International Journal of Statistics and Applied Mathematics 2018; 3(6): 56-61

International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2018; 3(6): 56-61

www.mathsjournal.com
Received: 13-09-2018
Accepted: 14-10-2018

Arun Kumar
Research Scholar, G D Goenka University, Gurugram Haryana, India

Dr. Deepika Garg
Assistant Professor G D Goenka University, Gurugram, Haryana. India

Dr. Pardeep Goel
Associate Professor MM, PG College, Fatehabad, Haryana, India

Correspondence
Arun Kumar
Research Scholar, G D Goenka University, Gurugram Haryana, India

Behaviour analysis of a bread making system

Arun Kumar, Dr. Deepika Garg and Dr. Pardeep Goel

Abstract
The paper discusses the behaviour analysis of a bread making system for system parameters utilizing Regenerative Point Graphical Technique (RPGT). Taking repair & failure rates consistent. A state diagram of framework portraying the transition rates is drawn. Articulations for way probabilities, MTSF, mean sojourn times, availability, system parameters, busy period of server are determined utilizing RPGT. Behaviour analysis of system is done which might be helpful to management in maintaining up the different units of the system Tables and graphs are set up to analyzed and draw the conclusion.

Keywords: Reliability, MTSF, System parameters, etc.

Introduction
The present paper behavioral analysis of a bread making system, which have five sub- units as Mixer, Tunnels, Divider, Oven & Proofer, one permanent repairman who repair all failed units as per the given schedule. There are five types of sub systems mixer (C), Divider (D), proofer (E), oven (F) and Tunnels (G), in sub units are connected in series configuration. Articulations for System parameters are acquired utilizing RPGT. Diagrams & tables are drawn for various estimations of repair & failure rate to think about their effect on the parameters values. Benefit optimization is also discussed. There is a single repairman for fix of fizzled units and in diminished states. The failures rates are exponentially circulated and fix rate are general and are autonomous and are diverse for various operative units. Units are of various limits. Repairs are perfect. The request of need for repair is unit C> unit D> unit E> unit F> unit G. The framework is down when any of the units is in fizzled state or at least two units are in diminished state. Disappointment and repaired are free.

Most of researchers have work in the field of reliability for different techniques. Kumar, R. Sharma and Goel P. [1] have discusses that Behavioral Analysis of Two Unit System Having Stand by having imperfect switch over device using RPGT. Gupta, R. Sharma & Bhardwaj p. [2] have discusses that Cost Benefit Analysis of a Urea Fertilizer Manufacturing system model. Rachita & Garg D. [3] discuss that the transient analysis of markovian queue model with multi stage service. Garg. D & Yadav R. [4] discusses that the system modeling and analysis a case study of EAEP manufacturing plant. Malik, S. C. [5] discusses that the Reliability Modeling and Profit Analysis of a Single-Unit System with Inspection by a Server who Appears and Disappears randomly. Goel, P. [6] discusses that the Availability Analysis and Cost Optimization of Complex System Having Imperfect Switch. Goel, P. & Singh, J. [7] discusses that the Availability Analysis of Butter Manufacturing System in a Diary Plant. Sharma, S.P. and Garg, H. [8] discusses that the Behavioral Analysis of Urea Decomposition System in a Fertilizer Plant. Devi, B., Bansal, R. and Goel, P. [9] discusses that the Reliability and Behavioral Analysis of Yarn Industry of Malwa Region Using RPGT. Malik, N. and Goel P. [10] discusses that the Profit Analysis of Two Modules under Software and Hardware Repair. Goyal, V., Goel R. and Goel P. [11] discusses that the Behavioral Analysis of Two Unit System with Preventive Maintenance in Both Units and Degradation in One Unit. Sharma, S., Gupta, S. and Goel P. [12] discusses that the Availability Modeling and Analysis of Fiber Glasses Industry Using RPGT and its Gamma-Rays Absorption Studies.

Assumptions

1. Single repairman which is available.
2. The conveyances of failure / repair times are consistent.
3. Failures / repairs rates of units are thought to be factually autonomous.
4. Repaired unit is impeccable.
5. We take DRR unit is never fizzled.

Notations

α_i / β_i : Constant repair/ failure rate of units ($0 \leq i \leq 4$).

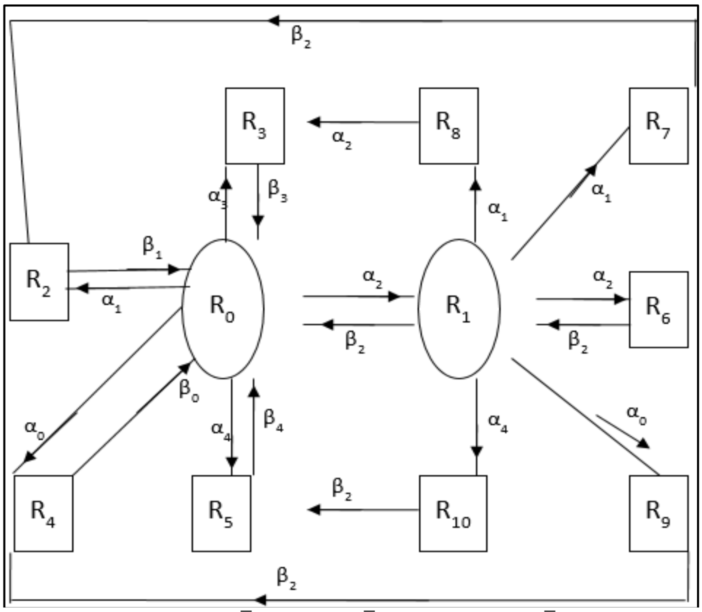
◯ : Full Working State

☐ : Failed State

C/c : Unit in full working / failed state.

D/d : Unit 'D' in full working / failed state. Similarly for other units bar over a unit notation shows unit is under repair.

Taking above assumptions & notations Transition Diagram of system is given below Figure 1.



R0 = CDEFG, R1 = $CDE\bar{F}G$, R2 = $CD\bar{E}FG$, R3 = CD (EF)$\bar{G}$
R4 = $C\bar{D}EFG$, R5 = $CDEF\bar{G}$, R6 = CDeFG, R7 = CdEFG
R8= CdEFG, R9 = cDEFG, R10 = CDEFg

Fig 1: Transition Diagram of Bakery System

Transition Probability of system is given below Table 1

$q_{i,j}$ (t) : Probability density function of regenerative state 'i' or to a failed state 'j' without visiting any other regenerative state in (0,t].

$p_{i,j}$: transition probability from a regenerative state 'i' to a regenerative state 'j'

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

Table 1: Transition Probabilities

$q_{i,j}(t)$	$P_{ij} = q^*_{i,j}(0)$
$q_{0,1}(t) = \alpha_2 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	$p_{0,1} = \alpha_2/(\alpha_1+\alpha_4+\alpha_2+\alpha_0+\alpha_3)$
$q_{0,2}(t) = \alpha_1 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	$p_{0,2} = \alpha_1/(\alpha_1+\alpha_4+\alpha_0+\alpha_2+\alpha_3)$
$q_{0,3}(t) = \alpha_1 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	$p_{0,3} = \alpha_3/(\alpha_4+\alpha_1+\alpha_2+\alpha_0+\alpha_3)$
$q_{0,3}(t) = \alpha_3 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	$p_{0,4} = \alpha_0/(\alpha_4+\alpha_1+\alpha_2+\alpha_3+\alpha_0)$
$q_{0,4}(t) = \alpha_0 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_4)t}$	$p_{0,5} = \alpha_4/(\alpha_1+\alpha_4+\alpha_2+\alpha_0+\alpha_3)$
$q_{0,5}(t) = \alpha_4 e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	
$q_{1,0}(t) = \beta_2 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,0} = \beta_2/(\beta_2+\alpha_1+\alpha_2+\alpha_1+\alpha_0+\alpha_4)$
$q_{1,6}(t) = \alpha_2 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,6} = \alpha_2/(\beta_2+\alpha_2+\alpha_1+\alpha_0+\alpha_1+\alpha_4)$
$q_{1,7}(t) = \alpha_1 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,7} = \alpha_1/(\beta_2+\alpha_4+\alpha_2+\alpha_1+\alpha_0+\alpha_1)$
$q_{1,8}(t) = \alpha_1 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,8} = \alpha_1/(\beta_2+\alpha_0+\alpha_1+\alpha_2+\alpha_1+\alpha_4)$
$q_{1,9}(t) = \alpha_0 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,9} = \alpha_0/(\beta_2+\alpha_1+\alpha_2+\alpha_1+\alpha_0+\alpha_4)$
$q_{1,10}(t) = \alpha_4 e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$p_{1,10} = \alpha_4/(\beta_2+\alpha_1+\alpha_2+\alpha_1+\alpha_0+\alpha_4)$
$q_{2,0}(t) = \beta_1 e^{-\beta_1 t}$	$p_{2,0} = (\beta_1/\beta_1) = 1$
$q_{3,0}(t) = \beta_3 e^{-\beta_3 t}$	$p_{3,0} = 1$

$q_{4,0}\ (t)= \alpha_0 e^{-\alpha_0 t}$	$p_{4,0}$= 1
$q_{5,0}\ (t)= \beta_4 e^{-\beta_4 t}$	$p_{5,0}$= 1
$q_{6,1}\ (t)= \beta_2 e^{-\beta_2 t}$	$p_{6,1}$= 1
$q_{7,2}\ (t)= \beta_2 e^{-\beta_2 t}$	$p_{7,2}$= 1
$q_{8,3}\ (t)= \alpha_2 e^{-\alpha_2 t}$	$p_{8,3}$= 1
$q_{9,4}\ (t)= \beta_2 e^{-\beta_2 t}$	$p_{9,4}$= 1
$q_{10,5}\ (t)= \beta_2 e^{-\beta_2 t}$	$p_{10,5}$= 1

Mean Sojourn Times of system is given below Table 2.

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

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

Table 2: Mean Sojourn Times

$R_i(t)$	$\mu_i=R_i^*(0)$
$R_0(t)= e^{-(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)t}$	$\mu_0 = 1/(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)$
$R_1(t)= e^{-(\beta_2+\alpha_1+\alpha_1+\alpha_2+\alpha_0+\alpha_4)t}$	$\mu_1 = 1/(\beta_2+2\alpha_1+\alpha_2+\alpha_0+\alpha_4)$
$R_2(t)= e^{-\beta_1 t}$	$\mu_2 = 1/\beta_1$
$R_3(t)= e^{-\beta_3 t}$	$\mu_3 = 1/\beta_3$
$R_4(t)= e^{-\alpha_0 t}$	$\mu_4 = 1/\alpha_0$
$R_5(t)= e^{-\beta_4 t}$	$\mu_5 = 1/\beta_4$
$R_6(t)= e^{-\beta_2 t}$	$\mu_6 = 1/\beta_2$
$R_7(t)= e^{-\beta_2 t}$	$\mu_7 = 1/\beta_2$
$R_8(t)= e^{-\alpha_2 t}$	$\mu_8 = 1/\alpha_2$
$R_9(t)= e^{-\beta_2 t}$	$\mu_9 = 1/\beta_2$
$R_{10}(t)= e^{-\beta_2 t}$	$\mu_{10} = 1/\beta_2$

Path Probability

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

$V_{0,0}$ = 1 (Verified), $V_{0,1} = [\alpha_2(\beta_2+2\alpha_1+\alpha_2+\alpha_0+\alpha_4)]/[(\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)(\beta_2+2\alpha_1+\alpha_0+\alpha_4)]$

$V_{0,2} = (\alpha_1\beta_2+2\alpha_1^2+\alpha_1\alpha_0+\alpha_1\alpha_4+\alpha_2\alpha_1)/ (\alpha_2+\alpha_3+\alpha_1+\alpha_0+\alpha_4)\ (\beta_2+2\alpha_1+\alpha_0+\alpha_4)$

$V_{0,3}$ = …….Continued

Path Modeling

Modeling of MTSF (T_0): The un-failed states to which

System can transit (from initial state '0'), before entering failed state are: 'i' = 0, 1 & 'ξ' = '0'.

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

$T_0 = (V_{0,0}\,\mu_0+V_{0,1}\mu_1)/(1\text{-}p_{0,1}p_{1,0})$

Modeling of Availability of the System (A_0): Regenerative states system is available are 'j' = 0, 1 & regenerative states are 'i' = 0 to 10 &'ξ' = '0' the modeling availability is given by

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

$A_0 = \left[\sum_j V_{\xi,j}\,, f_j, \mu_j\right] \div \left[\sum_i V_{\xi,i}\,, f_j, \mu_i^1\right] = (V_{0,0}\mu_0+V_{0,1}\mu_1)/D$

Where $D = (V_{0,0}\mu_0+V_{0,1}\mu_1+V_{0,2}\mu_2+V_{0,3}\mu_3+V_{0,4}\mu_4+V_{0,5}\mu_5+V_{0,6}\mu_6+V_{0,7}\mu_7+V_{0,8}\mu_8+V_{0,9}\mu_9+V_{0,10}\mu_{10})$

Modeling of the Busy Period of Server (Bo): Regenerative states where server j = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 & regenerative states are 'i' = 0 to 10, & ξ = '0', the modeling of busy server are

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

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

$B_0 = (V_{0,1}\mu_1+V_{0,2}\mu_2+V_{0,3}\mu_3+V_{0,4}\mu_4+V_{0,5}\mu_5+V_{0,6}\mu_6+V_{0,7}\mu_7+V_{0,8}\mu_8+V_{0,9}\mu_9+V_{0,10}\mu_{10})/D$

Modeling of the Expected Fractional Number of Inspections by the repair man (Vo): Regenerative states where repairmen do this job j = 1 & regenerative states are i = 0 to 10, & 'ξ' = '0', the number of the modeling repair man is given by

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

$$V_0 = \left[\sum_j V_{\xi,j}\right] \div \left[\sum_i V_{\xi,i}\,,\mu_i^1\right] = (V_{0,1}\mu_1/D)$$

Particular Cases:-For each of the calculation we assumed that unit DRR never failed.

Analytical Example with Particular Cases: Data Analysis and Regenerative Point Graphical Results: For each of the calculation we assumed that unit DRR never failed**,** for $\alpha_i = \alpha$, $\beta_i = \beta$, $(1 \le i \le 4)$

Mean Time to System Failure (T_0)
T_0 = $(\beta+5\alpha)^2/\alpha(25\alpha+4\beta)(\beta+4\alpha)$

MTSF

Table 3: Mean Time to System Failure Graph

	α = 0.5	**α = 0.6**	**α = 0.7**	**α = 0.8**
β = 0.1	0.49907	0.41601	0.35666	0.31212
β = 0.2	0.49829	0.41544	0.35623	0.31179
β = 0.3	0.49761	0.41495	0.35584	0.31148
β = 0.4	0.49704	0.41451	0.35550	0.31121

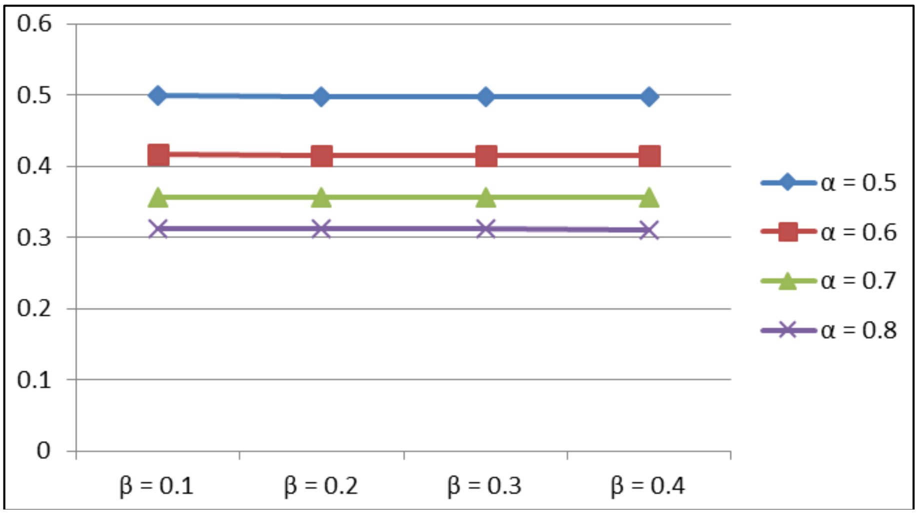


Fig 2: Behaviour analysis of the MTSF, versus failure rate of the unit of system for various estimations of the repair rate. It is concluded that T_0 decrease with increment in the estimations of the failure rate.

Availability of the System
(A_0) $\alpha_i = \alpha$, $\beta_i = \beta$, $(1 \le i \le 4)$
D = $(2\beta^2+14\alpha\beta+19\alpha^2)/5\alpha\,\beta(\beta+4\alpha)$
A_0 = $(\beta^2+5\alpha\beta)/(2\beta^2+14\alpha\beta+19\alpha)$

Table 4: Availability of the System (A_0) Table

A_0	**α = 0.5**	**α = 0.6**	**α = 0.7**	**α = 0.8**
β = 0.1	0.04753	0.04025	0.03491	0.03082
β = 0.2	0.08667	0.07441	0.06519	0.05801
β = 0.3	0.11948	0.10377	0.09171	0.08216
β = 0.4	0.14739	0.12927	0.11512	0.10377

Availability of the System (A_0) Graph

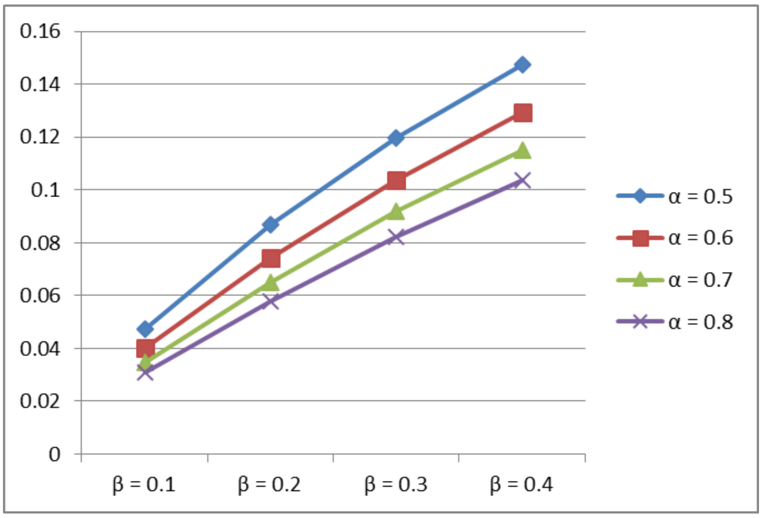


Fig 3: Availability of the System (A_0) Graph

From above we see that the Availability versus repair rate of the unit of system for various estimations of failure rate. It is reasoned that (A_0) decline with increment in the estimations of the repair rate and increment with the expansion in failure rates.

Busy Period of the Server (B_0) $\alpha_i = \alpha$, $\beta_i = \beta$, $(1 \le i \le 4)$
D = $(2\beta^2+14\alpha\beta+19\alpha^2)/5\alpha\,\beta\,(\beta+4\alpha)$
$\mathbf{B_0}$ = $(19\alpha^2+\beta^2+10\alpha\beta)/\,(19\alpha^2+2\beta^2+14\alpha\beta)$

Table 5: Busy Period of the Server (B0) Table

B_0	α = 0.5	α = 0.6	α = 0.7	α = 0.8
β = 0.1	0.96160	0.96753	0.97187	0.97518
β = 0.2	0.92937	0.93953	0.94713	0.95303
β = 0.3	0.90184	0.91509	0.92518	0.93312
β = 0.4	0.87801	0.89353	0.90553	0.91401

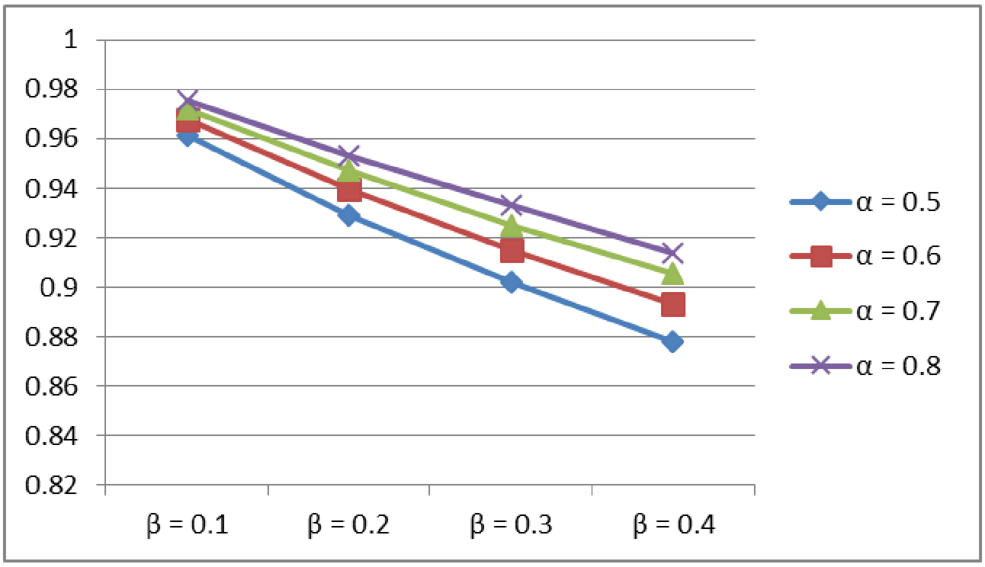


Fig 4: Busy Period of the Server Graph

It is conclude that the value of B_0 show the expected trend for various estimations of failure rate, as B_0 expanding when the repair rate is expanding and decrease with the increase/expanding in failure rate.

Expected Fractional Number of Inspection by the Repairman (V_0)
$\alpha_i = \alpha$, $\beta_i = \beta$, $(1 \le i \le 4)$
D = $(2\beta^2+14\alpha\beta+19\alpha^2)/\,5\alpha\beta(\beta+4\alpha)$
$\mathbf{V_0}$ = $(\beta^2+5\alpha\beta)/(10\beta^2+70\alpha\beta+95\alpha^2)$

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

V_0	$\alpha = 0.5$	$\alpha = 0.6$	$\alpha = 0.7$	$\alpha = 0.8$
$\beta = 0.1$	0.00950	0.00805	0.00698	0.00616
$\beta = 0.2$	0.01733	0.01488	0.01303	0.01160
$\beta = 0.3$	0.02389	0.02075	0.01834	0.01643
$\beta = 0.4$	0.02947	0.02585	0.02302	0.02075

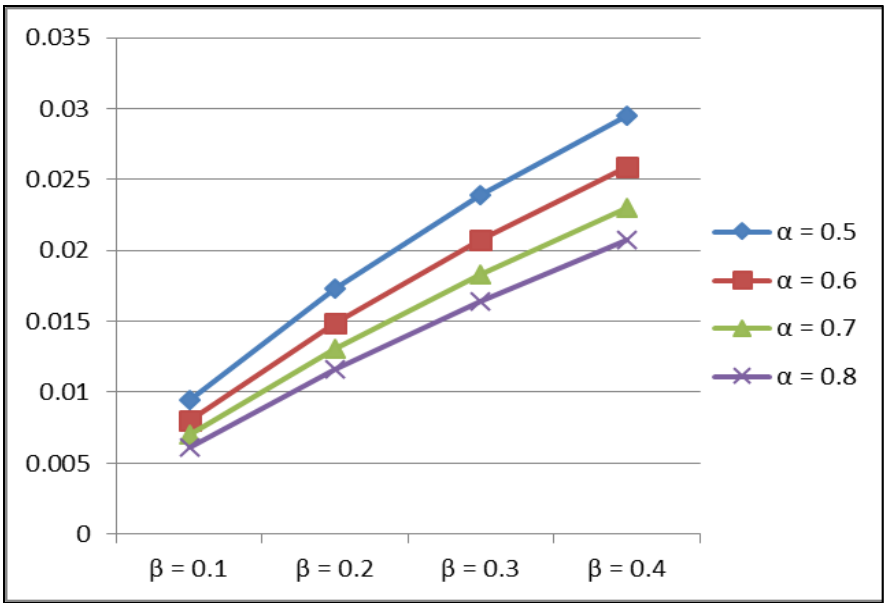


Fig 5: Expected Number of Server's Visits Graph

We see that the V_0 is decrease when the repair rate is increase & increment with the expansion in failure rate, which ought to be really.

References

1. Kumar R Sarla, Goel P. Behavioral Analysis of Two Unit System with Warm Stand by Having Imperfect Switch over Device Using RPGT, IJETSR. 2015; 2(11):202-212. ISSN 2394-3386.
2. Gupta R, Sharma S, Bhardwaj P. Cost Benefit Analysis of a Urea Fertilizer Manufacturing System Model, Journal of Statistics a Application & Probability Letters An International Journal. 2016; 3:119-132.
3. Rachita Ms, Garg D. Transient analysis of markovian queue model with multi stage service 21-22 Oct 2016, Red set, 2016, 264-272
4. Accepted Garg D, Yadav R. Systems Modeling and Analysis: A Case Study of EAEP manufacturing Plant, Indiacom-2017, IEEE ID-40353.
5. Malik SC. Reliability Modeling and Profit Analysis of a Single-Unit System with Inspection by a Server who Appears and Disappears randomly, Journal of Pure and Applied Mathematika Sciences, 67. 2008; (1-2):135-146.
6. Goel P. Availability Analysis And Cost Optimization Of Complex System Having Imperfect Switch Ph.D. Thesis, Kurukshetra University, Kurukshetra (KUK), India, 1997.
7. Goel P, Singh J. Availability Analysis of Butter Manufacturing System in a Diary Plant'; Proc. of International Conference on Operational Research for A Better Tomorrow, 1998, 109-116.
8. Sharma SP, Garg H. Behavioral analysis of urea decomposition system in a fertilizer plant, Int. J. Industrial and Systems Engineering. 2011; 8(3):271 -297.
9. Devi B, Bansal R, Goel P. Reliability and Behavioral Analysis of Yarn Industry of Malwa Region Using RPGT (A Case Study)", IJETMAS, Special Issue. 2015; 3:135-145. ISSN 2349-4476.
10. Malik N, Goel P. Profit Analysis of Two Modules under Software and Hardware Repair, IJETMAS, Special Issue. 2015; 3:111-119. ISSN 2349-4476.
11. Goyal V, Goel R, Goel P. Behavioral Analysis of Two Unit System with Preventive Maintenance in Both Units and Degradation in One Unit, IJETMAS, Special Issue. 2015; 3:120-130. ISSN 2349-4476.
12. Sharma S, Gupta S, Goel P. Availability Modeling and Analysis of Fiber Glasses Industry Using RPGT and its Gamma-Rays Absorption Studies", IJETMAS, Special Issue. 2015; 3:152-161. ISSN 2349-4476.