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Behaviour Analysis of a Case Study of Rico Manufacturing Plant Using RPGT

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ABSTRACT: - In this research paper, Behaviour analysis of a Rico Manufacturing Plant is carried out by using Regenerative Point Graphical Technique (RPGT) under specific conditions for system parameters**.** The paper analyzes the behavior of an EGR air exhaust pipe (EAEP) of Rico manufacturing plant consisting of five subsystems namelySand core making machine, Horizontal machine, Gravity die casting machine, Vibrator machine, and Cutting machine. All the machines are arranged in series. The system is in a working state when all subsystems are in good condition. A repair facility is accessible for all subunits.Finally, numerical analysis is carried out for calculating the performance measures and their comparisons.

Keywords: -Regenerative Point Graphical Technique, Availability,Rico Plant.

1. Introduction

Reliability is a significant concern in the arranging, manufacturing and plan process of mechanical segments. As the quantity of systems and size of the mining gear keep on increment, the implications of segment disappointment become consistently basic. An unexpected failure can influence in significantly higher repair costs than an arranged maintenance or repair. One methodology to reduce the impact of failures is to improve the reliability and availability of the segments. An initial phase in reliability and availability improvement is assortment and study of the right information.

Asi et al. (2021) have carried out a relative investigation of the five productive reliability techniques to start general rues for the probabilistic evaluation of bridge pier. Kumar et al.

(2019) the main objective of this paper is to an examined analysis of a washing unit in the paper industry utilizing RPGT. Kumar et al. (2018, 2017) have studied the behavior analysis of a bread system and edible oil refinery plant. Kumar et al. (2019) analyzed a cold standby framework with priority for preventive maintenance contains two identical subunits with server failure utilizing RPGT. Gupta (2008), Chaudhary et al. (2013), Goyal and Goel (2015), Yusuf (2012) and Gupta et al. (2016) have discussed behavior with perfect and imperfect switch-over of systems using various techniques.

2. Problem Description

The paper analyzes the behavior of an EGR air exhaust pipe (EAEP) of Rico manufacturing plant consisting of five subsystems.All the machines are arranged in series. The system is in a working state when all subsystems are in good condition.

Sand Core Making Machine (P): This machine creates sand core and sand core is utilized to create hollow bar from classified. It contained of the two sub-units. In which main is operational and other is standby mode.

Gravity Die Casting Machine (Q): In GDCM firstly sand core is fitted and after die close liquid aluminium pour in die with the assistance of pouring spoon physically. GDCM comprises of one substance and entire interaction don't work when GDCM notsucceed.

Vibrator Machine (R):- VM is utilized to all through the sand core from depression. VM comprises of one unit.

Cutting machine (S):-CM is accustomed to dressing of all pointless things that are cut from projecting like runner, parting line. The framework bombs when CM not is acteffectively.

Horizontal machine (T):-HM is utilized for Grinding, Drilling, and Stringing. HM comprises of one sub-unit. The entire procedure flops when HM not be successful.

3. Assumptions and notations

- Failure and repair rates are constant.
- The subsystem P worked as a standby mode.
- P, Q, R, S, and T are used for working state.
- p, q, r, s, and t are used for failed state.
- $\bar{p}$: It is used for standby mode.

- α_i / β_i ($1 \le i \le 6$): Indicates the failure/repair rates of SCMM, GDCM, VM, CM, and HM and $i \rightarrow 2$ specify the reduced state.

4. State transition diagram

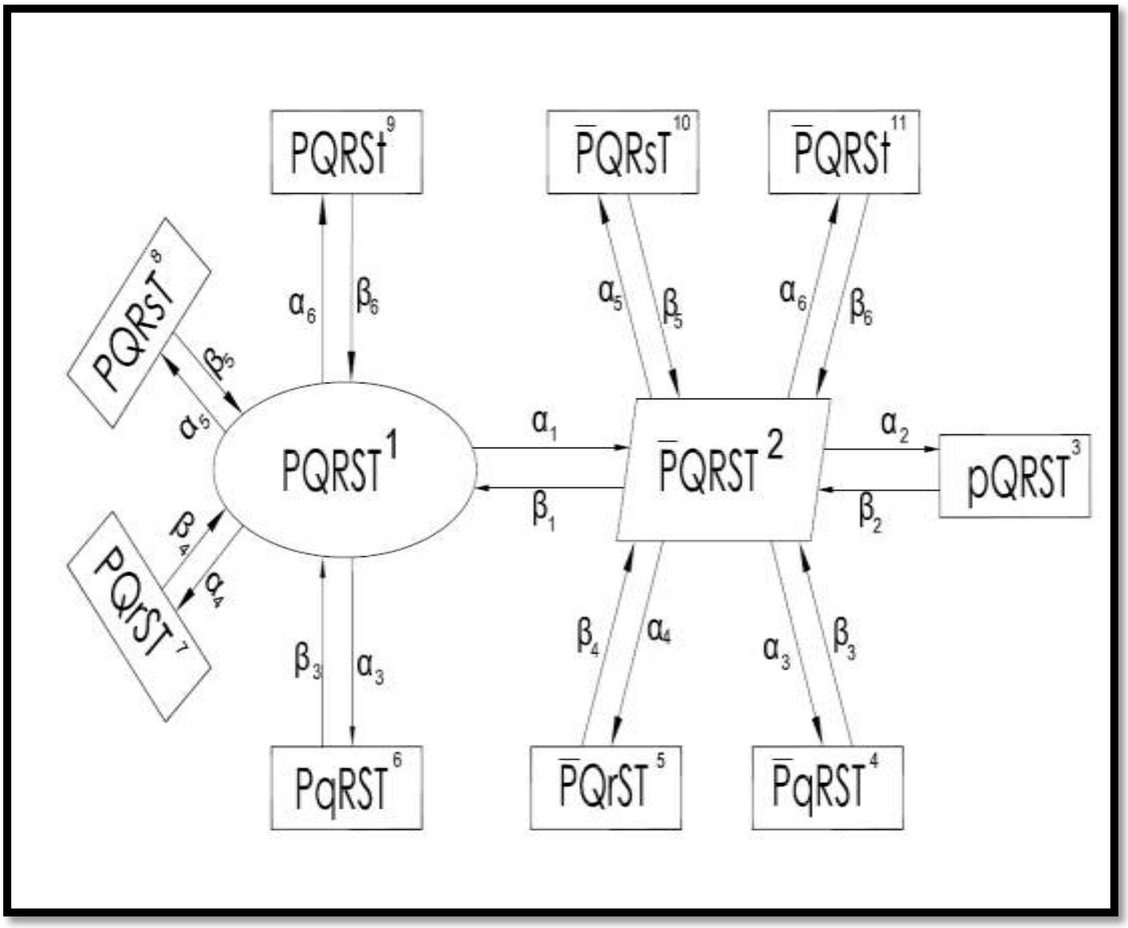

Fig. 1 State transition diagram

5. Transition Probabilities and the Mean Sojourn Time

$q_{i,j}(t)$**:** probability density capacity of main passage time from a state i to a regenerative state j or to a bombed state j without visiting someanother state in.

$p_{i,j}$**:** consistent state transition likelihood from a state i to a regenerative state j without visiting some another state. $p_{i,j} = q^*_{i,j}(0)$.

Table: 1Transition Probabilities

$q_{i,j}(t)$	$P_{ij} = q^*_{i,j}(0)$
$q_{1,i}(t) = \alpha_j e^{-(\alpha_6+\alpha_1+\alpha_5+\alpha_4+\alpha_3)t}$ Where i = 2,6,7,8,9 & j = 1,3,4,5,6	$p_{1,i} = \alpha_j/(\alpha_6+\alpha_1+\alpha_5+\alpha_4+\alpha_3)$ Where i = 2,6,7,8,9 & j = 1,3,4,5,6
$q_{2,1}(t) = \beta_1 e^{-(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)t}$ $q_{2,i}(t) = \alpha_j e^{-(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)t}$ Where i = 4,5,3,10,11 & j = 3,4,2,5,6	$p_{2,1} = \beta_1/(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)$ $p_{2,i} = \alpha_j/(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)$ Where i = 4,5,3,10,11 & j = 3,4,2,5,6
$q_{3,2}(t) = \beta_2 e^{-(\beta_2)t}$	$p_{3,2} = 1$
$q_{4,2}(t) = \beta_3 e^{-(\beta_3)t}$	$p_{4,2} = 1$
$q_{5,2}(t) = \beta_4 e^{-(\beta_4)t}$	$p_{5,2} = 1$
$q_{6,1}(t) = \beta_3 e^{-(\beta_3)t}$	$p_{6,1} = 1$
$q_{7,1}(t) = \beta_4 e^{-(\beta_4)t}$	$p_{7,1} = 1$
$q_{8,1}(t) = \beta_5 e^{-(\beta_5)t}$	$p_{8,1} = 1$
$q_{9,1}(t) = \beta_6 e^{-(\beta_6)t}$	$p_{9,1} = 1$
$q_{10,2}(t) = \beta_5 e^{-(\beta_5)t}$	$p_{10,2} = 1$
$q_{11,2}(t) = \beta_6 e^{-(\beta_6)t}$	$p_{11,2} = 1$

Table: 2 Mean Sojourn Time

$R_i(t)$	$\mu_i = R_i^*(0)$
$R_1(t) = e^{-(\alpha_6+\alpha_1+\alpha_5+\alpha_4+\alpha_3)t}$	$\mu_1 = 1/(\alpha_6+\alpha_1+\alpha_5+\alpha_4+\alpha_3)$
$R_2(t) = e^{-(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)t}$	$\mu_2 = 1/(\alpha_6+\alpha_3+\alpha_2+\alpha_5+\alpha_4+\beta_1)$
$R_3(t) = e^{-\beta_2 t}$	$\mu_3 = 1/\beta_2$
$R_4(t) = e^{-\beta_3 t}$	$\mu_4 = 1/\beta_3$
$R_5(t) = e^{-\beta_4 t}$	$\mu_5 = 1/\beta_4$
$R_6(t) = e^{-\beta_3 t}$	$\mu_6 = 1/\beta_3$
$R_7(t) = e^{-\beta_4 t}$	$\mu_7 = 1/\beta_4$
$R_8(t) = e^{-\beta_5 t}$	$\mu_8 = 1/\beta_5$
$R_9(t) = e^{-\beta_6 t}$	$\mu_9 = 1/\beta_6$
$R_{10}(t) = e^{-\beta_5 t}$	$\mu_{10} = 1/\beta_5$
$R_{11}(t) = e^{-\beta_6 t}$	$\mu_{11} = 1/\beta_6$

6. Transition Probabilities

The MTSF and every one of the key parameters of framework under consistent state conditions are assessed, applying RPGT and utilizing '1' as base-state of framework as under: The transition probability variables of all reachable states from base state '1' are:

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

$V_{1,2}$= $(1,2)/\{1-(p_{2,10}p_{10,2})\}\{1-(p_{2,11}p_{11,2})\}\{1-(p_{2,3}p_{3,2})\}\{1-(p_{2,4}p_{4,2})\}\{1-(p_{2,5}p_{5,2})\}$

$V_{1,3}$=………Continued

7. EVALUATION OF PARAMETERS

MTSF (T_0): The regenerative un-failed states to which the system can transit (initial state '1'), before entering any failed state are: 'i' = 1, 2. taking 'ξ' = '1'.

$$\text{MTSF}(T_0) = \left[\left\{\frac{\left\{pr\left(\xi \xrightarrow{sr\,(sff)} i\right)\right\}\mu i}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[1-\Sigma_{sr}\left\{\frac{\left\{pr\left(\xi \xrightarrow{sr\,(sff)} \xi\right)\right\}}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

T_0= $[\mu_1 p_{1,1}/\{1-p_{1,6}p_{6,1}\}\{1-p_{1,7}p_{7,1}\}\{1-p_{1,8}p_{8,1}\}\{1-(1-p_{1,9}p_{9,1})\}\{1-p_{1,2}p_{2,1}/[\{1-p_{2,3}p_{3,2}\}\{1-p_{2,4}p_{4,2}\}\{1-p_{2,5}p_{5,2}\}\{1-p_{2,10}p_{10,2}\}\{1-p_{2,11}p_{11,2}\}]\}$ + $\mu_2(1,2)/\{1-p_{2,3}p_{3,2}\}\{1-p_{2,4}p_{4,2}\}\{1-p_{2,5}p_{5,2}\}\{1-p_{2,10}p_{10,2}\}\{1-p_{2,11}p_{11,2}\}\{1-p_{2,1}p_{1,2}\}/[\{1-p_{1,6}p_{6,1}\}\{1-p_{1,7}p_{7,1}\}\{1-p_{1,8}p_{8,1}\}\{1-p_{1,9}p_{9,1}\}]$

Availability of System (A_0): From the figure the regenerative states at which the system is available are 'j' = 1, 2 and the regenerative states are 'i' = 1 to 11. Taking ξ = 1 the total time for which the system is available is given by

$$A_0 = \left[\Sigma_{j,sr}\left\{\frac{\{pr(\xi^{sr}\to j)\}fj,\mu j}{\Pi_{m_{1\neq\xi}}\{1-V_{\overline{m_1 m_1}}\}}\right\}\right] \div \left[\Sigma_{i,s_r}\left\{\frac{\{pr(\xi^{sr}\to i)\}\mu_i^1}{\Pi_{m_{2\neq\xi}}\{1-V_{\overline{m_2 m_2}}\}}\right\}\right]$$

$= (V_{1,1}\mu_1+V_{1,2}\mu_2)/ D$

$D= (V_{1,1}\mu_1+V_{1,2}\mu_2+V_{1,3}\mu_3+V_{1,4}\mu_4+V_{1,5}\mu_5+V_{1,6}\mu_6+ V_{1,7}\mu_7+V_{1,8}\mu_8+V_{1,9}\mu_9+V_{1,10}\mu_{10}+V_{1,11}\mu_{11})$

Server of busy period (B_0): The regenerative states where the server is busy while doing repairs are 'j' = 2 to 11 and the regenerative states are 'i' = 1 to 11. Taking 'ξ' = 1, the total fraction of time for which the server remains busy is

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

$= (V_{1,2}\mu_2+V_{1,3}\mu_3+V_{1,4}\mu_4+V_{1,5}\mu_5+V_{1,6}\mu_6+ V_{1,7}\mu_7+V_{1,8}\mu_8+V_{1,9}\mu_9+V_{1,10}\mu_{10}+V_{1,11}\mu_{11})/ D$

D= $(V_{1,1}\mu_1+V_{1,2}\mu_2+V_{1,3}\mu_3+V_{1,4}\mu_4+V_{1,5}\mu_5+V_{1,6}\mu_6+V_{1,7}\mu_7+V_{1,8}\mu_8+V_{1,9}\mu_9+V_{1,10}\mu_{10}+V_{1,11}\mu_{11})$

Expected Number of Server's Visits (V_0): The regenerative states where the server visits a fresh for repair of system are 'j' = 1,2and the regenerative states are 'i' = 1 to 11 for ξ = 3, the expected number of server's visits per unit time is given by

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

$= (V_{1,1}\mu_1+V_{1,2}\mu_2)/(V_{1,1}+V_{1,2}+V_{1,3}+V_{1,4}+V_{1,5}+V_{1,6}+V_{1,7}+V_{1,8}+V_{1,9}+V_{1,10}+V_{1,11})$

8. Results and Discussions

Particular Cases:-$\alpha_i = \alpha\ (1 \leq i \leq 6)$, $\beta_i = \beta\ (1 \leq i \leq 6)$

Mean Time to System Failure (T_0):-

Table 3: MTSF

α \ β	0.50	0.60	0.70
0.10	3.97	3.91	3.80
0.20	2.77	2.64	2.58
0.30	1.63	1.58	1.53

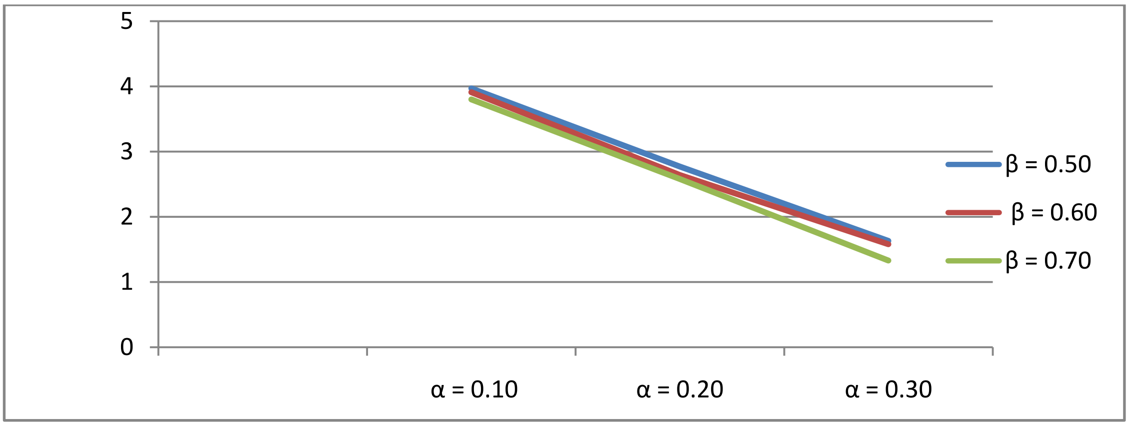

Figure 2: MTSF

Availability of the System (A_0):-

Table 4: Availability of System

α \ β	0.50	0.60	0.70
0.10	0.77	0.81	0.84
0.20	0.59	0.62	0.67
0.30	0.42	0.51	0.62

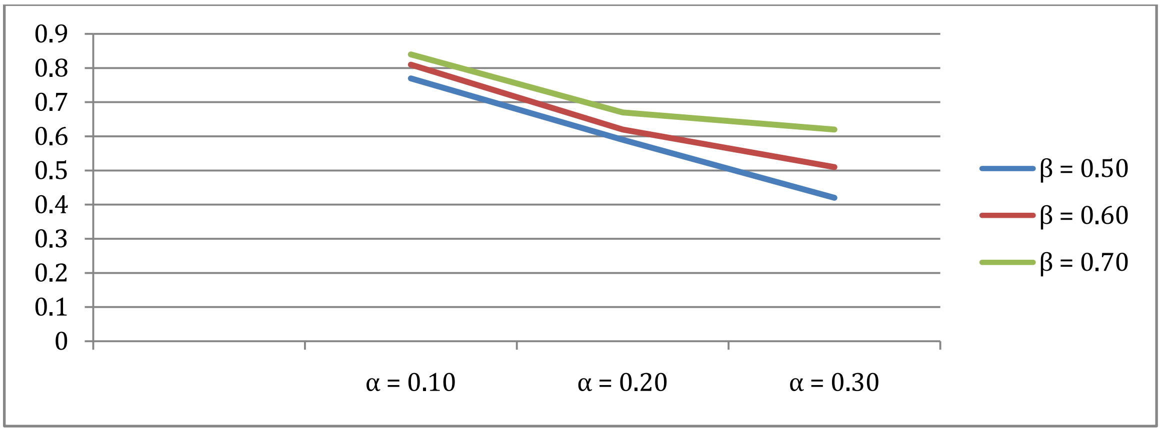

Figure 3: Availability of System

Server of busy period (B_0):-

Table 5: Server of busy period

α \ β	0.50	0.60	0.70
0.10	0.44	0.39	0.35
0.20	0.64	0.58	0.52
0.30	0.80	0.74	0.66

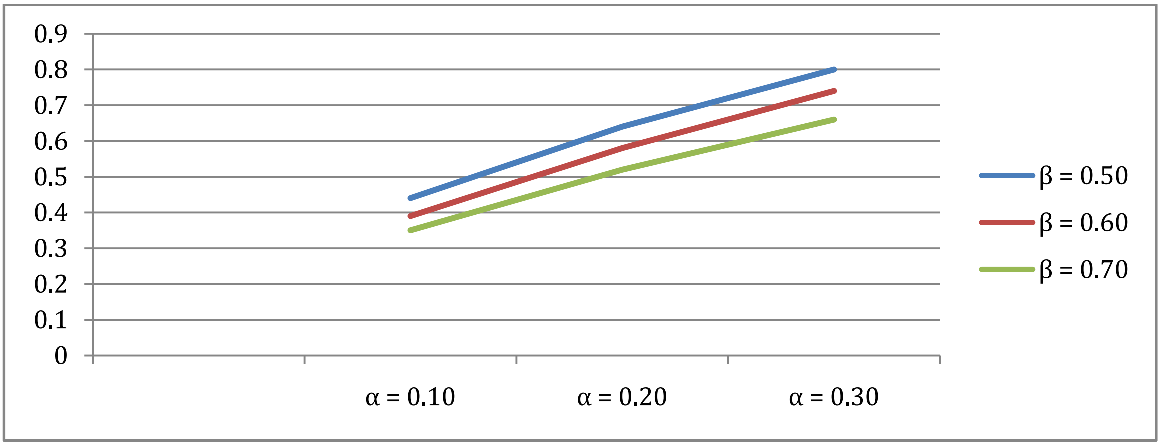

Figure 4: Server of the busy period

Expected Fractional No. of Inspection by Repairman (V_0) :-

Table 6: Expected Fractional No. of Inspection by Repairman

α \ β	0.50	0.60	0.70
0.10	0.12	0.16	0.19
0.20	0.14	0.19	0.23
0.30	0.21	0.28	0.33

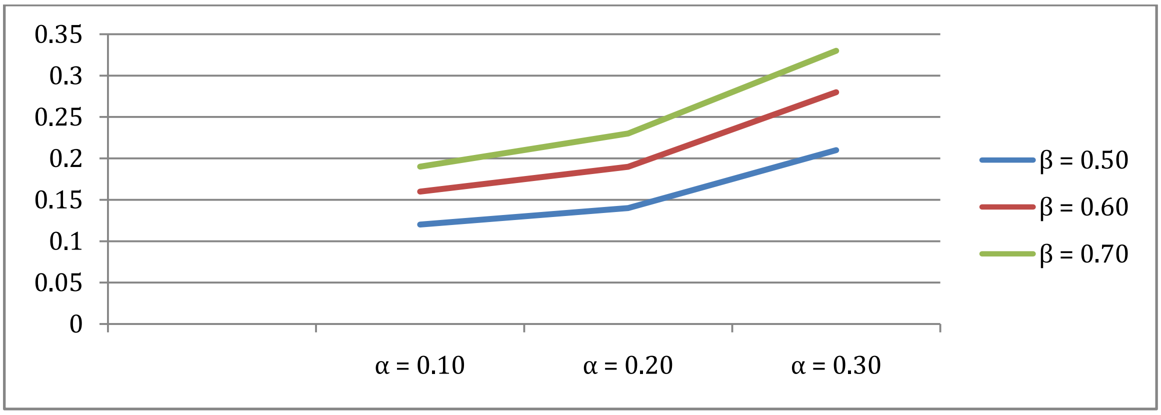

Figure 5: Expected Fractional No. of Inspection by Repairman

9. Conclusion

Reliability, Availability and Maintainability (RAM) analysis of Rico plant become an important aspect for making the system more efficient and productive. From the calculations and figures 3, it can be concluded that the availability of the system decreases with the increase in failure rate and increases with the increases in repair rate. It is also observed inthe figure 5 and table 6, that the expected no. of inspections by the repairman increases with the increase in failure rate and the figure 4; the server of the busy period and table 3; MTSF decreases with the increase in repair rates. Thus the effectiveness and the reliability of the plant can be improved by increasing the repair rate and decreasing the failure rate.

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