International Journal of Engineering, Science & Mathematics
Vol. 13 Issue 02, February 2024,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Sensitivity Analysis of Warm Stand-by Three Units System using RPGT technique

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DOI:ijmra.ijesm.44652.33215

ABSTRACT: - This article uses the Regenerative Point Graphical Technique (RPGT) to analyses the warm standby three unit system's sensitivity to system factors. assuming a constant failure and repair rate. The system's state diagram is created, showing the transition rates. RPGT is used to create expressions for path probabilities, mean sojourn times, mean time to system failure, system availability, busy period of the server, and expected number of server visits. A sensitive study of the system is conducted, which could help management maintain the system's diverse units. To compare and arrive at a conclusion, tables and graphs are generated.

Keywords: - RPGT, Sensitivity Analysis, System Parameters

1. Introduction:

Different mechanical systems are assemblies of several units, each of which is necessary for the proper operation of the system. The system fails as a whole if one unit malfunctions. This research paper discusses system parameters, availability modeling, behavioral analysis, and a single permanent repairman who uses the Regenerative Point Graphical Technique (RPGT) to repair and service the three warm and cold standby units in series with perfect switch over devices. This kind of system is seen in a fertilizer factory, where system A supplies coal primarily, system B supplies standby fuel diesel, system D supplies raw materials (using material supply from silo E in cold standby), and unit F handles processing. Dairy factories and many other sectors in comparable situations likewise face similar circumstances. Three different subsystem types are assumed in the system that follows: A with warm standby, B, D with cold standby, E, and F. Since the components of all three subsystems are connected in series, the failure of one component will cause the subsystem as a whole to fail. A unit's failure or operational state is ascertained using a fuzzy concept. There are three distinct units that make up the System. When the system is in a failed condition, no unit can fail any more. For the repair of malfunctioning units and in reduced conditions, there is only one repairman.Jieong et al. (2009) addressed multi-objective streamlining issues using GA, or a half-and-half calculation. While Kumar et al. (2017) examined the urea compost sector for system parameters, the primary goal of the paper by Kumar et al. (2019) focuses on the explored investigation of the washing element in the paper company consuming RPGT. Kumar et al.'s 2018 study concentrated on the examination of a bakery and an edible petroleum treatment facility. Malik et al. optimized the mist group of a coal-fired thermal effect shrub in 2022. In Anchal et al.'s analysis of the SRGM classic using variance condition, dual types of deficiencies—simple and hard as for the timing of these for disengagement and expulsion following their recognition—have been reported.The dependability, availability, and maintainability study gives several techniques to conduct out structure alteration, according to Komal et al. In 2021, Kumari et al. discussed benefit analysis of the stable agricultural harvester plants utilizing RPGT. Researchers Kumar et al. (2018) looked into the behaviour of a system that makes bread in their discussion of the reliability technology theory and its applications. Using RPGT, Kumar et al. (2019) looked at the profitability of a cold standby structure with priority for preventative maintenance that comprises of two identical units with server failure. The current paper consists of two units, one of which is accessible online and the other of which is kept in cold standby mode. The only two modes for both online and cold standby units are good and entirely failed. Bhunia et al. (2010) introduced GA in a series structure with a span portion to address issues with unshakable quality stochastic augmentation. Given the chance imperatives of the series framework, the review was able to find a solution to the issue of streamlining stochastic unshakeable quality. In 2017, Kumar examined the mathematical modelling and profit

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analysis of an edible oil refinery facility. Kumar et al. (2019) investigated mathematical modelling and behavioural analysis in a paper mill washing unit. A work by Kumar et al. (2018) looked at the profitability analysis of a 3:4:: outstanding system plant. The system modelling and analysis of the EAEP manufacturing plant was the subject of research by Rajbala et al. in 2019. Behavioural analysis has been studied in the urea fertiliser industry by Kumar et al. (2017). The RPGT technique was used to carry out the mathematical formulation. Different formulas for system parameters are produced by assuming that failure/repair rates are independent and constant. Tables and figures are used to discuss system sensitivity and behavior analysis.

The failures rates are exponentially distributed and repair rate are general and are independent and are different for different operative units. Units are of different capacities. Repairs are perfect i.e. Repaired unit works as a new one. Sub system F has priority in repair over other sub systems. When two units are in a decreased state or any one unit is failing, the system is down. The system is examined in steady state circumstances. Repairs and failures are separate entities. A system transition diagram is created to identify the primary, secondary, and tertiary circuits as well as the base state using standard notations, exponential failure rates, general and independent repair rates, and various probabilities. To solve the problem and find the system parameters, RPGT is used. Tables and graphs are used to assist explain system behavior. After examining specific situations, conversations are held to determine how failure and repair rates affect system characteristics. Additionally provided is the profit function.

2. Assumption & Notation used in this study: -

The following assumptions and notations are taken: -

1. There is one repairman whose availability is 24x7 and another server is called on need basis.

2. The distributions of failure and repair times are constant and different.

3. Failures and repairs are statistically independent.

4. Repair is perfect and repaired system is as good as new one.

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

μ_i : Mean sojourn time spent in state i, $\mu_i = \int_0^\infty R_i(t)dt$

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μ_i^1 : The total un-conditional time spent before transiting to any other regenerative states, given that the system entered regenerative state 'i' at t=0.

n_i : Expected waiting time spent while doing a given job, given that the system entered regenerative state 'i' at t=0; $\eta_i = W_i^*(0)$.

$q_{i,j}(t)$**:** 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. $p_{i,j} = q_{i,j}^*(0)$; where * denotes Laplace transformation.

ξ : Base state of the system.

f_j : Fuzziness measure of the j-state.

Full Capacity

Reduced state

Failed State

$\boldsymbol{\lambda}_i(1 \le i \le 5)$= Failure Rate of Units

$w_i(1 \le i \le 5)$= Repair Rate of Units

3. Transition Diagram

Taking into consideration the assumptions and notations the Transition Diagram of the system is given in Figure 1.

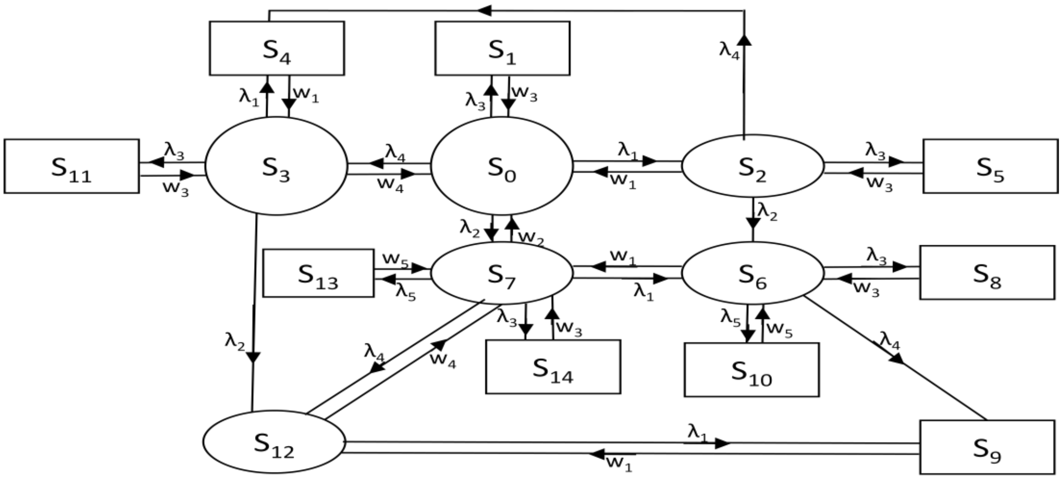

Figure 1: Transition Diagram

S_0 = A(B)D(E)F S_1 = A(B)D(E)f S_2 = aBD(E)F

S_3 = A(b)D(E)F S_4 = abD(E)F S_5 = aBD(E)f

S_6 = aBdEF S_7 = A(B)dEF S_8 = aBdEf

S_9 = abdEF S_{10} = aBdeF S_{11} = A(b)D(E)f

S_{12} = A(b)dEF S_{13} = A(B)deF S_{14} = A(B)dEf

4. Transition Probability and the Mean sojourn times.

Table 1: Transition Probabilities

$q_{i,j}(t)$	$P_{ij} = q^*_{i,j}(0)$
$q_{0,1}= \lambda_3 e^{-(\lambda_3+\lambda_1+\lambda_4+\lambda_2)t}$	$p_{0,1}= \lambda_3/(\lambda_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{0,2}= \lambda_1 e^{-(\lambda_1+\lambda_2+\lambda_3+\lambda_4)t}$	$p_{0,2}= \lambda_1/(\lambda_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{0,3}= \lambda_4 e^{-(\lambda_1+\lambda_2+\lambda_3+\lambda_4)t}$	$p_{0,3}= \lambda_4/(\lambda_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{0,7}= \lambda_2 e^{-(\lambda_1+\lambda_2+\lambda_3+\lambda_4)t}$	$p_{0,7}= \lambda_2/(\lambda_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{1,0}= w_3 e^{-w_3 t}$	$p_{1,0}= 1$
$q_{2,0}= w_1 e^{-(w_1+\lambda_4+\lambda_2+\lambda_3)t}$	$p_{2,0}= w_1/(w_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{2,4}= \lambda_4 e^{-(\lambda_4+\lambda_2+\lambda_3+w_1)t}$	$p_{2,4}= \lambda_4/(w_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{2,5}= \lambda_3 e^{-(\lambda_3+\lambda_4+\lambda_2+w_1)t}$	$p_{2,5}= \lambda_3/(w_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{2,6}= \lambda_2 e^{-(\lambda_2+\lambda_3+\lambda_4+w_1)t}$	$p_{2,6}= \lambda_2/(w_1+\lambda_2+\lambda_3+\lambda_4)$
$q_{3,0}= w_4 e^{-(w_4+\lambda_1+\lambda_3+\lambda_2)t}$	$p_{3,0}= w_4/(w_4+\lambda_1+\lambda_2+\lambda_3)$
$q_{3,4}= \lambda_1 e^{-(\lambda_1+\lambda_2+\lambda_3+w_4)t}$	$p_{3,4}= \lambda_1/(w_4+\lambda_1+\lambda_2+\lambda_3)$
$q_{3,11}= \lambda_3 e^{-(\lambda_3+\lambda_1+\lambda_2+w_4)t}$	$p_{3,11}= \lambda_3/(w_4+\lambda_1+\lambda_2+\lambda_3)$
$q_{3,12}= \lambda_2 e^{-(\lambda_1+\lambda_2+\lambda_3+w_4)t}$	$p_{3,12}= \lambda_2/(w_4+\lambda_1+\lambda_2+\lambda_3)$
$q_{4,3}= w_1 e^{-w_1 t}$	$p_{4,3}= 1$
$q_{5,2}= w_3 e^{-w_3 t}$	$p_{5,2}= 1$
$q_{6,7}= w_1 e^{-(w_1+\lambda_5+\lambda_4+\lambda_3)t}$	$p_{6,7}= w_1/(w_1+\lambda_3+\lambda_4+\lambda_5)$
$q_{6,8}= \lambda_3 e^{-(\lambda_3+\lambda_4+\lambda_5+w_1)t}$	$p_{6,8}= \lambda_3/(w_1+\lambda_3+\lambda_4+\lambda_5)$
$q_{6,9}= \lambda_4 e^{-(\lambda_4+\lambda_3+\lambda_5+w_1)t}$	$p_{6,9}= \lambda_4/(w_1+\lambda_3+\lambda_4+\lambda_5)$
$q_{6,10}= \lambda_5 e^{-(\lambda_5+\lambda_4+\lambda_3+w_1)t}$	$p_{6,10}= \lambda_5/(w_1+\lambda_3+\lambda_4+\lambda_5)$

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$q_{7,0}= w_2e^{-(w_2+\lambda_1+\lambda_3+\lambda_5+\lambda_4)t}$ $q_{7,6}= \lambda_1e^{-(\lambda_1+\lambda_3+\lambda_5+\lambda_4+w_2)t}$ $q_{7,12}= \lambda_4e^{-(\lambda_4+\lambda_5+\lambda_3+\lambda_1+w_2)t}$ $q_{7,13}= \lambda_5e^{-(\lambda_5+\lambda_3+\lambda_1+\lambda_4+w_2)t}$ $q_{7,14}= \lambda_3e^{-(\lambda_3+\lambda_1+\lambda_4+\lambda_5+w_2)t}$	$p_{7,0}= w_2/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$ $p_{7,6}= \lambda_1/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$ $p_{7,12}= \lambda_4/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$ $p_{7,13}= \lambda_5/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$ $p_{7,14}= \lambda_3/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$
$q_{8,6}= w_3e^{-w_3t}$	$p_{8,6}= 1$
$q_{9,12}= w_1e^{-w_1t}$	$p_{9,12}= 1$
$q_{10,6}= w_5e^{-w_5t}$	$p_{10,6}= 1$
$q_{11,3}= w_3e^{-w_3t}$	$p_{11,3}= 1$
$q_{12,7}= w_4e^{-(w_4+\lambda_1)t}$ $q_{12,9}= \lambda_1e^{-(\lambda_1+w_4)t}$	$p_{12,7}= w_4/(w_4+\lambda_1)$ $p_{12,9}= \lambda_1/(w_4+\lambda_1)$
$q_{13,7}= w_5e^{-w_5t}$	$p_{13,7}= 1$
$q_{14,7}= w_3e^{-w_3t}$	$p_{14,7}= 1$

Table 2:Mean Sojourn Times

$R_i(t)$	$\mu_i=R_i^*(0)$
$R_0(t)= e^{-(\lambda_1+\lambda_2+\lambda_3+\lambda_4)t}$	$\mu_0 = 1/(\lambda_1+\lambda_2+\lambda_3+\lambda_4)$
$R_1(t)= e^{-w_3t}$	$\mu_1 = 1/w_3$
$R_2(t)= e^{-(w_1+\lambda_2+\lambda_3+\lambda_4)t}$	$\mu_2= 1/(w_1+\lambda_2+\lambda_3+\lambda_4)$
$R_3(t)= e^{-(w_4+\lambda_1+\lambda_2+\lambda_3)t}$	$\mu_3= 1/(w_4+\lambda_1+\lambda_2+\lambda_3)$
$R_4(t)= e^{-w_1t}$	$\mu_4= 1/w_1$
$R_5(t)= e^{-w_3t}$	$\mu_5= 1/w_3$
$R_6(t)= e^{-(w_1+\lambda_3+\lambda_4+\lambda_5)t}$	$\mu_6= 1/(w_1+\lambda_3+\lambda_4+\lambda_5)$
$R_7(t)= e^{-(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)t}$	$\mu_7= 1/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)$
$R_8(t)= e^{-w_3t}$	$\mu_8= 1/w_3$
$R_9(t)= e^{-w_1t}$	$\mu_9= 1/w_1$
$R_{10}(t)= e^{-w_5t}$	$\mu_{10}= 1/w_5$
$R_{11}(t)= e^{-w_3t}$	$\mu_{11}= 1/w_3$

$R_{12}(t) = e^{-(w_4+\lambda_1)t}$	$\mu_{12} = 1/(w_4+\lambda_1)$
$R_{13}(t) = e^{-w_5 t}$	$\mu_{13} = 1/w_5$
$R_{14}(t) = e^{-w_3 t}$	$\mu_{14} = 1/w_3$

5. Path probabilities from the initial state

$V_{0,0} = 1$ (Verified)

$V_{0,2} = (0,2)$

$= p_{0,2}$

$V_{0,3}=$……….Continuous

5.1 Path Probabilities from the base state '7'

$V_{7,0} = (7,0)/[1-(0,2,0)][1-(0,3,0)]$

$= w_2/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)[((\lambda_1+\lambda_2+\lambda_3+\lambda_4)(w_1+\lambda_2+\lambda_3+\lambda_4)-\lambda_1 w_1)((\lambda_1+\lambda_2+\lambda_3$
$+\lambda_4)(w_4+\lambda_1+\lambda_2+\lambda_3)-\lambda_4 w_4)]/[(\lambda_1+\lambda_2+\lambda_3+\lambda_4)^2(w_4+\lambda_1+\lambda_2+\lambda_3)(w_1+\lambda_2+\lambda_3+\lambda_4)]$

$V_{7,1} = (7,0,1)/[1-(0,2,0)][1-(0,3,0)]$

$= w_2\lambda_3/(w_2+\lambda_1+\lambda_3+\lambda_4+\lambda_5)(\lambda_1+\lambda_2+\lambda_3+\lambda_4)L_0$

$V_{7,2} =$ …………Continuous

6. Methodology

MTSF(T_0): The regenerative un-failed states to which the system can transit(initial state '0'), before entering any failed state are: 'i' = 0,2,3,6,7,12 taking 'ξ' = '0'.

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

$$T_0 = (\mu_0+V_{0,2}\mu_2+V_{0,3}\mu_3+V_{0,6}\mu_6+V_{0,7}\mu_7+V_{0,12}\mu_{12})/\{1-p_{0,2}p_{2,0}-p_{0,3}p_{3,0} -[(p_{0,7}p_{7,0}+p_{0,2}p_{2,6}p_{6,7}p_{7,0}+p_{0,3}p_{3,12}p_{12,7}p_{7,0})/(1-p_{7,12}p_{12,7})(1-p_{7,6}p_{6,7})]\}$$

Availability of the System: The regenerative states at which the system is available are 'j' = 0,2,3,6,7,12 and the regenerative states are 'i' = 0 to 14 taking 'ξ' = '7' the total fraction of time for which the system is available is given by

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

$$A_0 = (V_{7,0}f_0\mu_0+V_{7,2}f_2\mu_2+V_{7,3}f_3\mu_3+V_{7,6}f_6\mu_6+V_{7,7}f_7\mu_7+V_{7,12}f_{12}\mu_{12})/K$$

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Let $K = V_{7,0}\mu_0^1+V_{7,1}\mu_1^1+V_{7,2}\mu_2^1+V_{7,3}\mu_3^1+V_{7,4}\mu_4^1+V_{7,5}\mu_5^1+V_{7,6}\mu_6^1+V_{7,7}\mu_7^1+V_{7,8}\mu_8^1$
$+V_{7,9}\mu_9^1+V_{7,10}\mu_{10}^1+V_{7,11}\mu_{11}^1+V_{7,12}\mu_{12}^1+V_{7,13}\mu_{13}^1+V_{7,14}\mu_{14}^1$

As f_i =1, for i = 0,2,3,6,7,12

andf_j = 0for j = 1,4,5,8,9,10,11,13,14 Taking $\mu_i^1 = \mu_i$

$= (V_{7,0}\mu_0+V_{7,2}\mu_2+V_{7,3}\mu_3+V_{7,6}\mu_6+V_{7,7}\mu_7+V_{7,12}\mu_{12})/K$

Busy Period of the Server: The regenerative states are $1 \leq j \leq 14$, where server is busy while doing repairs and regenerative states are 'i' = 0 to 14, taking ξ = '7', the total fraction of time for which the server remains busy is

$$B_0= \left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\to j)\},nj}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\to i)\}\mu_i^1}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

$B_0= (V_{7,1}\eta_1+V_{7,2}\eta_2+V_{7,3}\eta_3+V_{7,4}\eta_4+V_{7,5}\eta_5+V_{7,6}\eta_6+V_{7,7}\eta_7+V_{7,8}\eta_8+V_{7,9}\eta_9+V_{7,10}\eta_{10}$
$+V_{7,11}\eta_{11}+V_{7,12}\eta_{12}+V_{7,13}\eta_{13}+V_{7,14}\eta_{14})/K$
$= 1-V_{7,0}\mu_0/K$

Expected Number of Inspections by the repair man: The regenerative states where the repairman visits afresh for repair of the system are j = 1,2,3,7. The regenerative states are i = 0 to 14, Taking 'ξ' = '7', the number of visit by the repair man is given by

$$V_0= \left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\to j)\}}{\Pi_{k_{1\neq\xi}}\{1-V_{\overline{k_1 k_1}}\}}\right\}\right] \div \left[\sum_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\to i)\}\mu_i^1}{\Pi_{k_{2\neq\xi}}\{1-V_{\overline{k_2 k_2}}\}}\right\}\right]$$

$V_0 = (V_{7,1}+V_{7,2}+V_{7,3}+V_{7,7})/K$

7. Particular Cases

Sensitivity Analysis w.r.t. change in repair rates;

Taking λ_i= 0.15 ($1 \leq I \leq 5$) and varying w_1,w_2,w_3,w_4,w_5one by one respectively at 0.50, 0.60, 0.70, 0.80, 0.90

Mean Time to System Failure (To)

Table 3: Mean Time to System Failure (To) Table

w_i	w_1	w_2	w_3	w_4	w_5
0.50	**6.68**	**6.68**	**6.68**	**6.68**	**6.68**
0.60	6.68	6.68	6.68	6.68	6.68
0.70	6.68	6.68	6.68	6.68	6.68
0.80	6.68	6.68	6.68	6.68	6.68
0.90	6.68	6.68	6.68	6.68	6.68

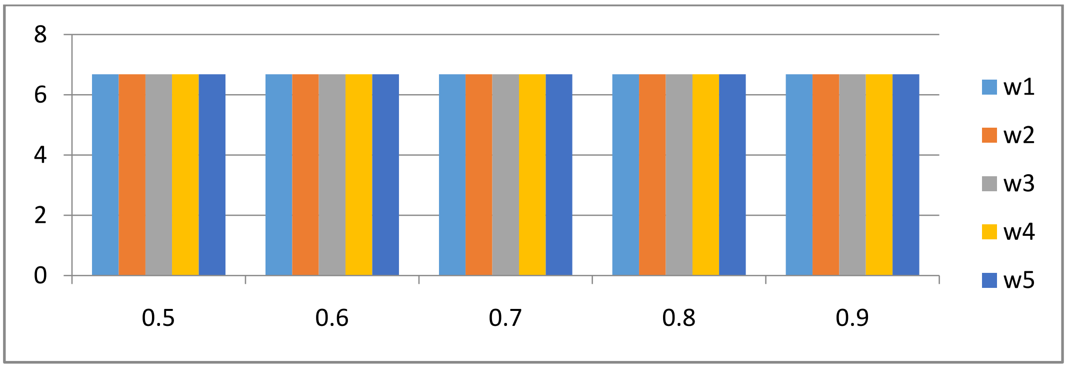

Figure 2: Mean Time to System Failure Graph

Availability of the System (Ao)

Table 4: Availability of the System (Ao) Table

w_i	w_1	w_2	w_3	w_4	w_5
0.50	0.853	0.852	0.842	0.844	0.848
0.60	0.855	0.853	0.848	0.846	0.850
0.70	0.856	0.854	0.853	0.849	0.851
0.80	0.857	0.855	0.858	0.853	0.852
0.90	0.859	0.856	0.862	0.855	0.853

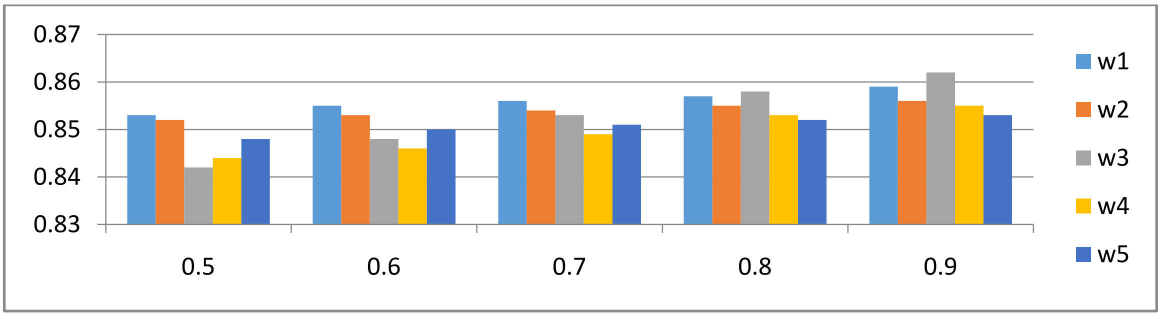

Figure 3: Availability of the System Graph

Busy Period of the Server's Visits (B0)

Table 5: Busy Period of the Server's Visits (B0) Table

w_i	w_1	w_2	w_3	w_4	w_5
0.50	0.384	0.399	0.392	0.391	0.387
0.60	0.379	0.384	0.388	0.389	0.386
0.70	0.376	0.376	0.384	0.386	0.385
0.80	0.373	0.371	0.380	0.384	0.385
0.90	0.369	0.365	0.377	0.381	0.384

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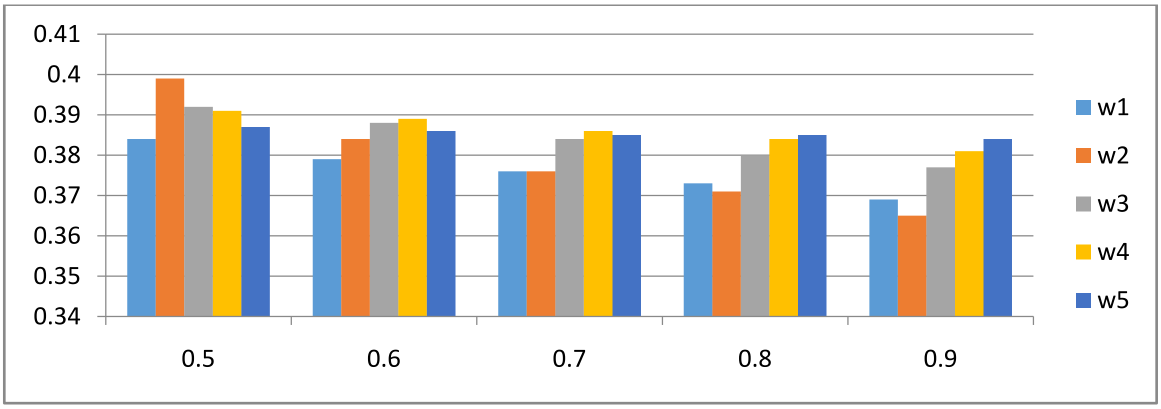

Figure 4: Busy Period of the Server's Visits Graph

Expected Fractional Number of Inspection by the repairman (V_0)

Table 6: Expected Fractional Number of Inspection by the repairman (V_0) Table

w_i	w_1	w_2	w_3	w_4	w_5
0.50	0.280	0.278	0.276	0.277	0.275
0.60	0.281	0.280	0.278	0.278	0.276
0.70	0.282	0.281	0.280	0.279	0.277
0.80	0.283	0.282	0.282	0.280	0.279
0.90	0.284	0.284	0.283	0.281	0.280

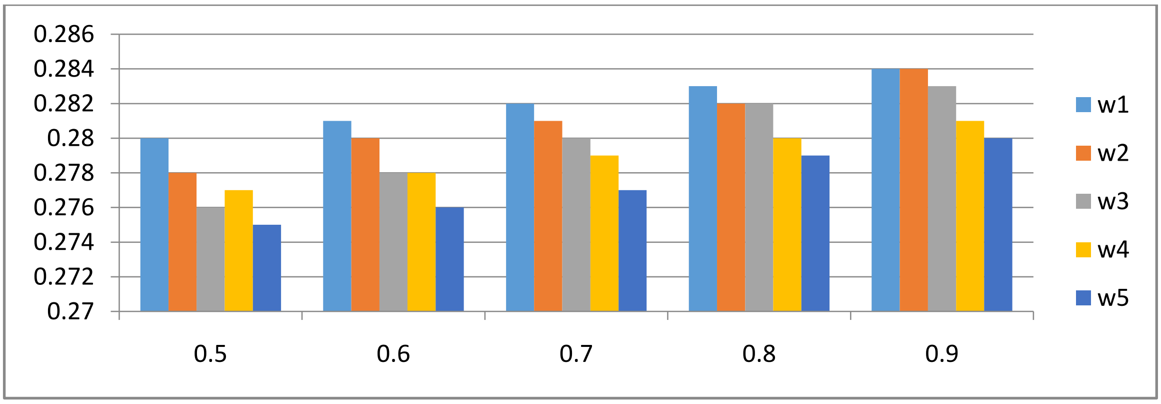

Figure 5: Expected Fractional Number of Inspection by the repairman Graph

Sensitivity analysis w.r.t. change in failure rates:

Fixing $w_i = 0.70$ ($1 \leq i \leq 5$) , varying λ_1, λ_2, λ_3,λ_4,$\lambda_5$one by one respectively at 0.10, 0.20, 0.30, 0.40, 0.50 we have

Mean Time to System Failure (To)

Table 7: Mean Time to System Failure (To) Table

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5
0.10	3.19	3.31	4.66	3.65	3.63
0.20	2.97	3.19	3.98	3.50	3.44
0.30	2.87	3.10	3.19	3.33	3.24
0.40	2.76	2.99	2.98	3.19	3.21
0.50	2.67	2.95	2.40	3.08	3.19

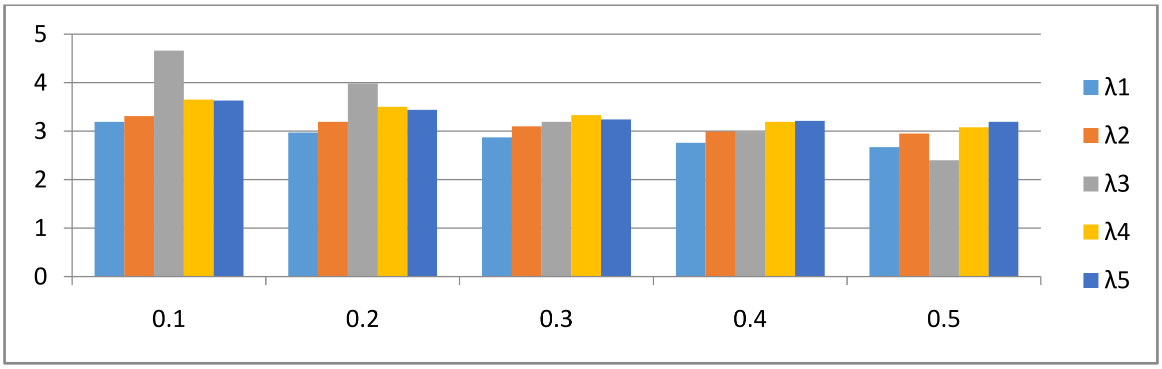

Figure 6: Mean Time to System Failure Graph

Availability of the System (Ao)

Table 8: Availability of the System (Ao) Table

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5
0.10	0.68	0.74	0.80	0.70	0.73
0.20	0.66	0.68	0.74	0.69	0.72
0.30	0.65	0.61	0.68	0.69	0.70
0.40	0.64	0.56	0.64	0.68	0.69
0.50	0.63	0.52	0.60	0.68	0.68

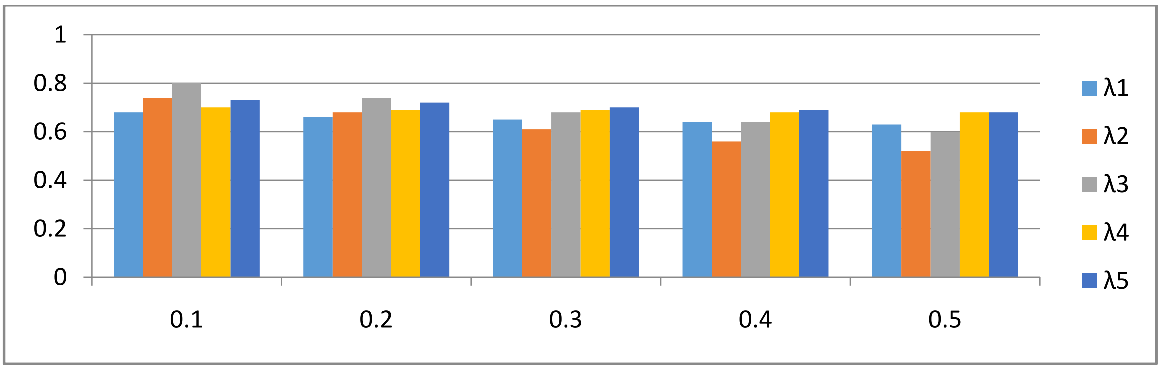

Figure 7: Availability of the System Graph

Busy Period of the Server's Visits (B_0)

Table 9: Busy Period of the Server's Visits (B_0) Table

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5
0.10	0.61	0.54	0.58	0.54	0.59
0.20	0.63	0.61	0.60	0.57	0.60
0.30	0.66	0.66	0.61	0.59	0.60
0.40	0.68	0.70	0.64	0.61	0.61
0.50	0.69	0.74	0.66	0.62	0.61

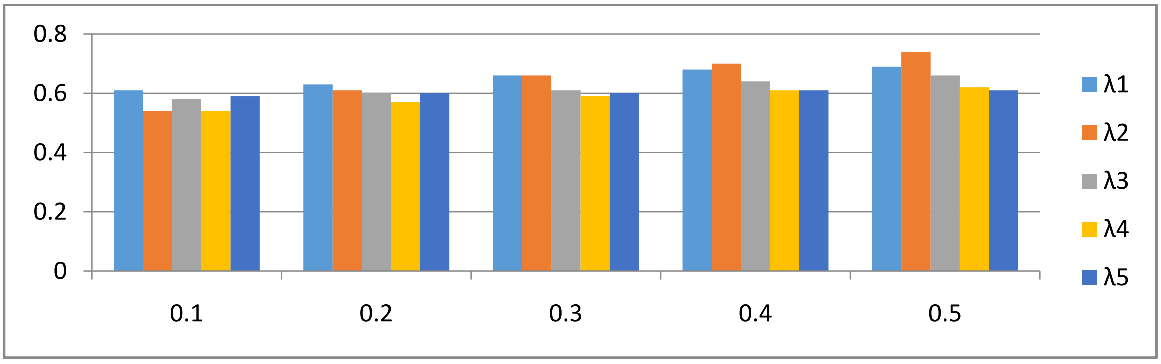

Figure 8: Busy Period of the Server's Visits Graph

Expected Fractional Number of Inspection by the repairman (V_0)

Table 10: Expected Fractional Number of Inspection by the repairman (V_0) Table

λ_i	λ_1	λ_2	λ_3	λ_4	λ_5
0.10	0.39	0.38	0.37	0.36	0.35
0.20	0.40	0.39	0.38	0.37	0.36
0.30	0.41	0.40	0.39	0.38	0.37
0.40	0.42	0.41	0.40	0.39	0.38
0.50	0.43	0.42	0.41	0.40	0.39

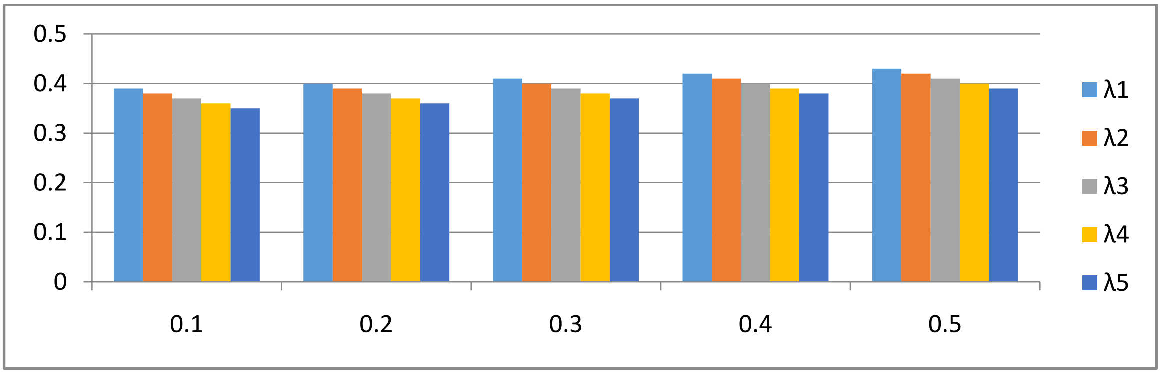

Figure 9: Expected Fractional Number of Inspection by the repairman Graph

8. Conclusion:-

The system's availability, the profit function, and the anticipated number of repairman inspections are all observed to decrease with an increase in failure rate and to increase with the repair rate, based on the analytical and figure discussions. Increased repair rates result in a decrease in the mean time to system breakdown and the busiest period of the server. By raising the repair rate and lowering the failure rate, the plant's effectiveness and dependability can be enhanced. The system cannot reach production after a limit, i.e. a recession occurs. A degraded state is a state of the system in which the system or units perform a function continuously up to a satisfactory but lower (lower) limit than specified due to its required functions. Mean Time to System Failure is independent of the repair rates of various units in table 3 and figure 2.Table 4 and Figure 3 conclude that the value of system availability does not significantly rise with an increase in repair rates. However, the unit repair rate was kept at its highest for maximum availability.As a result, repairmen should be effective in fixing the unit to have a lower value of the server's busy time. Table 5 and Figure 4 demonstrate that the busy period of the server peaks when the repair rate of unit reaches its maximum in comparison to other units.Figure 5 and Table 6 demonstrate that, in order to ensure uninterrupted operation, the server should make the fewest calls possible as we proceed from top to bottom in our assessment of V_0, which increases as unit repair rates rise.Figure6 and Table 7 both demonstrate that when the failure rate of various units increases, the estimation of T_0 decreases more quickly.According to Table 8 and Figure7, availability is at its lowest when the failure rate of sub-units is at its largest and at its maximum when the failure rate is 0.50, with values of 0.52.Table 9 shows that the busy period value is 0.74, indicating that the unit failure rate ought to be at its lowest. Keep the failure rate as low as possible to prevent the lower value of busy period.Table 10 indicates that the failure rate of unit is expected to increase at a faster pace. As a result, unit requires more cases for upkeep over other units; figure 9 illustrates this same pattern.

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