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Availability Optimization Of Nidec Manufacturing Plant Using Markov Process

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Abstract:
In the current work, Reliability Analysis the system parameters of the Nidec Manufacturing Plant using Markov Process has been optimisation. The goal of the present paper is to optimize input variables of the Nidec Manufacturing Plant to maximize framework availability. Nidec Manufacturing Plant contains six subsystems named as CNC machine (K), VMC machine (L), CNC hobbing machine (M), Induction hording machine (N), Grinding machine (O), and Polishing machine (P) so Nidec plant is a very complex system. All the subsystems are connected in series. In this paper, we have evaluated availability and reliability for the considered system by applying Markov process. The value of availability and reliability is decreased by increasing the time. Consistent state accessibility is accomplished by consuming normalizing condition.

Keywords: Reliability Analysis, system parameters, Nidec Manufacturing Plant

1. Introduction

Reliability typical overall performance measures have brilliant segment in existing day system, bread making system, electrical energy plants, engineering constructions and to preserve up higher significant diploma or section diploma of a reliability measure require in the basis. In the mainstream of the buildings these tiers are saved up by charitable educated fix and renovation events, however at the equal time to keep first-class feasible stage standby redundant units for a proper machine are admired. To do a sensitivity analysis on a cold standby framework made up of two identical units with server failure and prioritized for preventative maintenance, Kumar et al. (2019) used RPGT, two halves make up the paper, one of which is in use and the other of which is in cold standby mode. PSO was used by Kumari et al. (2021) to research limited situations. Devi and Garg (2022) discussed the three algorithms specifically HA, COGA and HGAPSO are applied to solve RAP. Present paper carriages a comprehensive literature review to classify, evaluate and intercept the standing studies related to the RAP Devi et al. (2023). behaviour of a bread plant was examined by Kumar et al. (2018). Kumar et al. (2019) investigated mathematical formulation and behavior study of a paper mill washing unit. In this paper behaviour and Availability analysis of Nidec manufacturing plant are evaluated. The Nidec manufacturing plant contains six subsystems named as CNC machine (K), VMC machine (L), CNC hobbing machine (M), Induction hording machine (N), Grinding machine (O), and Polishing machine (P) so Nidec plant is a very complex system. All the subsystems are connected in series. A solitary server is available for 24 x 7 hours to repair all type of failures of the subunits. All units have instantly recognizable failure and repair rates in all states. A state transition diagram is developed using Markov process. The investigation of the system is completed by accepting that failure and reparation rates are constant/persistent. The mathematical modeling is done by Markov-death process. The results are presented in the form of Tables and graphs are prepared to analyze the effect of varying failure and repair rates on the system parameters, followed by discussion. The block diagrams of the subsystem are shown in figure 1.

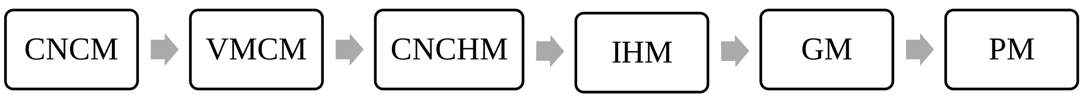

Figure 1: Block diagram of the subsystems.

2. Assumptions and Notations:

- C, V, H, I, G, P: represents good working states.
- c, v, h, i, g, p: indicates failed states.
- $m_2, m_3, m_4, m_5, m_6, m_7$: indicates the failure rates.
- $n_2, n_3, n_4, n_5, n_6, n_7$: indicates the failure rates.
- Failure and repair rates are constant.
- If the server is free, repair of the failed unit will begin immediately. Otherwise, the failed unit is queued for repair.

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3. State Transition Diagram:

State transition diagram is used to represent finite state machines. This is used to model an object that has a finite number of possible states and whose interaction with the outside world can be described by changes in states depending on the number of events. The transition diagram of NIDEC manufacturing plant described below:

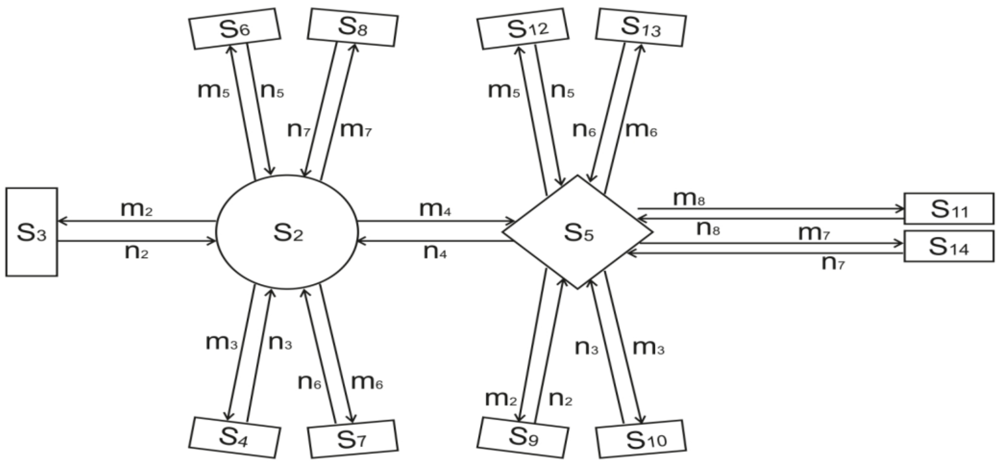

Figure 2: Transition Diagram

4. Mathematical Modeling:

The Mathematical Modelling is done by Markov -Birth Death process and obtained the linear differential equations. These equations are solved by recursive method.

$\frac{ds_2(t)}{dt} + (m_2 + m_3 + m_4 + m_5 + m_6 + m_7)s_2(t) = n_2 s_3(t) + n_3 s_4(t) + n_4 s_5(t) + n_5 s_6(t) + n_6 s_7(t) + n_7 s_8(t)$ …………………………………………………….……(1)

$\frac{ds_3(t)}{dt} + n_2 s_3(t) = m_2 s_2(t)$………………………………………………...….….(2)

$\frac{ds_4(t)}{dt} + n_3 s_4(t) = m_3 s_2(t)$………………………………………………...….….(3)

$\frac{ds_5(t)}{dt} + (m_2 + m_3 + n_4 + m_5 + m_6 + m_7 + m_8)s_5(t) = m_4 s_2(t) + n_2 s_9(t) + n_3 s_{10}(t) + n_5 s_{12}(t) + n_6 s_{13}(t) + n_7 s_{14}(t) + n_8 s_{11}(t)$………………………………..…………………………………………(4)

$\frac{ds_6(t)}{dt} + n_5 s_6(t) = m_5 s_2(t)$……………………………………………...…………………………(5)

$\frac{ds_7(t)}{dt} + n_6 s_7(t) = m_6 s_2(t)$……………………………………………...…………………………(6)

$\frac{ds_8(t)}{dt} + n_7 s_8(t) = m_7 s_2(t)$……………………………………………...…………………………(7)

$\frac{ds_9(t)}{dt} + n_2 s_9(t) = m_2 s_5(t)$……………………………………………...…………………………(8)

$\frac{ds_{10}(t)}{dt} + n_3 s_{10}(t) = m_3 s_5(t)$…………………………………………............................……….(9)

$\frac{ds_{11}(t)}{dt} + n_8 s_{11}(t) = m_8 s_5(t)$…………………………………………..........................……….(10)

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$\frac{ds_{12}(t)}{dt} + n_5 s_{12}(t) = m_5 s_5(t)$……………………………………………………………………….(11)

$\frac{ds_{13}(t)}{dt} + n_6 s_{13}(t) = m_6 s_5(t)$……………………………………………………………………….(12)

$\frac{ds_{14}(t)}{dt} + n_7 s_{14}(t) = m_7 s_5(t)$……………………………………………………………………….(13)

Therefore, the steady state probability of the system can be obtained by taking $\frac{d}{dt} \to 0$ and $p_l(t) \to p_l$ as $t \to \infty$ in above equations (1 to 13). The system's steady state probabilities are attained in terms of P_0 as follow:

$\frac{dp_i(t)}{dt} \to 0$ *and* $p_i(t) \to p_i, i = 2,3,4, \ldots \ldots, 14$

$(m_2 + m_3 + m_4 + m_5 + m_6 + m_7)s_2 = n_2 s_3 + n_3 s_4 + n_4 s_5 + n_5 s_6 + n_6 s_7 + n_7 s_8$
……………………………………………………………………………………... (14)

$n_2 s_3 = m_2 s_2$……………………………………………………………………….(15)

$n_3 s_4(t) = m_3 s_2$……………………………………………………………………….(16)

$(m_2 + m_3 + n_4 + m_5 + m_6 + m_7 + m_8)s_5 = m_4 s_2 + n_2 s_9 + n_3 s_{10} + n_5 s_{12} + n_6 s_{13} + n_7 s_{14} + n_8 s_{11}$……………………………………………………………….(17)

$n_5 s_6 = m_5 s_2$……………………………………………………………………….(18)

$n_6 s_7 = m_6 s_2$……………………………………………………………………….(19)

$n_7 s_8 = m_7 s_2$……………………………………………………………………….(20)

$n_2 s_9 = m_2 s_5$……………………………………………………………………….(4.21)

$n_3 s_{10} = m_3 s_5$……………………………………………………………………….(22)

$n_8 s_{11} = m_8 s_5$……………………………………………………………………….(23)

$n_5 s_{12} = m_5 s_5$……………………………………………………………………….(24)

$n_6 s_{13} = m_6 s_5$……………………………………………………………………….(25)

$n_7 s_{14} = m_7 s_5$……………………………………………………………………….(26)

we have

$s_3 = \alpha s_2, \alpha = \frac{m_2}{n_2}$

$s_4 = \alpha_1 s_2, \alpha_1 = \frac{m_3}{n_3}$

$s_5 = \alpha_2 s_2, \alpha_2 = \frac{m_4}{n_4}$

$s_6 = \alpha_3 s_2, \alpha_3 = \frac{m_5}{n_5}$

$s_7 = \alpha_4 s_2, \alpha_4 = \frac{m_6}{n_6}$

$s_8 = \alpha_5 s_2, \alpha_5 = \frac{m_7}{n_7}$

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$s_9 = \alpha\, \alpha_2 s_2, \alpha_2 = \frac{m_4}{n_4}$

$s_{10} = \alpha_1\alpha_2 s_2, \alpha_2 = \frac{m_4}{n_4}$

$s_{11} = \alpha_1\alpha_4 s_2, \alpha_1 = \frac{m_3}{n_3}, \alpha_4 = \frac{m_6}{n_6}$

$s_{12} = \alpha_2\alpha_3 s_2, \alpha_2 = \frac{m_4}{n_4}, \alpha_3 = \frac{m_5}{n_5}$

$s_{13} = \alpha_2\alpha_4 s_2, \alpha_2 = \frac{m_4}{n_4}, \alpha_4 = \frac{m_6}{n_6}$

$s_{14} = \alpha_2\alpha_5 s_2, \alpha_2 = \frac{m_4}{n_4}, \alpha_5 = \frac{m_7}{n_7}$

The Probability $S_i\ (t)$ is evaluated using normalizing condition

$\sum_{i=2}^{14} P_i = 1$

$1 = s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} + s_{11} + s_{12} + s_{13} + s_{14}$

$1 = s_2 + \alpha s_2 + \alpha_1 s_2 + \alpha_2 s_2 + \alpha_3 s_2 + \alpha_4 s_2 + \alpha_5 s_2 + \alpha\alpha_2 s_2 + \alpha_1\alpha_2 s_2 + \alpha_1\alpha_4 s_2 + \alpha_2\alpha_3 s_2 + \alpha_2\alpha_4 s_2 + \alpha_2\alpha_5 s_2$

$1 = s_2(1 + \alpha + \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 + \alpha\alpha_2 + \alpha_1\alpha_2 + \alpha_1\alpha_4 + \alpha_2\alpha_3 + \alpha_2\alpha_4 + \alpha_2\alpha_5)$

$1 = s_2 * H$

$s_2 = \frac{1}{H}$

$A_v = s_2$

5. Results and Discussion:

Time-dependent Availability:

MATLAB software is used to compute the results of the time-dependent availability of the system.

Table 1: Effect of availability w.r.t. time

Time (months)	Availability
0	1
15	0.97
30	0.92
45	0.88
60	0.84
75	0.79
90	0.73
105	0.68
120	0.56
135	0.49
150	0.39
165	0.31
180	0.27

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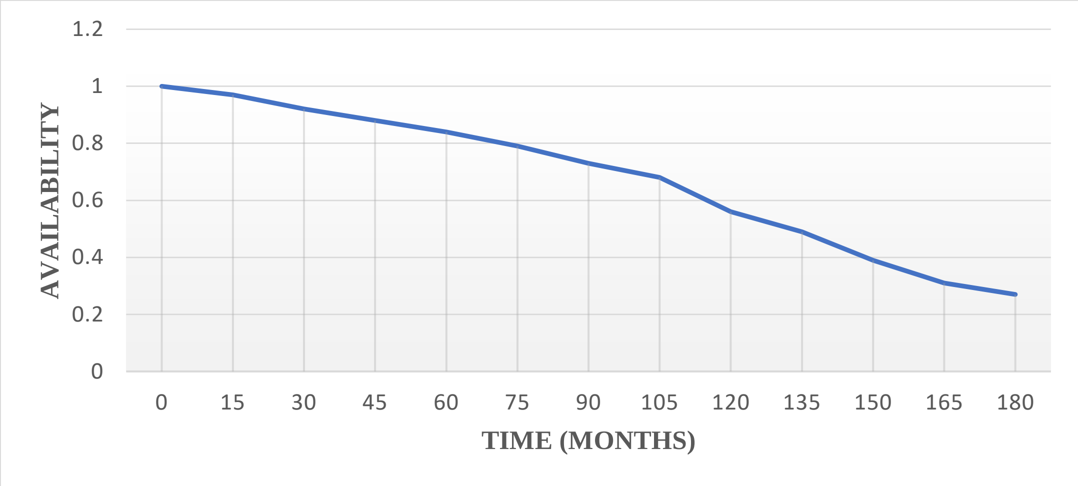

Fig. 3: Variation of availability w.r.t. time

Steady-state Availability of the system:
The results of steady-state availability are described in form of tables and graphs. The table 2 is developed by fixed the (n_3 = 0.02, m_3 = 0.002, n_4 = 0.03, m_4= 0.003, n_5 = 0.04, m_5 = 0.004, n_6 = 0.05, m_6 = 0.005, n_7 = 0.06, m_7 = 0.006,) as a constant and varying the value of (n_i, m_i), where i run from 2 to 7.

Table 2: Effect of availability w.r.t. failure and repair rates of CNC machine

m_2 → n_2 ↓	0.01	0.03	0.05	0.07	0.09	0.11	Constant Value
0.001	0.7791	0.7625	0.7516	0.7468	0.7303	0.7201	n_3 = 0.02, m_3 = 0.002, n_4 = 0.03, m_4= 0.003, n_5 = 0.04, m_5 = 0.004, n_6 = 0.05, m_6 = 0.005 n_7 = 0.06, m_7 = 0.006
0.003	0.8378	0.7780	0.7652	0.7530	0.7470	0.7310	
0.005	0.8965	0.7830	0.7750	0.7620	0.7510	0.7420	
0.007	0.9460	0.8315	0.7810	0.7700	0.7640	0.7520	
0.009	0.9540	0.8620	0.8130	0.7870	0.7720	0.7635	
0.011	0.9730	0.8760	0.8234	0.7986	0.7867	0.7546	

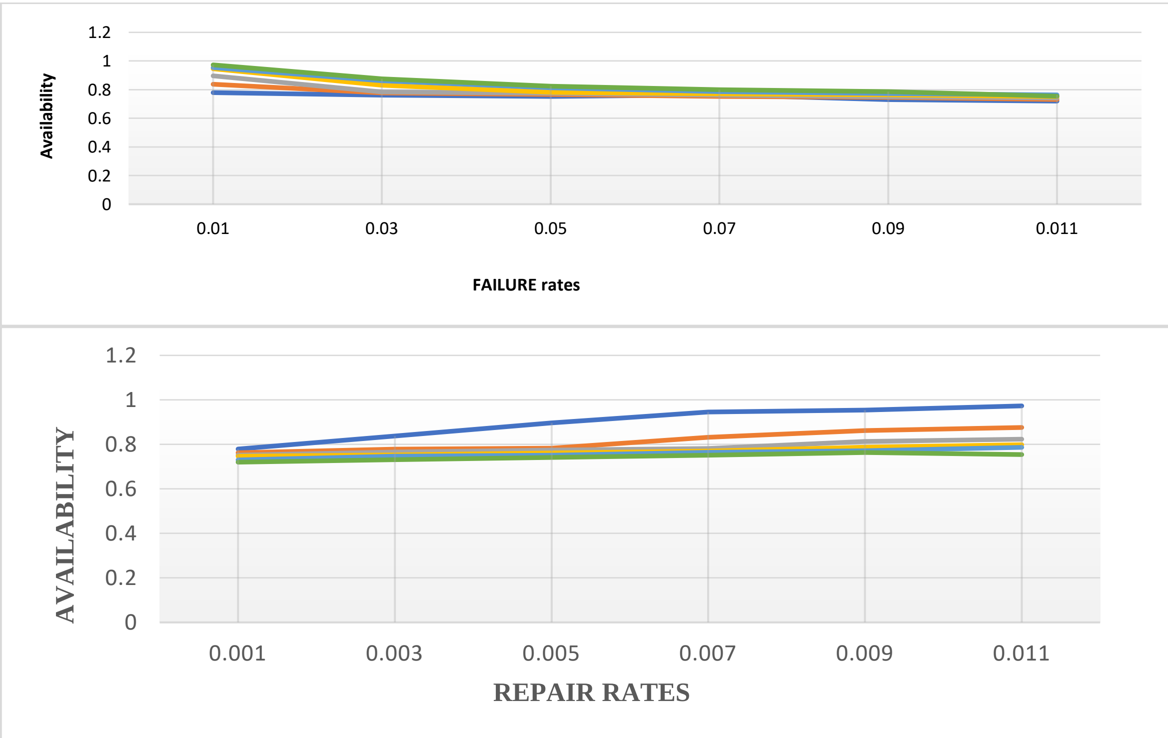

Fig. 4: Variation of availability w.r.t. failure and repair rates of CNC machine

6. Conclusion:

Though, the education in the area of dependability has been regular at somewhat a faster speed, but mutual formulae in the secure form are not generated for semi Markov in which the conditions of the technique change giving to a partial, aperiodic and irreducible Markov chain, From table 1, It is concluded that as time passes, the system's time-dependent availability reduces. From table 2, the maximum value of availability is 0.9730 which is obtained when failure rate is minimum (0.01) and repair rate is maximum (0.011). MATLAB software is used to compute the results of the time-dependent availability of the system.

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