International Journal of Engineering, Science and Mathematics
Vol. 11 Issue 03, March 2022,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in,
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-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Sensitivity Analysis of a Biscuit Making Plant in Sonipat

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DOI: 10.6084/m9.figshare.19811767

Abstract: In this research paper sensitivity analysis of a biscuit making plant having three units with constant failure and repair rate using RPGT is carried out. 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.

Keywords: Biscuit Plant, RPGT, Sensitivity Analysis

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 paper discussed the sensitivity analysis to analyze transient behavior of repairable biscuit manufacturing plant using RPGT, based on Markov modeling for modeling system parameters equations. A biscuit manufacturing plant in Sonipat in Haryana has been taken up or study. A biscuit industrial plant contains of following sub-units tilter framework and dough hopper (A), cutter and conveyor (B), metal detector and rotary system (M). Unit 'A' is more perilous, hence a cold standby sub-unit is providing in the framework to enhance the accessibility and another parameters of the framework. To keep the best value of framework parameter a server upkeep facility is also providing, it is usually expected that server never fails, but almost server may not be continuously accessible or not fail due to one reason or another, hence requirements service/ treat sub-unit or same signify to do its intended purpose. Significance order to repair the sub-units and server are M > B > A.Rajbala & Kumar [2021] discussed the reliability and availability analysis using RPGT-A general approach. Kumar and Garg [2019] have discussed the reliability technology theory. Kumar et al. [2018] have studied behaviour analysis of a bread making system. Kumar et al. [2019] analyzed sensitivity analysis of a cold standby framework with priority for PM. Rajbala, et al. [2019] have studied the system modeling and analysis: a case study EAEP manufacturing plant. Kumar et al. [2017] have studied behavior analysis in the urea fertilizer industry. Kumar et al. [2017] have examined the profit analysis of an edible oil refinery plant. Kumar et al. [2019] studied the behavioral analysis of a washing unit in paper mill. Agrawal et al. [2021] studied the Water Treatment Reverse Osmosis Plant using RPGT. Kumar et. al. [2018] paper analyzed sensitivity analysis of 3:4:: good system plant. Kumari et al. [2021] studied the constrained problems using PSO. Kumar and Garg [2021] studied the Reliability technology theory and application.

Notations

$y_{i:}$ Constantrepair rates; $x_{i:}$ Constantfailure rates

AOS:- Availability of the System; BPOS:- Busy Period of the Server

ENOIR:- Expected Number of Inspections by repairman

Transition Diagrams:

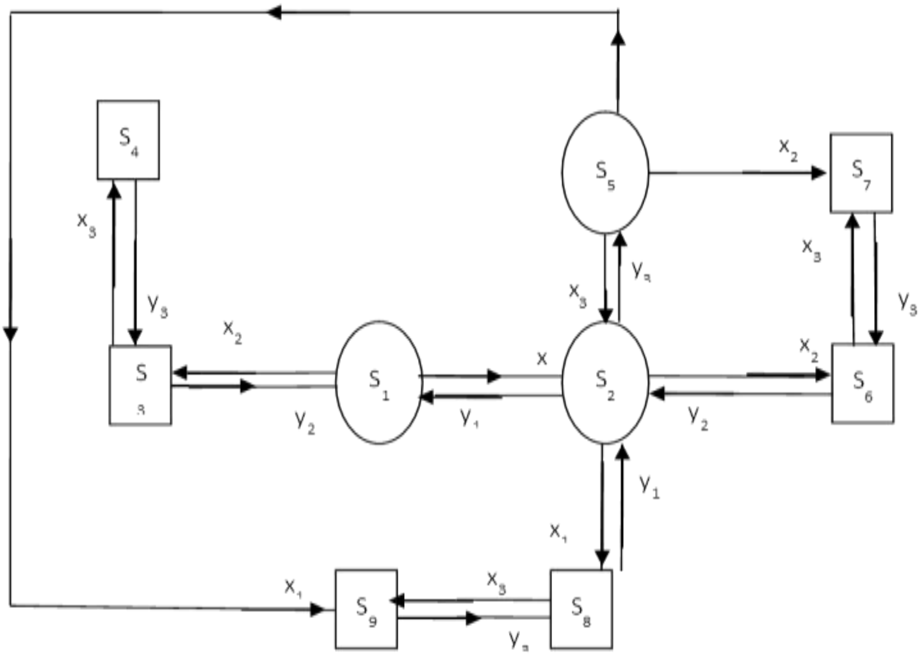

Fig. 1: Transition Diagram of Biscuits Plant in Sonipat

S_0 = A(A)B, S_1 = aAB, S_2 = A(A)b, S_3 = A(A)bM,

S_4 = aABM, S_5 = aAb, S_6 = aAbM, S_7 = aaB, S_8 = aaBM,

Transition Probabilities [$q_{i,j}(t)$]

$q_{1,2}(t) = x_1\ e^{-(x_1+x_2)t}$

$q_{1,3}(t) = x_2\ e^{-(x_1+x_2)t}$

$q_{2,1}(t) = y_1\ e^{-(x_1+x_2+x_3+y_1)t}$

$q_{2,5}(t) = x_3\ e^{-(x_1+x_2+x_3+y_1)t}$

$q_{2,6}(t) = x_2\ e^{-(x_1+x_2+x_3+y_1)t}$

$q_{2,8}(t) = x_1\ e^{-(x_1+x_2+x_3+y_1)t}$

$q_{3,1}(t) = y_2\ e^{-(y_2+x_3)t}$

$q_{3,4}(t) = x_3\ e^{-(y_2+x_3)t}$

$q_{4,3}(t) = y_3\ e^{-y_3t}$

$q_{5,2}(t) = y_3\ e^{-(x_1+x_2+y_3)t}$

$q_{5,7}(t) = x_2\ e^{-(x_1+x_2+y_3)t}$

$q_{5,9}(t) = x_1\ e^{-(x_1+x_2+y_3)t}$

$q_{6,2}(t) = y_2\ e^{-(x_3+y_2)t}$

$q_{6,7}(t) = x_3\ e^{-(x_3+y_2)t}$

$q_{7,6}(t) = y_3\ e^{-y_3t}$

$q_{8,2}(t) = y_1\ e^{-(x_3+y_1)t}$

$q_{8,9}(t) = x_3\ e^{-(x_3+y_1)t}$

$q_{9,8}(t) = y_3 e^{-y_3t}$

$p_{i,j} = q^*_{i,j}(t)$

$p_{1,2} = x_1/(x_1+x_2)$

$p_{1,3} = x_1/(x_1+x_2)$

$p_{2,1} = x_1/(x_1+x_2+x_3+y_1)$

$p_{2,5} = x_3/(x_1+x_2+x_3+y_1)$

$p_{2,6} = x_2/(x_1+x_2+x_3+y_1)$

$p_{2,8} = x_1/(x_1+x_2+x_3+y_1)$

$p_{3,1} = y_2/(y_2+x_3)$

$p_{3,4} = x_3/(y_2+x_3)$

$p_{4,3} = 1$

$p_{5,2} = y_3/(x_1+x_2+y_3)$

$p_{5,7} = x_2/(x_1+x_2+y_3)$

$p_{5,9} = x_1/(x_1+x_2+y_3)$

$p_{6,2} = y_2/(x_3+y_2)$

$p_{6,7} = x_3/(x_3+y_2)$

$p_{7,6} = 1$

$p_{8,2} = y_1/(y_1+x_3)$

$p_{8,9} = x_3/(y_1+x_3)$

$p_{9,8} = 1$

Mean Sojourn Times [$R_i(t)$]

$R_1(t)=e^{-(x_1+x_2)t}$

$R_2(t)=e^{-(x_1+x_2+x_3+y_1)t}$

$R_3(t)=e^{-(y_2+x_3)t}$

$R_4(t)=e^{-y_3t}$

$R_5(t)=e^{-(x_1+x_2+y_3)t}$

$R_6(t)=e^{-(x_3+y_2)t}$

$R_7(t)=e^{-y_3t}$

$R_8(t)=e^{-(y_1+x_3)t}$

$R_9(t)=e^{-y_3t}$

$\mu_i=R_i^*(0)$

$\mu_1 = 1/(x_1+x_2)$

$\mu_2 = 1/(x_1+x_2+x_3+y_1)$

$\mu_3 = 1/(y_2+x_3)$

$\mu_4 = 1/y_3$

$\mu_5 = 1/(x_1+x_2+y_3)$

$\mu_6 = 1/(x_3+y_2)$

$\mu_7 = 1/y_3$

$\mu_8 = 1/(y_1+x_3)$

$\mu_9 = 1/y_3$

Evaluation of Path Probabilities: Applying RPGT and utilizing '1' as initial-state of the framework, we discovery transition probability aspects of allaccessible states from first state 'ξ' = '1' .

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

$V_{1,2}= p_{1,2}/(1-p_{2,5}\,p_{5,2})[1-\{(p_{2,6}\,p_{6,2}/(1-p_{6,7}\,p_{7,6})\}][1-\{(p_{2,8}\,p_{8,2}/(1-p_{8,9}\,p_{9,8})\}]$

$V_{1,3} =$ …..Continuous

Transition state probabilities from base state '2' are

$V_{2,1} = p_{2,1}/\{(1 - p_{1,3}\, p_{3,1})/(1 - p_{3,4}\, p_{4,3})\}$

$V_{2,2} = 1$

$V_{2,3} = \ldots$Continuous

Modeling System Parameters

MTSF (T_0): Regenerative un-failed states to which the framework can transit (initial state '2'), earlierincoming any fizzled state are: 'i' = 1, 2, 5 attractive 'ξ' = '1'

$T_0 = (V_{1,1}\,\mu_1 + V_{1,2}\,\mu_2 + V_{1,5}\,\mu_5)/\{1- (1, 2, 1)\}$

AOS (A_0): Regenerative states at which the framework is accessible are 'i' = 1, 2, 5attractive 'ξ' = '1'

$A_0 = (V_{2,1}\,\mu_1 + V_{2,2}\,\mu_2 + V_{2,5}\,\mu_5)/Z_1$

$\therefore Z_1 = V_{2,1}\,\mu_1 + V_{2,2}\,\mu_2 + V_{2,3}\,\mu_3 + V_{2,4}\,\mu_4 + V_{2,5}\,\mu_5 + V_{2,6}\,\mu_6 + V_{2,7}\,\mu_7 + V_{2,8}\,\mu_8 + V_{2,9}\,\mu_9$

BPOS (B_0): Regenerative states where server is busy are $2 \leq j \leq 9$, attractive ξ = '1'

$B_0 = 1-(\mu_j/D)$

ENOIR (V_0): Regenerative states where repair man does this job j = 2, 5 taking 'ξ' = '1', number of visit by repair man is given by

$V_0 = (V_{1,2} + V_{1,5})/ D$

Sensitivity Analysis: Effect of repair rates on system (keeping failure rates fixed): -

Effect on MTSF (T_0) parameters

Table 1: MTSF

y_i	y_1	y_2	y_3
0.8	7.495	7.495	7.495
0.9	7.495	7.495	7.495
1	7.495	7.495	7.495

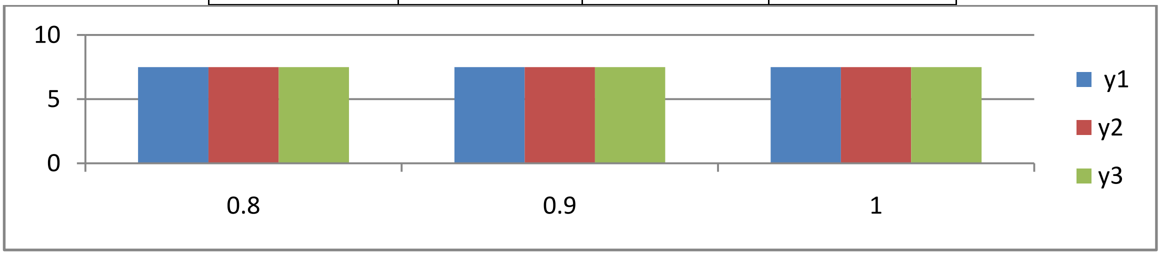

Fig. 2: MTSF

Effect on AOS (A_0)

Table 2: AOS

y_i	y_1	y_2	y_3
0.8	0.822	0.817	0.812
0.9	0.829	0.822	0.819
1	0.832	0.825	0.822

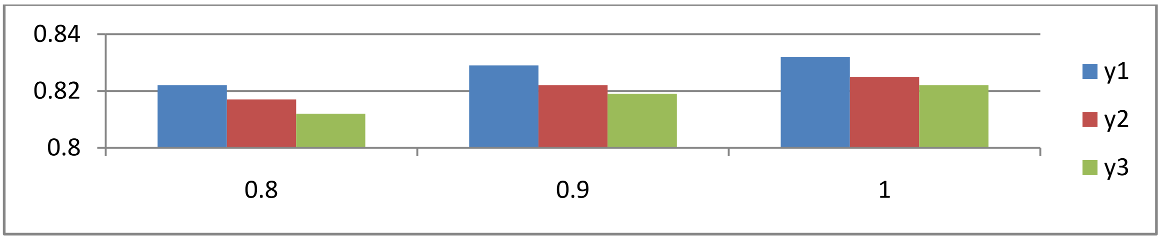

Fig. 3: AOS

Effect on BPOS (B_0)

Table 3: BPOS

y_i	y_1	y_2	y_3
0.8	0.211	0.232	0.289
0.9	0.198	0.211	0.246
1	0.167	0.185	0.211

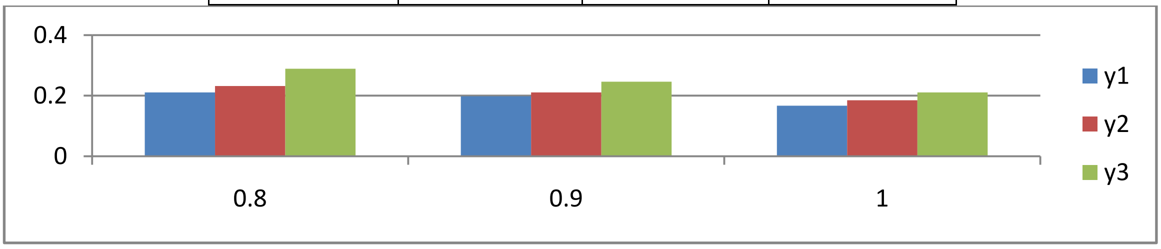

Fig. 4: BPOS

Effect on ENOIR (V_0)

Table 14: ENOIR

y_i	y_1	y_2	y_3
0.8	0.108	0.121	0.156
0.9	0.104	0.108	0.129
1	0.091	0.098	0.108

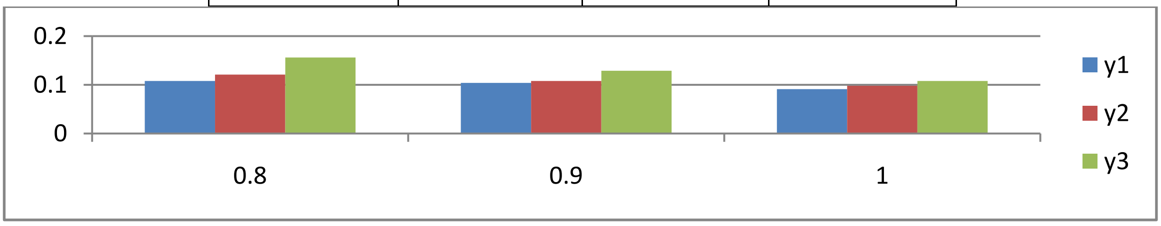

Fig. 5: ENOIR

Effect of change of failure rates (keeping repair rate fixed)

MTSF

Table 5: MTSF

x_i	x_1	x_2	x_3
0.1	3.125	3.186	3.198
0.2	2.999	3.125	3.156
0.3	2.962	3.103	3.125

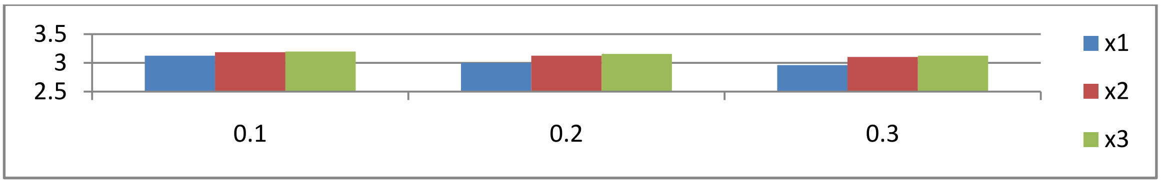

Fig. 6: MTSF

AOS

Table 6: AOS

x_i	x_1	x_2	x_3
0.1	0.996	0.999	0.999
0.2	0.959	0.996	0.998
0.3	0.906	0.923	0.996

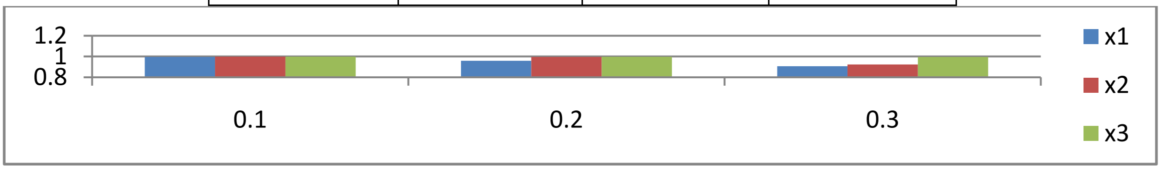

Fig. 7:AOS

BPOS (B_0)

Table 7: BPOS

x_i	x_1	x_2	x_3
0.1	0.353	0.286	0.261
0.2	0.389	0.353	0.302
0.3	0.423	0.379	0.353

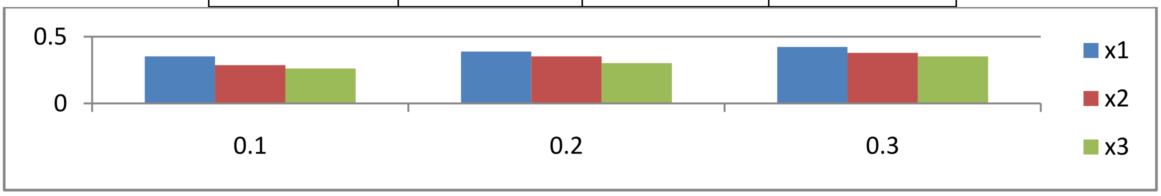

Fig. 8: BPOS

ENOIR (V_0)

Table 8: ENOIR

x_i	x_1	x_2	x_3
0.1	0.213	0.213	0.213
0.2	0.298	0.270	0.243
0.3	0.308	0.286	0.285

Fig. 9:ENOIR

Conclusion: From above tables and graph we see that the result obtained using RPGT is same as obtained by using RPT. But in RPGT one attained the result very easily and quickly without writing any state equations and without any cumbersome procedures, long calculations and simplifications.. It is hoped that the RPGT for the analysis of the framework will be very accommodating to the organizations, manufactures and the individual engaged in reliability manufacturing and working for the performance.

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