professionals engaged in assuring reliability in the engineering disciplines.

The first major committee "Advisory Group on the Reliability of Electronic Equipment" (AGREE) was set up during 1950 by US department of defence to work on the reliability methods in the field military appliances. The committee raised the following facts about any system:

- Raise the reliability of components.
- Enhance the quality and reliability requirements for suppliers.
- Analysis the collected data and try to get the hinderance in success due to failure factor.

The effect of redundancy on the reliability of a machine improvement has been discussed by **Flehinger, [1].** This paper made a comparison regarding reliability carried off by the redundancy joined with complete and smaller units. The failures of any component were checked by a detector, and at that time, a switch-over device was used to continue working smoothly. The analysis of the effect of imperfection in switching devices on overall system reliability has been done. The reliability has been calculated with the help of the probabilities associated with the failure detectors.

The characteristics of a system working with two components with features of redundant (standby) related to reliability were evaluated, **S. Parkash, [2].** To gain more and more advantage, the time for working has been improved by the presence of an imperfect switch device to continue the process without any hindrance. How the repair echelon has an impact on availability has been discussed.

A paper on a system arranged with two cold standbys consisting of n units was presented by **Usha and Ramanarayanan, [3].** In the first model, the Erlang failure time distribution was adopted by operating units, and the repair time distribution is general, whereas in the second model, the situation is reversed. This paper formulates the equation using renewal theory, describes the models, and finds a transmission probability function with different characteristics directly affecting reliability.

The elaboration of the liability of a system involving the process of crushing as an important point in sugar milling has been covered, **Kumar et al. [4].** With the use of supplementary variable technique, the PDE regarding reliability and MTSF is formulated, and solutions to them have been obtained using Lagrange's method by assuming the non-variable failure rate and general distribution character of repair under steady state.

The time to perform the intended function whenever a requirement called for three subsystems of a paper manufacturing process that uses a washing system was presented in **1989**. With the fixed number of failures and repairs in particular time (exponentially distributed), All three states (good, reduced, and failed) are computed in terms of availability and MTTF by **Kumar et al. [5].** A standby unit is also used in that system. The various parameters are obtained by solving different equations using simple probability considerations. The purpose of the tables and figures is to analyze how different pieces of equipment behave.

The two units, whose work performance has been continued without any hinderance due to the presence of redundant cold stands, came in to work during the maintenance of the original unit. The paper presented by **Goel and Shrivastava,[6]** assumed that a bivariate exponential correlation existed between the non-successful operation and repair times of each unit. The various reliability attributes, such as the time consumed by the system before any failure and its mean, and the up-and-down steady state probability related to the transition diagram of the function of the system, have been calculated by the regenerative epochs.

The reliability characteristics of a system with the attribute of three unlike units under the facility of repair have been examined, **Wei Li et al., [7].** The repairable facilities were also different; there were two in total. The different system parameters to measure the performance of a system are calculated with the help of explicit expressions such as: 1) point-wise and steady state availability; 2) failure frequency and renewal frequency; and 3) reliability and time taken by the system before successive failures with its mean.

The analysis of a steel utensil manufacturing plant having four subsystems was enlightened in **1999** by **Singh and Mahajan,[8]**. The reliability and long-run availability of plants with the supposition of sustained F/R rates are examined using differential equations, which are solved with the method of Laplace transforms. The first subsystem cutter never fails, and a switch-over device for this subsystem is used. The impact of rate-growing of failure of a subsystem, or hence its repair, on availability is counted for each subsystem, and a comparison has been made regarding its effect.

A paper to understand the profit of four units having a series configuration with mixed standby components was released in 2000 by Wang **and Kuo**,[9]. This system had both the WSB and CSB parts. For the purpose of providing configuration, the MTTF with the steady-state availability critical point has been derived. A comparison between these configurations has been made in order to analyse the various parameters while taking the exponential distribution of parameters into account. Additionally discussed was the cost analysis of four configurations.

The focus on PLC, which is a programmable logic controller, has been given by **Parashar and Taneja, [10].** The current paper, published looked at a hot standby system that allows industry to continue without interruption. There were three ways in which the failure happened: minor, which could be fixed by a regular repair person; major, which required expertise to fix on demand; and major, which was irreparable. The relationship between MTSF, state availability, time spent by both novice and expert repairmen, and the number of replacements for failed parts is used to analyze the system's productivity. Using the regenerative and semi-Markov processes, a graphic study has been done to assess the profit made by the system and other aspects of the system.

According to Said and Hamid, [11] the operation of two systems with two unit CSBs was compared. The first one has triple modes of operation, i.e., ordinary, partial, and whole malfunctioned concepts, whereas the second one has only normal and total failure. In order to compare the preventive maintenance of the two systems, an exponential distribution is used to represent the breakdown and restoration percentage in the LDE. With the aid of the generated table and plotted graphs, an appropriate comparison was made to ascertain the impact of fail approach and preventive maintenance on system productivity.

An evaluation of the costs and benefits of a two-unit CSB system that has two categories of restoration (small repair or unneglected repair) has been dealt with, **Rashad et al., [12].** A handyman who can't handle some of the trickier repairs will always be able to perform a small fix. When the first repairman is not up to par, the second one gets called in. The standby unit is operated by a switch. After the major repair is completed, the unit functions as new. Distinctive random variables possessing an arbitrary distribution are failure time, repair time, and patience time.

The two reliability models were presented by **Chander and Bhardwaj, [13]**. They both had two of the three redundant systems, with two original units operating in parallel configuration and one unit being used as a cold standby. While the duplicate units are repaired without inspection to maintain uninterrupted processing, the original units are inspected at the time of failure. In model second, the maintenance of the original operating unit was a preference as compared to stand-by units. The rate at which a system fails to perform its duty is taken under the characteristics of an exponential system, where the repair times are distributed arbitrarily. Several expressions were developed to assess the system's productivity through the application of semi-Markov and regenerative processes. Transition probabilities are also used to obtain the profit analysis of both models, and the graphs are designed to compare the outcomes of the two models.

A cost-benefit analysis of the stochastic model for a 2/3 redundant system has been conducted using semi-Markov and regenerative process techniques, **Bhardwaj and Malik, [14]**. Each of the two models has three identical units; if two of the units are working, the system is working as it should. While a system in model 2 is repaired as quickly as possible at a reduced working time, in model 1, a system has been prepared without inspection. Replacing failed units with new ones has been considered a means of maintaining system reliability if repair work has not been completed. The various indexes, including profit, BPS, MTSF, and so on, which are crucial metrics for evaluating a system's performance, are obtained.

The results of the plant engaging in the manufacture of polytube consisting of four units have been computed, Singla et al., [15]. The method of supplementary variables is employed to solve the Chapman-Kolmogorov differential equations. In this method, the likelihood of breakdowns and the number of repairs made within a specific time frame are treated as variables. The reliability of a system and, consequently, its overall availability are determined using the Runge-Kutta fourth-order method.

The outcomes of a four-series configuration with both features being redundant, i.e., warm and cold, have been analyzed by **Mohammed A. Hajeeh, [16].** The reliability of the system has been carried out in the presence of normal reasons for its non-performance. Calculations are made for the following: (1) MTTF; and (2) steady-state time interval, wherein exponential distribution of breakdown and restoration times is assumed. By providing a creative example, all the configurations have been compared.

When subsystems with independent failures were subjected to simultaneous exposure by **Shakuntala et al.**, [17], the availability index of the pipe manufacturing industry was compared. A system's continuous failure rate and fluctuating repair rate are indicators of its long-term availability (i.e. The differential equation is used to find solutions to the equations by creating distinct tables for various parameters. For example, while the timing of a subsystem's failure is considered to be the same, the time it takes for each to be repaired and return to operation varies.

We have considered two distinct failures in a stochastic model for a system by **Yusuf and Bala, [18]**, that consists of two units with similar characteristics that are arranged in parallel. In this model, the three modes, i.e., working normally or stagnation or complete breakdown, are present, whereas in the second model, only two modes are considered: ordinary working and breakdowns; here is no room for degradation here. The system's deterioration in the first model can be mild, rapid, or slow. By constructing the LDE (linear differential equations), the variation are plotted to illustrate the impact of the degradation on the system's success between failure and available time. According to the paper's conclusion, systems with varying degrees of deterioration experience a decrease in both availability and MTSF more than those with no deterioration. Because of this, degradation had an immediate impact on the system.

It has become clearer how to model mathematically a two units computer system, one of which is running whereas the other of which is regarded as a cold standby, **Kumar and Malik, [19]**. The unit needs to be repaired because it has both hardware and software components that can malfunction independently or work together. There is currently only one repairman available. Based on semi-Markov and RPGT, server reliability parameters have been developed. In contrast to replacing hardware, replacing a software component comes first. The arbitrary distribution is allocated to preventive maintenance, repair, and replacement with distinct pdfs, and the failure time is regarded as exponentially distributed. The purpose of the graphs is to examine how the rates of preventive maintenance affect the outcomes.

It was decided to concentrate on the graphical depiction of reliability parameters linked to a two-unit system with cold standby capability. This paper by **Kakkar et al., [20]** concluded the outcome based on the supposition that repaired components might malfunction again, necessitating random repair provided by a server as needed. To quickly determine the results and comprehend the fluctuations in the profit function, the RPGT technique has been applied.

The study of the various system reliability attributes under the condition of perfect repair of 2 out of 3 systems has been covered by **Yusuf and Hussaini, [21]**. The outcome is analyzed using Kolmogorov's forward method. According to the paper's conclusion, achieving a flawless repair is crucial for raising overall availability as well as associated metrics like MTSF and BPS, which in turn affect system output.

The optimization of the skim milk powder unit's performance has been addressed, **Kajal and Tewari, [22].** The unit consists of six complex units arranged in a row within a dairy plant. In nature, the failure and repair epochs were distributed exponentially. The mathematical work comparing optimal availability and appropriate maintenance strategies under the Markov birth-death process is evaluated using the genetic algorithm and MATLAB.

The computer system having original operating parts and cold standby with the idea of redundancy and PM was focused on by **S.C. Malik, [23]**. Both the standby and computer units are equipped with hardware and software that can malfunction or function independently. The hardware is approached by the repair facility, and regular maintenance updates the software. If the hardware repair is not completed by a certain date, a new piece of hardware is installed. In contrast, the PM, replacement facility, and upgrade time were indicated by the exponential distribution linked to the hardware and software failure epochs. The semi-Markov model's epoch of the regenerative concept is used to assess the system's mean failure time and the computer system's profit function at the lowest possible cost.

H. Garg, [24] introduced a new methodology for evaluating an industry's systems' operational efficiency using ambiguous data. In order to comprehend the operational effectiveness of systems using swarm optimization techniques under fuzzy concepts, the nonlinear optimization problem equations have been solved. With the help of a varying time consumed during up and down time, the indexes that tell about a system completely, such as the total time for which a system is performing its function, called availability and maintenance factor effect on system, are demonstrated. The calculation's results have been contrasted with those obtained using various methodologies, including the Lambda-Tau methodology and particle swarm optimization, etc.

A redundant system having three similar units (in functioning or characteristics) to analyze and compare the system productivity related to its liability by designing three models has been discussed by **Yusuf and Hussaini,[25]**. For all three types of failure, there is one repairman available for each model. For model one, preventive maintenance is given prior to failure; in contrast, models two and three are examined without it, and model three is searched for as linear conjugative (2:3). To present models, the profit function and various system parameters are found using Kolmogorov's forward equations method. After the models' respective levels of efficiency were compared, it was discovered that the first model was more important than the rest.

The availability and behaviour analysis of a distillery plant made up of three dissimilar units have been conferred, **Chaudhary et al.,[26].** A partial failure occurs, causing the main unit to function less effectively and accomplish its intended task less effectively. Different expressions for MTSF, time for which system is operating, and counting in numbers that the server will serve the machine for its better performance have been calculated to study the outcomes with the help of some special cases, tables, and graphs. Additionally, it was thought that the unit's repairs were flawless. The analysis of graph and table results demonstrated that one index has a direct or inverse effect on another.

A proposal for a method for availability analysis of a butter oil production system with optimization of productivity consisting of typically subsystems under exponential distribution has been given out by **Aggarwal et al., [27].** The seven subsystems were put on display for observation using the Ranga-Kutta method to compute time-dependent MTBF and related features of this plant. The outcomes of calculations are used to develop maintenance guidelines and suggestions for enhancing the functionality and capacity of equipment, ultimately raising the bar for butter oil quality.

A review article on reliability indexes of different systems has been given out to represent the fact that factors are very important to increasing the reliability of any system by **Kumar et al., [28].** The notion of reliability, which is widely applied in the field of reliability engineering, has been explained through a variety of definitions and formulas. An account of the field's history has been written using distinct techniques.

A repairable 2:4 system has been represented through stochastic modelling and analysis by this paper, **Yusuf et al., [29].** The four repairmen handle the four different kinds of failures that arise. Kolmogorov's forward method is used to analyze, under an exponential distribution, the expression for system failure and its mean with the available ability and cost benefit of system production. The study's findings indicated that a system's parameters magnified its abilities for repair, albeit in an unprofitable way and with an increase in the likelihood of failure. Therefore, with the right maintenance, the system can be improved to a more dependable state with a high profit margin. As a result of it, the system that has the facility of communication has adopted this feature, i.e., two out of four at a high rate.

Reliability and Behavioral Analysis of the Yarn Industry of the Malawa Region Using RPGT has been introduced by **Devi et al., [30].** Three unit systems' behavioral analyses are covered in this paper. Because the subunits are arranged in parallel mode, the system is compelled to produce results with reduced capacity; however, operating the system when two units are in a reduced state is not profitable. The following defines the various parameters that will be used to elaborate the reliability indices using the regenerative point graphical technique.

Mean time to system failure: -

$$\text{MTSF}=\left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(0\xrightarrow{Sr(sff)}i\right)\right\}.\mu_i}{\prod_{k_1\neq 0}\left\{1-V_{\overline{k_1,k_1}}\right\}}\right\}\right] \div \left[1-\sum_{s_r}\left\{\frac{\left\{pr\left(o\xrightarrow{Sr(sff)}0\right)\right\}}{\prod_{k_2\neq 0}\left\{1-V_{\overline{k_2,k_2}}\right\}}\right\}\right]$$

Availability of the system:

$$A_0=\left[\sum_{j,Sr}\left\{\frac{\left\{pr\left(\xi\overset{Sr}{\rightarrow}j\right)\right\}f_j.\mu_j}{\prod_{k_1\neq\xi}\left\{1-V_{\overline{K_1,K_1}}\right\}}\right\}\right]\div\left[\sum_{i,Sr}\left\{\frac{\left\{pr\left(\xi\xrightarrow{Sr(sff)}i\right)\right\}.\mu_i^1}{\prod_{k_2\neq\xi}\left\{1-V_{\overline{K_2,K_2}}\right\}}\right\}\right]$$

Busy period of the server:

$$B_0=\left[\sum_{j,Sr}\left\{\frac{\left\{pr\left(\xi\overset{Sr}{\rightarrow}j\right)\right\}n_j}{\prod_{k_1\neq\xi}\left\{1-V_{\overline{K_1,K_1}}\right\}}\right\}\right]\div\left[\sum_{i,Sr}\left\{\frac{\left\{pr\left(\xi\overset{Sr}{\rightarrow}i\right)\right\}.\mu_i^1}{\prod_{k_2\neq\xi}\left\{1-V_{\overline{K_2,K_2}}\right\}}\right\}\right]$$

The number of the Server's visits/ Replacements:

$$V_0=\left[\sum_{i,Sr}\left\{\frac{\left\{pr\left(\xi\overset{Sr}{\rightarrow}j\right)\right\}}{\prod_{k_1\neq\xi}\left\{1-V_{\overline{K_1,K_1}}\right\}}\right\}\right]\div\left[\sum_{i,Sr}\left\{\frac{\left\{pr\left(\xi\overset{Sr}{\rightarrow}i\right)\right\}.\mu_i^1}{\prod_{k_2\neq\xi}\left\{1-V_{\overline{K_2,K_2}}\right\}}\right\}\right]$$

The debate about reliability modeling and behavioral scanning of warm and cold standby units System arrangement in a series manner with perfect switch-over devices and with a single repairman has been done, **Kumar et al., [31].** A with a warm standby, B, D with a cold standby, E, and F are the three different kinds of subsystems**.** Each of the three subsystems' components is connected in series, so if one fails, the subsystem and the system as a whole will also fail. Fuzzy concepts were able to explain the system's arranged pattern and its results.

The feature of the Warm Standby system of the original unit, but with an Imperfect Switch to change the main unit to this redundant for maintaining the loss that could be possible due to partial failure existence or some time complete blockage of work, was gone through by **Kumar and Sarla, [32].** RPGT has been used in the evaluation of work performance and productivity.

Minaxi et al., [33] have examined the Malwa Region juice industry's use of RPGT to compare and determine the relationship between various system parameters of three units with regard to time. The system can operate in two ways: either with reduced capacity because of the partial efficiency of two units, or with a complete stoppage of performance because of the zero efficiency of any one unit. Profit optimization was also considered.

A deep investigation of the spinning mill of the Malwa Region by Sarla **et al., [34]** altered the behavioral analysis of the spinning mill, whose reliability attributes depend upon the attributes of reliability of each subsystem. The facility for one permanent repairman and one specialist repairman is provided by the plant organizer.

The paper talked about behavior scanning of a system that has a single unit that goes to degradation after a complete failure using the technique of RPGT, Ritikesh **and Goel, [35].** When a unit is operating at maximum capacity, it can experience two different kinds of failures: partial failures and direct failures. After each malfunction, our lone repairman inspects and fixes these units. A complete failure prevents us from restoring the unit to its full capacity.

The fiber glass industry, which has a system made up of three subsystems and works at full capacity in which two units are present in parallel configuration with two forms of breakdowns, direct and partial failure modes, and the third is located in series configuration and can fail directly, has been pondered by **Sharma et al., [36].** The gamma-ray shielding properties of selected fiber glasses have also been investigated.

The discussion about the profit of the overall production of two modules under the facility of repairing software and hardware has been done, Navneet and Goel, [37]. This paper has worked on two modules that perform their duties either in complete capacity or in reduced capacity. The module failures are H/W and S/W. The time consumed for which the system is accessible has been located. The repair time and failure time are independent for S/W and H/W failures in this paper.

The edible oil refinery in the Malwa Region has been studied to get information about the overall results and finalize production. This paper by **Bansal and Rajkala, [38]** revealed that the reliability of each of the four units combined to form the overall reliability by consider the fact of regenerative process. The three units are further made up of subunits, of which one has the capability to work in reduced form. The results of the system have been interpreted with the help of comparing graphs and tables.

There has been information provided about how well a dairy plant performs in terms of availability by **Chaudhary et al., [39]** and discussed about the working of four unit configurations in series mode, out of which one unit is allowed to perform its work in a reduced form due to a small failure in its technique, RPGT. The various indices that define the system outcomes—like MTSF, BPS, and availability—have been computed in order to examine total production.

The behavioral analysis of a system working with two units that are under PM but degradation takes place in one unit using RPGT was explored by **Goyal and Goel, [40].** A unit can fail directly or through partial failure; on the other hand, a second unit can fail through partial failure only. This paper presents two approaches to repair: perfect for the second unit and imperfect for the first.

A practical idea for analyzing a dairy plant with a system of skim milk that has six repairable subsystems arranged in a mixed configuration was proposed (**Aggarwal et al., [41]. The Markov** birth-death process is preferred to find the mean time between failures in an exponential distribution. In order to address the maintenance strategy and productivity of the skim milk powder system, Chapman-Kolmogorov differential equations are developed and their solutions are found using the fourth-order Runga-Kutta method.

An issue of the analysis of a banking server by considering a standby system warm in nature was taken up, Kumar **and Goel, [42].** The entire system worked with the local server unit; whenever this server stopped performing its function, a standby remote server was replaced to continue the process without hindering the performance. The table and graphic presentation have been explored to understand the consequences of a rigid F/R rate on the analysis using RPGT.

The revenue modelling of a machine that include two units with standby has been considered by **Kumar, [43].** This paper is devoted to the two-unit redundant system having perfect switch-over devices. According to discussion, whenever a unit reaches a position of failure, it becomes important to switch on the standby unit on time along with the repair of the failure unit and put it back in its original position as soon as possible without difficulty in working. This paper revealed some of the folds that become normal causes for less efficient productivity of systems, like 1) on/off of switches over devices 2) online and offline use of the standby system; 3) detection of a failed unit and switching of it 4) After repairing the original unit, put it back in its original position or not. How these factors influenced the parameters related to system production has been discussed here.

The concept of parallel residency using a cost-benefit analysis with parallel arrangements was studied by **Gitanjali and Malik, [44].** The repairman is available to perform its function on time. If, under any circumstances, the server is not able to do its function of repairing, then the replacement of a failed unit using the feature of redundancy is involved in continuing the process. The expressions are formulated to know the various properties related to the machine work using RPGT under the exponential distribution.

The idea of a parallel system with an external device attached to it has been explained by **Yusuf, [45].** The opinion of preventive maintenance has been introduced in two ways. 1) Come in working and complete its function before failure of any unit. 2) active when the original unit is replaced by a supporting unit and maintenance takes place offline. The system's production is analyzed by solving an expression with the help of Kolmogorov's forward equation method, which plays a vital role for designers, engineers, and preventive managers.

A system having the facility of standing by, cold in nature, was enlightened by **Kumar and Goel, [46]**. A repairman is provided at the plant for the repair of the component, which works at a decreased capacity following its restoration. The old one is replaced with a new one, whose maintenance is prioritized over the old one if the repair work has not met the requirements. The various parameters, including the system's failure mean time, the duration of the system's duty, and the profit of the overall results by minimizing cost, are obtained by using RPGT while taking into account various distributions, such as Rayleigh, Exponential, and Weibull for the random variable. In order to gain more benefits and availability for the system, obstacles are removed during its operation, and the degraded unit receives the necessary inspection and maintenance, resulting in an increasing amount of profit in the market.

Garg, [47] revealed a review of the very easy and understandable technique of RPGT. The analysis of parameters related to the reliability of a system, i.e., reliability, availability, etc., has been done using the regenerative technique by considering a condition of steady state. This paper explains that the increment in repair rate results in an increment in availability and MTSF through the conclusion of graphs using easy equations in this technique.

The fuzzy reliability concept to locate the system liability of a sugar plant having three subsystems was discussed by Aggarwal **et al., [48].** The consequence of increasing failure chances as a result of it, repairing of the subsystem on availability for crystallization system having the capacity of tolerance of fault has been analyzed. The Kolmogorov differential equations are developed from a mathematical model portrayed using the rule of mnemonics. The system's ability to boost production while consuming less plant finance has been evaluated through the application of the fourth-order Runga-Kutta method to the equations.

The reliability model for the availability analysis of two-unit systems, such as in a milk plant, where one unit completely stops performance after the failure, has been discussed by **Kumar, [49].** The first unit is available only when complete failure exists, and the second unit has direct failure and repair, which is considered to be perfect. In this paper, a single server for repair units on each failure is available, and the breakdown rate and restoration rate are considered with distribution exponentially. This paper concluded that the variation in different parameters related to reliability was correlated with the variation in corresponding failure and repair chances. This paper focuses on increasing the availability of units in the manufacturing industry. This paper also assumed that both units couldn't fail simultaneously.

A urea plant having a subsystem with a separated operational nature has been considered by **Kumar et al., [50].** By considering the constant number of failures after each failure and hence its repair to continue the work, a problem is designed. Transition diagrams are made to write down the expressions for the path probabilities and the main sojourn times. To examine the relationship between the busy period of MTSF and the rising failure rates of individual components or subparts and the associated repair procedures, various tables and graphs are analyzed in order to comprehend the behavior of the urea plant.

The turn of failure and service of a system on the performance and hence outcomes by finding the different parameters like profit, MTSF, etc. to know about the working and nature of the system has been considered, Goyal **and Malhotra, [51].** The outcomes related to the parameter are highlighted by a tabular and graphical study, as is the relationship between the above-written parameters. A study has been done from 1963 to 2017 to check how the different parameters, like MTSF availability and others, are directly or inversely proportional to the different rates.

The stochastic analysis of a standby model of two units working under non-identical properties was dealt with by **Gupta et al., [52].** One unit out of two is preferred over the other one. The repair discipline of the unit is FCFS. By assuming that the malfunctioned and fixing rates, Multiple measurements are obtained using RPGT.

The study of the polythene packing industry having two units A and B whose reliability collectively made the reliability of the whole system has been made, V. Goyal, [53]. The transition probabilities of a state diagram of a system are traced out, and printer maintenance is taken throughout the entire process of the mechanism. The breakdown possibility and the repair policy are distributed exponentially, and fuzzy logic is applicable to get knowledge about the workings of systems that may operate in full capacity or reduced capacity.

The sensitive analysis of the edible oil refinery system, which consists of four different subsystems P,Q,R, and S, whose reliability plays an equal role in system reliability, has been concerned, **Thori and Goel, [54].** The unit P has a component in a parallel configuration, and the other unit has a component in a series configuration. Each of the four units has a distinct and steady failure distribution, and by creating tables and graphs and applying the RPGT technique, one can assess a system's behavior analysis based on various repairs and failure rates. This paper concludes that countable factors such as cost and market demand, as well as the control of countable failures and repair of possible units, can improve the efficiency of the system's operation.

A case study for punching tools by knowing the best fit distribution model by observing the effect of maintenance on the system's reliability and cost by the team of engineers giving the maintenance has been presented by **Ahmad, [55].** This study focused on four major maintenance facilities, concluded the significance of reliability analysis to increase efficiency, and helped the technical team consume the maintenance facility for higher production.

A light on the analysis of a bread-making system under the aegis of system parameters utilizing a technique named RPGT has been put forth by **Kumar et al., [56].** Systems used to make bread consist of five subunits connected in series. This paper considers the repair and failure rate, which is exponentially distributed and constant, and whether a permanent repairman is available for the failed units. Using RPGT, different graphs and tables are drawn to measure the system parameters, like MTTF, whose graph is drawn versus the failure rate, which shows that a decreasing curve results due to increasing failure time in hours. Benefit optimization is also discussed. Different requirements and varying priorities apply to the maintenance of the five units.

The analysis of a standby stochastic system having two units that are operated along with a third similar unit in the cold standby mode has been considered by **Devi et al., [57].** By dissimilar modes of failure (minor or major) and hence respectively repairing facilities using ordinary or expert service, different system parameters (MTSF) and availability of a system are calculated using the new approach RPGT techniques to overcome the difficulties by taking Laplace transforms of state equations.

The sensitivity of two units has been analyzed, in which the first unit has subunits arranged in parallel such that if one of the subunits fails, the system works in reduced state, whereas the second unit has subunits arranged in series configuration such that if one of the subunits fails, the second unit fails, and hence the whole system fails, **Sunita and Goel, [58].** A transition diagram is created using separate circuits and the RPGT to examine system parameters for example MTTF, availability, BPS, and the potential number of server visits. This paper considered the failure rate as exponentially constant and the repair rate as general and independent. This paper concluded that management may decide to maintain repair rates of units to increase the production of a system.

The working efficiency of a washing unit present in the paper industry made up of three subunits using RPGT has been focused on by **Kumar et al., [59].** The first subunit has a subcomponent with a series configuration; the second unit has some subcomponents with a parallel configuration; and the last unit has a standby unit. To determine the reliability characteristics given the MTSF, busy period, etc., a transition diagram is created. using the effect of constant repair and failure rates of individual units. A repairman is constantly available for system maintenance. The tables and graphs are portrayed by considering fixing conditions about failure possibility and hence repair of one out of others.

The mathematical framework and reliability interpretation of the server policy of the library were discussed by **Jindal and Garg**, [60]. The main agenda of the study was to figure out the reliability of the library server using CAS Mathematica (which is mathematical software). First-order differential equations were developed to facilitate the multiple selections of non-functioning state time and repaired state time of the system's subsystems in order to compute reliability.

The availability analysis of a soft drink plant having six subsystems was performed by **Kumar, [61].** Mathematical modeling using differential equations with the help of the mnemonic rule is prepared to analyze the presentation of the system. The breakdown and the fixing rate parameters of each component follow the exponential distribution. A genetic algorithm has been applied to constrained and unconstrained optimization programs. The availability of different components has been analyzed to increase production.

The model approach to having a feasible, optimum, and reliable result using the concept of triangular intuitionistic fuzzy numbers for a system was performed by **Yazdi, [62].** The spearman correlation concept has been utilized to analyze the dependability and performance of the suggested model.

A two-subsystem system that is set up in series mode, with the additional subsystem having three parallel configuration units that are worked in 2 out of 3 criteria has been explained by **Gahlot et al., [63].** The factor of humans was also considered in the overall liability of the system. The failure rate follows the distribution exponentially, while the repair rate follows a different distribution, i.e., general and Gumbel-Hougaard family copula. The supplementary variable approach is employed here to have the comparison results between the time and reliability indices.

A multi-component system has been inspected by **Yue Shi et al., [64]** to fulfill the reliability requirements using the concept of rolling horizons under the concept of maintenance. This paper reveals that if the system reliability does not fulfill the demanding requirement, then a dynamic priority-based heuristic algorithm can be applied to identify the component for preventive maintenance. The results have been made, which show the reduction in expenses and enhanced system reliability.

The behavior analysis of a cooling tower power plant, which has six components in the series structure, has been focused on by **Gupta et al., [65].** The performance measure of a cooling tower has been judged by finding some related terms like availability and maintainability. The different measures MTTF and MTTR, which help measure system performance, have been counted with the mathematical modeling based on the Markov model.

The woolen industry using RPGT, which has four subsystems, has been discussed by **Kumar**, [66]. The different parametric measures, such as MTTF, availability, countable server visits, and time consumed during repair, with the impact of the malfunctioned time of the system and its restoration times, are calculated. Also, optimizing profit is elaborated with the help of tables and graphs in this paper.

The profit analysis as well as failure and repair rate of a subunit of a biscuit manufacturing plant consisting of five different subsystems arranged in a series configuration such that breakdown of one unit results in breakdown of the whole system has been concerned by **Garg**, [67]. The two units mentioned above have some subcomponents that are arranged in a series. By approaching RPGT, the path probabilities mean sojourn times, MTSF, availability of a system, etc. are determined to analyze the benefits of the system.

A multistate system that may operate between perfect functioning and complete failure, considering the concept of preventive maintenance to satisfy customer demand, has been discussed by **Qin and Li, [68]**. By involving the Markov chain theory and imperfect maintenance theory, indices like reliability, availability, and MTTF are interpreted with the help of differential equations.

Automation in the manufacturing sector has led to an increase in plant capacity in the process industries. While increased output and better product quality are the results of this, massive investment is also the main concern for all automated plants. Operating systems are therefore expected to be reliable, long-lasting, and to take good care of equipment. The current paper by **Singh et al., [69] deals** with a summary of the reliability assessments of various manufacturing sectors, such as sugar, milk, petroleum, etc. The countable approaches and algorithms were applied by researchers to get information about the ability of the system to perform its task effectively. Some of the techniques are elaborated on in this paper.

Reena Garg, [70] discussed the behavioral analysis of a single unit system using RPGT. This resume policy has been adopted for repair purposes.

A paper about a multi-state high-pressure homogenizer operating model was conferred by **Jia et al., [71]**. The effect of multiple environmental parameters on the system under a hybrid dynamic environment has been focused on. The different reliability parameters with environmental factors have been discussed using the process of Markov chains with finite states. This paper compared the reliable factors for the performance of a system based on the situation of fixed and variable outer conditions and found the results to evaluate the parameters regarding the system.

Vladimir et al., [72] demonstrated the sensitive analysis of an oil and gas industry with a k-out-of-n system model by assessing the reliability index with the help of the two-dimensional Markov process. The forward Kolmogorov equations for the time-dependent process were made, and results were carried out, which concluded that the most system reliability indices become practically insensitive to the shape of components under repair time distribution when the 'rare' component failure has been taken.

The work by **Aggarwal et al., [73]** highlighted the profit analysis and the operating time, indicating that the machine is better suited to finish the intended task of the H2O treatment reverse osmosis plant, which consisted of four units. The RPGT technique is used to ascertain how various parameters fluctuate as a machine's work capacity changes and improves.

One algorithm inspired by nature, called particle swarm optimization, was presented by Singla et al., [74]. Three distinct applications of PSO for cost-benefit analysis are presented in this paper. While a second approach involved thinking about a linear and nonlinear constrained concept, the first scenario—constraints on the sphere function—was examined both with and without it. Ultimately, the outputs of the observation process were obtained by applying a complex constrained condition. The resulting results are organized into tables and graphs for the purpose of comparing the various reliability metrics.

Garg and Garg,[75] discussed a bio-coal manufacturing plant to gather information about the advantages of its operation and the overall system's dependability, which varies with demand. The production was greatly impacted by the shift in demand. It consequently becomes challenging to lower output whenever demand declines. It is necessary to stop the plant, i.e., when overall production surpasses demand, it is in a down situation. Using the Markov process and the idea of RPGT, various tabular and graphical representation are created to determine the accessible time period, mean time of plant failure, and profit of manufacturing plants.

Barak et al., [76] have addressed the reliability measure of a milk plant with units A and B arranged in a parallel configuration**.** If one or both of the units cannot operate fully, the system will function at a reduced capacity and will be impeded in its ability to carry out its assigned task. After the failure of any component, the repairman gave preference to maintaining unit A as compared to unit B. Different graphs and tables are made to analyze the production of milk plants using the technique of the regenerative process.

The reliability system parameters of a poly tube plant, which have four units arranged in series configuration, out of which the first two units have subunits having series arrangement and the other two units have subunits arranged in parallel, were computed by **Kumar et al., [77].** To comprehend the system's behavior analysis, various tables and graphs of MTSF and BPS of a repairman with chances of failure—and thus the need to repair the system's various units—are drawn.

The profit analysis of the behavior of a thresher plant in agriculture was conducted by **Kumari et al., [78].** The plant as a whole was composed of three subsystems arranged in series: the feeding hopper, concave, and blower**.** In this research, state probabilities are used to derive a number of parameters under steady-state conditions using the proper RPGT approach. The analysis concluded that the repairman would be used more frequently as the likelihood of work stopping for unavoidable reasons increased because of the decreased profit function.

The focus on the deviation of availability of a screw plant working with four units arranged in series configuration as a system corresponding with time has been given out by **Bansal et al., [79].** By creating a mathematical model and applying the Markov birth-death process, it has been possible to find a fully functional plant with minuscule failures and complete flaws. Using a program like MATLAB, the idea of differential equations has been applied to obtain results regarding a system's availability. Following a review of the graphs' conclusions and the results, which might not have been as high as anticipated, the maintenance planning step was carried out in order to generate an overall higher profit.

The idea behind RAM, i.e., reliability, availability, and maintainability of threshing machines, was revealed by **Sharma et al., [80].** Lagrange's method has been applied to the problem in order to find the availability as well as some parameters, such as MTSF and MDT. In order to understand how the subsystem weakens the system (thresher) and causes a failed state, a transition model of the system has been created and discussed in this paper. The repair of the threshing drum is a priority to magnify the result in favor of profit and decrease the reason for losses.

Kumari et al., [81] embody a highly successful solution to the redundancy allocation issue in order to maximize the dependability of rubber plant equipment by using the COGA. Under certain limitations, the system's reliability has been computed while taking the non-poisson problem into account. This article has covered how to assign a system to the redundancy approach that works best for it.

The impact of maintenance and the resulting reliability for operation management were studied by **Afolalu et al., [82].** This paper revealed that downtime due to faults in machine performance has become a root cause of big losses related to productivity and finances. According to this paper, the strategies, which included periodically performing proper maintenance on machines, had a positive impact on other parameters related to system reliability and overall performance.

It was Kamal et al., [83] that first proposed the concept of selective maintenance; their recommended course of action is to prioritize maintaining the component that will reduce production loss or deterioration-related production loss. The most recent method for multifunction systems in a neutrosophic setting is heavily criticized in this article. By taking into account neutrosophic goal programming under allocation problems, the parameters involved in enhancing the overall system's reliability adhere to fuzzy programming under replaceable and repairable concepts. In order to improve the performance of an entire plant under beta distribution, this paper suggests a new epoch MO-SMAM (multi-objective selective maintenance allocation problem) for comparison of reliability parameters.

The paper proposes to use two procedures to optimize system reliability. The outcomes of an optimization process and a case study have been examined by Modibbo et al., [84] to gain knowledge about more efficiency at the minimum cost. Under deterioration, a technique of uniformly minimum variance unbiased estimators and minimum likelihood estimators is used to verify the reliability parameters.

Vladimir,[85] and associates have contemplated conducting research on an underwater pipeline monitoring system**.** A mathematical k-out-of-n-good system model has been developed using an example under the influence of preventive maintenance. The PM quality of systems has been examined using a variety of distributions, including the exponential, gamma, Weibull, and log normal distributions, using a general algorithm.

A model k-out-of-n system with a single repair facility has been discussed by **Vladimir et al., [86].** While the repair times in this model follow a general distribution, component lifetimes have been fitted with an exponential distribution. A numerical investigation using an algorithm has been conducted in relation to the operation of unmanned rotorcraft high-altitude platforms.

The subject of **Saini et al., [87]**'s study is a sugar manufacturing system with five subunits arranged so that the failure of one subunit causes the plant as a whole to fail, with a varying failure rate. A plant's dependability and results are directly impacted by a component failure. To increase plant output, the feature of routinely caring for components has been introduced. With the aid of graphs showing the subsystems' reliability, the various tables are depicted, thereby portraying the entire plant. A variety of metrics are examined, including the time between failures and the time to repair.

With four subsystems, **Kumar**,[88] has suggested building a rice plant. Using transition diagrams and the regenerative point technique, the impact of both failure and restoration rates on system specifications, like as MTSF, availability, number of repairman visits for repair or inspection, and time spent by them with the concept of waiting time included with profit count, is investigated. Fuzzy logic comprehends the reasons behind system malfunctions.

Garg and Garg, [89] also addressed the profitability of a briquette machine that malfunctions because of two kinds of minor or major faults with neglected faults. With the aid of the RPGT technique, the various parameters—such as availability, busy period, anticipated repairman visit, and profit optimization—have been determined. In order to determine the effectiveness of the briquette machine for burning coal or wood, an artificial bee colony optimization algorithm is applied to obtain results under the influence of repair and failure rates.

A nature-inspired algorithm for particle swarm optimization to optimize the cost of rubber plants has been discussed by **Kumari et al., [90].** By adhering to certain cost constraints, PSO has been used to obtain machine performance that is countable by reliability and the use of redundant components to improve it.

Kumar, [91] discussed the dependability metrics, including the wait time for the repairman

The discussion of the briquette machine system under the neglected faults was made by **Garg and Garg,[92].** Neglected problems like overheating and irregular noises have been addressed with preventive maintenance. In the context of preventive maintenance, the machine's availability, profit, busy period, and MTTF have all been evaluated using the Artificial Bee Colony algorithm. To aid in a more effective understanding of the results, a graphical representation has been created.

With the aid of a transition diagram for a urea fertilizer system, **Garg et al.,[93]** examined the reliability indices to determine the impact of system failure.The system having nine subsystems connected in the series has been discussed, and their performance has been analyzed using the technique of RPGT to decrease the overall risk of machine failure for improved reliability of work. This paper elucidated the impact of subunit repairs on a machine's MTSF and available time.

A semi-Marco process with the regenerative point technique has been used by **Naithani et al., [94]** to comprehend the behavior of a system that consists of a main unit that has the ability to automatically switch out two subunits following a failing process that is set up in parallel mode. This study came to the conclusion that every time the units' replacement time varied, the reliability index (MTSF) was impacted. The purpose of the graphs is to increase demand based on customers and display the profit of the entire system.

Saini et al., [95] have optimized a steam turbine plant with its availability, exponential failure time behavior, and arbitrary repair time behavior. When it comes to system failure and repair, the PSO with GA method has been utilized to relate the various system parameters at varying times. The purpose of creating and solving the differential equations is to determine the total system profit and efficiency.

By introducing the BLLP-Bi-level programming plan to the optimization problem pertaining to the liability of a system undergoing selective maintenance, as presented by **Khan et al**.,[96]. This paper addressed the existing gap. There's a numerical example to demonstrate the Khun-Trucker approach under linear constraints. This work demonstrates how additional variables impacted reliability indices and how those modifications impacted overall performance.

To comprehend the impact of malfunctioning units on system reliability, an approach known as RPGT is employed. In order to achieve good performance, **Singla et al., [97]** examined the two types of malfunctions, examined the results for both failure types, and displayed the results as having the system reliability parameter.

Singla et al., [98] used the Markov method concept to assess the availability and performability of various coal-fired thermal plant subsystems. The outcomes acquired via this approach are juxtaposed with those acquired via an artificial neural network.

Raghav et al., [99] set a numerical example to have the maximum availability and design a cost function for a series-parallel system using the different approach for having the comparison. The software tool MATLAB is used for application of approaches PSO, GA and Fuzzy goal programming.

This paper dealt with overview effect of malfunction and recovery rate with some safety issue of a process industry to check about the relationships between various rate over time with reliability, maintainability and availability by A. Kumar et al., [100].

The impact of standby hot and cold on a software and hardware of a system is discussed to put a light on reliability and availability. The function of both stand by is highlighted by M. Lalji et al., [101].

The marginal reliability importance and joint reliability importance are highlighted by R. Gao et al., [102] to examine the importance of an individual component or couple components of ur-m-k-out-of-n systems using chance theory.

A deep learning process was examined by Singla et al.,[103] in order to optimize the reliability parameters and boost industry revenues and manufacturing of a 2:3 good system.

Researchers Shivani et al. [104], examine a series parallel system to employ the Laplace transformation with and without the copula approach to have a sensitive analysis of reliability parameters.

By considering the concept of redundancy allocation problem, A K-out-n system is studied by D. Xu et al., [105]. By following the exponential distribution in Malfunction rate,a satellite power supply system is numerical solved to check about its available performance time.

In 2024, Singla et al.,[106] investigate a failing system by applying a genetic algorithm to ascertain the reliability metrics influenced by the rate of degradation and the rate of preventive maintenance.

A multi configured series complex system under k-out-n subsystems has been discussed by P. Su et al., [107] and checked about the reliability of system using a well developed algorithm based on generalized universal generating function.

This paper configured a difference between the old concept for reliability metrics and modern tool for this. The use of AI and Machine learning is focused by M. Yazdi, [108] to have better results about method.

A 1-out-of-n standby non- identical system has been optimised over provided time. The functional times are bounded and fluctuate with respect to resources provided and storage units. The study by G. Levitin et al., [109] focused on the maximization of mission success probability with the help of a algorithm.

A mathematical model of multi objectives manufactured industry is subjected to Pythagorean hesitant fuzzy (PHF) to optimised the reliability for maximization and minimisation of cost. The comparison of work by S. Jana et al., 110] has been done also with existing method in context of degree of closeness.

A method of Runge-Kutta method has been applied to a multi server redundant machine system to count the relationships between reliability metrics and the rate of working and failure and also compare the study to those delivered by an adaptive neuro-fuzzy inference system (ANFIS) technique. The study also included the concept of multiple working vacation policy of server by P. K. Chahal, [111].

The degradation of system under influence of fatigue of machine parts and human error are considered under semi Markov process by H. Che et al., [112] . A k-out-n system has Been discussed to know about the reliability metrics and effect on them due to deterioration.

5. BEHAVIOUR RELIABILITY ATTRIBUTES WITH REFERENCES TO VARIANCE SYSTEM PARAMETERS.

Table 1 summarises the reliability attributes effected by fluctuation in differ parameters investigated by various researchers.

Table 1: The attributes of behavioral reliability in relation to various system parameters.

Reference Number	Reliability attributes	FR	RR	PM	IR
Singh & Mahajan [8]	Availability	IP			
Wang & Kuo [9]	MTTF and Availability with CSB	IP			
El-Said & El-Hamid [11]	Availability and MTSF		DP		
Rashad et al. [12]	MTSF		DP		
	Availability and Profit		DP		
Chander & Bhardwaj [13]	Profit Difference		DP		
	MTSF				
Singla et al. [15]	Availability of each subsystem		DP		
Yusuf & Bala [18]	MTSF	IP			
Kumar & Malik [19]	MTSF	IP			
	Availability			DP	
	Profit			DP	
Kakkar et al. [20]	Profit	IP	DP		
	MTSF	IP	DP		
Yusuf & Hussaini [21] [25]	Availability		DP		
	Profit		DP		
	MTSF		DP	DP	
S. Kajal & Tewari [22]	MTSF	IP			
	Profit	IP			
Malik [23]	Availability	IP		DP	
	MTTF	IP		DP	
	Profit	IP		DP	
Garg [24]	Availability		DP	DP	
Chaudhary et al. [26]	Availability		DP		
Aggarwal et al. [27]	Availability	IP	DP	DP	
Devi et al.[30]	Availability	IP	DP		
	MTSF		DP		
	Busy Period		IP		
Kumar et al. [31]	Busy Period with WSB	DP	IP		
	MTSF with WSB	IP	DP		
	Busy Period with CSB	DP	IP		

	MTSF with CSB	IP	DP		
Kumar et al. [32]	Busy Period		IP		
	Availability		DP		
Minaxi et al. [33]	Availability	IP	DP		
Sarla et al. [34]	Availability	IP	DP		
	Busy Period	DP	IP		
Sharma et al. [36]	Availability	IP	DP		
	MTSF	IP			
Navneet et al. [37]	Profit		DP		
Bansal et al. [38]	Availability	IP	DP		
	Profit	IP	DP		
Chaudhary [39]	Availability		DP		
Goyal et al. [40]	Availability		DP		
	Busy Period	DP			
Kumar & Goel [42]	Busy Period	DP	IP		
	Availability	IP	DP		
Kumar [43]	Profit	IP	DP		
Kumar and Goel [46]	MTSF	IP	DP	DP	DP
Aggarwal et al. [48]	Availability	IP			
Kumar et al. [50] [56] [59]	Availability	IP	DP		
Goyal [53]	Availability		DP		
Thori & Goel [54]	Busy Period	IP			
Devi et al. [57]	Availability	IP	DP		
	MTSF	IP	DP		
M. Kumar [61]	Performance			DP	
R. Kumar [66]	Profit		DP		
D. Garg [67]	Profit		DP		
Qin et al. [68]	Availability			DP	
	Production			DP	
R. Garg [70]	Expected number of server	IP			
Aggarwal et al. [73]	Availability	IP	DP		
	Profit	IP	DP		
	Busy Period	DP	IP		
Garg & Garg [75]	Availability	IP	DP		
Barak et al. [76]	Performance	IP	DP		
Kumar et al. [77]	MTSF	IP			
	Busy Period	DP			

	Availability	IP	DP		
Kumari et al. [78]	Profit	IP	DP		
Sharma et al. [80]	MTSF	DP			
	Efficiency		DP		
A. Kumar [88]	Profit	IP	DP		
Garg & Garg [89] [92]	Availability	IP	DP		
Kumari et al. [90]	Availability	IP			DP
A.Kumar[91]	Profit	IP	DP		
Garg et al. [93]	Profit	IP	DP		
	Availability	IP	DP		
Naithani et al. [94]	Availability	IP	DP		DP
Raghav et al. [99]	Cost	DP	IP	IP	
Singla et al. [103]	Reliability		DP	DP	
Shivani et al. [104]	MTSF	IP	DP		
	Availability	IP	DP		
	Reliability	IP	DP		
	Profit	IP	DP		

6. DIFFERENT METHODOLOGY USED BY DIFFERENT RESEARCHERS TO KNOW BEHAVIOUR RELIABILITY INDICES.

Table 2 and Table 3 summarizes the different methods used by different researchers to know the different reliability parameters of system.

Table 2 : The different researchers with respect to different Soft algorithm methodology.

Soft Analysis algorithm methods	References
Particle Swarm Optimization	Garg [24], Singla et al. [74],
Rolling Horizon Approach	Yue Shi et al. [64]
RPGT and Artificial Bee colony	Garg & Garg [89] [92]
Neutrosophic Goal Programming	Kamal et al. [83]
Genetic Algorithm Technique	M. Kumar [61] , Singla et al
Machine Learning	M. Yazdi [108] ,Singla et al

Table 3 : The different researchers with respect to different Hard algorithm methodology.

Hard Analysis methods used by researchers	References
Lagrange's Method	Kumar et al. [4] , Singla et al. [17],Sharma et al. [80]
Regenerative Point Technique & Sei Markov Process	Kumar & Malik [19], Chander & Bhardwaj [13], Parashar & Taneja [10], Bhardwaj & Malik [14], Naithani et al. [94]
RPGT	Kakkar et al. [20],Malik [23],Chaudhary et al. [26],Devi et al.[30], Kumar et al. [31] [32], Minaxi et al. [33] , Sarla et al. [34], Goel & Ritikesh [35], Sharma et al. [36] , Navneet et al. [37], Bansal et al. [38], Chaudhary [39], Goyal et al. [40], Kumar & Goel [42], Kumar [43], Gitanjali & Malik [44], Chaudhary et al. [26], Kumar and Goel [46], Kumar [49], Kumar et al. [50] [56] [59], Gupta et al. [52],Goyal [53], Thori & Goel [54],Devi et al. [57], R. Kumar [66], D. Garg [67], R. Garg [70], Aggarwal et al. [73], Garg & Garg [75], Barak et al. [76], Kumar et al. [77], Kumari et al. [78], A. Kumar[88] [91], Garg et al. [93]
Markov Birth Death Process	Bansal et al. [79], Aggarwal et al. [27], S. Kajal & Tewari [22], Gupta et al.[65], Qin et al. [68], Jia et al. [71]
Runga Kutta Fourth Order Method	Aggarwal et al. [48] , Aggarwal et al. [27], P. K. chahal et al. [108]
Linear Differential Equation Method	El-Said & El-Hamid [11], Yusuf & Bala [18]
Kolmogorov's Forward Equation	Yusuf & Hussaini [21] [25], Yusuf [45],
Supplementary Variable Technique	Ghalot et al. [63], Singla et al. [15]
Laplace Transformation Method	Rashad et al. [12], Singh & Mahajan [8],Shivani et al. [104]
Khun- Trucker Approach	Khan et al.[96]

The data given in Table 2 and Table 3 was used to summarize the overall methodology by researcher and following figure shows the results.

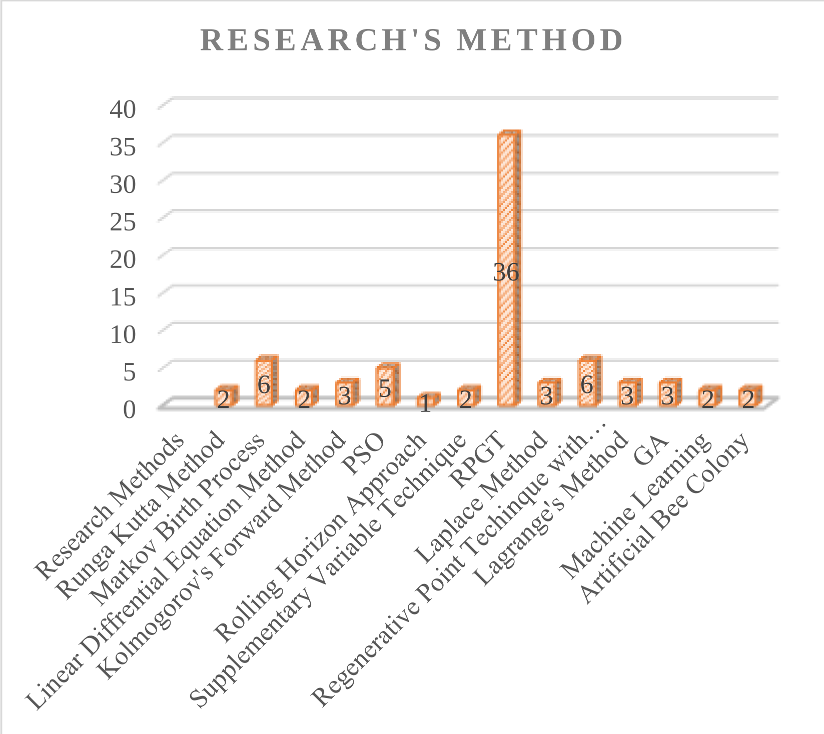

Figure 2: The different types of method vs number of researchers.

7. CONCLUSION

From Table 1, Table 2, and Figure 2, the following can be inferred:

Different systems become more available as the rate of repairs rises and fall as the rate of failures rises. It is possible to enhance it by performing periodic maintenance and inspections. Reduced failure rates boost a system's MTSF and profit; consequently, industry profits are directly correlated with repair rates. The busy period of the repairman increases with respect to the failure possibilities in a directly proportional manner. On the other hand, it decreases in an inversely proportional manner with repair rate. Overall performance can be increased by providing facilities for good maintenance and proper examination. Most of the researchers found that the RPGT technique is the most effective means of obtaining a dependable result when compared to alternative approaches when using the regenerative point technique to solve the various equations. In current Scenrio Different soft analysis algorithm coming in demand due to accurate performance and well reults.

8. FUTURE SCOPE

As this paper demonstrates, researchers have been instrumental in improving the reliability analysis of various industries or systems through the use of various algorithms and techniques. With the rapid advancement of technology, a new algorithm may make it simple to solve the stochastic process. By applying a novel method to boost any system's overall performance or production, the various equations might not take as long to solve. To meet societal demands, the researcher might concentrate on increasing reliability indices at a very low cost and with more profit. Furthermore, a variety of soft analysis algorithms can compute reliability more quickly and easily. Today's improved performance may be aided by elements of corrective and preventive maintenance. Also, the combination of two methods may provide a better approach for finding the outcomes than earlier. A comparison can be done to check the efficiency of one method over another, which influences the upcoming authors to invent something new in earlier techniques.

9. LIMITATIONS

- The equations formed sometimes become too cumbersome to solve.
- The method used to find out the results sometimes represents very difficult outcomes.
- Sometimes the mathematical model becomes too lengthy to understand, and the output based on it becomes difficult to understand.
- It's not easy to apply technique to formed equations.

The selection of a proper algorithm is too important, and its neglect becomes obstacles to improving performance.

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