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Sensitivity analysis of a biscuit making plant

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Abstract
In this research paper sensitivity analysis of a biscuit making plant having five units with constant failure and repair rate using RPGT is carried out. A transition state diagram showing the directed path and steady states is drawn using Markov method. Transition probabilities, mean sojourn times, system parameters are modeled using RPGT. Fixing failure/ repair rates of units and varying the other sensitivity tables and graphs are drawn followed by analysis.

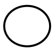
Keywords: Sensitivity Analysis, Regenerative Point Graphical Technique (RPGT), system parameters

Introduction
Modern products have vided range from simple to complex; hence bakery plants should have quality design with optimal availability and optimal system parameters. The competition and challenge in modern engineering bakery plants is to guarantee optimal manufacturing costs and minimum design cycle time to attain performance and reliability. This chapter discusses sensitivity analysis to analyze transient behavior of repairable biscuit manufacturing plant using RPGT, based on Markov modeling for modeling system parameters equations. The effect of failure and repair of units is examined to realize optimum level of performance of system parameters. Now a day availability/maintainability analysis of process industries is having increased importance which may benefit the industry with higher productivity and lower maintenance activities with costs. Different performance measures used in process industry are indicates to define the performance of a plant in terms of system parameters. Most of these parameters are linked to operational stage while a few of these are useful to design the units at an early stage. A biscuit manufacturing plant in Bahadurgarh (Rohtak) in Haryana has been taken up or study. In this chapter a subsystem of the plant (visit is a continuous processing and production system) is analyzed taking pre-emptive resume priority repair policy. The failure and repair rates of units are takes as constant, transient probability consideration on under Markov-process are helpful to draw the transient state diagram of the system under steady state. Laplace transformations are used to evaluate mean sojourn times of various stage expressions for system parameters are modeled using RPGT. Keeping failure or repair rates of units fixed while varying other for different units, their effect on system performance parameters is given by drawing tables and graphs, followed by discussions. Kumar, J. & Malik, S. C. [1] have discussed the concept of preventive maintenance for a single unit system. Liu, R. [2], Malik, S. C. [3], Nakagawa, T. and Osaki, S. [4] have discussed reliability analysis of a one unit system with un-repairable spare units and its applications. Goel, P. & Singh J. [5], Gupta, P., Singh, J. & Singh, I.P. [6], Kumar, S. & Goel, P. [7], Gupta, V. K. [8], Chaudhary, Goel & Kumar [9] Sharma & Goel [10], Ritikesh & Goel [11], Goyal & Goel [12] and Yusuf, I. [13] have discussed behavior with perfect and imperfect switch-over of systems using various techniques.

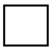
Assumptions and Notations: The following assumptions and notations are taken:
1. There is single repairman who is always available.
2. The distributions of failure /repair times are constant and also different.
3. Failures and repairs are statistically independent.
4. Repair is perfect and repaired system is as good as new one.
5. Nothing can fail when the system is in failed state.

6. The system is discussed for steady-state conditions.

$\left(i \xrightarrow{S_r} j\right)$: *R-th* directed simple path from *i*-state to j-state; r takes positive integral values
For different paths from *i*-state to j-state.
$\left(\xi \xrightarrow{sff} i\right)$: A directed simple failure free path from ξ -state to i-state.
$V_{m,m}$: Probability factor of the state m reachable from the terminal state m of the M-cycle.
$V_{\overline{m,m}}$: Probability factor of the state m reachable from the terminal state m of the $m -^{\overline{cycle}}$.
R_i (t): Reliability of the system at time t, given that the system entered the un-failed Regenerative state 'i' at t= 0.
A_i (t): Probability of the system in up time at time't', given that the system entered Regenerative state 'i' at t= 0.
B_i (t): Reliability that the server is busy for doing a particulars job at time't'; given That the system entered regenerative state 'i' at t= 0.
V_i (t): The expected no. of server visits for doing a job in (o,t] given that the system Entered regenerative state 'i' at t= 0.
',': denote derivative
μ_i: Mean sojourn time spent in state i, before visiting any other states; $\mu_i = \int_0^\infty R_i(t)dt$
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; $\eta_i = W_i^*(0)$.
ξ: Base state of the system.
f_j: Fuzziness measure of the j-state.
Hi ($1 \le i \le 5$): Constant repair rate of units.
Mi ($1 \le i \le 5$): Constant failure rate of units.

 Full Capacity Working State

 Reduced State

 Failed State

A/$\bar{A}$/a: Unit in full capacity working/reduced state/failed state.
B/b: Unit 'B' in full capacity working/failed state etc.
Taking into consideration the above assumptions and notations the Transition Diagram of the system is given in Figure 1.

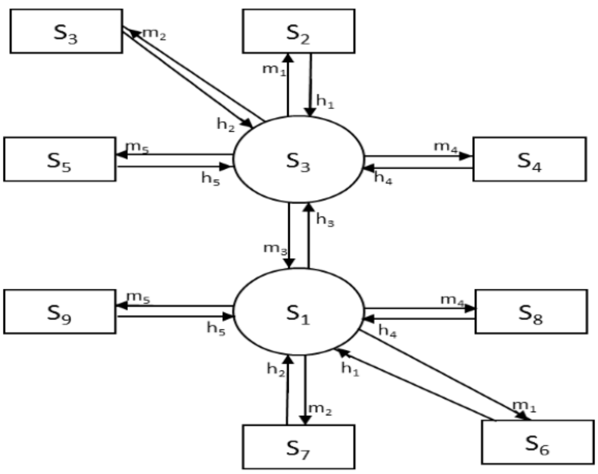


Fig 1

S_0 = ABDEF S_1 = aBDEF S_2 = ABDeF S_3 = ABDEf S_4 = AbDEF S_5 = ABdEF S_6 = a´BDeF
S_7 = a´BDEf S_8 = a´bDEf S_9 = a´BdEF

Table 1: Primary, Secondary & Tertiary Circuits at various vertices.

Vertex i	Primary Circuits (CL1)	Secondary Circuits (CL2)
0	(0,1,0), (0,2,0), (0,3,0), (0,4,0), (0,5,0)	(1,6,1), (1,8,1), (1,7,1), (1,9,1) Nil
1	(1,0,1) (1,6,1) (1,8,1) (1,7,1)	Nil (0,2,0) (0,3,0) (0,4,0)

	(1,9,1)	(0,5,0)
2	(2,0,2)	(0,1,0), (0,3,0), (0,4,0), (0,5,0)
3	(3,0,3)	(0,1,0), (0,2,0), (0,4,0), (0,5,0)
4	(4,0,4)	(0,1,0), (0,2,0), (0,3,0), (0,5,0)
5	(5,0,5)	(0,1,0), (0,2,0), (0,3,0), (0,4,0)
6	(6,1,6)	(1,0,1), (1,7,1), (1,8,1), (1,9,1)
7	(7,1,7)	(1,0,1), (1,6,1), (1,8,1), (1,9,1)
8	(8,1,8)	(1,0,1), (1,6,1), (1,7,1), (1,9,1)
9	(9,1,9)	(1,0,1), (1,6,1), (1,7,1), (1,8,1)

Table 2: From the table 1, we see that at working state '0' there are maximum number of primary circuits, hence state '0' is the base state. Primary, Secondary, Tertiary Circuits w. r. t. the Simple Paths (Base-State '0')

Vertex j	$\left(0 \xrightarrow{S_r} j\right)$: ($P_0$)	(P_1)	(P_2)
0	$\left(0 \xrightarrow{S_1} 0\right)$: (0,1,0)	(1, 6, 1)	Nil
	$\left(0 \xrightarrow{S_2} 0\right)$: (0,2,0)	(1,7,1)	Nil
	$\left(0 \xrightarrow{S_3} 0\right)$: (0,3,0)	(1,8,1)	Nil
	$\left(0 \xrightarrow{S_4} 0\right)$: (0,4,0)	(1,9,1)	Nil
	$\left(0 \xrightarrow{S_5} 0\right)$: (0,5,0)	Nil	Nil
1	$\left(0 \xrightarrow{S_1} 1\right)$: (0,1)	(1,6,1), (1,7,1), (1,8,1), (1,9,1)	Nil
2	$\left(0 \xrightarrow{S_1} 2\right)$: (0,2)	Nil	Nil
3	$\left(0 \xrightarrow{S_1} 3\right)$: (0,3)	Nil	Nil
4	$\left(0 \xrightarrow{S_1} 4\right)$: (0,4)	Nil	Nil
5	$\left(0 \xrightarrow{S_1} 5\right)$: (0,5)	Nil	Nil
6	$\left(0 \xrightarrow{S_1} 6\right)$: (0,1,6)	(1,6,1), (1,7,1), (1,8,1), (1,9,1)	Nil
7	$\left(0 \xrightarrow{S_1} 7\right)$: (0,1,7)	(1,6,1), (1,7,1), (1,8,1), (1,9,1)	Nil
8	$\left(0 \xrightarrow{S_1} 8\right)$: (0,1,8)	(1,6,1), (1,7,1), (1,8,1), (1,9,1)	Nil
9	$\left(0 \xrightarrow{S_1} 9\right)$: (0,1,9)	(1,6,1), (1,7,1), (1,8,1), (1,9,1)	Nil

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. $p_{i,j} = q^*_{i,j}(0)$; where * denotes Laplace transformation.

Table 3: Transition Probabilities

$q_{i,j}(t)$	$P_{ij} = q^*_{i,j}(0)$
$q_{0,1}(t) = m_3 e^{-(m_1+m_2+m_3+m_4+m_5)t}$ $q_{0,2}(t) = m_1 e^{-(m_1+m_2+m_3+m_4+m_5)t}$ $q_{0,3}(t) = m_2 e^{-(m_1+m_2+m_3+m_4+m_5)t}$ $q_{0,4}(t) = m_4 e^{-(m_1+m_2+m_3+m_4+m_5)t}$ $q_{0,5}(t) = m_5 e^{-(m_1+m_2+m_3+m_4+m_5)t}$	$p_{0,1} = m_3/(m_1+m_2+m_3+m_4+m_5)$ $p_{0,2} = m_1/(m_1+m_2+m_3+m_4+m_5)$ $p_{0,3} = m_2/(m_1+m_2+m_3+m_4+m_5)$ $p_{0,4} = m_4/(m_1+m_2+m_3+m_4+m_5)$ $p_{0,5} = m_4/(m_1+m_2+m_3+m_4+m_5)$
$q_{1,0}(t) = h_3 e^{-(m_1+m_2+m_4+m_5+h_3)t}$ $q_{1,6}(t) = m_1 e^{-(m_1+m_2+m_4+m_5+h_3)t}$ $q_{1,7}(t) = m_2 e^{-(m_1+m_2+m_4+m_5+h_3)t}$ $q_{1,8}(t) = m_4 e^{-(m_1+m_2+m_4+m_5+h_3)t}$ $q_{1,9}(t) = m_5 e^{-(m_1+m_2+m_4+m_5+h_3)t}$	$p_{1,0} = h_3/(m_1+m_2+m_4+m_5+h_3)$ $p_{1,6} = m_1/(m_1+m_2+m_4+m_5+h_3)$ $p_{1,7} = m_2/(m_1+m_2+m_4+m_5+h_3)$ $p_{1,8} = m_4/(m_1+m_2+m_4+m_5+h_3)$ $p_{1,9} = m_5/(m_1+m_2+m_4+m_5+h_3)$
$q_{2,0} = h_1 e^{-h_1 t}$	$p_{2,0} = 1$
$q_{3,0} = h_2 e^{-h_2 t}$	$p_{3,0} = 1$
$q_{4,0} = h_4 e^{-h_4 t}$	$p_{4,0} = 1$
$q_{5,0} = h_5 e^{-h_5 t}$	$p_{5,0} = 1$
$q_{6,1} = h_1 e^{-h_1 t}$	$p_{6,1} = 1$
$q_{7,1} = h_2 e^{-h_2 t}$	$p_{7,1} = 1$
$q_{8,1} = h_4 e^{-h_4 t}$	$p_{8,1} = 1$
$q_{9,1} = h_5 e^{-h_5 t}$	$p_{9,1} = 1$

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 4: Mean Sojourn Times

$R_i(t)$	$\mu_i=R_i^*(0)$
$R_0(t)= e^{-(m_1+m_2+m_3+m_4+m_5)t}$	$\mu_0 = 1/(m_1+m_2+m_3+m_4+m_5)$
$R_1(t)= e^{-(m_1+m_2+m_4+m_5+h_3)t}$	$\mu_1 = 1/(m_1+m_2+m_4+m_5+h_3)$
$R_2(t)= e^{-h_1 t}$	$\mu_2 = 1$
$R_3(t)= e^{-h_2 t}$	$\mu_3 = 1$
$R_4(t)= e^{-h_4 t}$	$\mu_4 = 1$
$R_5(t)= e^{-h_5 t}$	$\mu_5 = 1$
$R_6(t)= e^{-h_1 t}$	$\mu_6 = 1$
$R_7(t)= e^{-h_2 t}$	$\mu_7 = 1$
$R_8(t)= e^{-h_4 t}$	$\mu_8 = 1$
$R_9(t)= e^{-h_5 t}$	$\mu_9 = 1$

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 '0' as the base-state of the system as under:

The transition probability factors of all the reachable states from the base state 'ξ' = '0' are:

Probabilities from state '0' to different vertices are given as

$V_{0,0} = 1$

$V_{0,1} = (0,1)/[\{1-(1,6,1)\}\{1-(1,7,1)\}\{1-(1,8,1)\}\{1-(1,9,1)\}]$

$= p_{0,1}/\{(1-p_{1,6}p_{6,1})(1-p_{1,7}p_{7,1})(1-p_{1,8}p_{8,1})(1-p_{1,9}p_{9,1})\}$

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

$V_{0,3} = (0, 3) = p_{0,3}$

$V_{0,4} = (0, 4) = p_{0,4}$

$V_{0,5} = (0, 5) = p_{0,5}$

$V_{0,6} = (0,1,6)/ [\{1-(1,6,1)\}\{1-(1,7,1)\}\{1-(1,8,1)\}\{1-(1,9,1)\}]$

$= p_{0,1}p_{1,6}/\{(1-p_{1,6}p_{6,1})(1-p_{1,7}p_{7,1})(1-p_{1,8}p_{8,1})(1-p_{1,9}p_{9,1})\}$

$V_{0,7} = (0,1,7)/ [\{1-(1,6,1)\}\{1-(1,7,1)\}\{1-(1,8,1)\}\{1-(1,9,1)\}]$

$= p_{0,1}p_{1,7}/\{(1-p_{1,6}p_{6,1})(1-p_{1,7}p_{7,1})(1-p_{1,8}p_{8,1})(1-p_{1,9}p_{9,1})\}$

$V_{0,8} = (0,1,8)/ [\{1-(1,6,1)\}\{1-(1,7,1)\}\{1-(1,8,1)\}\{1-(1,9,1)\}]$

$= p_{0,1}p_{1,8}/\{(1-p_{1,6}p_{6,1})(1-p_{1,7}p_{7,1})(1-p_{1,8}p_{8,1})(1-p_{1,9}p_{9,1})\}$

$V_{0,9} = (0,1,9)/ [\{1-(1,6,1)\}\{1-(1,7,1)\}\{1-(1,8,1)\}\{1-(1,9,1)\}]$

$= p_{0,1}p_{1,9}/\{(1-p_{1,6}p_{6,1})(1-p_{1,7}p_{7,1})(1-p_{1,8}p_{8,1})(1-p_{1,9}p_{9,1})\}$

Mtsf (T_0): The regenerative un-failed states to which the system can transit (initial state '0'), before entering any failed state are: 'i' = 0,1 taking 'ξ' = '0'.

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

$T_0 = (V_{0,0\mu 0}+V_{0,1\mu 1})/ \{1-(0, 1, 0)\}$

Availability of the System (A_0): The regenerative states at which the system is available are 'j' = 0, 1 taking base state 'ξ' = '0' the total fraction of time for which the system is available is given by

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

$A_0 = \left[\sum_j V_{\xi,j}\,, f_j, \mu_j\right] \div \left[\sum_i V_{\xi,i}\,, f_j, \mu_i^1\right]$

$A_0 = (V_{0,0}\mu_0+V_{0,1}\mu_1)/D$

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

Busy Period of the Server: The regenerative states where server is busy are $j = 1 \leq i \leq 9$ and taking ξ = '0', the total fraction of time for which the server remains busy is

$$B_0=\left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\to j)\},nj}{\Pi_{m_1\neq\xi}\{1-V_{\overline{m_1m_1}}\}}\right\}\right]\div\left[\sum_{i,sr}\left\{\frac{\{pr(\xi^{sr}\to i)\}\mu_i^1}{\Pi_{m_2\neq\xi}\{1-V_{\overline{m_2m_2}}\}}\right\}\right]$$

$$B_0=\left[\sum_j V_{\xi,j}, n_j\right]\div\left[\sum_i V_{\xi,i}, \mu_i^1\right]$$

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

Expected Number of Inspections by the repair man: The regenerative states where the repair man visits a fresh are j = 1, 2, 3, 4, 5, taking 'ξ' = '0', the number of visit by the repair man is given by

$$V_0=\left[\sum_{j,sr}\left\{\frac{\{pr(\xi^{sr}\to j)\}}{\Pi_{k_1\neq\xi}\{1-V_{\overline{k_1k_1}}\}}\right\}\right]\div\left[\sum_{i,sr}\left\{\frac{\{pr(\xi^{sr}\to i)\}\mu_i^1}{\Pi_{k_2\neq\xi}\{1-V_{\overline{k_2k_2}}\}}\right\}\right]$$

$$V_0=\left[\sum_j V_{\xi,j}\right]\div\left[\sum_i V_{\xi,i}, \mu_i^1\right]$$

$$V_0 = (V_{0,\,1\mu1}+V_{0,\,2\mu2}+V_{0,\,3\mu3}+V_{0,\,4\mu4}+V_{0,\,5}\mu_5)/D$$

Sensitivity Analysis: Effect of failure rates of units on system parameters and varying repair rates, we have
MTSF (T_0): For fixed failure rates

Table 5: MTSF (T_0) Table

h_i	h_1	h_2	h_3	h_4	h_5
0.80	2.56	2.56	2.56	2.56	2.56
0.90	2.56	2.56	2.57	2.56	2.56
1.00	2.56	2.56	2.573	2.56	2.56

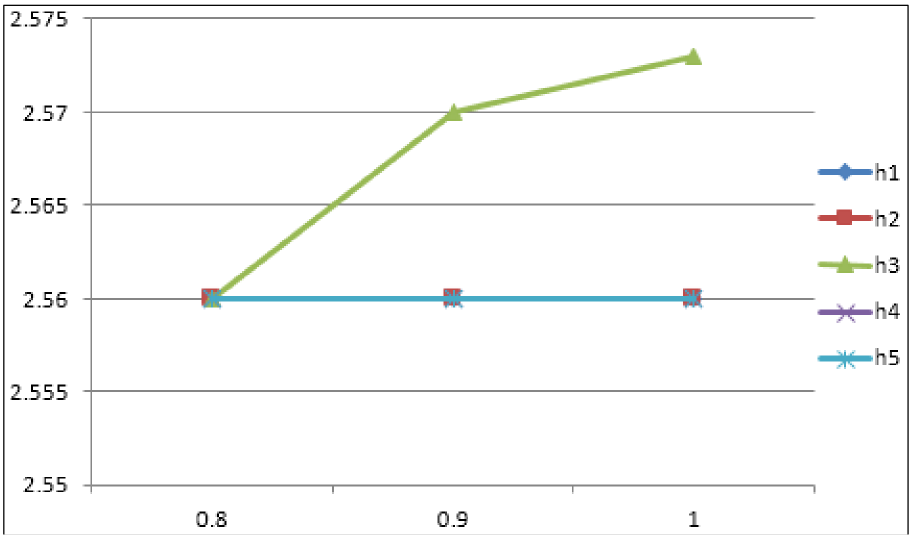


Fig 2: MTSF (T_0) Graph

On watching the table and graph drawn for fixed failure rates of units (taking failure rates of units (m_i = 0.10 □ 'i') and varying repair of units, it is concluded that there not much gain in the value of T_0, however there is a slight increase in the value of T_0 an increasing repair rate of unit 'A'. Hence it is recommended that there is no benefit in the value of T_0 on increasing the repair rates of units i.e. increasing repair rates of units will not contribute much in the value of T_0.

Table 6: Availability of the System Table

h_i	h_1	h_2	h_3	h_4	h_5
0.80	0.717	0.717	0.717	0.717	0.717
0.90	0.717	0.717	0.720	0.717	0.717
1	0.717	0.717	0.722	0.717	0.717

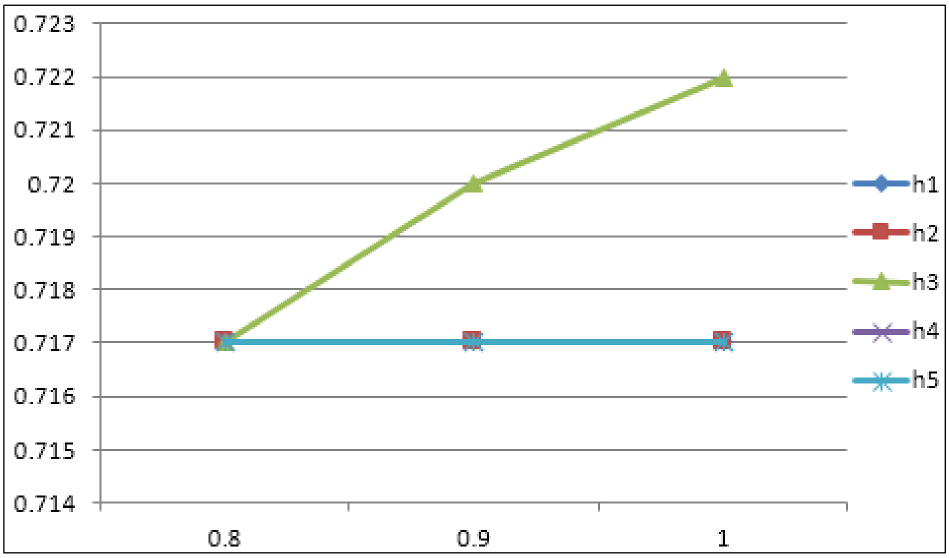


Fig 3: Availability of the System Graph

Keeping failure rates of units fixed (mi = 0.10 □ 'i') and increasing repair rates of units, there is no gain in the value of A_0 as is observed from the table and graph. Hence systems have fixed A_0 for fixed failure rates of units and are independent of the repair rates of units. However there is a small gaining A_0 on increasing repair rate of unit A_0.

Table 7: Busy Period of the Server Table

h_i	h_1	h_2	h_3	h_4	h_5
0.80	0.357	0.357	0.357	0.357	0.357
0.90	0.357	0.357	0.353	0.357	0.357
1	0.357	0.357	0.348	0.357	0.357

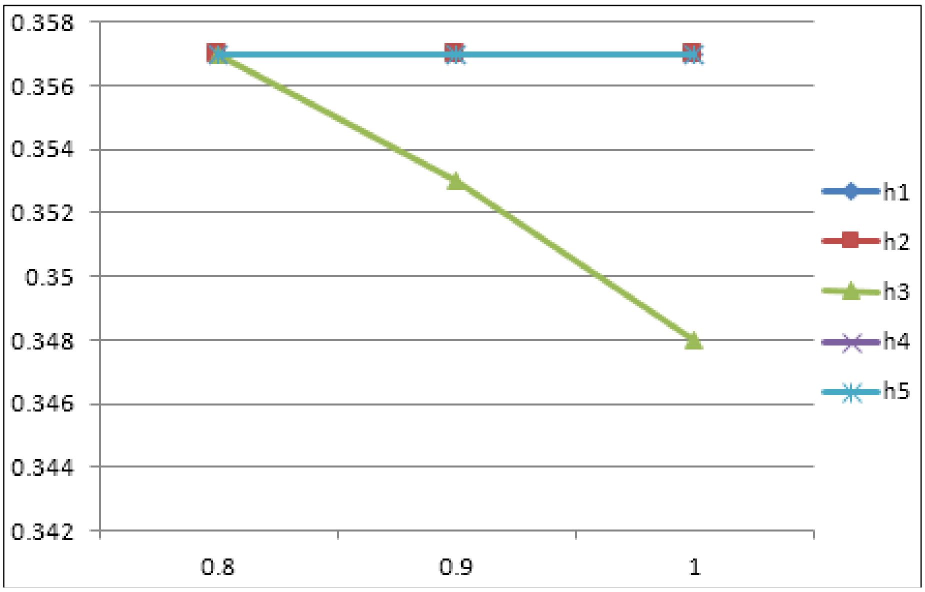


Fig 4: Busy Period of the Server Graph

Keeping failure rates of units (mi = 0.10 □ 'i'). There is not much significance reduction in bus period of the server on increasing the repair rates of units, except or unit 'A' there is a marginal reduction in value of B_0 is clear from the table and graph drawn. Hence better/ repair expert facilities are of not much use.

Table 8: Expected Number of Server's Visits Table

h_i	h_1	h_2	h_3	h_4	h_5
0.80	0.331	0.331	0.331	0.331	0.331
0.90	0.331	0.331	0.327	0.331	0.331
1	0.331	0.331	0.322	0.331	0.331

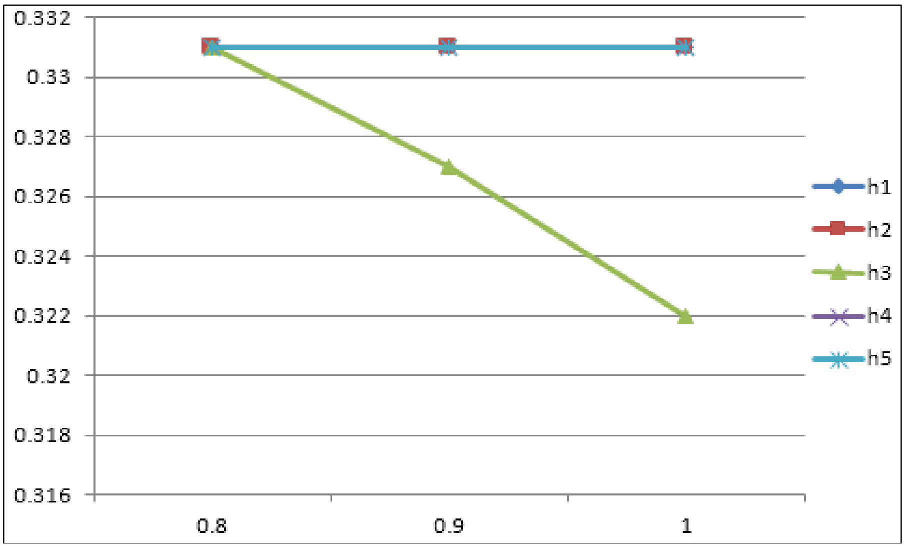


Fig 5: Expected Number of Server's Visits Graph

Fixing failure rates of unit at 0.10 and increasing the repair of individual units, table and graph for values of V_0 is drawn, which shows that better repair facilities do not reduce the value of V_0, there is a very small scope to optimize value of V_0 with the increase in repair rate of unit 'A' or we can say that value of V_0 may solely depend on failure rates of units.

Effect of failure rates of units on system parameters

For fixed repair rate h_i = 0.80 □ i

Table 9: MTSF (T_0) Table

m_i	m_1	m_2	m_3	m_4	m_5
0.10	2.56	2.56	2.56	2.56	2.56
0.20	2.11	2.11	2.31	2.11	2.11
0.30	1.69	1.69	2.25	1.69	1.69

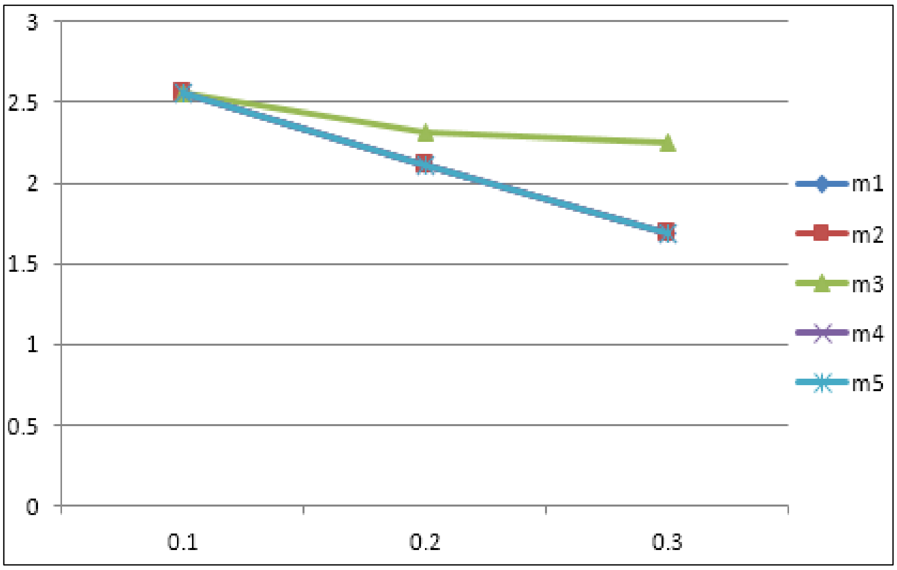


Fig 6: MTSF (T_0) Graph

On moving from top to down in table and from the graph it is concluded that value of T_0 decreases with the increase in failure rates of value units, but is least effected with the increase in failure rate of unit 'A', as on failure of unit 'A' alternatively dung is managed manually. For a good system value of T_0 should be as large possible, hence it is recommended that unit B, D, E, F should be best in quality and design as for as possible.

Table 10: Availability of the System Table

m_i	m_1	m_2	m_3	m_4	m_5
0.10	0.717	0.717	0.717	0.717	0.717
0.20	0.669	0.669	0.675	0.669	0.669
0.30	0.623	0.623	0.639	0.623	0.623

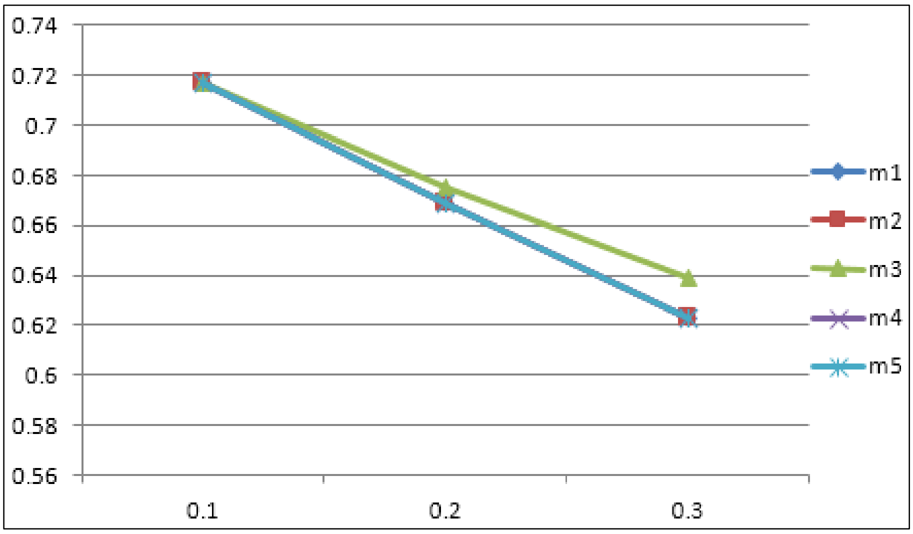


Fig 7: Availability of the System Graph

From the table and graph, we see that keeping repair rate of all units fixed and increasing failure rates of units. There is decrease in the value of A_0 but is least effected with the increase in failure rates of unit 'A' over the others. For an idea system value of A_0 should be as large as possible hence failure rates of units should be very small or which all units of the system should be best in quality and design or best value of A_0.

Table 11: Busy Period of the Server Table

m_i	m_1	m_2	m_3	m_4	m_5
0.10	0.357	0.357	0.357	0.357	0.357
0.20	0.402	0.402	0.402	0.402	0.402
0.30	0.441	0.441	0.441	0.441	0.441

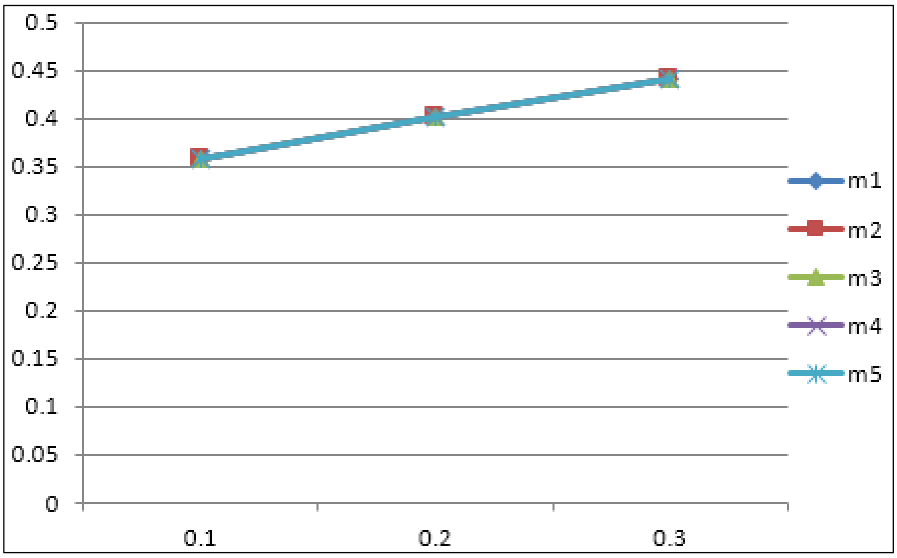


Fig 8: Busy Period of the Server Graph

For a good system value of B_0 should be as small as possible, from the table and graph we see that value of B_0, increase with the increase in failure rates of units and also increases by equal proportions, so keep value of B_0 small failure rates of all units should be as small as possible for which management should arrange and provide all units of best in quality and design, which may increase the cost for best values of B_0.

Table 12: Expected Number of Server's Visits Table

m_i	m_1	m_2	m_3	m_4	m_5
0.10	0.331	0.331	0.331	0.331	0.331
0.20	0.366	0.366	0.366	0.366	0.366
0.30	0.403	0.403	0.403	0.403	0.403

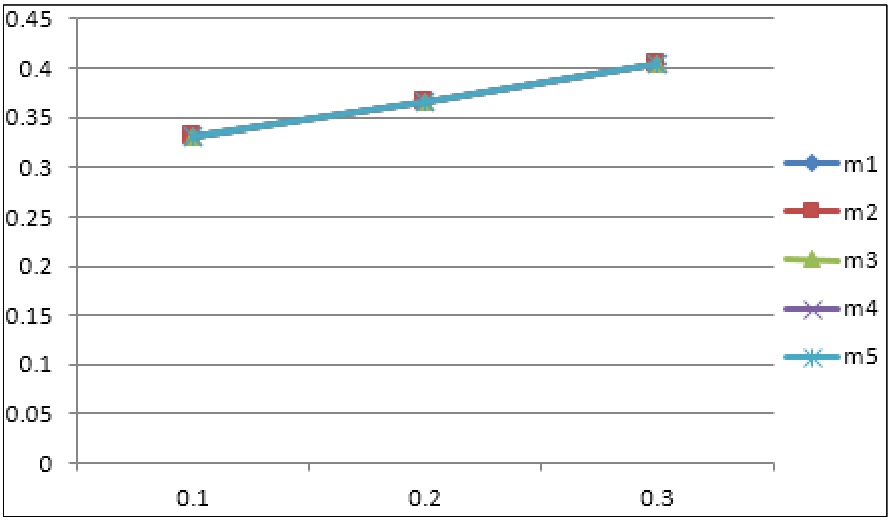


Fig 9: Expected Number of Server's Visits Graph

For a system of repute value of V0 should be as small as possible as large value of V0 will increase the maintenance cost and being bad name to the industry. From the table and graph it is observed that value of V0 increases with the increase in failure rates of units (keeping repair rates fixed). Moreover, increase in failure rates of individual units, increases the value of V_0 by equal proportions. So for an ideal system it is recommended that to keep value of V_0 smallest possible, all the units should be best in quality and design with lowest possible failure rates.

Conclusion

Over all it is concluded that for optimum values of system parameters, all units should be best in quality and design with smallest possible failure rates. Improvement in repair facilities does not have more significant contribution to optimize the system parameter values.

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