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Reliability Analysis and Comparison the solution of the system parameters of the cast iron manufacturing plant

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Abstract:

In the current work, Reliability Analysis and Comparison the solution of the system parameters of the cast iron manufacturing planthas been optimisation. The goal of the present paper is to optimize input variables of the cylinder block in cast iron plant, to maximize framework availability. Cast iron plant includes mainly, five subsystems linked in series configuration. 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. For examination, Repair and disappointment rates, and Transition paces of each and every subsystem is taken from upkeep record sheets. Consistent state accessibility is accomplished by consuming normalizing condition.

Keywords: Reliability Analysis, system parameters, cast iron

1. Introduction

Reliability and availability are significant characteristics of a repairable system. Any upgrading in the reliability and availability of a component is related with the condition of additional endeavor and cost. Consequently, it is basic to utilize strategies or methods for availability designation among different subsystems of a system with the minimum endeavor and cost. In general, the significance of component should be utilized through the design or assessment of component to conclude which parts or subsystems have the best significance for the availability of the component. With the help of significance estimates one can recognize the systems that merit extra innovative work to improve their availabilities, so that the best increase is achieved in the component availability.(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). 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.

Kumar et al. (2019) investigated mathematical formulation and behavior study of a paper mill washing unit, PSO was used by Kumari et al. (2021) to research limited situations. Using a heuristic approach, Rajbala et al. (2022) investigated the redundancy allocation problem in the cylinder manufacturing plant.

2. ASSUMPTIONS AND NOTATIONS:

The following assumptions are accompanying with transition diagram:

- Firstly, the system is in working state
- The system has mainly 3 states good, standby and failed states
- All disappointment and repair rates are continuous
- The system can stand repaired, when it is in individually failed mode
- The repaired structure works identical a novel one
- S: Laplace Transform variable
- t: Time scale
- m_i: Failure rates of unit
- h_i : Repair rates of units; where i=1, 2, 3, 4, 5

3. State Transition Diagram:

State transition diagram is second-hand to characterize finite state machines. This is second-hand to model an object that has a finite integer of conceivable states and whose collaboration through the outside ecosphere can stand described thru variations in states depending on the number of events. The transition diagram of Cylinder Block in Cast Iron manufacturing plant described in table 1.

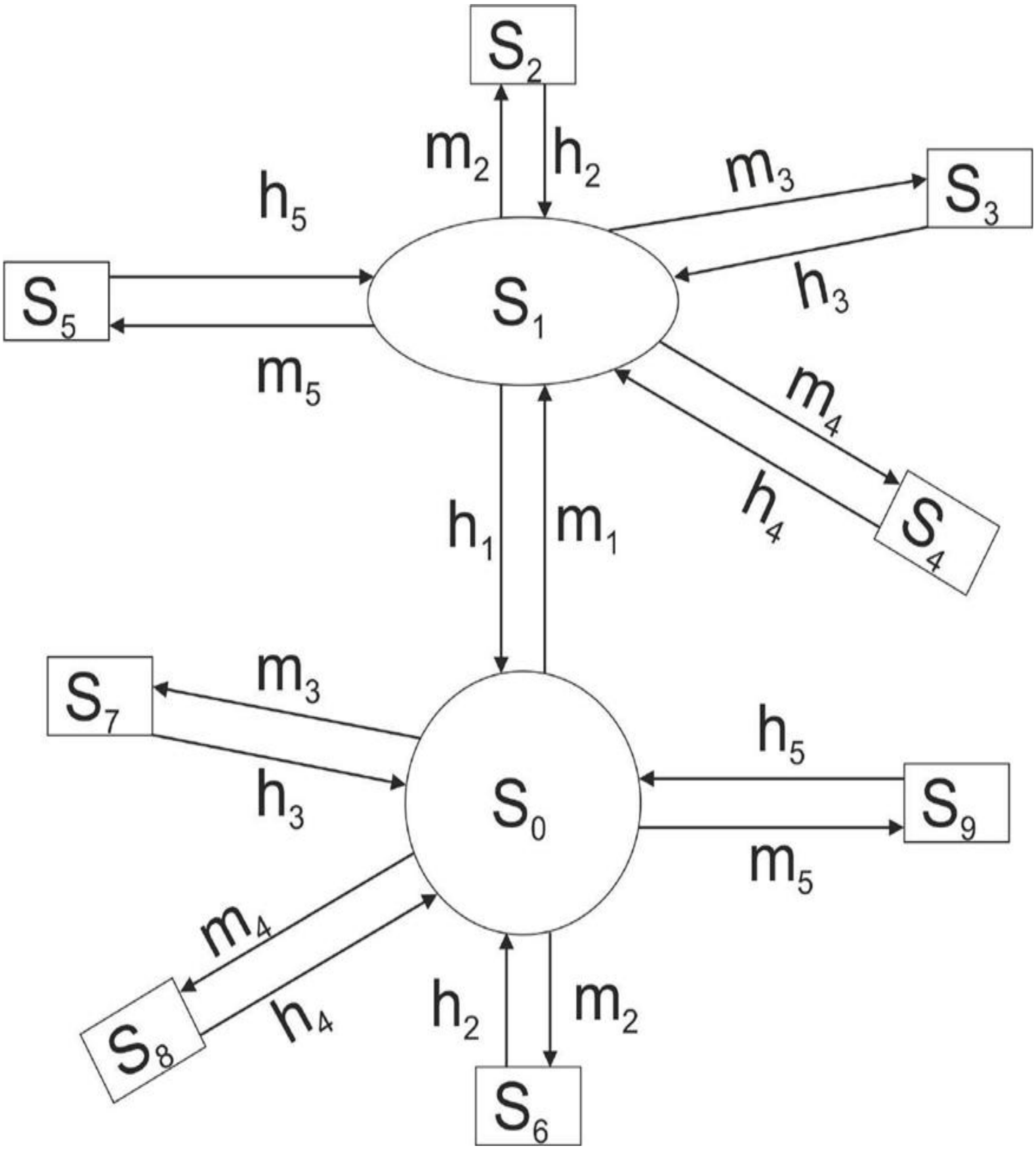

Fig. 1:State Transition Diagram

S_0 = ABDEF,	S_1 = aBDEF,	S_2 = ABDeF,	S_3 = ABDEf,
S_4 = AbDEF,	S_5 = ABdEF,	S_6 = a′BDeF,	S_7 = a′BDEf,
S_8 = a′bDEf,	S_9 = a′BdEF		

$S_0\ ABDEF\ (T)$: Transition state probabilities of the state S_0 when entirely the units are in working condition.

$S_1 a' BDEF\ (T)$, $S_2 a' bDEF\ (T)$, $S_3 a' BdEF\ (T)$, $S_4 a' BDeF\ (T)$, $S_5 a' BDEf\ (T)$, $S_6\ AbDEF\ (T)$, $S_7\ ABdEF\ (T), S_8\ ABDeF\ (T)$, $S_9\ AbDEf(T)$: Transition state probabilities of the state $S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9$ respectively

Some arithmetic examples are similarly presented to explain the model mathematically. The state description of the organization is specified in Table underneath:

S0 The system is in working condition	S1 The system is in stand by mode due to subsystem A.	S2 The system is in unsuccessful state due tondisappointment of subsystem B
S3 The system is inunsuccessful state due to disappointment of subsystem d	S4 The system is in unsuccessful state due to disappointment of one of the unit of E.	S5 The system is in unsuccessful state due to disappointment of subsystem A and active unit of subsystem F.
S6 The system is in unsuccessful state due to disappointment of subsystem B.	S7 The system is in unsuccessful state due to disappointment of subsystem D.	S8 The system is in unsuccessful state due to disappointment of one of the subsystem E.
	S9 The system is in unsuccessful state due to disappointment of subsystem F.	

4. MATHEMATICAL MODELING:

$$\left[\frac{\partial}{\partial t} + m_1 + m_2 + m_3 + m_4 + m_5\right] S_0\ ABDEF\ (T) = h_1 S_1 a^{'} BDEF\ (T) + h_2 S_6\ AbDEF\ (T) + h_3 S_7\ ABdEF\ (T) + h_4 S_8\ ABDeF\ (T) + h_5 S_9\ AbDEf(T) \quad (1)$$

$$\left[\frac{\partial}{\partial t} + m_2 + m_3 + m_4 + m_5 + h_1\right] S_1 a^{'} BDEF\ (T) = h_2 S_2 a^{'} bDEF\ (T) + h_3 S_3 a^{'} BdEF\ (T) + h_4 S_4 a^{'} BDeF\ (T) + h_5 S_5 a^{'} BDEf\ (T) + m_1 S_0\ AbDEF(T) \quad (2)$$

$$\left[\frac{\partial}{\partial t} + h_2\right] S_2 a^{'} bDEF\ (T) = m_2 S_1 a^{'}\ BDEF(T) \quad (3)$$

$$\left[\frac{\partial}{\partial t} + h_3\right] S_3 a^{'} BdEF\ (T) = m_3 S_1 a^{'}\ BDEF(T) \quad (4)$$

$\left[\frac{\partial}{\partial t} + h_4\right] S_4 a^{'} BDeF\ (T) = m_4 S_1 a^{'}\ BDEF(T)$ (5)

$\left[\frac{\partial}{\partial t} + h_5\right] S_5 a^{'} BDEf\ (T) = m_5 S_1 a^{'}\ BDEF(T)$ (6)

$\left[\frac{\partial}{\partial t} + h_2\right] S_6\ ABDEF\ (T) = m_2 S_0\ A\ BDEF(T)$ (7)

$\left[\frac{\partial}{\partial t} + h_3\right] S_7\ ABdEF\ (T) = m_3 S_0\ ABDEF(T)$ (8)

$\left[\frac{\partial}{\partial t} + h_4\right] S_8\ ABDeF\ (T) = m_3 S_0\ ABDEF(T)$ (9)

$\left[\frac{\partial}{\partial t} + h_5\right] S_9\ ABDEf\ (T) = m_5 S_0\ ABDEF(T)$ (10)

Initial condition

$S_{0\ ABDEF}\ (t) = 1$at t=0 and all additional likelihoods are zero firstly

Enchanting Laplace transformation of equ. (1-10), we get

$[s + m_1 + m_2 + m_3 + m_4 + m_5]\overline{S_0}\ ABDEF(t) =$
$1 + h_1 \bar{S}_1 a^{'} BDEF\ (T) + h_2 \bar{S}_6\ AbDEF\ (T) + h_3 \bar{S}_7\ ABdEF\ (T) + h_4 \bar{S}_8\ ABDeF\ (T) +$
$h_5 \bar{S}_9\ AbDEf(T)$ (11)

$[s + m_2 + m_3 + m_4 + m_5 + h_1]\bar{S}_1 a^{'} BDEF\ (T) = h_2 \bar{S}_2 a^{'} bDEF\ (T) + h_3 \bar{S}_3 a^{'} BdEF\ (T) +$
$h_4 \bar{S}_4 a^{'} BDeF\ (T) + h_5 \bar{S}_5 a^{'} BDEf\ (T) + m_1 \bar{S}_0\ AbDEF(T)$ (12)
$[s + h_2]\bar{S}_2 a^{'} bDEF\ (T) = m_2 \bar{S}_1 a^{'}\ BDEF(T)$ (13)

$[s + h_3]\bar{S}_3 a^{'} BdEF\ (T) = m_3 \bar{S}_1 a^{'}\ BDEF(T)$ (14)

$[s + h_4]\bar{S}_4 a^{'} BDeF\ (T) = m_4 \bar{S}_1 a^{'}\ BDEF(T)$ (15)

$[s + h_5]\bar{S}_5 a^{'} BDEf\ (T) = m_5 \bar{S}_1 a^{'}\ BDEF(T)$ (16)

$[s + h_2]\bar{S}_6\ ABDEF\ (T) = m_2 \bar{S}_0\ A\ BDEF(T)$ (17)

$[s + h_3]\bar{S}_7\ ABdEF\ (T) = m_3 \bar{S}_0\ ABDEF(T)$ (18)

$[s + h_4]\bar{S}_8\ ABDeF\ (T) = m_3 \bar{S}_0\ ABDEF(T)$ (19)

$[s + h_5]\bar{S}_9\ ABDEf\ (T) = m_5 \bar{S}_0\ ABDEF(T)$ (20)

Solving the equations from 10 to 20, we get

$\bar{S}_0\ ABDEF\ (S) = \frac{1}{B-A-C}$ (21)

Where $B = s + m_1 + m_2 + m_3 + m_4 + m_5$

$$C = \frac{h_2 m_2}{S + h_2} - \frac{h_3 m_3}{S + h_3} - \frac{h_4 m_4}{S + h_4} - \frac{h_5 m_5}{S + h_5}$$

$\bar{S}_1\ ABDEF\ (S) = \frac{A}{h_1} \bar{S}_0\ ABDEF\ (S)$ (22)

Where $A = s + m_2 + m_3 + m_4 + m_5 + h_1 - m_1 - \frac{h_2 m_2}{S+h_2} - \frac{h_3 m_3}{S+h_3} - \frac{h_4 m_4}{S+h_4} - \frac{h_5 m_5}{S+h_5}$

$\bar{S}_2\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_2 A}{s+h_2}\right] \bar{S}_0\ ABDEF\ (S)$ (23)

$\bar{S}_3\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_3 A}{s+h_3}\right] \bar{S}_0\ ABDEF\ (S)$ (24)

$\bar{S}_4\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_4 A}{s+h_4}\right] \bar{S}_0\ ABDEF\ (S)$ 25)

$\bar{S}_5\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_5 A}{s+h_5}\right] \bar{S}_0\ ABDEF\ (S)$ (26)

$\bar{S}_6\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_2}{s+h_2}\right] \bar{S}_0\ ABDEF\ (S)$ (27)

$\bar{S}_7\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_3}{s+h_3}\right] \bar{S}_0\ ABDEF\ (S)$ (28)

$\bar{S}_8\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_4}{s+h_4}\right] \bar{S}_0\ ABDEF\ (S)$ (29)

$\bar{S}_9\ ABDEF\ (S) = \frac{1}{h_1}\left[\frac{m_5}{s+h_5}\right] \bar{S}_0\ ABDEF\ (S)$ (30)

The Laplace transformation of the likelihoods that the structure is in working states and failed state at any time is as shadows

$$\bar{S}_{working}\ (s) = \bar{S}_0\ ABDEF\ (S) + \bar{S}_1\ ABDEF\ (S) + \bar{S}_2\ ABDEF\ (S) + \bar{S}_3\ ABDEF\ (S) + \bar{S}_4\ ABDEF\ (S) + \bar{S}_5\ ABDEF\ (S)$$

$\bar{S}_{working}\ (s) =$

$\left[1 + \frac{1}{B-A-C} + \frac{A}{h_1} + \frac{1}{h_1}\left[\frac{m_2 A}{s+h_2}\right] + \frac{1}{h_1}\left[\frac{m_3 A}{s+h_3}\right] + \frac{1}{h_1}\left[\frac{m_4 A}{s+h_4}\right] + \frac{1}{h_1}\left[\frac{m_5 A}{s+h_5}\right] \bar{S}_0\ ABDEF\ (S)\right]$ (31)

$$\bar{S}_{down}\ (s) = \bar{S}_6\ ABDEF\ (S) + \bar{S}_7\ ABDEF\ (S) + \bar{S}_8\ ABDEF\ (S) + \bar{S}_9\ ABDEF\ (S)$$

$\left[\frac{1}{h_1}\left[\frac{m_2}{s+h_2}\right] + \frac{1}{h_1}\left[\frac{m_3}{s+h_3}\right] + \frac{1}{h_1}\left[\frac{m_4}{s+h_4}\right] + \frac{1}{h_1}\left[\frac{m_5}{s+h_5}\right]\right]$ (32)

5. PARTICULAE CASES:

The likelihood that the system will stand up and running at a given period t is known as availability. It is invariably linked to the idea of maintainability. The availability is unwavering by the rates of disappointment and repair. Considering the various parameter values as

$m_1 = 0.10, m_2 = 0.20, m_3 = 0.30, m_4 = 0.40, m_5 = 0.50$ *and* $h_1 = h_2 = h_3 = h_4 = h_5 = 1$ and situating all the values in equation (6.31) and then attractive the Laplace transform, we acquire

$$P_{working}\ (t) = 0.70936500\ 00 + 0.24556778\ 38e^{(-4.1180911638\ )} + 0.0163121213e^{(-3.3246570638\ )} + 0.3114325671\ e^{(-2.1180911638\ )} + 0.4532167856\ e^{(-1.1289865638\ )} + 0.3214567876\ e^{(-0.1176543638\ )} \quad (33)$$

Currently, changeable time unit time t since 0 to 10 in (33), we obtained table 1 and similarly Fig. 2 on behalf of the behaviour of availability of the organization with respect to period.

Table 1: Availability as function of time

Time (t)	$P_{working}\ (t)$
0	1.00000
1	0.79627
2	0.78024
3	0.77861
4	0.76321
5	0.75321
6	0.73421
7	0.72349
8	0.72314
9	0.71532
10	0.71430

Availability as function of time

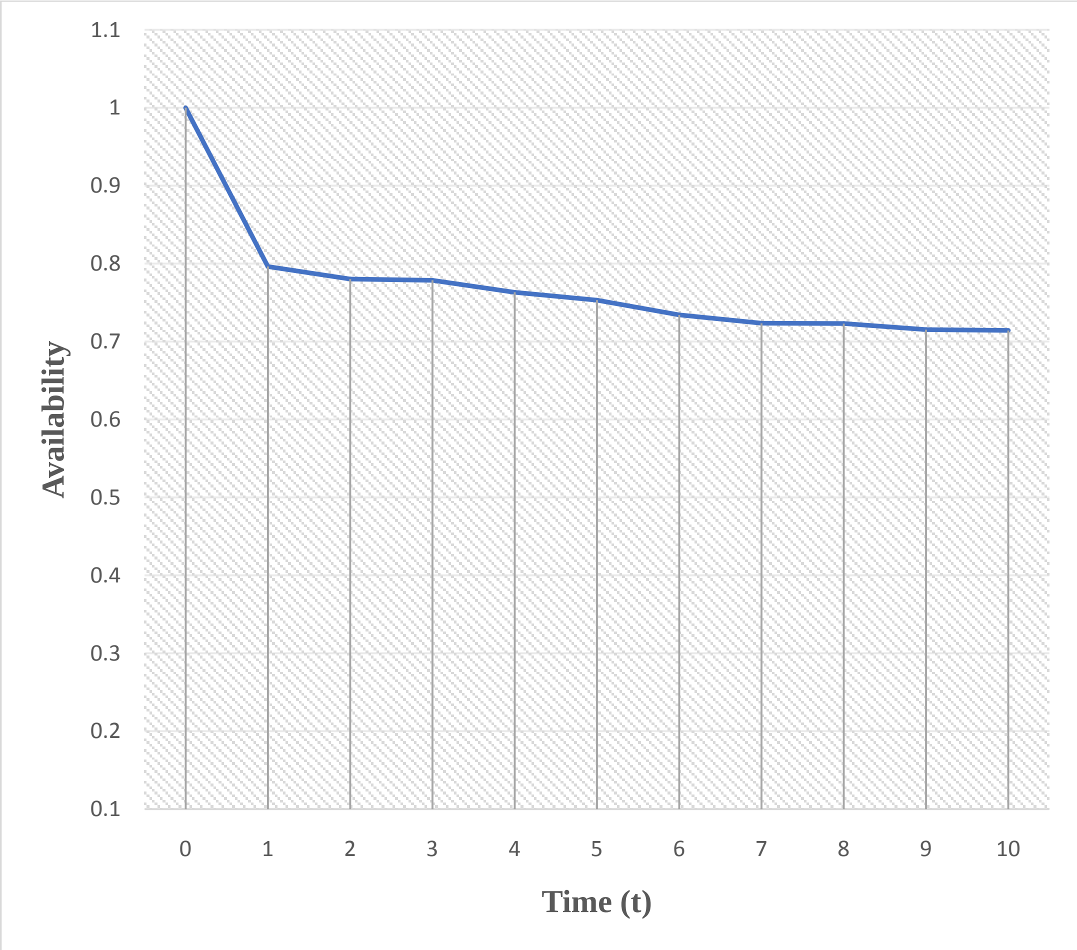

Fig. 2: Availability as function of time

6. Reliability Analysis

The **reliability** function is theoretically defined as the probability of success at time t, which is denoted R(t). In practice, it is calculated using different techniques and its value ranges between 0 and 1, where 0 indicates no probability of success while 1 indicates definite success. It is always a function of time. It is also depended on environmental conditions which may or may not vary with time. Taking all repair equal to zero in (31) and taking inverse Laplace transform, one may get

$$R(t) = \left(\frac{1}{2}\right) \times e^{-(m_1+m_2+m_3+m_4+m_5)}(m_5^2 t^2 + 2\, m_5(t) + 2) \quad (34)$$

Let us fix the failure rates as $m_1 = 0.15, m_2 = 0.30, m_3 = 0.45, m_4 = 0.60, m_5 = 0.75$. By putting all these values in (34) and varying time unit t from 0 to 10, one can obtain from table 2 and fig 3, which represents the reliability variation of the system.

Table 2: Reliability as function of time

Time (t)	Reliability R(t)
0	1.00000
1	0.64445
2	0.48629
3	0.25632
4	0.14350
5	0.09234
6	0.00703
7	0.00423
8	0.00321
9	0.00214
10	0.00048

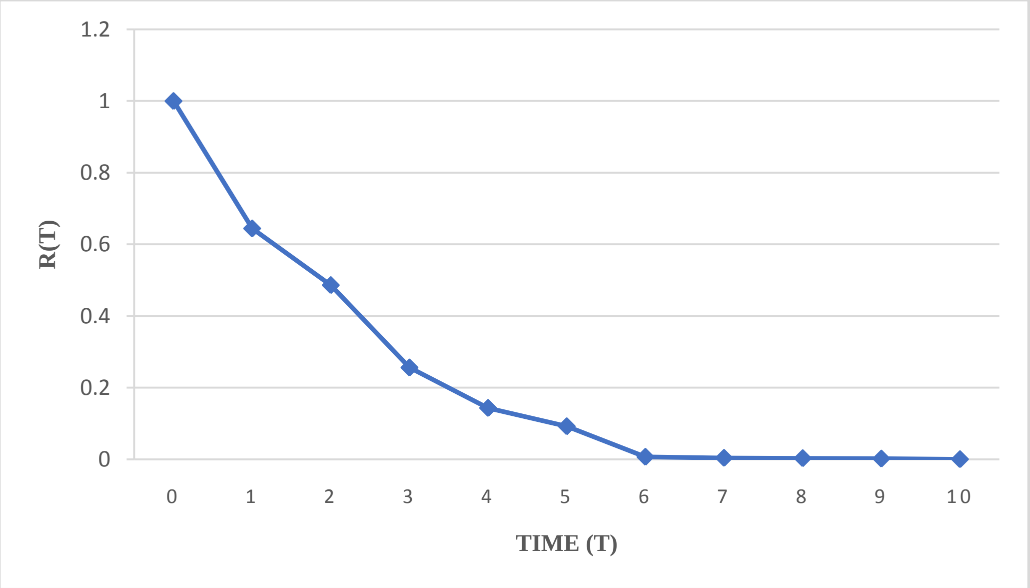

Fig. 3: Reliability as function of time

7. Comparison of the papers results:

- In theTime Dependent and Steady State Availability of Cast Iron Manufacturing Plant using Recursive Method of the Cylinder Block in Cast Iron Manufacturing Plant using Markov birth-death process has been generated. The differential equations are calculated for time-dependent by using the ODE-45 method in MATLAB. It is seen that the subsystem A is the most critical subsystem as far as maintenance is concerned. So, subsystem A should be given priority as the result of its repair rate on the availability is much higher than other subsystems.

- Here, in Availability Optimization of the system parameters of Cylinder Block in Cast Iron manufacturing plant by Runge- kutta method the optimal value of system availability is obtained using GA for the different combinations of repair and failure rates. The genetic algorithm is successfully applied to adjust the failure and repair rate parameters at the same time. Impact of various parameters of GA, such as the number of generations,the crossover rate to population size and availability was also analyzed and displayed on the chart.
- In Availability Optimization of Cylinder Block in Cast Iron Manufacturing Plant using Genetic Algorithmthe reliability of the designed system with respect to thetime when all the failure and repair rates have some fixed values.
- The availability of the stated system withrespect to time *t*. Critical examination of corresponding Fig. 2 yields that the valuesof theavailability decrease approximately in an even mannerwith the incrementintime.In this study, different techniques are used and obtained the different values of availability with respect to different values of failure and repair rates. The best optimal result is 98.60%.

8. Conclusion

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. From the results and analysis of the designed system, one can accomplish the following:

Table 1 gives us the idea of the availability of the stated system withrespect to time *t*. Critical examination of corresponding Fig. 2 yields that the values of theavailability decrease approximately in an even mannerwith the augmentationintime.

Table 2 shows the trends of reliability of the designed system with respect to thetime when all the failure and repair rates have some fixed values. From the graph(Fig.2),weconcludedthat thereliability of the system decreasesmoresharplywith the passage of time. Reliability may be improved by clarity of expression,lengtheningthemeasure,and other informalmeans.

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