DOI: 10.15415/mjis.2013.12010

Profit Analysis of Non-Identical Parallel System with Two Types of Failure Using Discrete Distribution

Jasdev Bhatti
Research Scholar, Chitkara University, Punjab, India
Email: jasdevbhatti1983@gmail.com

Ashok K Chitkara
Chancellor, Chitkara University, Punjab, India
Email: ashok.chitkara@chitkara.edu.in

Mohit Kakkar
Research Scholar, Chitkara University, Punjab, India
Email: mohit.kakkar@chitkara.edu.in

Abstract

This paper has analyzed the two non-identical operative parallel system considering two units (automatic and manual one) by using regenerative point technique. For the automatic unit the concept of inspection policy has been introduced to detect the kind of failures (major or minor) before being repaired by some repair mechanism. But the manual unit is free from such inspection policy. Various important measures of reliability i.e MTSF, steady state availability, busy period of repairman and inspector, profit function has been evaluated by designing model for the system and using discrete distribution & regenerative point techniques. Profit function and MTSF are also analyzed graphically.

Keywords: Geometric distribution, Regenerating point technique, MTSF, Availability, Busy period and Profit function.

1 INTRODUCTION

In the literature of reliability analysis many researchers had given their contribution by analyzing complex systems by using continuous distribution.Many reliability models have been discussed considering two identical / non- identical parallel unit's by many researchers including. Considering the two kinds of failure with single repair facility two unit's standby system have been analyzed by. In 2009 two dissimilar cold standby systems with three different failures and preventive maintenance have been discussed by. Thus in all these analysis, random variable is taken as a continuous distribution. But this is true only in case of large data, which is not as always possible. So in case of discrete random variable, discrete

Mathematical Journal of Interdisciplinary Sciences
Vol. 1, No. 2,
March 2013
pp. 27–40

distribution is considered to be appropriate for obtaining the effectiveness of different reliability measures.

In the area of reliability using discrete distribution had given there ideas by analyzing two unit parallel system with Geometric failure and repair time distributions. Since there is always a possibility for failure of any system during in its operative conditions in different measure. So to detect the type of failure inspection is very much required which had been always ignored by the researchers, whether using conitinous or discrete distribution.

Now in this paper, two non-identical parallel systems have been design with the concept of inspection policy for detecting the kind of failure where inspection and repair time are taken as geometric distribution. Initially both the unit's are in operative conditions. On the failure of an automatic unit, an inspection facility has been provided to detect the kind of failures (minor or major) to avoid any confussion for repairman. But the manual one is free from such inspection policy. System is considered to be in operative state if atleast one out of two unit's remains in its operative condition. But in case the system goes to failure state priority to get repair will be given to the manual one on the automatic unit as the repairman time taken by manual is less as compaired to other.

The model is analysed stochastically and the expressions for the various reliability measures of system effectiveness such as mean time to system failure, steady state availability, and busy period for both inspector and repairman were obtained.Graphs were also been drawn to analysed the behavior of MTSF and profit function with respect to repair and failure rate.

2 MODEL DESCRIPTION

The following assumptions are associated with the model:

- A system consists of two non-identical units (automatic and manual one) arranged in a parallel network.
- Initially both units are in operative condition.
- System is considered to be in operative condition if atleast one of the unit's is in its operative condition.
- The system is assumed to be in the failed state when both units together were in failed conditions whether the cause of failure is major or minor.
- Inspection policy is being introduced to the failed automatic unit for inspecting the kind of failures (minor or major). But the manual one is free from such inspection policy.
- A single repairman is available for repairing both types of failed unit whether the cause is major or minor one. In case of system failure

preference to get repaired first will be given to the manual one on the automatic unit.

- A repaired unit's works as good as new.

2.1 Nomenclature

O	:	Unit is in operative mode
A_o / M_o	:	Automatic / Manual unit is in operative mode.
A_i	:	Automatic unit is in failure mode and under inspection.
A_{mr} / A_{Mr}	:	Automatic unit is in failure mode (minor or major) and under repair.
A_{mw} / A_{Mw}	:	Automatic unit is in failure mode (minor & major) and waiting for repair.
M_r	:	Manual unit is in minor failure mode and under repair.
a	:	Probability that automatic unit goes to failed state with minor failure.
b	:	Probability that automatic unit goes to failed state with major failure.
p_1 / q_1	:	Probability that automatic unit goes to failed state or not.
p_2 / q_2	:	Probability that the failed unit is inspected satisfactory or not.
p_3/ q_3	:	Probability that manual unit goes to failed state or not.
r/s	:	Failed unit (automatic or manual) get repaired or not.
$q_{ij}(t)$ / $Q_{ij}(t)$	:	p.d.f and c.d.f of first passage time from regenerative state i to regenerative state j.
$P_{ij}(t)$	:	Steady state transition probability from state S_i to S_j.
μ_i	:	Mean sojourn time in state S_i.

Table 1: Nomenclature"

Up States

$$S_0 \equiv (A_0, M_0), \quad S_1 \equiv (A_i, M_0), \quad S_2 \equiv (A_{mr}, M_0),$$
$$S_3 \equiv (A_{Mr}, M_0), \quad S_7 \equiv (A_0, M_r)$$

Down State

$$S_4 \equiv (A_{mw,} M_r), \quad S_5 \equiv (A_{MW}, M_r), \quad S_6 \equiv (A_i, M_r).$$

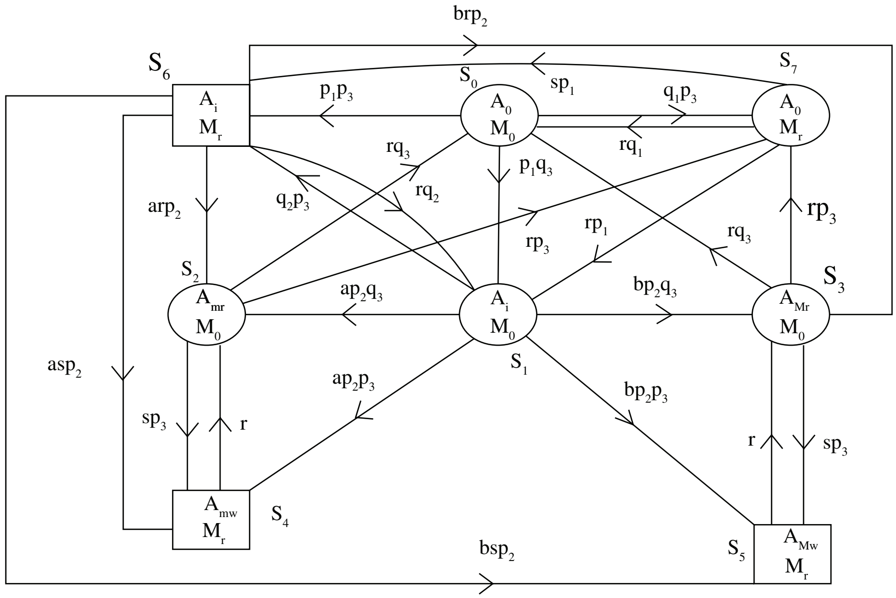

Figure 1: Transition Diagram

3 TRANSITION PROBABILITIES AND SOJOURN TIMES

$$Q_{01}(t) = \frac{p_1 q_3[1-(q_1q_3)^{(t+1)}]}{1-q_1q_3} \qquad Q_{06}(t) = \frac{p_1 p_3[1-(q_1q_3)^{(t+1)}]}{1-q_1q_3}$$

$$Q_{07}(t) = \frac{q_1 p_3[1-(q_1q_3)^{(t+1)}]}{1-q_1q_3} \qquad Q_{12}(t) = \frac{ap_2 q_3[1-(q_2q_3)^{(t+1)}]}{1-q_2q_3}$$

$$Q_{13}(t) = \frac{bp_2 q_3[1-(q_2q_3)^{(t+1)}]}{1-q_2q_3} \qquad Q_{14}(t) = \frac{ap_2 p_3[1-(q_2q_3)^{(t+1)}]}{1-q_2q_3}$$

$$Q_{15}(t) = \frac{bp_2 p_3[1-(q_2q_3)^{(t+1)}]}{1-q_2q_3} \qquad Q_{16}(t) = \frac{q_2 p_3[1-(q_2q_3)^{(t+1)}]}{1-q_2q_3}$$

$$Q_{20}(t) = Q_{30}(t) = \frac{rq_3[1-(sq_3)^{(t+1)}]}{1-sq_3} \qquad Q_{24}(t) = Q_{35}(t) = \frac{sp_3[1-(sq_3)^{(t+1)}]}{1-sq_3}$$

$$Q_{27}(t) = Q_{37}(t) = \frac{rp_3[1-(sq_3)^{(t+1)}]}{1-sq_3} \qquad Q_{42}(t) = Q_{53}(t) = \frac{r[1-s^{(t+1)}]}{1-s}$$

$$Q_{61}(t)=\frac{rq_2[1-(sq_2)^{(t+1)}]}{1-sq_2} \qquad Q_{62}(t)=\frac{arp_2[1-(sq_2)^{(t+1)}]}{1-sq_2}$$

$$Q_{63}(t)=\frac{brp_2[1-(sq_2)^{(t+1)}]}{1-sq_2} \qquad Q_{64}(t)=\frac{asp_2[1-(sq_2)^{(t+1)}]}{1-sq_2}$$

$$Q_{65}(t)=\frac{bsp_2[1-(sq_2)^{(t+1)}]}{1-sq_2} \qquad Q_{70}(t)=\frac{rq_1[1-(sq_1)^{(t+1)}]}{1-sq_1}$$

$$Q_{71}(t)=\frac{rp_1[1-(sq_1)^{(t+1)}]}{1-sq_1} \qquad Q_{76}(t)=\frac{sp_1[1-(sq_1)^{(t+1)}]}{1-sq_1}$$

(1-20)

The steady state transition probabilities from state S_i to S_j can be obtained from

$$P_{ij}=\lim_{t\to\infty} Q_{ij}$$

It can be verified that

$$P_{01}+P_{06}+P_{07}=1, \qquad P_{12}+P_{13}+P_{14}+P_{15}+P_{16}=1,$$

$$P_{20}+P_{24}+P_{27}=P_{30}+P_{35}+P_{37}=1, \qquad P_{42}+P_{53}=1,$$

$$P_{61}+P_{62}+P_{63}+P_{64}+P_{65}=1, \qquad P_{70}+P_{71}+P_{76}=1.$$

3.1 Mean Sojourn Times

Let T_i be the sojourn time in state S_i (i = 0, 1, 2, 3, 4, 5, 6, 7), then mean sojourn time in state S_i is given by

$$\mu_i=E(T_i)=\sum_{t=0}^{\infty}P(T_i>t)$$

so that

$$\mu_0=\frac{1}{1-q_1q_3}, \qquad \mu_1=\frac{1}{1-q_2q_3}, \qquad \mu_2=\mu_3=\frac{1}{1-sq_3},$$

$$\mu_4=\mu_5=\frac{1}{1-s}, \qquad \mu_6=\frac{1}{1-sq_2} \qquad \mu_7=\frac{1}{1-sq_1}.$$

Mean sojourn time (m_{ij}) of the system in state S_i when the system is to transit into S_j is given by

$$m_{ij} = \sum_{t=0}^{\infty} t\, q_{ij}(t)$$

$$\begin{aligned}
&m_{01} + m_{06} + m_{07} = q_1 q_3 \mu_0,\\
&m_{12} + m_{13} + m_{14} + m_{15} + m_{16} = q_2 q_3 \mu_1,\\
&m_{20} + m_{24} + m_{27} = m_{30} + m_{35} + m_{37} = s q_3 \mu_2\\
&m_{42} + m_{53} = s\mu_4,\\
&m_{61} + m_{62} + m_{63} + m_{64} + m_{65} = s q_2 \mu_6,\\
&m_{70} + m_{71} + m_{76} = s q_1 \mu_7.
\end{aligned}$$

4 RELIABILITY AND MEAN TIME TO SYSTEM FAILURE

Let $R_i(t)$ be the probability that system works satisfactorily for atleast t epochs 'cycles' when it is initially started from operative regenerative state S_i (i = 0, 1, 2, 3,7).

$$\begin{aligned}
&R_0(t) = Z_0(t) + q_{01}(t-1) © R_1(t-1) + q_{07}(t-1) © R_7(t-1).\\
&R_1(t) = Z_1(t) + q_{12}(t-1) © R_2(t-1) + q_{13}(t-1) © R_3(t-1).\\
&R_2(t) = Z_2(t) + q_{20}(t-1) © R_0(t-1) + q_{27}(t-1) © R_7(t-1).\\
&R_3(t) = Z_3(t) + q_{30}(t-1) © R_0(t-1) + q_{37}(t-1) © R_7(t-1).\\
&R_7(t) = Z_7(t) + q_{70}(t-1) © R_0(t-1) + q_{71}(t-1) © R_1(t-1).
\end{aligned} \quad (21\text{-}25)$$

Taking geometric transformation on both sides, we get

$$R_0(h) = \frac{N_1(h)}{D_1(h)}$$

The mean time to system failure is

$$\mu_i = \lim_{h-4} \frac{N_1(h)}{D_1(h)} - 1 = \frac{N_1}{D_1}$$

where

$$\begin{aligned}
N_1 &= \mu_0 + \mu_1(P_{01} + P_{07}P_{71}) + (P_{12} + P_{13})[\mu_2(P_{01} + P_{07}P_{71}) + P_{27}(\mu_7 P_{01} - \mu_0 P_{71})]\\
&\quad + \mu_7 P_{07}.\\
D_1 &= 1 - \mu_1(P_{12} + P_{13})[P_{20}(P_{01} + P_{07}P_{71}) + P_{27}(P_{71} + P_{70}P_{01})] - P_{07}P_{70}.
\end{aligned}$$

(26-27)

5 AVAILABILITY ANALYSIS

Let A_i (t) is the probability that the system is up at epoch t when it is initially started from regenerative state S_i. By simple probabilistic argument the following recurrence relations are obtained.

$$A_0(t) = Z_0(t) + q_{01}(t-1)© A_1(t-1) + q_{06}(t-1)©A_6(t-1) + q_{07}(t-1)© A_7(t-1).$$

$$A_1(t) = Z_1(t) + q_{12}(t-1)© A_2(t-1) + q_{13}(t-1)©A_3(t-1) + q_{14}(t-1)© A_4(t-1) + q_{15}(t-1)©A_5(t-1) + q_{16}(t-1) © A_6(t-1).$$

$$A_2(t) = Z_2(t) + q_{20}(t-1)© A_0(t-1) + q_{24}(t-1)©A_4(t-1) + q_{27}(t-1)© A_7(t-1).$$

$$A_3(t) = Z_3(t) + q_{30}(t-1)© A_0(t-1) + q_{35}(t-1)©A_5(t-1) + q_{37}(t-1)© A_7(t-1).$$

$$A_4(t) = q_{42}(t-1)© A_2(t-1).$$

$$A_5(t) = q_{53}(t-1)© A_3(t-1).$$

$$A_6(t) = q_{61}(t-1)© A_1(t-1) + q_{62}(t-1)©A_2(t-1) + q_{63}(t-1)© A_3(t-1) + q_{64}(t-1)© A_4(t-1) + q_{65}(t-1)© A_5(t-1).$$

$$A_7(t) = Z_7(t) + q_{70}(t-1)© A_0(t-1) + q_{71}(t-1)©A_1(t-1) + q_{76}(t-1)© A_6(t-1).$$

(28-35)

By taking geometric transformation and solving the equation

$$A_0(h) = \frac{N_2(h)}{D_2(h)}$$

and

$$Z_1(\mathrm{h}) = \mu_i$$

The steady state availability of the system is given by

$$A_0 = \lim_{t\to\infty} A_0(t)$$

Hence, by applying 'L' Hospital Rule, we get

$$A_0 = -\frac{N_2(1)}{D_2'(1)}$$

where

$$\begin{aligned} N_2(1) = {} & \mu_0(1\text{-}P_{16}P_{61})(P_{20} + P_{27}P_{70}) + \mu_1\{(1\text{-}P_{24})[P_{01} + P_{06}P_{61} + P_{07}(P_{71} + P_{76}P_{61})] \\ & + P_{27}(P_{06}P_{71}\text{-}P_{01}P_{76})(1\text{-}P_{61})\} \\ & + \mu_2(1\text{-}P_{16}P_{61})(1\text{-}P_{07}P_{70}) + \mu_7(1\text{-}P_{16}P_{61})(P_{27} + P_{20}P_{07}) \end{aligned} \tag{36}$$

$$\begin{aligned} D_2' = {} & -\{q_1q_3\mu_0(1\text{-}P_{16}P_{61})(P_{20}+P_{27}P_{70}) + q_2q_3\mu_1\{(1\text{-}P_{24})[P_{01}+P_{06}P_{61} \\ & + P_{07}(P_{71}P_{76}P_{61})] + P_{27}(P_{06}P_{71}\text{-}P_{01}P_{76})(1\text{-}P_{61})\} \\ & + sq_3\mu_2(1\text{-}P_{16}P_{61})(1\text{-}P_{07}P_{70}) + s\mu_4\{(P_{01}+P_{07}P_{71})[P_{14}+P_{15}+P_{16}(P_{64}P_{65}) \\ & + P_{24}\left(P_{12}P_{13}+P_{16}(P_{62}+P_{63})\right)] + (P_{06}+P_{07}P_{76})[P_{64}+P_{65}P_{61}(P_{14}+P_{15}) \\ & + P_{24}(P_{62}+P_{63}+P_{61}(P_{12}+P_{13}))] + P_{27}(P_{06}P_{71}\text{-}P_{01}P_{76})[(P_{64}+P_{65})(1\text{-}P_{16})\text{-}(P_{14} \\ & + P_{15})(1\text{-}P_{61})]\} + sq_2\mu_6\{(1\text{-}P_{24})[P_{06}+P_{01}P_{16}+P_{07}(P_{76}+P_{71}P_{16})] \\ & + P_{27}(P_{01}P_{76}\text{-}P_{06}P_{71})(1\text{-}P_{16})\} + sq_1\mu_7(1\text{-}P_{16}P_{61})(P_{27}+P_{20}P_{07}) \end{aligned} \tag{37}$$

6 BUSY PERIOD ANALYSIS

6.1 Busy Period of Inspector

Let $B_i(t)$ be the probability of the inspector who inspect the failed unit before being repaired by repairman. Using simple probabilistic arguments, as in case of reliability and availability analysis the following recurrence relations can be easily developed.

$$B_0(t) = q_{01}(t\text{-}1)© B_1(t\text{-}1) + q_{06}(t\text{-}1)© B_6(t\text{-}1) + q_{07}(t\text{-}1)© B_7(t\text{-}1).$$

$$\begin{aligned} B_1(t) = {} & Z_1(t) + q_{12}(t\text{-}1)© B_2(t\text{-}1) + q_{13}(t\text{-}1)© B_3(t\text{-}1) + q_{14}(t\text{-}1)© B_4(t\text{-}1) \\ & + q_{15}(t\text{-}1)© B_5(t\text{-}1) + q_{16}(t\text{-}1)© B_6(t\text{-}1). \end{aligned}$$

$$B_2(t) = q_{20}(t\text{-}1)© B_0(t\text{-}1) + q_{24}(t\text{-}1)© B_4(t\text{-}1) + q_{27}(t\text{-}1)© B_7(t\text{-}1).$$

$$B_3(t) = q_{30}(t\text{-}1)© B_0(t\text{-}1) + q_{35}(t\text{-}1)© B_5(t\text{-}1) + q_{37}(t\text{-}1)© B_7(t\text{-}1).$$

$B_4(t) = q_{42}(t-1)© B_2(t-1).$

$B_5(t) = q_{53}(t-1)© B_3(t-1).$

$B_6(t) = Z_6(t) + q_{61}(t-1)© B_1(t-1) + q_{62}(t-1)© B_2(t-1) + q_{63}(t-1)© B_3(t-1)$
$+ q_{64}(t-1)© B_4(t-1) + q_{65}(t-1)© B_5(t-1).$

$B_7(t) = q_{70}(t-1)© B_0(t-1) + q_{71}(t-1)© B_1(t-1) + q_{76}(t-1)© B_6(t-1).$

(38-45)

By taking geometric transformation and solving the equation

$$B_0(h) = \frac{N_3(h)}{D_2(h)}$$

The probability that the inspection facility is busy in inspecting the failed unit is given by

$$B_0 = \lim_{t \to \infty} B_0(t)$$

Hence, by applying 'L' Hospital Rule, we get

$$B_0 = -\frac{N_3(1)}{D_2'(1)}$$

where

$$\begin{aligned} N_3(1) = {} & \mu_1\{(1- P_{24})[P_{01} + P_{06}P_{61} + P_{07}(P_{71} + P_{76}P_{61})] \\ & + P_{27}(P_{06}P_{71} - P_{01}P_{76})(1- P_{61})\} + \mu_6\{(1- P_{24})[P_{06} + P_{01}P_{16} \\ & + P_{07}(P_{76} + P_{71}P_{16})] + P_{27}(P_{01}P_{76} - P_{06}P_{71})(1- P_{16})\} \end{aligned} \quad (46)$$

and $D_2'(1)$ is the same as in availability analysis.

6.2 Busy period of repairman

Let $B_i'(t)$ be the probability that the repair facility is busy in repair of failed unit when the system initially starts from regenerative state Si. Using simple probabilistic arguments, the following recurrence relations can be easily developed.

$B_0'(t) = q_{01}(t-1)© B_1'(t-1) + q_{06}(t-1)© B_6'(t-1) + q_{07}(t-1)© B_7'(t-1).$

$B_1'(t) = q_{12}(t-1)© B_2'(t-1) + q_{13}(t-1)© B_3'(t-1) + q_{14}(t-1)© B_4'(t-1)$
$+ q_{15}(t-1)© B_5'(t-1) + q_{16}(t-1)© B_6'(t-1).$

$$B_2'(t) = Z_2(t) + q_{20}(t\text{-}1)© B_0'(t\text{-}1) + q_{24}(t\text{-}1)© B_4'(t\text{-}1) + q_{27}(t\text{-}1)© B_7'(t\text{-}1).$$

$$B_3'(t) = Z_3(t) + q_{30}(t\text{-}1)© B_0'(t\text{-}1) + q_{35}(t\text{-}1)© B_5'(t\text{-}1) + q_{37}(t\text{-}1)© B_7'(t\text{-}1).$$

$$B_4'(t) = Z_4(t) + q_{42}(t\text{-}1)© B_2'(t\text{-}1).$$

$$B_5'(t) = Z_5(t) + q_{53}(t\text{-}1)© B_3'(t\text{-}1).$$

$$B_6'(t) = Z_6(t) + q_{61}(t\text{-}1)© B_1'(t\text{-}1) + q_{62}(t\text{-}1)© B_2'(t\text{-}1) + q_{63}(t\text{-}1)© B_3'(t\text{-}1) + q_{64}(t\text{-}1)© B_4'(t\text{-}1) + q_{65}(t\text{-}1)© B_5'(t\text{-}1).$$

(47-54)

By taking geometric transformation and solving the equation

$$B_0'(h) = \frac{N_4(h)}{D_2(h)}$$

The probability that the repair facility is busy in repair of failed unit is given by

$$B_0' = \lim_{t\to\infty} B_0(t)$$

Hence, by applying 'L' Hospital Rule, we get

$$B_0' = -\frac{N_4(1)}{D_2'(1)}$$

where

$$N_4(1) = \mu_2(1-P_{16}P_{61})(1-P_{07}P_{70}) + \mu_4\{(P_{01} + P_{07}P_{71})[P_{14} + P_{15} + P_{16}(P_{64} + P_{65}) + P_{24}(P_{12} + P_{13} + P_{16}(P_{62} + P_{63}))] + (P_{06} + P_{07}P_{76})[P_{64} + P_{65} + P_{61}(P_{14} + P_{15}) + P_{24}(P_{62} + P_{63} + P_{61}(P_{12} + P_{13}))] + P_{27}(P_{06}P_{71} - P_{01}P_{76})[(P_{64} + P_{65})(1-P_{16}) - (P_{14} + P_{15})(1-P_{61})]\} + \mu_6\{(1-P_{24})[P_{06} + P_{01}P_{16} + P_{07}(P_{76} + P_{71}P_{16})] + P_{27}(P_{01}P_{76} - P_{06}P_{71})(1-P_{16})\} + \mu_7(1-P_{16}P_{61})(P_{27} + P_{20}P_{07}).$$

(55)

and $D_2'(1)$ is the same as in availability analysis.

7 PROFIT FUNCTION ANALYSIS

The expected total profit in steady-state is

$$P = C_0A_0 - C_1B_0 - C_2B_0' \tag{54}$$

where

C_0: be the per unit up time revenue by the system.

C_1 & C_2: be the per unit down time expenditure on the system.

8 GRAPHICAL REPRESENTATION

The behaviour of the MTSF and the profit function w.r.t failure rate and repair rate have been studied through graphs by fixing the values of certain parameters a, b, C_0, C_1 and C_2 as

a = 0.4, b = 0.6, C_0 = 2000, C_1 = 400 and C_2 = 600.

On the basis of the numerical values taken as:

P = 1452.4822, r = 0.2 and s = 0.8

The values of various measures of system effectiveness are obtained as:

Mean time to system failure (MTSF) = 10.45143.

Availability (A_0) = 1.168995.

Busy period of Inspector (B_0) = 0.215102.

Busy period of repairman (B_0') = 1.332444.

Figure 2 show the behavior of MTSF w.r.t failure rate (p_1) for different values of repair rate (r). It appears from graph that MTSF decreases with increase in failure rate.

Figure 3 show the behavior of MTSF w.r.t repair rate (r) for different values of failure rate (p_1). It appears from graph that MTSF increases with increase in repair rate.

Figure 4 show the behavior of Profit function w.r.t failure rate (p_1) for different values of repair rate (r). It appears from graph that Profit function decreases with increase in failure rate.

Figure 5 show the behavior of Profit function w.r.t repair rate (r) for different values of failure rate (p_1). It appears from graph that Profit funtion increases with increase in repair rate.

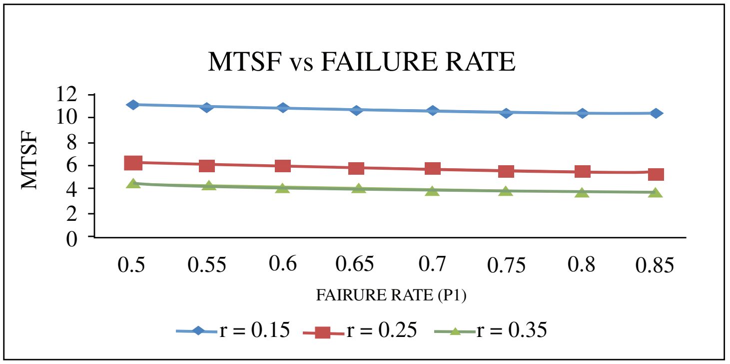

Figure 2: MTSF vs FAILURE RATE

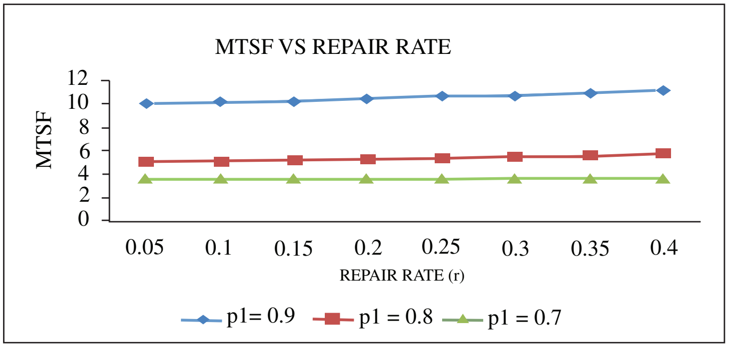

Figure 3: MTSF vs REPAIR RATE

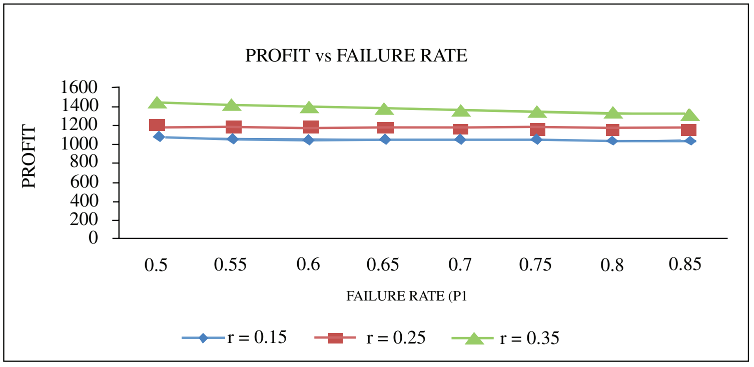

Figure 4: PROFIT vs FAILURE RATE

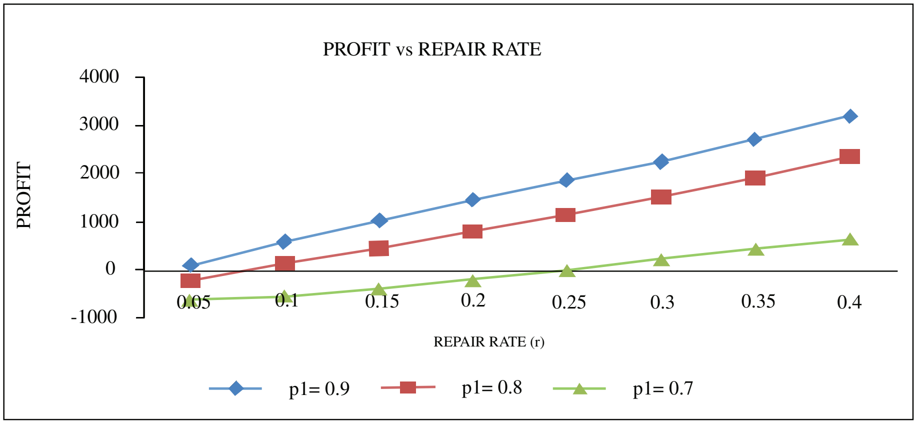

Figure 5: PROFIT vs REPAIR RATE

9 CONCLUSION

This paper discuss the importance of introducing inspection policy to the system having different kind of failures and also the use of discrete distribution for obtaining the effectiveness of different reliability measures.Thus the results obtained, provides an effective information and new ideas for other fellow researchers and companies to prefer such conditions for same systems as per to this paper.

10 REFERENCES

Agarwal S.C, Sahani M, Bansal S (2010) "Reliability characteristic of cold-standby redundant syatem", *IJRRAS* ,May 2010 3(2).

Bhardwaj N (2009) "Analysis of two unit redundant system with imperfect switching and connection time", *International transactions in mathematical sciences and Computer*,July-Dec. 2009, Vol. 2, No. 2, pp. 195-202.

Bhardwaj N, Kumar A, Kumar S (2008) "Stochastic analysis of a single unit redundant system with two kinds of failure and repairs", *Reflections des*. *ERA-JMS*, Vol. 3 Issue 1 (2008), 115-134

Gupta R, Varshney G (2007) "A two identical unit parallel syatem with Geometric failure and repair time distributions", *J. of comb. Info. & System Sciences*, Vol. 32, No.1-4, pp 127-136 (2007)

Haggag M.Y (2009) "Cost Analysis of a System Involving Common Cause Failures and Preventive Maintenance", *J.Math* & *Stat*., 5(4):305-310, 2009, ISSN 1549-3644. http://dx.doi.org/10.3844/jmssp.2009.305.310

Haggag. M.Y. (2009), "Cost analysis of two-dissimilar unit cold standby system with three states and preventive maintenance using linear first order differential equations" *J.Math* & *Stat.*, 5(4):395-400, 2009, ISSN 1549-3644. http://dx.doi.org/10.3844/jmssp.2009.395.400

Mokaddis.G.S, Salah M, Sherbeny ELayid. M (2009), "Stochastic behavior of a two-unit warm standby system with two types of repairman and patience time", *Journal of mathematics and statistics* 5(1):42-46, 2009ISSN 1549-364©2009 science publications. http://dx.doi.org/10.3844/jmssp.2009.42.46

Said K.M.EL, Salah M, Sherbeny EL (2005) "Profit analysis fof a two unit cold standby system with preventive maintenance and random change in Units", *Journal of mathematics and statistics* 1(1):71-77, 2005, ISSN 1549-3644 (2005) http://dx.doi.org/10.3844/jmssp.2005.71.77

Mr. Jasdev Bhatti is Assistant Professor in Department of Mathematics, Chitkara, School of Applied Sciences, Chitkara University, Rajpura, Punjab. He has published various research papers in different reputed National and International Journals.

Ashok K Chitkara, Chancellor, Chitkara University, Himachal Pradesh, India

Mohit Kakkar is Assistant Professor in Department of Mathematics (HOD), Chitkara, School of Applied Sciences, Chitkara University, Rajpura, Punjab.