EXPLORE THE DYNAMICS OF MANUFACTURING INDUSTRIES: RELIABILITY ANALYSIS THROUGH STOCHASTIC PROCESS MODELING

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Abstract

In nowadays, the chief attention of the researcher is to study how the reliability analysis of manufacturing industrial systems by using the stochastic process. This topic tells us, how the manufacturing industries perform over time with the help of mathematical models which include randomness and uncertainty. Through stochastic processes we examine the reliability of these systems, technologists can recognize possible failure points and develop tactics to improve overall performance and effectiveness. The reliability of a manufacturing industrial system can be examined through a stochastic process, which permits for the estimate of failure rates and maintenance agendas. This analysis can lead to more well-organized and cost-effective procedure of the system. In this study, the researcher analysed the possibility plan for reliability through many distributions such as the normal distribution, gamma distribution, weibull distribution, and exponential distribution. The result of the study was prepared using Minitab software. The result of the study shows that the normal distribution of reliability fits best in comparison to the gamma, weibull, and exponential distributions.

Keywords: Manufacturing Industry, Reliability.

1. Introduction

The introduction of stochastic models in the field of manufacturing industrial systems has confirmed to be an operative device for forecasting system reliability and classifying potential failure points. By including probabilistic parameters into the analysis, technologists and managers can up to date about maintenance agendas, system upgrades, and other tactics to recover overall system performance. As technology continues to advance and data collection methods become more sophisticated, the use of stochastic models is likely to become even more widespread in the field of industrial engineering. The world is expanding quickly and heading towards a "smart world" where technology controls everything. The cost and complexity of industrial processes have greatly increased with the advancement of technology in the twenty-first century. Hence, it has become crucial to run industrial systems with the least amount of downtime possible in order to achieve optimal productivity, boost revenue, and prevent losses. Hence, dependability and investigation of complex industrial systems is a need that cannot be avoided.

Many studies have been done on the subject of dependability modelling, analysis, and complex industrial systems under various operating situations and hypotheses. So first read a review on the modelling and analysis of complex industrial systems' reliability, in which different reliability indices were presented in relation to various system parameters and various failure and repair rate distribution types used by various authors were discussed. Taking into account different failure distributions analysed failure data, and goodness of fit testing.

It was discovered that the exponential distribution was the foundation for the consequences of stochastic processes for system performance, and additional behaviour analysis of the process industry was conducted based on steady-state availability analysis and reliability analysis. In order to determine if the findings obtained genuinely have an exponential distribution, we develop a stochastic model for an industrial process in this study. Several of the foundational ideas are covered in the part after this one before we move on. Shihu Xiang, Jun Yang [1] analyzed in the paper reliability of WSN by considering random failures, energy consumption, environmental randomness and interference. F Delmotte et al [2] presented in their paper, modelling of reliability with possibility theory, a new approach based on a fusion rule by using a vector expressing the dependability on the data basics. Hasan et al [3], observed in their paper that the higher order logic formalization of some fundamental reliability theory concepts which can be built for reliability analysis in engineering system. J Dunyak et al [4] discussed in their paper that the probability of any event can be calculated by fuzzy fault tree which is independent of union, intersection and complements of any sequence of event. This allows a comprehensive analysis of the system. Q Zhang et al [5] discussed the belief reliability which is defined as the chance that a system is within a feasible domain. Measuring system reliability by a reasonable metric is a common problem in reliability engineering and the metric can degenerate either probability theory-based reliability or uncertainty theory-based reliability. Shakuntla Singla, Pooja Dhawan [6] analysis the behavior of a single unit subdivision after a complete failure by the help of RPGT. The situation is constructed and resolved by using RPGT to calculate system constraints. K Sachdeva et al [7] studies the sensitivity and productivity of a stochastic model whose technical faults may clear into either guarantee or coverage policies, the producer is answerable for all repair or replacement costs during normal or extended warranty. Profit and availability are calculated in all conditions. Kumar et al [8] presented in their paper overview of reliability analysis. Reliability analysis in different industries like milk, sugar, Thermal plant, petroleum industries etc. and to optimize the reliability using different techniques like G.A., H.A, PSO, machine learning etc.

2. Reliability analysis

It represents the Time to Failure as a statistical distribution, which is often defined by a certain pattern, using a Reliability Distribution Analysis. The aforementioned distribution types may be used. The timing of failure for a component is an example of a random event for which the result is unpredictable. Probability distributions are used to represent such occurrences. It is uncertain when that component will fail prior to putting a demand on it. A probability distribution models the distribution of the chance of failure at various periods. Random variables will be identified in this book by a capital letter, such as T for time. Researcher use little letter, such as t for time, to indicate when the random variable takes on a value. For instance, we would find P (T≤t) if we wanted to know the likelihood that the component would fail before time t. There are two types of random variables: discrete and continuous. The random variable in a discrete distribution has a specific or countable range of potential values, such as the number of demands before failure. The random variable in a continuous distribution is not restricted to certain potential values, unlike the time-to-failure distribution.

Probability $R(t) = P(T>t), t \geq 0,$ Where T- Random variable
t- Time

Failure probability distribution function $F(t) = 1 - R(t) = P(T \leq t)$

Probability density function $F(t) = \int_{-\infty}^{T} f(t)\,dt$

(i) Normal Distribution

A distribution in which continuous random variable has the probability density function with the following formula is given by

f (t) = $\frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(t-\mu)^2}{2\sigma^2}}$ Where μ and $\boldsymbol{\sigma}$ are arbitrary constant

(ii) Gamma distribution

A distribution in which continuous random variable has the probability density function with the following formula is given by

f (t) = c t^{a-1} e^{-bt} , t ≥ 0 Where a, b and c are constant

(iii) Weibull distribution

A distribution in which continuous random variable has the probability density function with the following formula is given by

f (t) = a t^b $e^{\frac{-(at^{b+1})}{(b+1)}}$, t ≥ 0 Where a and b are constant

(iv) Exponential distribution

A distribution in which continuous random variable has the probability density function with the following formula is given by

f (t) = $\begin{cases} \lambda e^{-\lambda t}, & 0 < t < \infty \\ 0, t < 0 \end{cases}$

3. MANUFACTURING INDUSTRY PROCESS

A Manufacturing industry is chosen for reliability distribution and to know about the failure. The industrial procedure is divided into five sub systems. The sub system name with number of machines, their failure and mean time failure explained as below.

Table 1: *Industrial Process with Failures*

Industrial Process with Failures			
Sub System	Number of machines	Failure condition	Mean time failure MTBF
A. Storage Room	5	Never Fails	100000
B. Mixture	3	Failed when 2 machines fail	20000
C. Slasher	5	Failed when 3	16000
D. Loom	300	Failed when 30 machines fail	50000
E. Machine for Fabric Inspection	3	Failed when all 3 machines fail	80000

The reliability for stochastic model R1 (t) =1-$\sum_{i=1}^{4} P_i(t) = 0$

The value of transient probabilities is obtained by using following equations.

$$P_o'(t) + \sum_{i=1}^{4} \lambda i P_0(t) = 0,$$

$P_i'(t) = \lambda_i P_0(t)$ Where i=1, 2, 3, 4

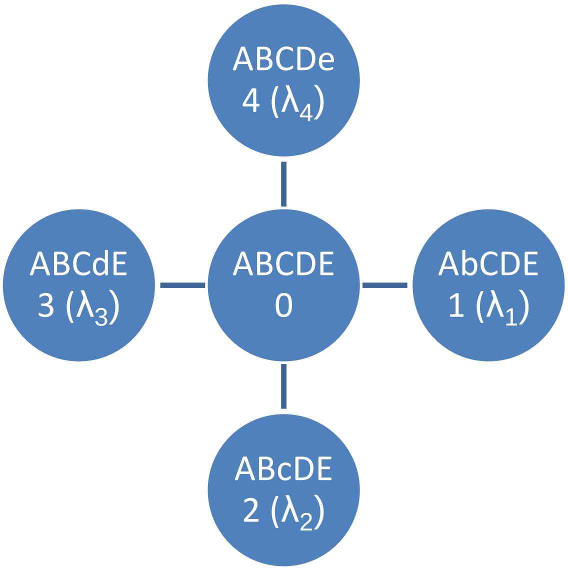

Figure 1: *Space diagram of manufacturing Industrial Process*

The above figure describes the sub system of industry in which A, B, C, D and E are the operating conditions and a, b, c, d and e describe the failed state of the model.

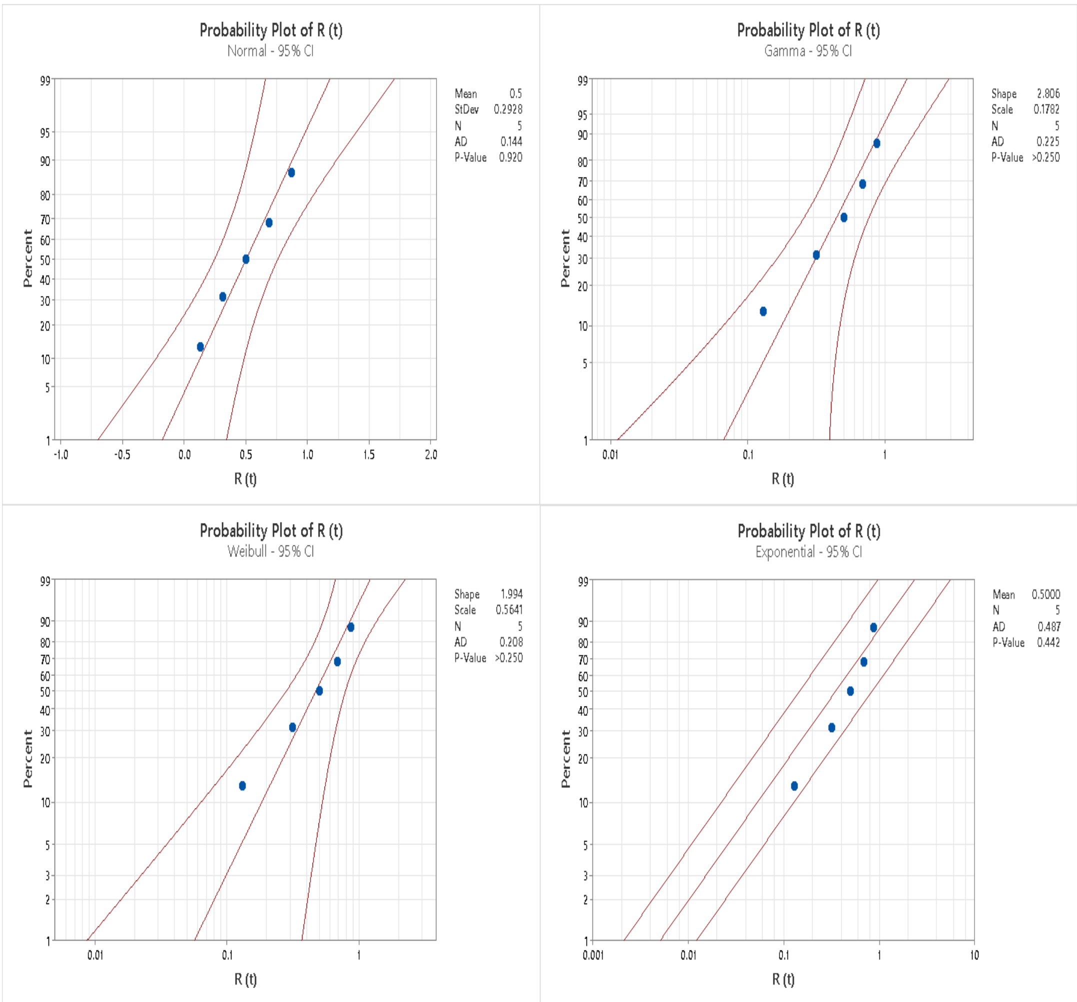

Figure 2: *Reliability analysis through Probability Curve for Normal, Gamma, Weibull and Exponential Distribution*

4. Result

The reliability of the model checked using the above equations. The probability distribution can be explained and plots by using Minitab software. In probability curve left line shows the lower bounds for confidence intervals, right line shows upper bounds for confidence intervals and middle line shows most fitted probability distribution. When value of P is more than its given value them distribution is best fit. In the above figure 2. it is cleared that normal distribution of probability is best fit. So, the conclusion of this study is that for reliability of an industry normal distribution is the fit. So, this represents the best distribution for maintenance of an industrial process.

5. Conclusion

The reliability distribution of an industrial system can be effectively analysed through stochastic processes, which provide a probabilistic framework for modelling and predicting system failures. This approach can help industries optimize maintenance schedules and improve overall system performance.

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