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AVAILABILITY ANALYSIS OF A MANUFACTURING PLANT USING RPGT

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Abstract

In this paper, behaviour of a milk food plant is analyzed which is separated by binary components, one component is milk manufacturing and the binary component is secondary manufacturing goods like raw milk, milk packets, desi Ghee, etc that are manufactured by another unit. By using some assumptions, the availability of the structure is found out with respect to the failure rate vs repair rate of the subsystems. For this purpose, the state transition diagram Figure 1 is made and the states of possibilities of the system are discussed the calculation of the availability of the structure with the help of Regenerative point to graphical technique (RPGT) is analyzed. Table 7 and Figure 2 reveal the analysis of the availability of the system.

Keywords: Availability, Analyse, Transition Diagram, Manufacturing plant.

I. Introduction

At present time, producers have to manufacture their products successively to see the growing demand for their goods. Manufacturer can increase their production with their raw materials as much as they have in a well-organized manner. This research for analyzing the availability and behavioral Investigation of milk food plants is separated into two components, using the Regenerative Point Graphical Technique (RPGT). These two components are designated as 'P' and 'Q' where 'P' is the milk manufacturing component and 'Q' is for secondary goods like raw milk, packets of milk, desi ghee, etc. As milk is in high demand in the marketplace component 'P' is the crucial component for the structure, therefore, component 'P' is retained in active condition for the long run, so repairing component 'P' is a priority over component of 'Q'. The structure is in completely active condition if there is at least one of the components in active form and the structure would fail if both of the components failed.

None of them could be flopped if the structure is in damage form. If both of the components are in active form, then the structure is in fully producing form. When any component of the structure fails then the structure works in concentrated form and during the damage component is gone for instant recovery. Repair is flawless, repairing of the components did not harm the structure and the recovered component acted at full capacity as it is a new one. And in continuation, if 'P' and 'Q' both of the components of the structure are damaged, then recovery of component 'P' is specified before the recovery of component 'Q'. These are supposed to be statistically independent of one another. A state transition diagram Figure 1 of the structure is drawn to find 'base condition'. The structure is deliberated for steady-state circumstances but the many constraints of the structure are evaluated with the help of RPGT.

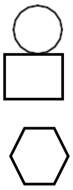
II. System Description

II.i. Assumptions

- The structure contains two indistinguishable components 'P' and 'Q'. 'P' is the main component and 'Q' component is secondary.
- One serviceman for the repair facility is accessible for both components 'P' and 'Q'.
- Recovery of the components is flawless in other words it does not harm any portion of the components during recovery.
- When both components fail then the structure is in failed form.
- When both components 'P' and 'Q' are in the failed form then the serviceman repair component 'P' on an urgent basis.
- The structure is deliberated for time-dependent circumstances.
- Both the components cannot flop instantaneously.

II.ii. Notations:

S_i : State of possibilities where $i = 0,1,2,3$;
P, Q: Fully working units of the system;
p, q : Failure units of the system;
h_i : Failure rate;
m_i : Repair rate;
$q_{m,n}$: Transition Possibility from a reformative stage 'm' to a reformative stage n without visiting any other reformative stage;
$p_{m,n}$: Laplace transform of $q_{m,n}$ at '0'in time interval $(0, t]$;
$R_j(t)$: Dependability of the structure at time interval t, when the system arrived into reformative stage 't';
$A_j(t)$: Availability of the structure at a time 't', when structure arrived in reformative stage 'j';
μ_j : Mean sojourn time;
$V_j(t)$: Expected no. of serviceman visit in the plant due to failure of components of structure of reformative stage 'j';



: Fully working state;
: Failed State;

: Regenerative State;

Considering the above conventions and symbolizations, the state transition diagram of the structure is:

II.iii. State Transition Diagram:

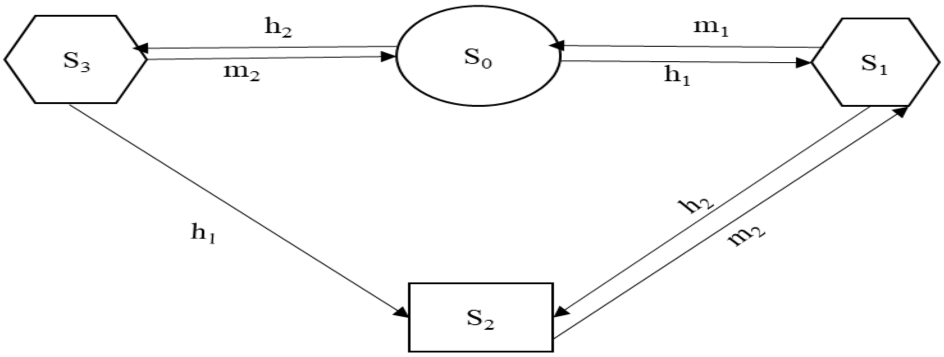


Fig. 1. State Transition Diagram

Where, $S_0 = PQ$; $S_1 = pQ$; $S_2 = pq$; $S_3 = Pq$;
Stages S_0, S_1, S_2, and S_3 are reformative stages. The possible transitions among stages with possible time are shown in Figure 1.

Table 1: The path of transition from vertices $i = 0, 1, 2, 3$ to various vertices

i	0	1	2	3
0	(0,1,0) (0,3,0) (0,3,2,1,0)	(0,1) (0,3,2,1)	(0,1,2) (0,3,2)	(0,3)
1	(1,0)	(1,0,1)	(1,0,3,2)	(1,0,3)
2	(2,1,0)	(2,1)	(2,1,0,3,2)	(2,1,0,3)
3	(3,0)	(3,0,1) (3,2,1)	(3,2) (3,0,1,2)	(3,0,3)

Table 2: Principal, Subordinate & Tertiary routes at several vertices.

i	$CL1$	$CL2$	$CL3$
0	(0,1,0) (0,3,0) (0,3,2,1,0)	(1,2,1) – –	– – –
1	(1,0,1)	(0,1,0) (0,3,0)	– –
2	(2,1,0,3,2)	(1,0,1) (0,3,0)	– –
3	(3,0,3)	(0,1,0)	–

Analysis table of Prime, Subordinate & Tertiary routes to determine the base state by using Table 1 and Table 2 is given in Table 3.

Table 3: Description of Principal, Subordinate and Tertiary Routes to find base state

Vertex i	No. of Principal Routes	No. of Subordinate Routes	No. of Tertiary Routes
0	03	1	-
1	01	2	-
2	01	2	-
3	01	1	-

From Table 3 it is observed that at working state '0' there is a maximum number of routes, therefore state '0' is the base state.

Table 4: Principal, Subordinate & Tertiary circuits w.r.t. simple paths (Initial - State '0')

J	$\left(0 \xrightarrow{S_r} j\right): P_0$	(P_1)	(P_2)
0	$\left(0 \xrightarrow{S_0} 0\right)$: (0,1,0) $\left(0 \xrightarrow{S_1} 0\right)$: (0,3,0) $\left(0 \xrightarrow{S_2} 0\right)$: (0,3,2,1,0)	(1,2,1) – (2,1,2)	– – –

J	$\left(0 \overset{S_r}{\rightarrow} j\right) : P_0$	(P_1)	(P_2)
1	$\left(0 \overset{S_0}{\rightarrow} 1\right)$: (0,1) $\left(0 \overset{S_1}{\rightarrow} 1\right)$: (0,3,2,1)	(1,2,1) (2,1,2)	– –
2	$\left(0 \overset{S_0}{\rightarrow} 2\right)$: (0,1,2) $\left(0 \overset{S_1}{\rightarrow} 2\right)$: (0,3,2)	(1,2,1) (2,1,2)	– –
3	$\left(0 \overset{S_0}{\rightarrow} 3\right)$: (0,3)	–	–

III. Evolution Possibilities and the Mean Sojourn Time:

III.i. Evolution Possibilities:

$\boldsymbol{q_{m,n}(t)}$: The possibility density function (p.d.f.) of the primary route period from a reformative stage 'm' to a reformatory stage 'n' or else to an unsuccessful stage 'n' without visiting any other reformative stage in the time interval $(0, t]$.
$\boldsymbol{p_{m,n}(t)}$: The steady-state evolution possibility from a reformative stage 'm' to a reformative stage 'n' without visiting any other reformative stage. $p_{m,n}(t) = q_{m,n} * (t)$;
where * denotes Laplace transformation.

Table 5: Transition Possibilities

$\boldsymbol{q_{m,n}(t)}$	$\boldsymbol{p_{m,n}(t) = q_{m,n} * (t)}$
$q_{0,1}(t) = h_1 e^{-(h_1+h_2)t}$ $q_{0,3}(t) = h_2 e^{-(h_1+h_2)t}$	$p_{0,1}(t) = h_1/(h_1 + h_2)$ $p_{0,3}(t) = h_2/(h_1 + h_2)$
$q_{1,0}(t) = m_1 e^{-(m_1+h_2)t}$ $q_{1,2}(t) = h_2 e^{-(m_1+h_2)t}$	$p_{1,0}(t) = m_1/(m_1 + h_2)$ $p_{1,2}(t) = h_2/(m_1 + h_2)$
$q_{2,1}(t) = m_2 e^{-(m_2)t}$	$p_{2,1}(t) = 1$
$q_{3,0}(t) = m_2 e^{-(h_1+m_2)t}$ $q_{3,2}(t) = h_1 e^{-(h_1+m_2)t}$	$p_{3,0}(t) = m_2/(h_1 + m_2)$ $p_{3,2}(t) = h_1/(h_1 + m_2)$

Hence, it can be easily verified that the forecast of a total stage possibility is 1.
$p_{0,1} + p_{0,3} = 1;\ \ p_{1,0} + p_{1,2} = 1;\ \ p_{3,0} + p_{3,2} = 1;\ \ p_{2,1} = 1$

III.ii. Mean Sojourn Time:

$R_j(t)$: The dependability of the structure at time interval t, when the structure is in reformatory stage 'j'.

μ_j : The mean sojourn time is the time consumed in the stage 'j', before staying any other stages calculated with the assistance of $R_j(t)$.

Table 6: Mean Sojourn Time

$R_j(t)$	$\mu_j = R_j^*(0)$
$R_0(t) = e^{-(h_1+h_2)t}$	$\mu_0 = 1/(h_1+h_2)$
$R_1(t) = e^{-(m_1+h_2)t}$	$\mu_1 = 1/(m_1+h_2)$
$R_2(t) = e^{-(m_2)t}$	$\mu_2 = 1/(m_2)$
$R_3(t) = e^{-(h_1+m_2)t}$	$\mu_3 = 1/(h_1+m_2)$

IV. Evaluation of path possibilities:

The Accessibility of the organization under stable stage circumstances is assessed, by applying the technique 'Regenerative Point Graphical Technique (RPGT)' and using '0'as the base stage of the structure as given below:
The evolution possibility components of all the accessible stages from the base-stage '0' are:

$$V_{0,0} = (0,1,0)/[1-(1,2,1)] + (0,3,0) + (0,3,2,1,0)/[1-(2,1,2)]$$
$$= p_{0,1}p_{1,0}/(1-p_{1,2}p_{2,1}) + p_{0,3}p_{3,0} + p_{0,3}p_{3,2}p_{2,1}p_{1,0}/(1-p_{2,1}p_{1,2}) \quad (1)$$

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

$$= p_{0,1}/[1-p_{1,2}p_{2,1}] + (p_{0,3}p_{3,2}p_{2,1})/[1-p_{2,1}p_{1,2}] \quad (2)$$

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

$$= p_{0,1}p_{1,2}/[1-p_{1,2}p_{2,1}] + (p_{0,3}p_{3,2})/[1-p_{2,1}p_{1,2}] \quad (3)$$

$$V_{0,3} = (0,3) = p_{0,3} \quad (4)$$

V. Availability of the System (A_0):

It is clear from Figure 1 that the regenerative state presents the state where the structure is accessible are $j = 0,1,3$ and reformative states are $i = 0\ to\ 3$. By using Table 5 and Table 6, the availability of the system can be calculated as:

$$A_0 = (\sum_{i=0,1,3} V_{0,i}\,\mu_i)/(\sum_{i=0,1,2,3} V_{0,i}\,\mu_i)$$

$$A_0 = (V_{0,0}\mu_0 + V_{0,1}\mu_1 + V_{0,3}\mu_3)/(V_{0,0}\mu_0 + V_{0,1}\mu_1 + V_{0,2}\mu_2 + V_{0,3}\mu_3) \quad (5)$$

V.i. Availability (A_0) Vs Repair Rate (m) and Failure Rate (h):

Table 7: Availability (A_0) Vs Repair Rate (m) and Failure Rate (h)

h	$(m = 0.80)$	$(m = 0.85)$	$(m = 0.90)$	$(m = 0.95)$
0.05	0.893561	0.899207	0.904283	0.908873
0.06	0.875942	0.882407	0.888231	0.893506
0.07	0.859302	0.866511	0.873017	0.87892
0.08	0.843558	0.851447	0.858578	0.865056
0.09	0.828639	0.837149	0.844854	0.851864
0.10	0.814480	0.823559	0.831793	0.839293

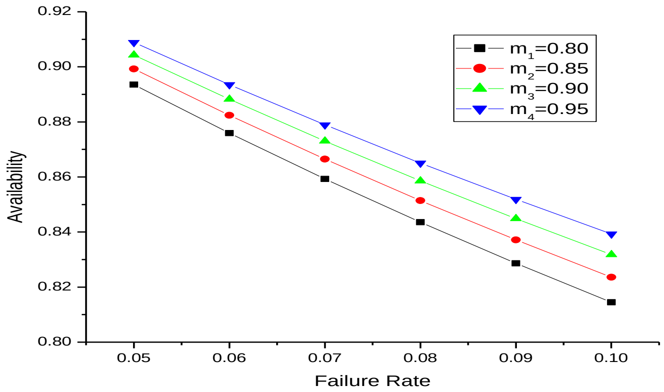


Fig. 2. Availability Vs Repair rate and failure rate

VI. Result and Discussion

- The accessibility of the organization is evaluated for numerous values of the defective rate (h) by keeping $h = 0.05, 0.06, 0.07, 0.08, 0.09, 0.10$; and for numerous values of the repair (m) by keeping $m = 0.80, 0.85, 0.90, 0.95$ as shown in Table 7.
- Figure 2 is a graphical representation of the relation between Availability (A_0) and repair and failure rate.

VII. Conclusion:

It can be concluded that the relation between repair rate and availability is positively co-related and failure rate and availability are reversible.

Conflict of interest:

The author declares that there was no conflict of interest in this paper.

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