International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 12– No.33, September 2020 – www.ijais.org

An Availability Measurement of Multi Component Power Plant by using Boolean Function Technique under different Distributions

Kashiful Haq
Associate Professor
Department of Computer Science
Meerut, India

Yusuf Perwej
Associate Professor
Department of Computer Science & Engineering
Delhi, India

ABSTRACT
The most essential part of our daily life is electricity. With the absence of it, every living human being will be sent to dark ages and in fact life itself would be incomplete and miserable without it. A power plant is an industrial facility that generates electricity from primary energy. Most power plants use one or more generators that convert mechanical energy into electrical energy in order to supply power to the electrical grid for society's electrical needs. In this research paper we have tried hard to calculate the reliability of a complex power plant with three generators, so that their future behaviour can be monitored and controlled for uninterrupted electrical power supply to the society.

Keywords
MTTF (Mean Time to Failure), R (Reliability), Q (Unreliability), P_r (Probability), R_S (Reliability State), R_{SW} (Reliability State using Weibull Distribution), R_{SE} (Reliability State using Exponential Distribution).

1. INTRODUCTION
For several years now, deriving value from "big data" [1] has been a concern for executives focused on the distribution side of electric utilities. It was only a matter of time before generating units and fleets also had the capability to collect, analyze, and act upon huge volumes of near-real-time data [2]. In this paper, the authors' have discussed the logical probability methods [3] of reliability analysis which describe the structure of complex equipment and the features of its functioning by the help of mathematical logic, the quantitative estimation of reliability being done with the aid of probability laws [4]. Here, the authors' have considered a complex system having three subsystems in parallel redundancy. This complex system is identical with an engineering system consisting of three generators G1, G2 and G3 in parallel redundancy [5]. These power generators are connected with a sub power board (SPB) and some switch Boards SB1, SB2, SB3, SB4, respectively. All these components are connected with the help of perfectly reliable cables C1, C2------C9. Thus, the complex system under consideration is nothing but a multi-component power plant. The object of the system is to supply power generated by the generators G1, G2 and G3 to consumers through output board (OPB) and consequently, the reliability of the power supply is also calculated by means of Boolean function technique with considering that failure times for various components of the system follow arbitrary time distribution. Moreover an important parameter, viz., MTTF [6] has also calculated for exponential failure time distribution for different components of the system. Some numerical examples along with graphical [7] illustration have also been appended at the end to highlight the utility of the model for practical applications [8]. In the power sector, the most popular application in this category is condition monitoring and predictive maintenance of a wide variety of assets. The IoT-based approach transitions from traditional reactive [9] and periodic maintenance strategies to proactive strategies. The applications are focused on the highest value assets in generation plants, and in the transmission and distribution grid [10].

2. ASSUMPTIONS
The following assumptions have been associated with the model.

(i) The state of every component and of the whole system is either good or bad. There is no reduced efficiency state.

(ii) There is no repair facility to the failed component.

(iii) The states of all the components are statistically independent.

(iv) The reliability of every component is known in advance.

(v) The failure times of all components are arbitrary.

(vi) Initially, all the components are in working state of full efficiency.

(vii) The supply of power can fail, if at least one component in all the routes of supply fails.

(viii) The cables used, are hundred percent reliable.

3. NOTATIONS
The following notations have used throughout this model and shown in proposed model figure 1.

x_1, x_2, x_3 : State of generators G1 ,G2 andG3 respectively.

x_4, x_9 : State of sub power board (SPB) and output board (OPB), respectively [11].

x_5, x_6 , x_7, x_8 : State of switch boards SB1, SB2 , SB3 and SB4 respectively.

$$x_k = \begin{cases} 0 \; in\, failed\, state \\ 1 \; in\, good\, state, k = 1,2,---9 \end{cases}$$

International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 12– No.33, September 2020 – www.ijais.org

x' : Negation of x

$\wedge$: Conjunction

$\vee$: Disjunction

C_1, C_2------C_9: Cables connecting power supply to load.

4. FORMULATION OF MATHEMATICAL MODEL

The authors' explain some of the performance measures of the system which are of interest from the system's design point of view and analysis. In the present concerned proposed model, the performance measures of the power supply plant is quantified with respect to Reliability and Availability of the system.where as Reliability R(t) is a classical measure defined as the probability that the system functions well in the interwal (0,t) and is symbolically defined as $R(t) = P_r\{ z(u) = 1, 0 \leq u \leq t : z(0) = 1\}$,Equivalently, let X be the the random variable representing the duration of the first system failure starting with initial operable condition at t = 0. Then, the reliability R(t) of the system is equal to Pr { X > t }.and Availability A(t) is defined by the probability that a system is in operating condition at time 't'. Hence, $A(t) = P_r\{ z(t) = 1 : z(0) = 1\}$. As you can see the following differences between the performance measures Reliability and Availability. The reliability is an interval function while Availabilty is a point function describing the behavior of the system at a specified epoch.Secondly, the reliability function precludes the failure of the system during the interval under consideration, while availability function does not impose any such restriction on the behavior of the system.Associated with A(t), there is another measureA' (t)=1-A(t), probability that the system is unavailable at a time 't'.In Pointwise Availabilty the probability that the will be able to operate with tolerance limits at a given instant and is also called operational readiness. Symbolically, it is $A(t) = P_r\{ X(t) = 1\}$ where, X(t) is a binary variable having values 1 and 0, respectively for the operation and non-operation of the system at an intant't'.

Now, the object of the proposed system is to supply power, generated by the generators G1, G2 and G3 through OPB to consumers. Using Boolean function technique, the authors' have considered all possible scenarios by taking the combination of all units that are essential for a fully working power plant as the readers' of this research paper will understand the logical matrix by seeing the first row of the matrix, for example X_1 is a unit resembling generator G_1 which is connected through cable C_1 to the subpower board SPB which is unit X_4 which is further connected through cable C_4 to sub power board SB1which is unit X_5 and with Cable C_7 to the final output board OPB which is unit X_9. Lastly, the proposed power plant and the conditions [12] of capability of the successful operation of complex system in terms of logical matrix [13] are expressed as.

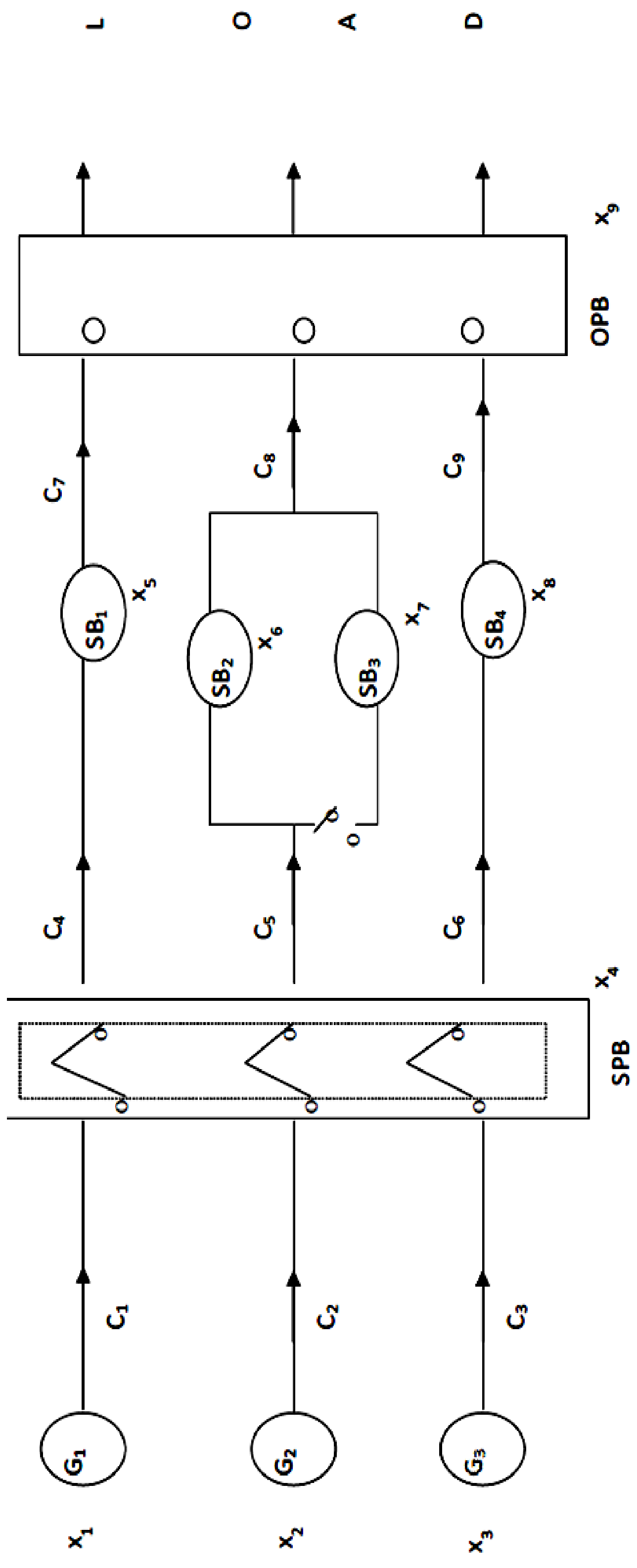

Fig 1: The System Configuration of Proposed Model

$$f(x_1,x_2----x_9) = \begin{pmatrix} x_1 & x_4 & x_5 & x_9 \\ x_1 & x_4 & x_6 & x_9 \\ x_1 & x_4 & x_7 & x_9 \\ x_1 & x_4 & x_8 & x_9 \\ x_2 & x_4 & x_5 & x_9 \\ x_2 & x_4 & x_6 & x_9 \\ x_2 & x_4 & x_7 & x_9 \\ x_2 & x_4 & x_8 & x_9 \\ x_3 & x_4 & x_5 & x_9 \\ x_3 & x_4 & x_6 & x_9 \\ x_3 & x_4 & x_7 & x_9 \\ x_3 & x_4 & x_8 & x_9 \end{pmatrix} --------(1)$$

5. THE SOLUTION OF THE PROPOSED MODEL

By application of algebra of logical, equation (1) may be written as.

$$f(x_1\, x_2 ---x_9) = (x_4 x_9\ \wedge g(x_1 x_2 x_3 x_5 x_6 x_7 x_8) --- (2)$$

Where,

$$g(x_1 x_2 \cdots\cdots x_8) = \begin{vmatrix} x_1 & x_5 \\ x_1 & x_6 \\ x_1 & x_7 \\ x_1 & x_8 \\ x_2 & x_5 \\ x_2 & x_6 \\ x_2 & x_7 \\ x_2 & x_8 \\ x_3 & x_5 \\ x_3 & x_6 \\ x_3 & x_7 \\ x_3 & x_8 \end{vmatrix} --- (3)$$

Or,

$$g(x_1 x_2 \cdots\cdots x_8) = \begin{vmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{vmatrix} --- (4)$$

Where,

$$A_i = |x_1 \quad x_{4+i}| \quad , \quad i = 1,2,3,4$$
$$A_j = |x_2 \quad x_j| \quad , \quad j = 5,6,7,8$$
$$A_k = |x_3 \quad x_{k-4}| \quad , \quad k = 9,10,11,12$$

Using orthogonalization algorithm, equation (4) may be written as.

$$g(x_1 x_2 \cdots\cdots x_8) = \begin{vmatrix} A_1 \\ A'_1 & A_2 \\ A'_1 & A'_2 & A_3 \\ A'_1 & A'_2 & A'_3 & A_4 \\ A'_1 & A'_2 & A'_3 & A'_4 & A_5 \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A_6 \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A_7 \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A'_7 & A_8 \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A'_7 & A'_8 & A_9 \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A'_7 & A'_8 & A'_9 & A_{10} \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A'_7 & A'_8 & A'_9 & A'_{10} & A_{11} \\ A'_1 & A'_2 & A'_3 & A'_4 & A'_5 & A'_6 & A'_7 & A'_8 & A'_9 & A'_{10} & A'_{11} & A_{12} \end{vmatrix}$$

$$---(5)$$

By using algebra of logic, one can obtain the following results.

$$A'_i = \begin{vmatrix} x'_1 & \\ x_1 & x'_{4+i} \end{vmatrix} \quad , \quad i = 1,2,3,4$$

$$A'_j = \begin{vmatrix} x'_2 & \\ x_2 & x'_j \end{vmatrix} \quad j = 5,6,7,8$$

$$A'_k = \begin{vmatrix} x'_3 & \\ x_3 & x'_{k-4} \end{vmatrix} \quad k = 9,10,11,12$$

Now,

$$A'_1 A_2 = \begin{vmatrix} x'_1 & \\ x_1 & x'_5 \end{vmatrix} \wedge |x_1 \quad x_6|$$
$$= |x_1 \quad x'_5 \quad x_6| \quad ---(6)$$

International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 12– No.33, September 2020 – www.ijais.org

Similarly,

$A'_1 A'_2 A_3 = (x_1 x'_5 x'_6 x_7)$ -----(7)

$A'_1 A'_2 A'_3 A_4 = (x_1 x'_5 x'_6 x'_7 x_8)$ -------(8)

$A'_1 A'_2 A'_3 A'_4 A_5 = (x'_1\ x_2\ x_5)$ -------(9)

$A'_1 A'_2 A'_3 A'_4 A'_5 A_6 = (x'_1\ x_2\ x'_5\ x_6)$ -------(10)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A_7 = (x'_1\ x_2\ x'_5\ x'_6\ x_7)$ -------(11)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A'_7 A_8 = (x'_1 x_2 x'_5\ x'_6\ x'_7\ x_8)$ -------(12)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A'_7 A'_8 A_9 = (x'_1\ x'_2\ x_3\ x_5)$ -------(13)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A'_7 A'_8 A'_9 A_{10} = (x'_1 x'_2\ x_3\ x'_5\ x_6)$ -------(14)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A'_7 A'_8 A'_9 A'_{10} A_{11}$

$= (x'_1 x'_2\ x_3\ x'_5 x'_6 x_7)$ -------(15)

$A'_1 A'_2 A'_3 A'_4 A'_5 A'_6 A'_7 A'_8 A'_9 A'_{10} A'_{11} A_{12}$

$= (x'_1 x'_2\ x_3\ x'_5 x'_6 x'_7 x_8)$ -------(16)

By using equations (6) through (16), equation (5) becomes,

$$g\,(x_1 x_2 \cdots\cdots x_8) = \begin{vmatrix} x_1 & x_5 \\ x_1 & x'_5 & x_6 \\ x_1 & x'_5 & x'_6 & x_7 \\ x_1 & x'_5 & x'_6 & x'_7 & x_8 \\ x'_1 & x_2 & x_5 \\ x'_1 & x_2 & x'_5 & x_6 \\ x'_1 & x_2 & x'_5 & x'_6 & x_7 \\ x'_1 & x_2 & x'_5 & x'_6 & x'_7 & x_8 \\ x'_1 & x'_2 & x_3 & x_5 \\ x'_1 & x'_2 & x_3 & x'_5 & x_6 \\ x'_1 & x'_2 & x_3 & x'_5 & x'_6 & x_7 \\ x'_1 & x'_2 & x_3 & x'_5 & x'_6 & x'_7 & x_8 \end{vmatrix} \quad --- \ (17)$$

In view of equation (17), equation (2) becomes,

$$f\,(x_1 x_2 \cdots\cdots x_9) = \begin{vmatrix} x_1 & x_4 & x_5 & x_9 \\ x_1 & x_4 & x'_5 & x_6 & x_9 \\ x_1 & x_4 & x'_5 & x'_6 & x_7 & x_9 \\ x_1 & x_4 & x'_5 & x'_6 & x'_7 & x_8 & x_9 \\ x'_1 & x_2 & x_4 & x_5 & x_9 \\ x'_1 & x_2 & x_4 & x'_5 & x_6 & x_9 \\ x'_1 & x_2 & x_4 & x'_5 & x'_6 & x_7 & x_9 \\ x'_1 & x_2 & x_4 & x'_5 & x'_6 & x'_7 & x_8 & x_9 \\ x'_1 & x'_2 & x_3 & x_4 & x_5 & x_9 \\ x'_1 & x'_2 & x_3 & x_4 & x'_5 & x_6 & x_9 \\ x'_1 & x'_2 & x_3 & x_4 & x'_5 & x'_6 & x_7 & x_9 \\ x'_1 & x'_2 & x_3 & x_4 & x'_5 & x'_6 & x'_7 & x_8 & x_9 \end{vmatrix} \quad --- \ (18)$$

Since R.H.S. of equation (18) is the disjunction of pair wise disjoint conjunctions, therefore, reliability [14] of the supply of the complex system is given by.

$Rs = \Pr\,[f\,(X_1, X_2 \text{----} X_9) = 1]$

$= R_9\ [R_1R_5 + R_1Q_5R_6 + R_1Q_5Q_6R_7 + R_5Q_5Q_6Q_7R_8 + Q_1R_2R_5 + Q_1R_2Q_5R_6 + Q_1R_2Q_5\ Q_6R_7 + Q_1R_2Q_5\ Q_6Q_7R_8 + Q_1Q_2R_3\ R_5 + Q_1Q_2R_3\ Q_5R_6 + Q_1Q_2R_3Q_5Q_6R_7 + Q_1Q_2R_3\ Q_5Q_6Q_7R_8]$ ------ (19)

Where, R_1, R_2 .... R_9 are the reliabilities of the components [15] of the complex system corresponding to the states x_1 , x_2 ----- x_9 , respectively.

Q_1 $(=1-R_1)$, Q_2 $(=1-\ R_2)$ ---------------, Q_9 are the corresponding unreliability's.

6. SOME PARTICULAR CASES

In this segment, we are discussing the various cases in this model.

Case I: If Reliability of Every Component is Being R

Then equation (19) yields.

$Rs = R^4[12 - 30R + 34R^2 - 21R^3 + 7R^4 - R^5\ ]$ -------- (20)

Case II: When Failure Rates Follow Weibull Distribution

Let failure rates of generators G_1 , G_2 and G_3 ;sub power board SPB ; switch boards SB_1, SB_2, SB_3 ,SB_4 ; output board OPB be λ_1, λ_2 ----- λ_9 respectively, then from equation (19) reliability [16] of whole system at instant 't' is given as.

$$R_{SW}\,(t) = \sum_{i=1}^{53} exp.\{-b_i t^p\} - \sum_{j=1}^{52} exp.\{-a_j t^p\} - - \quad - -(21)$$

Where, p is a positive parameter and b_i's and a_j's are mentioned as below.

$b_1 = c + \lambda_1 + \lambda_5$
$b_2 = c + \lambda_1 + \lambda_6$
$b_3 = c + \lambda_1 + \lambda_7$
$b_4 = c + \lambda_1 + \lambda_8$
$b_5 = c + \lambda_1 + \lambda_5 + \lambda_6 + \lambda_7$
$b_6 = c + \lambda_1 + \lambda_5 + \lambda_6 + \lambda_8$
$b_7 = c + \lambda_1 + \lambda_5 + \lambda_7 + \lambda_8$
$b_8 = c + \lambda_1 + \lambda_6 + \lambda_7 + \lambda_8$
$b_9 = c + \lambda_2 + \lambda_5$
$b_{10} = c + \lambda_2 + \lambda_6$
$b_{11} = c + \lambda_2 + \lambda_7$
$b_{12} = c + \lambda_2 + \lambda_8$
$b_{13} = c + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_7$
$b_{14} = c + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_8$
$b_{15} = c + \lambda_2 + \lambda_5 + \lambda_7 + \lambda_8$
$b_{16} = c + \lambda_2 + \lambda_6 + \lambda_7 + \lambda_8$
$b_{17} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_6$
$b_{18} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_7$
$b_{19} = c + \lambda_1 + \lambda_2 + \lambda_6 + \lambda_7$
$b_{20} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_8$
$b_{21} = c + \lambda_1 + \lambda_2 + \lambda_6 + \lambda_8$
$b_{22} = c + \lambda_1 + \lambda_2 + \lambda_7 + \lambda_8$
$b_{23} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$b_{24} = c + \lambda_3 + \lambda_5$
$b_{25} = c + \lambda_3 + \lambda_6$
$b_{26} = c + \lambda_3 + \lambda_7$

$b_{27} = c + \lambda_3 + \lambda_8$
$b_{28} = c + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7$
$b_{29} = c + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_8$
$b_{30} = c + \lambda_3 + \lambda_5 + \lambda_7 + \lambda_8$
$b_{31} = c + \lambda_3 + \lambda_6 + \lambda_7 + \lambda_8$
$b_{32} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_6$
$b_{33} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_7$
$b_{34} = c + \lambda_1 + \lambda_3 + \lambda_6 + \lambda_7$
$b_{35} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_8$
$b_{36} = c + \lambda_1 + \lambda_3 + \lambda_6 + \lambda_8$
$b_{37} = c + \lambda_1 + \lambda_3 + \lambda_7 + \lambda_8$
$b_{38} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$b_{39} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5$
$b_{40} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_6$
$b_{41} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_7$
$b_{42} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_8$
$b_{43} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7$
$b_{44} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_8$
$b_{45} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_7 + \lambda_8$
$b_{46} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_7 + \lambda_8$
$b_{47} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6$
$b_{48} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_7$
$b_{49} = c + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_7$
$b_{50} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_8$
$b_{51} = c + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_8$
$b_{52} = c + \lambda_2 + \lambda_3 + \lambda_7 + \lambda_8$
$b_{53} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$

Also,

$a_1 = c + \lambda_1 + \lambda_5 + \lambda_6$
$a_2 = c + \lambda_1 + \lambda_5 + \lambda_7$
$a_3 = c + \lambda_1 + \lambda_6 + \lambda_7$
$a_4 = c + \lambda_1 + \lambda_5 + \lambda_8$
$a_5 = c + \lambda_1 + \lambda_6 + \lambda_8$
$a_6 = c + \lambda_1 + \lambda_7 + \lambda_8$
$a_7 = c + \lambda_1 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$a_8 = c + \lambda_2 + \lambda_5 + \lambda_6$
$a_9 = c + \lambda_2 + \lambda_5 + \lambda_7$
$a_{10} = c + \lambda_2 + \lambda_6 + \lambda_7$
$a_{11} = c + \lambda_2 + \lambda_5 + \lambda_8$
$a_{12} = c + \lambda_2 + \lambda_6 + \lambda_8$
$a_{13} = c + \lambda_2 + \lambda_7 + \lambda_8$
$a_{14} = c + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$a_{15} = c + \lambda_1 + \lambda_2 + \lambda_5$
$a_{16} = c + \lambda_1 + \lambda_2 + \lambda_6$
$a_{17} = c + \lambda_1 + \lambda_2 + \lambda_7$
$a_{18} = c + \lambda_1 + \lambda_2 + \lambda_8$
$a_{19} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_7$
$a_{20} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_6 + \lambda_8$
$a_{21} = c + \lambda_1 + \lambda_2 + \lambda_5 + \lambda_7 + \lambda_8$
$a_{22} = c + \lambda_1 + \lambda_2 + \lambda_6 + \lambda_7 + \lambda_8$
$a_{23} = c + \lambda_3 + \lambda_5 + \lambda_6$
$a_{24} = c + \lambda_3 + \lambda_5 + \lambda_7$
$a_{25} = c + \lambda_3 + \lambda_6 + \lambda_7$
$a_{26} = c + \lambda_3 + \lambda_5 + \lambda_8$
$a_{27} = c + \lambda_3 + \lambda_6 + \lambda_8$
$a_{28} = c + \lambda_3 + \lambda_7 + \lambda_8$
$a_{29} = c + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$a_{30} = c + \lambda_1 + \lambda_3 + \lambda_5$
$a_{31} = c + \lambda_1 + \lambda_3 + \lambda_6$
$a_{32} = c + \lambda_1 + \lambda_3 + \lambda_7$
$a_{33} = c + \lambda_1 + \lambda_3 + \lambda_8$
$a_{34} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7$
$a_{35} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_8$
$a_{36} = c + \lambda_1 + \lambda_3 + \lambda_5 + \lambda_7 + \lambda_8$
$a_{37} = c + \lambda_1 + \lambda_3 + \lambda_6 + \lambda_7 + \lambda_8$
$a_{38} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6$
$a_{39} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_7$
$a_{40} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_7$
$a_{41} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_8$
$a_{42} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_8$
$a_{43} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_7 + \lambda_8$
$a_{44} = c + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7 + \lambda_8$
$a_{45} = c + \lambda_2 + \lambda_3 + \lambda_5$
$a_{46} = c + \lambda_2 + \lambda_3 + \lambda_6$
$a_{47} = c + \lambda_2 + \lambda_3 + \lambda_7$
$a_{48} = c + \lambda_2 + \lambda_3 + \lambda_8$
$a_{49} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_7$
$a_{50} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_6 + \lambda_8$
$a_{51} = c + \lambda_2 + \lambda_3 + \lambda_5 + \lambda_7 + \lambda_8$
$a_{52} = c + \lambda_2 + \lambda_3 + \lambda_6 + \lambda_7 + \lambda_8$

And $c = \lambda_4 + \lambda_9$

Case III: When Failure Rates Follow Exponential Time Distribution

Exponential distribution is a particular case of Weibull distribution [17] for p = 1 and is much useful in numerous practical problems [18]. The reliability of the system in this case at any instant‘t’, [19] can be obtained by putting p = 1 in equation [20] (21), and is

$$R_{SW}(t) = \sum_{i=1}^{53} exp.\{-b_i\, t\} - \sum_{j=1}^{52} exp.\{a_j\, t\} \quad ------- (22)$$

Where, $b'_i s$ and $a'_j s$ are stated earlier.

$$M\ T\ T\ F = \int_0^{\infty} R_{SE}(t).dt = \sum_{i=1}^{53} \frac{1}{b} - \sum_{j=1}^{52} \frac{1}{a} \quad -------- (23)$$

7. THE NUMERICAL COMPUTATION

For the numerical illustration of the result obtained, the authors’ assume the following values of data and then we obtain the variation in the Reliability parameter with respect to Time.

Setting $\lambda_1 = \lambda_2 =$ ------------ $\lambda_9 = q$, [21] we get

$$R_{SW}(t) = 12e^{-4qt^p} - 30e^{-5qt^p} + 34e^{-6qt^p} - 21e^{-7qt^p} + 7e^{-8qt^p} - e^{-9qt^p} \quad ----- (24)$$

$$R_{SE}(t) = 12e^{-4qt} - 30e^{-5qt} + 34e^{-6qt} - 21e^{-7qt} + 7e^{-8qt} - e^{-9qt} \quad ----(25)$$

And,

$$M\ T\ T\ F = \frac{0.4305556}{q} \quad ----(26)$$

In equation (24), putting p = 2, q = 0.01 and t = 0, 1, ------10;

In equation (25), putting q = 0.01 and t = 0, 1, --------------10;

In equation (26), putting q = 0.01, 0.02 --------- 0.1;

Using these [22] values one can compute from the tables 1 and tables 2 and sketch the graphs [23] as given in figure 1 and figure 2 respectively [24].

Table 1: The Rsw and Rse Time Data

t	R_{SW} (t)	R_{SE} (t)
0	1	1
1	0.980198	0.980198
2	0.960782	0.923059
3	0.941740	0.834692
4	0.923059	0.723456
5	0.904727	0.598530
6	0.886735	0.469348
7	0.869071	0.345535
8	0.851729	0.236253
9	0.834692	0.148461
10	0.817958	0.085002

Table 2: The Failure Rate and Mean Time to Failure Data

q	MTTF
0.01	43.05556
0.02	21.52778
0.03	14.35185
0.04	10.76389
0.05	8.611112
0.06	7.175929
0.07	6.150794
0.08	5.381945
0.09	4.783951
0.10	4.305556
0.11	3.914142

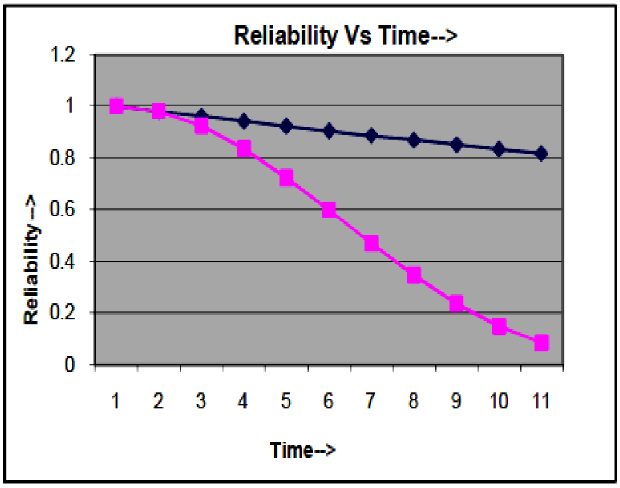

Fig 2: The Reliability vs Time

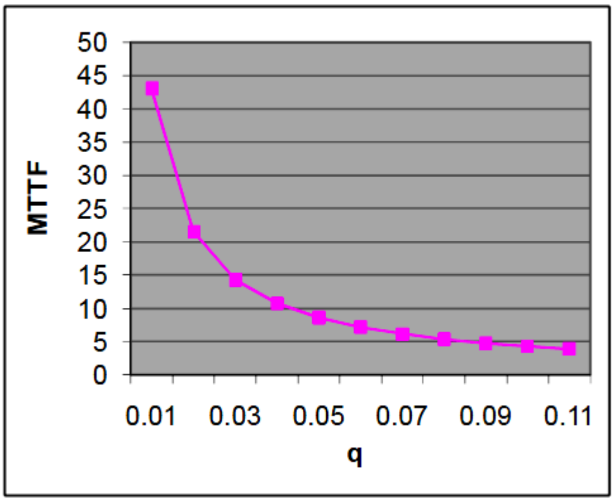

Fig 3: The Mean Time to Failure and Failure Rate

8. CONCLUSION

In this paper figure 2 shows the reliability of the system at any given instant ‘t’, when failure rates follow Weibull or exponential time distribution. After making a critical examination of table and graph, the authors’ conclude that the reliability of the power plant decreases at a uniform rate when the failures rates follow exponential time distribution, but in case of Weibull distribution it decreases initially fast, but thereafter it decreases at a uniform rate. In the end figure 3 shows the graph of ‘MTTF’versus failure rate ‘q’. MTTF decreases catastrophically in the beginning but after q = 0.05 it decreases approximately at uniform rate.

9. ACKNOWLEDGEMENTS

The author would like to thank the reviewers anonymous for their constructive comments and that helped whit their revision to improve the resulting quality of this paper. I would like to express my gratitude towards my family and colleges for their co-operation and help me in completing this paper.

10. REFERENCES

[1] Yusuf Perwej, “An Experiential Study of the Big Data,” for published in the International Transaction of Electrical and Computer Engineers System (ITECES), Vol. 4, No. 1, page 14-25, 2017, DOI:10.12691/iteces-4-1-3

[2] Nikhat Akhtar, Firoj Parwej, Yusuf Perwej, “A Perusal Of Big Data Classification And Hadoop Technology,” International Transaction of Electrical and Computer Engineers System (ITECES), Vol. 4, No. 1, page 26-38, 2017, DOI: 10.12691/iteces-4-1-4.

[3] E. W. Adams, A Primer of Probability Logic, Stanford, CA:CSLI Publicationss, 1998

[4] Gupta, P.P., Agarwal, S.C., “A Boolean Algebra method for reliability calculation”, Microelectron, Reliab. Vol. 23, pp 863-865, 1983

[5] Gopalan, M.N., Nagarwalla, H.E., “Cost benefits analysis of a one-server two-unit cold standby system with repair and preventive maintenances", Microelectron, Reliab. Vol. 25, pp 267-269, 1985

[6] Gupta, P.P., Sharma, R.K., “Evaluation of Reliability and MTTF of a power plant with the aid of Boolean

Function expansion algorithm", Microelectron, Reliab. Vol. 26, pp 821-824, 1986

[7] Moslem Amiri , Václav Přenosil," General solutions for MTTF and steady-state availability of NMR systems", 9th International Symposium on Reconfigurable and Communication-Centric Systems-on-Chip (ReCoSoC), IEEE, France, 2014

[8] Gopalan, M.N., Bhanu , K.S. , "Cost analysis of a two unit repairable system subject to one line preventive maintenances and /or repair", Microelectron, Reliab. Vol. 35 (2) ,pp 251 – 258, 1995

[9] Yusuf Perwej , Kashiful Haq, Firoj Parwej, M. M. Mohamed Hassan ," The Internet of Things (IoT) and its Application Domains", International Journal of Computer Applications (IJCA) ,USA , Vol. 182, No.49, PP. 36- 49, 2019, DOI: 10.5120/ijca2019918763

[10] Yusuf Perwej, M. A. AbouGhaly, Bedine Kerim and Hani Ali Mahmoud Harb. "An Extended Review on Internet of Things (IoT) and its Promising Applications", Communications on Applied Electronics (CAE), Vol. 9, No. 26, Pages 8– 22, 2019, DOI: 10.5120/cae2019652812

[11] Hoang Pham: "On the optimal design of k- out – of – n: G Sub systems", IEEE TR on Reliab. 45 (2), pp 254 – 260, 1996

[12] Jen.Shyan, W. , Rong – Jaye, C. , "Efficient algorithm for reliability of a circular consecutive – k – out – of – n : F system", IEEE TR . on reliability , Vol. 55 , issue – 1 , pp 163- 164, 2006

[13] Md. Arshaduzzaman, Yusuf Perwej, Ashwani Kumar Sinha, "Empirical Study of Cocyclic Copurity and the Dualization of Cyclic Purity", International Journal of Applied Information Systems, USA, Volume 10 , No.9, Page 15-18 , May 2016, DOI : 10.5120/ijais2016451547

[14] Harry W. Jones," Achieving Maximum Reliability Growth in Newly Designed Systems", Annual Reliability and Maintainability Symposium (RAMS), IEEE, USA, 2018

[15] Joorel, J.P.S., Hynderi, P.D., "Behaviour of a priority standby redundant system with different types of repair facilities", Microelectron, Reliab. Vol. 35 (5) ,pp 833 – 836, 1995

[16] Kyung, S., Park, Kwang,T. Jung, "Estimating human error probabilities from paired ratio", Microelectron, Reliab. Vol.36 (3) ,pp 399 -402,1996

[17] Lai, C. D., Xie , M. , Murthy , D.N.P., "On same recent modifications of Weibull distribution", IEEE TR .on reliability , Vol. 54 , issue – 4 , pp 563 -564, 2005

[18] Marseguerra, M., Zio, E., Podofilline , L. Coit , D. W. , "Optimal design of reliable network system in presence of uncertainty", IEEE TR. On reliability, Vol. 54, issue – 2 ,pp 243 – 253, 2005

[19] Papastavridis, S.G., Koutras, M.V., "Bounds for reliability of consecutive k- with in m-out -of-n : F systems" IEEE TR. on reliability , Vol. 55 , issue -1 ,pp 156- 160, 2006

[20] Mokaddis, G.S., Tawfak , M. L. , "Some characteristics of a two dissimilar unit cold standby redundant system with three modes", Microelectron, Reliab. Vol.36 (4) ,pp 497- 504, 1996

[21] G. Schneeweiss Winfrid, "Toward a Deeper Understanding of the Availability of Series-Systems Without Aging During Repairs", IEEE Transactions on Reliability, vol. 54, no. 1, pp. 98-99, 2005

[22] Pandey, D. , Jacob Mendus , "Cost analysis , Availability and MTTF of a 3- state standby complex system under common cause and human failures" Microelectron, Reliab. Vol.35 ,pp 91 -95, 1995

[23] V. V. Singh, Mangey Ram & S. B. Singh, "Stochastic analysis of a standby complex system with waiting repair strategy", IEEE Transactions on System, Man, and Cybernetics Part A: System and humans" Vol. 43 No. 3, P. P-698-707, 2013.

[24] Singh, J., Goyal, P., "Availability analysis of a standby complex system having imperfect switch over device", Microelectron, Reliab. Vol. 35, pp 285-288, 1996.