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Mathematical Modeling and Behaviour Analysis of a Fertilizer Plant

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Abstract

This paper discusses Availability and Behavioral Analysis of a Fertilizer Plant divided into three units system having standby in one unit with perfect switch – over device and priority in repair using Regenerative Point Graphical Technique. The system works in full capacity when all units are good fails when any of the units fails and works in reduced capacity when standby unit is online. Single repair facility is available for all units. The system is discussed for steady – state conditions. Failure times are taken as exponential and repair times as general and different for all units. Various parameters such as Mean time to system failure, Availability, Busy Periods of Server and Expected Number of repairman visits (Replacements) are evaluated. Analytical cases are taken to draw the tables and graphs followed by discussion and concluding remarks.

Keywords: - Reliability, Availability, Transition Diagram, MTSF, Busy Period, RPGT

1. Introduction

In this paper we have discussed availability and behavioral analysis of a fertilizer plant divided into three units system having standby in one unit with perfect switch – over device and priority in repair. System works in full capacity when all units are good, in reduced state when standby unit is online and in failed state when any of the unit is in failed state. The paper analyzes behavioral of a fertilizer plant divided into three units namely furnace B having standby unit C switched in by a perfect switch – over device upon failure of unit B. Heating system in the furnace is generally operated by burning coal and when there is shortage of coal supply then diesel oil is used as fuel. The second unit A is considered as chemical processing unit in which Nitrogen is collected from the air by splitting into its components and Hydrogen is taken from water by decomposition. Nitrogen and Hydrogen are mixed together using catalyst to form urea fertilizer and a number of by-products. The urea granules are packed in plastic bags by a packing unit C. The raw material obtained from air and water in weigh belts conveyors are weighed and moved to mixture for producing homogenous Mixture. The material is mixed with the Recycle material and taken for granulation in granulation drum where the partial granulation is achieved with very fine jet of Water spray. The fine powder gets deposits on small Nuclei. This process can be Controlled to produce particle size as per the demand of customers. The material is taken to dryer when hot air generated in the furnace is passed through it. The Raw materials having low melting points easily melts and get deposited on the Nuclei. The high temperature evaporates water and the material air dried. Further the material is cooled by blowing ambient air through it in cooler drum. The 1-4 mm as desired size homogenous particles are obtained using vibrating process. The screened particles of uniform size are precisely packed in bags. Priority in repair to the three units is in order A>B>C. Single repair facility is available for all units. The system is discussed for steady – state conditions failure times are taken as exponential and repair times are general and different for all units and behavioral Analysis of a Fertilizer Plant Using Regenerative Point Graphical Technique (RPGT) is discussed. Taking into considerations various probabilities a transition diagram of the system is developed to determine, Primary Circuits, Secondary Circuits, Tertiary Circuits and base state. Various parameters such as mean time to system failure availability of system, busy period of server and expected number of server's visits are evaluated using Regenerative Point Graphical Technique. Kumar et al [2018] discussed the behavior investigation of a bread plant exhausting RPGT. In order to do a sensitivity analysis on a cold standby framework made up of two identical units with server failure and prioritized for preventative maintenance, Kumar et al. [2019] used RPGT. Two halves make up the current paper, one of which is in use and the other of which is in cold standby mode. The good and fully failed modes are the only differences between online and cold standby equipment. A case study of an EAEP manufacturing facility was examined by Rajbala et al. [2019] in their work on system modeling and analysis in [2019]. A study of the urea fertilizer industry's behavior was conducted by Kumar et al. [2017]. Mathematical formulation and profit function of a comestible oil refinery facility were investigated by Kumar et al. in [2017]. In a paper mill washing unit, Kumar et al. [2019] investigated mathematical formulation and behavior study. In their study, Kumar et al. [2018] investigated a 3:4:: outstanding system plant's sensitivity analysis. Using a heuristic approach, Rajbala et al. [2022] investigated the redundancy allocation problem in the cylinder manufacturing plant. Particular cases are taken to study the effect failure and repair rates on mean time to system failure, availability of system and tables graphs also drawn to express the effect, followed by concluding remarks. Various parameters such as Mean time to system failure, Availability, Busy Periods of Server and Expected Number of repair man visits (Replacements) are evaluated. Analytical cases are taken to draw the tables and graphs followed by discussion and concluding remarks.

2. **Assumptions and Notations**:

1. The system consists of three non-identical units, A, B and C of different capacities.
2. A single repair facility is available for all units.
3. A repaired unit is like a new one.

$\lambda_1/\lambda_2/\lambda_3/\lambda_4$: Constant failure rate of units A/ of unit B / of unit C & of unit D.

g(t)/G(t) / $\underline{G}$(t) : Probability density function/ Cumulative distribution function / complement of cumulative distribution function of unit A.

h(t)/H(t) / $\underline{H}$(t) : Probability density function / Cumulative distribution function / complement of cumulative distribution function of the unit B.

f(t)/F(t) / $\underline{F}$(t) : Probability density function / Cumulative distribution function / complement of cumulative distribution function of the unit C.

r(t)/R(t) / $\underline{R}$(t) : Probability density function / Cumulative distribution function / complement of cumulative distribution function of the unit D.

A/a : Main unit in the operative state / failed state.

B/b : Operative state / failed state.

C/c : Operative state / failed state.

D/d : Operative state / failed state.

3. **Transition Diagram:**

Following the above assumption sand notations the Transition Diagram of the system is given in Figure 1.

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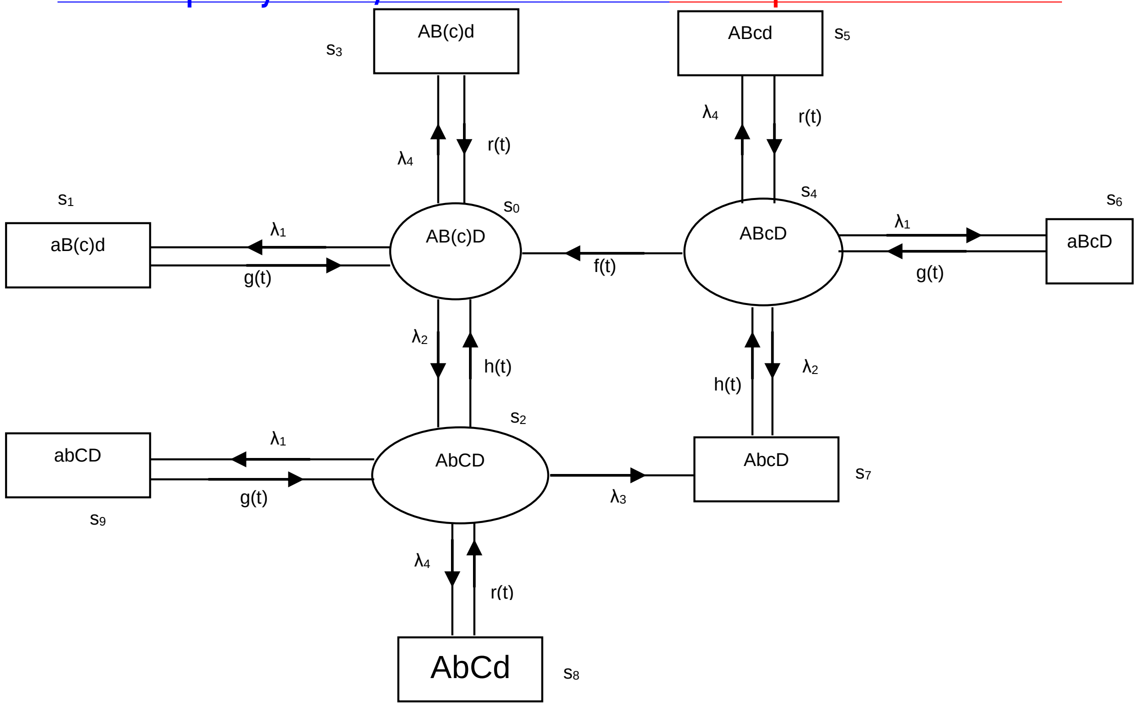

Figure – 1: Transition Diagram

4. Transition Probability and the Mean sojourn times.

$q_{i,j}(t)$ **:** Probability density function (p.d.f.) of the first passage time from a regenerative state 'i' to a regenerative state 'j' or to a failed state 'j' without visiting any other regenerative state in (0,t].

$p_{i,j}$**:** Steady state transition probability from a regenerative state 'i' to a regenerative state 'j' without visiting any other regenerative state.

Table 1: Transition Probability

$q_{i,j}^{(t)}$	$P_{ij} = q^*_{i,j}{}^{(t)}$
$q_{0,1}^{(t)} = \lambda_1 e^{-(\lambda 1+\lambda 2+\lambda 4)t}$ $q_{0,2}^{(t)} = \lambda_2 e^{-(\lambda 1+\lambda 2+\lambda 4)t}$ $q_{0,3}^{(t)} = \lambda_4 e^{-(\lambda 1+\lambda 2+\lambda 4)t}$	$p_{0,1} = \lambda_1/(\lambda_1+\lambda_2+\lambda_4)$ $p_{0,2} = \lambda_2/(\lambda_1+\lambda_2+\lambda_4)$ $p_{0,3} = \lambda_4/(\lambda_1+\lambda_2+\lambda_4)$
$q_{1,0}^{(t)} = g(t)$	$p_{1,0} = g^*(0)$
$q_{2,0}^{(t)}=h(t)\, e^{-(\lambda 1+\lambda 3+\lambda 4)t}$ $q_{2,7}^{(t)}= \lambda_3 e^{-(\lambda 1+\lambda 3+\lambda 4)t}\, (\bar{H}(t))$ $q_{2,8}^{(t)}= \lambda_4 e^{-(\lambda 1+\lambda 3+\lambda 4)t}\, (\bar{H}(t))$ $q_{2,9}^{(t)}= \lambda_1 e^{-(\lambda 1+\lambda 3+\lambda 4)t}\, (\bar{H}(t))$	$p_{2,0}=h^*(\lambda_1+\lambda_3+\lambda_4)$ $p_{2,7}= \lambda_3[1-h^*(\lambda_1+\lambda_3+\lambda_4)]/(\lambda_1+\lambda_3+\lambda_4)$ $p_{2,8}= \lambda_4[1-h^*(\lambda_1+\lambda_3+\lambda_4)]/(\lambda_1+\lambda_3+\lambda_4)$ $p_{2,9}= \lambda_1[1-h^*(\lambda_1+\lambda_3+\lambda_4)]/(\lambda_1+\lambda_3+\lambda_4)$
$q_{3,0}^{(t)}=r(t)$	$p_{3,0} = r^*(0)$
$q_{4,5}^{(t)}= \lambda_4 e^{-(\lambda 1+\lambda 2+\lambda 4)t}\, (\bar{F}(t))$ $q_{4,6}^{(t)}= \lambda_1 e^{-(\lambda 1+\lambda 2+\lambda 4)t}\, (\bar{F}(t))$ $q_{4,7}^{(t)}= \lambda_2 e^{-(\lambda 1+\lambda 2+\lambda 4)t}\, (\bar{F}(t))$ $q_{4,0}^{(t)}= f(t) e^{-(\lambda 1+\lambda 2+\lambda 4)t}$	$p_{4,5}= \lambda_4[1-f^*(\lambda_1+\lambda_2+\lambda_4)]/(\lambda_1+\lambda_2+\lambda_4)$ $p_{4,6}= \lambda_1[1-f^*(\lambda_1+\lambda_2+\lambda_4)]/(\lambda_1+\lambda_2+\lambda_4)$ $p_{4,7}= \lambda_2[1-f^*(\lambda_1+\lambda_2+\lambda_4)]/(\lambda_1+\lambda_2+\lambda_4)$ $p_{4,0}= f^*(\lambda_1+\lambda_2+\lambda_4)$
$q_{5,4}^{(t)}= r(t)$	$p_{5,4}= r^*(0)$
$q_{6,4}^{(t)}= g(t)$	$p_{6,4}= g^*(0)$
$q_{7,4}^{(t)}= h(t)$	$p_{7,4}= h^*(0)$
$q_{8,2}^{(t)}= r(t)$	$p_{8,2}= r^*(0)$
$q_{9,2}^{(t)}= g(t)$	$p_{9,2}= g^*(0)$

Mean Sojourn Times

$R_i(t)$: Reliability of the system at time t, given that the system in regenerative state i.

μ_i : Mean sojourn time spent in state i, before visiting any other states;

Table 2: Mean Sojourn Times

$R_i(t)$	$\mu_i = R_i^*(0)$
$R_0(t) = e^{-(\lambda_1+\lambda_2+\lambda_4)t}$	$\mu_0 = 1/(\lambda_1+\lambda_2+\lambda_4)$
$R_1^{(t)} = \underline{(G(t))}$	$\mu_1 = -g^{*1}(0)$
$R_2^{(t)} = e^{-(\lambda_1+\lambda_3+\lambda_4)t}\,\underline{(H(t))}$	$\mu_2 = 1-h^*(\lambda_1+\lambda_3+\lambda_4)/(\lambda_1+\lambda_3+\lambda_4)$
$R_3^{(t)} = \underline{R(t)}$	$\mu_3 = -r^{*1}(0)$
$R_4^{(t)} = e^{-(\lambda_1+\lambda_2+\lambda_4)t}\,\underline{(f(t))}$	$\mu_4 = 1-f^*(\lambda_1+\lambda_2+\lambda_4)/(\lambda_1+\lambda_2+\lambda_4)$
$R_5^{(t)} = \underline{R(t)}$	$\mu_5 = -r^{*1}(0)$
$R_6^{(t)} = \underline{G(t)}$	$\mu_6 = -g^{*1}(0)$
$R_7^{(t)} = \underline{H(t)}$	$\mu_7 = -h^{*1}(0)$
$R_8^{(t)} = \underline{R(t)}$	$\mu_8 = -r^{*1}(0)$
$R_9^{(t)} = \underline{G(t)}$	$\mu_9 = -g^{*1}(0)$

5. Evaluation of Parameters:

The Mean time to system failure and all the key parameters of the system under steady state conditions are evaluated, applying Regenerative Point Graphical Technique (RPGT) and using '4' as the base-state of the system as under: The transition probability factors of all the reachable states from the base state '4' are:

$V_{4,0} = p_{4,0} / [1- p_{0,1}\, p_{1,0}]\ \{[1- p_{2,9}\, p_{9,2}]\ [1- p_{2,8}\, p_{8,2}]- p_{0,2}\, p_{2,0}\}[1- p_{0,3}\, p_{3,0}]$

$V_{4,1} = p_{4,0}\, p_{0,1} / [1- p_{0,1}\, p_{1,0}]\ \{[1- p_{2,9}\, p_{9,2}]\ [1- p_{2,8}\, p_{8,2}]-p_{0,2}\, p_{2,0}\}\ [1- p_{0,3}\, p_{3,0}]$

$V_{4,2} = p_{4,0}p_{0,2} /[1-p_{0,1}\, p_{1,0}]\{[1-p_{2,9}\, p_{9,2}][1-p_{2,8}p_{8,2}]-p_{0,2}p_{2,0}\}[1-p_{0,3}p_{3,0}][1-p_{2,8}p_{8,2}]\ [1-p_{2,9}p_{9,2}]$

$V_{4,3} =$ ……..continuous

(i). MTSF(T_0): The regenerative un-failed states to which the system can transit(initial state '0'), before entering any failed state are: 'i' = 0,2 taking 'ξ' = '0'.

$$\text{MTSF}\ (T_0) = \left[\sum_{i,sr}\left\{\frac{\left\{pr\left(\xi \xrightarrow{sr(sff)} i\right)\right\}\mu i}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[1-\sum_{sr}\left\{\frac{\left\{pr\left(\xi \xrightarrow{sr(sff)} \xi\right)\right\}}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

$$= \mu_0 + p_{0,2}\mu_2 / [1- p_{0,2}\ p_{2,0}]$$

(ii). Availability of the System: From the figure the regenerative states at which the system is available are 'j' = 0,2,4 and the regenerative states are 'i' = 0 to 9 taking 'ξ' = '4' the total fraction of time for which the system is available is given by

$$A_0 = \left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\rightarrow j)\}f_{j,}\mu j}{\prod_{m_1\neq\xi}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\rightarrow i)\}\mu_i^1}{\prod_{m_2\neq\xi}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

$A_0 = V_{4,0}\mu_0 + V_{4,2}\mu_2 + V_{4,4}\mu_4/V_{4,0}\ \mu_0 + V_{4,1}\ \mu_1 + V_{4,2}\ \mu_2 + V_{4,3}\ \mu_3 + V_{4,4}\ \mu_4 + V_{4,5}\ \mu_5 + V_{4,6}\ \mu_6 + V_{4,7}\ \mu_7 + V_{4,8}\ \mu_8 + V_{4,9}\ \mu_9$

where $f_j = 1$, $\mu_j^1 = \mu_j$ for all j)

(iii). Busy Period of the Server: The regenerative states where server 'j' = 1,2,3,4,5,6,7,8,9 and regenerative states are 'i' = 0 to 9, taking ξ = '4', the total fraction of time for which the server remains busy is

$$B_0 = \left[\sum_{j,s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{S_r} j\right)\right\}.\eta_j}{\prod_{m_1\neq\xi}\{1-V_{m_1,m_1}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\left\{pr\left(\xi \xrightarrow{S_r} i\right)\right\}.\mu_i^1}{\prod_{m_2\neq\xi}\{1-V_{m_2,m_2}\}}\right\}\right]$$

$B_0 = V_{4,1}\mu_1+V_{4,2}\mu_2+V_{4,3}\mu_3+V_{4,4}\mu_4+V_{4,5}\mu_5+V_{4,6}\mu_6+V_{4,7}\mu_7+V_{4,8}\mu_8+V_{4,9}\mu_9/V_{4,0}\ \mu_0 +V_{4,1}\mu_1+V_{4,2}\mu_2 +V_{4,3}\mu_3+V_{4,4}\ \mu_4+V_{4,5}\ \mu_5+V_{4,6}\ \mu_6+V_{4,7}\ \mu_7+V_{4,8}\ \mu_8+V_{4,7}\ \mu_9$

where $n_j = \mu_j$, $\mu_j^1 = \mu_j$ for all j)

(iv). Expected Number of Inspections by the repair man: From the figure the regenerative states where the repair man do this job j = 1 the regenerative states are i = 0 to 9, Taking 'ξ' = '4', the number of visit by the repair man is given by

$$I_0 = \left[\sum_{j,s_r}\left\{\frac{\{pr(\xi \xrightarrow{s_r} j)\}.\eta_j}{\prod_{m_1 \neq \xi}\{1-V_{m_1,m_1}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi \xrightarrow{s_r} i)\}.\mu_i^1}{\prod_{m_2 \neq \xi}\{1-V_{m_2,m_2}\}}\right\}\right]$$

$I = V_{4,1} / V_{4,0}\,\mu_0 + V_{4,1}\,\mu_1 + V_{4,2}\,\mu_2 + V_{4,3}\,\mu_3 + V_{4,4}\,\mu_4 + V_{4,5}\,\mu_5 + V_{4,6}\,\mu_6 + V_{4,7}\,\mu_7 + V_{4,8}\,\mu^1_8 + V_{4,9}\,\mu^1_9$

where $\mu_j^1 = \mu_j$ for all j)

6. PARTICULAR CASE: -

Let us take: $g(t) = we^{-wt}$, $h(t) = w_1e^{-w_1t}$, $f(t) = w_2e^{-w_2t}$, $r(t) = w_3e^{-w_3t}$,

After Particulars:

$p_{0,1} = \lambda_1 / \lambda_1 + \lambda_2 + \lambda_4$, $p_{0,2} = \lambda_2 / \lambda_1 + \lambda_2 + \lambda_4$, $p_{0,3} = \lambda_4 / \lambda_1 + \lambda_2 + \lambda_4$, $p_{1,0} = 1$

$p_{2,0} = w_1 / w_1 + \lambda_1 + \lambda_3 + \lambda_4$, $p_{2,7} = \lambda_3 / w_1 + \lambda_3 + \lambda_4 + \lambda_1$, $p_{2,8} = \lambda_4 / w_1 + \lambda_1 + \lambda_3 + \lambda_4$

$p_{2,9} = \lambda_1 / w_1 + \lambda_1 + \lambda_3 + \lambda_4$, $p_{3,0} = 1$, $p_{4,5} = \lambda_4 / w_2 + \lambda_1 + \lambda_2 + \lambda_4$, $p_{4,6} = \lambda_1 / w_2 + \lambda_1 + \lambda_2 + \lambda_4$

$p_{4,7} = \lambda_2 / w_2 + \lambda_1 + \lambda_2 + \lambda_4$, $p_{4,0} = w_2 / w_2 + \lambda_1 + \lambda_2 + \lambda_4$, $p_{5,4} = 1$, $p_{6,4} = 1$, $p_{7,4} = 1$

$p_{8,2} = 1$, $p_{9,2} = 1$, $\mu_0 = 1 / \lambda_1 + \lambda_2 + \lambda_4$, $\mu_1 = 1 / w$ $\mu_2 = 1 / w_1 + \lambda_1 + \lambda_3 + \lambda_4$,

$\mu_3 = 1 / w$, $\mu_4 = 1 / w_2 + \lambda_1 + \lambda_2 + \lambda_4$, $\mu_5 = 1 / w_3$, $\mu_6 = 1 / w$, $\mu_7 = 1 / w_1$

$\mu_8 = 1 / w_3$, $\mu_9 = 1 / w$

7. Analytical Discussion:

- The following tables, graphs and conclusions are obtained for $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda$, $w = w_1 = w_2 = w_3$

MSTF (T₀): The regenerative un-failed states to which the system can transit (initial state '0') before entering any failed state are i =0,2 and taking 'ξ' = 0

MTSF $(T_0) = 4\lambda + w / \lambda\,(9\lambda+2w)$

The MTSF of system is calculated for different values of failure rate (λ) by taking λ = 0.005, 0.006, 0.007, 0.008, 0.009 & 0.10 and for different values of the repair rate (w) by taking w = 0.80, 0.85, 0.90 & 0.95. The data so obtained are shown in Table 3.

Table 3: Mean time to system Table

λ	w = 0.80	w = 0.85	w = 0.90	w = 0.95
0.005	99.696	99.713	99.729	99.743
0.006	83.031	83.048	83.064	83.077
0.007	71.128	71.145	71.160	71.174
0.008	62.201	62.218	62.233	62.246
0.009	55.258	55.275	55.290	55.303
0.010	49.704	49.721	49.735	49.749

Table 3 shows the behavior of MTSF (To) Vs Repair rate (w) of the unit of the system for different values of the failure rate (λ). From the above table we can conclude that MTSF is increasing which should be so when the repair rate increasing and decreases when the failure rate increases which should be so in practical situations.

Availability (A₀) Vs Repair Rate (w) and failure rate: - The availability of the system is calculated for different values of the failure rate (λ) by taking λ = 0.05, 0.06 & 0.07 and for different values of the repair (w) by taking w = 0.80, 0.85 & 0.90. The data so obtained is shown in Table 4.

Availability $(A_0) = w\,\{z[(1-v)^2+m\lambda]+m\lambda(1-v)^2\}/\lambda[2\lambda+3v-zv(1-2v)-3v^2(v+2)]+w\{z[(1-v)^2+m\lambda]+m\lambda(1-v)^2\}$

Table 4: Availability

λ	(ω=0.80)	(ω=0.85)	(ω=0.90)

0.05	0.88393	0.89037	0.89595
0.06	0.86320	0.87052	0.87687
0.07	0.84309	0.85121	0.85859

The above table shows that the availability of the system is increasing when the repair rate is increasing and decrease with the increase in failure rate, which should be actually.

Busy period of server:

$B = \lambda[2z+3v-zv(1-2v)-3v^2(v+2)]+w\{z[(1-v)^2+m\lambda]+m\lambda(1-v)^2\}-zw(1-v)^2/\lambda[2z+3v-zv(1-2v)-3v^2(v+2)]+w\{z[(1-v)^2+m\lambda]+m\lambda(1-v)^2\}$

Table 5: Busy Period

λ	(ω=0.80)	(ω=0.85)	(ω=0.90)
0.05	0.203891	0.193529	0.184024
0.06	0.236101	0.224394	0.214565
0.07	0.267219	0.254361	0.243862

Expected Number of Inspections by the repair man:

$I = z/\lambda[2z+3v-zv(1-2v)-3v^2(v+2)]+w\{z[(1-v)^2+m\lambda]+m\lambda(1-v)^2\}/\lambda w(1-v)^2$

Table 6: Number of Inspections per unit time

λ	(ω=0.80)	(ω=0.85)	(ω=0.90)
0.05	0.03980	0.04033	0.04080
0.06	0.04583	0.04654	0.04712
0.07	0.05130	0.05220	0.05293

8. Conclusion:

From the graphs and tables, we see that increase in the repair rate (w) increases the availability of the system and the mean time to system failure where as increase in failure rate decrease the availability and mean time to system which should be so pactically. The study can be extended to more than three units system; the Regenerative Point Graphical Technique is useful to evaluate the key parameters of the system in a simple way, without writing any state equations and without doing any lengthy and number calculations. We also see from the busy period of server table that when we increase the repair rate busy period of server decrease and when we increase the failure rate then busy period of server also increase. Also from expected number of inspections by the repair man table we see that. In future, Researchers can evaluate the parameters, when repair rate sand failure rate are variable and also discuss the cost and profit benefit analysis. Further results can also be applied to find the waiting time of units and number of server visits, as if the states where the server is on prime visit or on a secondary visit are determined separately using the formula. Since the cost of secondary visit is usually less than primary visit of server, therefore the system can be run with low maintenance cost. Various system parameters can also be evaluated taking any state as base state. As failure rates are beyond control, so determine the repair rates and reduce the fixing the target of availability management can cost of maintenance.

References: -

1. Rajbala, Kumar, A. and Garg, D. (2019). Systems Modelling and Analysis: A Case Study of EAEP Manufacturing Plant. *International Journal of Advanced Science and Technology*, 28(14), 08-18. http://sersc.org/journals/index.php/IJAST/article/view/1419
2. Kumar, A., Garg, D., and Goel, P. (2019). Mathematical modelling and behavioural analysis of a washing unit in paper mill. *International Journal of System Assurance Engineering and Management*, 1(6), 1639-1645. DOI: 10.1007/s13198-019-00916-4

3. Kumar, A., Garg, D., and Goel, P. (2019). Sensitivity analysis of a cold standby system with priority for preventive maintenance. *Journal of Advance and Scholarly Researches in Allied Education*, 16(4), 253-258. http://ignited.in/I/a/88998
4. Kumar, A., Goel, P. and Garg, D. (2018). Behaviour analysis of a bread making system. *International Journal of Statistics and Applied Mathematics*, 3(6), 56-61.
5. Kumar, A., Garg, D., Goel, P., Ozer, O. (2018). Sensitivity analysis of 3:4:: good system. *International Journal of Advance Research in Science and Engineering*, 7(2), 851-862.
6. Kumar, A., Garg, D., and Goel, P. (2017). Mathematical modelling and profit analysis of an edible oil refinery industry. *Airo International Research journal*, XIII, 1-14.
7. Kumar, A., Goel, P., Garg, D., and Sahu, A. (2017). System behaviour analysis in the urea fertilizer industry. *Book: Data and Analysis [978-981-10-8526-0] Communications in computer and information Science (CCIS), Springer*, 3-12. https://doi.org/10.1007/978-981-10-8527-7_1
8. Rajbala, Kumar, A. and Khurana, P. (2022). Redundancy allocation problem: Jayfe cylinder Manufacturing Plant. *International Journal of Engineering, Science & Mathematic*, 11(1), 1-7.DOI:10.6084/m9.figshare.18972917.