INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATION & MANAGEMENT

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BEHAVIORAL STUDY OF RELIABILITY CHARACTERISTICS OF A SYSTEM MODEL WITH BIVARIATE EXPONENTIAL FAILURE AND REPAIR TIMES

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ABSTRACT

A system model consisting of two subsystems 1 and 2 is investigated and analyzed. In subsystem 1 there are two units A and B and both unit should work for the subsystem to work while in subsystem 2 there is only one unit C. Subsystem 2 fails in two ways one is natural failure and other is catastrophic failure. Subsystem 1 is given preference in operation. Failure time distribution of subsystem 2 is assumed to be negative exponential and repair time distribution is general. Failure and repair times for the units of subsystem 1 and 2 are assumed to be correlated random variables having bivariate exponential distribution.

KEYWORDS
availability, bivariate exponential distribution, catastrophic failure, , mean time to system failure, Reliability.

1. INTRODUCTION

A large number of researchers in the field of reliability have analyzed system models with catastrophic and common cause failures. Different authors have used different techniques for analyzing such system models.Goel and Gupta (1984) analyzed a system models having two parallel units with partial and catastrophic failures and preventive maintenance using regenerative point technique. Dhillon and N-Yang carried out reliability and availability analysis of a warm standby system with common cause failures and human error using supplementary variable techniques. Hidakka (1992) obtained the reliability of r-out of-n (F) system with common cause failures and maintenance.

In the present paper we discuss a system consisting of two subsystems 1 and 2.In subsystem 1 there are two units A and B and both unit should work for the subsystem to work while in subsystem 2 there is only one unit C. Subsystem 2fails in two ways one is natural failure and other is catastrophic failure. Subsystem 1 is given preference in operation. Failure time distribution of subsystem 2 is assumed to be negative exponential and repair time distribution is general. Failure and repair times for the units of subsystem 1 and 2 are assumed to be correlated random variables having bivariate exponential distribution of the form.

$$f_{X_iY_i}(x,y) = \alpha_i\beta_i(1-r_i)e^{-(\alpha_i x_i+\beta_i y_i)}I_0\left(2\sqrt{\alpha_i\beta_i r_i x_i y_i}\right)$$

$$\alpha_i, \beta_i,\ x_i, y_i > 0, |r_i| < 1$$

Where,

X_i ≡ r.v. denoting the time to failure of ith unit of subsystem 1
Y_i ≡ r.v. denoting the time to repair of ith unit of subsystem 1
r_i ≡ correlation coefficient (x_i, y_i)

and $I_0(z) = \sum_{K=0}^{\infty} \frac{(z/2)^K}{(K!)^2}$ is modified Bessel's function of type one and order zero.

Using regenerative point technique following measures of system effectiveness have been obtained.

(1) Reliability and mean time to system failure (MTSF)
(2) Pointwise and steady state availability of the system.
(3) Expected up time of the system and expected busy period of the repairman during (0, t)
(4) Expected numbers of repairs during (0,t).
(5) Net expected profit incurred by the system during (0, t) and in steady state.

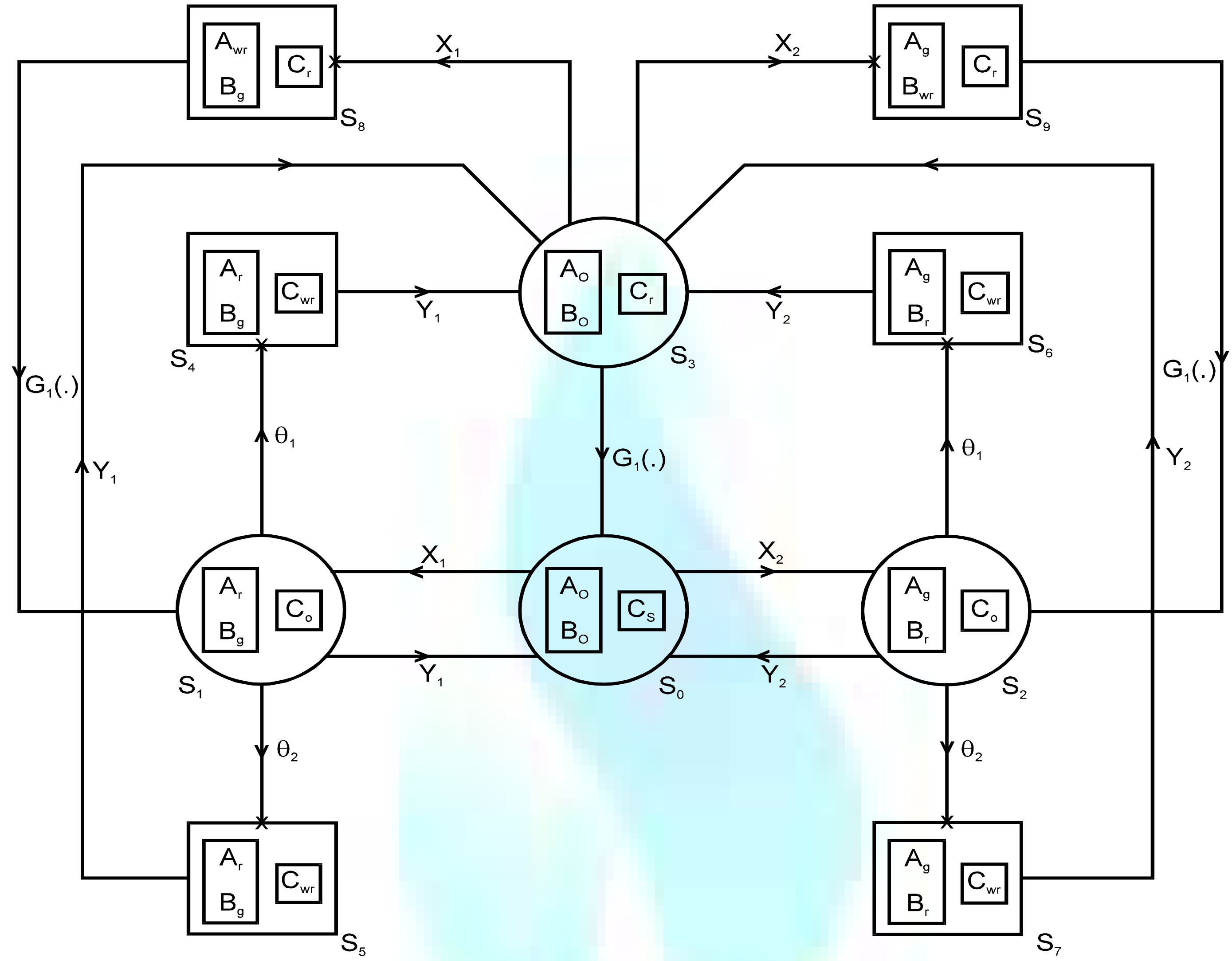
2. SYSTEM DESCRIPTION AND ASSUMPTIONS

The system is analyzed under following practical assumptions:-

(i) The system comprises of two subsystems, subsystem 1 and 2 which work independently. Subsystem1 consists of two non- identical units arranged in series whereas subsystem 2 consists of one unit only.
(ii) Initially subsystem 1 works and subsystem 2 is kept in cold standby.
(iii) Subsystem 1 is given preference in operation over subsystem 2 which is used in case either units of subsystem 1 fail.
(iv) Subsystem 2 can fails in two ways: first it may fail naturally and second it may fail catastrophically.
(v) Failure and repair times for the units of subsystem 1 are assumed to be correlated random variables having bivariate exponential distribution.
(vi) Failure time distribution of subsystem 2 is assumed to be negative exponential and repair time distribution is general.
(vii) A single repair facility is available to repair the failed units.
(viii) Service discipline is FCFS
(ix) A repaired unit works as good as new.

FIG.1

TRANSITION DIAGRAM



3. NOTATION AND STATES OF THE SYSTEM

X_i : random variable representing failure time of the ith unit of subsystem1

Y_i : random variable representing repair time of the ith unit of subsystem 1

$f_{X_iY_i}(x,y)$:the joint p.d.f. of X_i and Y_i i.e.

$f_{X_iY_i}(x,y) = \alpha_i\beta_i(1-r_i)e^{-(\alpha_i x_i+\beta_i y_i)}I_0\left(2\sqrt{\alpha_i\beta_i r_i x_i y_i}\right),$

$\alpha_i, \beta_i,\ x_i, y_i > 0, |r_i| < 1$

$g_i(x)$: marginal p.d.f of X_i i.e$g_i(x) = \alpha_i(1-r_i)e^{-\alpha_i(1-r_i)x_i}, i = 1,2$

$k_i(y_i|x)$: conditional p.d.f of $(Y_i|X_i = x)$ i.e

$k_i(y_i|x) = \beta_i e^{-(\alpha_i r_i x_i+\beta_i y_i)}I_0\left(2\sqrt{\alpha_i\beta_i r_i x_i y_i}\right), i = 1,2$

p_{ij} : steady state probability of transition from regenerative state S_i to S_j

$p_{ij}^{(k)}$: steady state probability of transition from regenerative state S_i to $S_j$via non- regenerative state S_k.

ψ_i : mean sojourn time in state S_i .

$Z_i(t)$: probability that the system sojourns in state S_i up to time t.

Symbols for the state of the system

$A_o/B_o/C_o$: Components A, B, and C are operative

A_g/B_g : Components A and B are good

$A_r/B_r/C_r$: Components A, B and C are under repair

$A_{wr}/B_{wr}/C_{wr}$: Components A, B and C are waiting for repair

Possible states of the system are:

$S_0=\begin{pmatrix} A_o, B_o \\ C_s \end{pmatrix}$, $S_1=\begin{pmatrix} A_r, B_g \\ C_o \end{pmatrix}$, $S_2=\begin{pmatrix} A_g, B_r \\ C_o \end{pmatrix}$, $S_3 = \begin{pmatrix} A_o, B_o \\ C_r \end{pmatrix}$, $S_4=\begin{pmatrix} A_r, B_g \\ C_{wr} \end{pmatrix}$

$S_5=\begin{pmatrix} A_r, B_g \\ C_{wr} \end{pmatrix}$, $S_6=\begin{pmatrix} A_g, B_r \\ C_{wr} \end{pmatrix}$, $S_7=\begin{pmatrix} A_g, B_r \\ C_{wr} \end{pmatrix}$, $S_8=\begin{pmatrix} A_{wr}, B_g \\ C_r \end{pmatrix}$, $S_9=\begin{pmatrix} A_g, B_{wr} \\ C_r \end{pmatrix}$

4. TRANSITION PROBABILITIES AND SOJOURN TIMES

First we find the following direct and indirect steady state probabilities of transition:

$p_{ij} = \lim_{t\to\infty} Q_{ij}(t) = \lim_{s\to 0} \tilde{Q}_{ij}(s)$

and

$p_{ij}^{(k)} \ \lim_{t\to\infty} Q_{ij}^{(k)}(t) = \lim_{s\to 0} \tilde{Q}_{ij}^{(k)}(s)$

Thus

$p_{01} = \alpha_1(1-r_1)\int e^{-[\alpha_1(1-r_1)+\alpha_2(1-r_2)]u}du = \frac{\alpha_1(1-r_1)}{\alpha_1(1-r_1)+\alpha_2(1-r_2)}$

Similarly,

$\mathrm{p}_{02} = \frac{\alpha_2(1-\mathrm{r}_2)}{\alpha_1(1-\mathrm{r}_1)+\alpha_2(1-\mathrm{r}_2)}$

Conditional steady state probabilities of transitions are:

$p_{10|x} = \int dK_1(u|x)e^{-(\theta_1+\theta_2)u} = k_1^*[(\theta_1+\theta_2)|x]$

Similarly,

$p_{10|x} = k_1^*[(\theta_1+\theta_2)|x]$, $p_{26|x} = \frac{\theta_1}{\theta_1+\theta_2}\{1-k_2^*[(\theta_1+\theta_2)|x]\}$

$p_{27|x} = \frac{\theta_2}{\theta_1+\theta_2}\{1-k_2^*[(\theta_1+\theta_2)|x]\}$, $p_{13|x}^{(4)} = \{1-k_1^*[(\theta_1+\theta_2)|x]\}$

$p_{13|x}^{(5)} = \frac{\theta_1}{\theta_1+\theta_2}\{1-k_1^*[(\theta_1+\theta_2)|x]\}$, $p_{43|x} = p_{63|x} = p_{81|x} = p_{92|x} = 1$

Unconditional steady state probabilities of transition are

$p_{10} = \int p_{10|x}\, g_1(x)dx = \beta_1(1-r_1)[\beta_1(1-r_1)+\beta_2(1-r_2)]^{-1}$

$p_{13}^{(4)} = \theta_1[\beta_1(1-r_1)+\theta_1+\theta_2]^{-1}$, $p_{13}^{(5)} = \theta_2[\beta_1(1-r_1)+\theta_1+\theta_2]^{-1}$

$p_{23}^{(6)} = \theta_1[\beta_2(1-r_2)+\theta_1+\theta_2]^{-1}$, $p_{23}^{(7)} = \theta_2[\beta_2(1-r_2)+\theta_1+\theta_2]^{-1}$

$p_{20} = \beta_2(1-r_2)[\beta_2(1-r_2)+\theta_1+\theta_2]^{-1}$, $p_{30} = g_1^*\{\alpha_1(1-r_1)+\alpha_2(1-r_2)\}$

$p_{38} = \frac{\alpha_1(1-r_1)}{\alpha_1(1-r_1)+\alpha_2(1-r_2)}[g_1^*\{\alpha_1(1-r_1)+\alpha_2(1-r_2)\}]$

$p_{39} = \frac{\alpha_1(1-r_1)}{\alpha_1(1-r_1)+\alpha_2(1-r_2)}[1-[g_1^*\{\alpha_1(1-r_1)+\alpha_2(1-r_2)\}]]$

It can be easily verified that

$$p_{01}+p_{02} = 1, \quad p_{30}+p_{31}^{(8)}+p_{31}^{(9)} = 1, \quad p_{10}+p_{13}^{(4)}+p_{13}^{(5)} = 1 \qquad \text{(1-5)}$$

$$p_{20}+p_{23}^{(6)}+p_{23}^{(7)} = 1, \quad p_{43} = p_{53} = p_{63} = p_{73} = p_{81} = p_{92} = 1$$

Let the random variable T_i denotes the sojourn time in state S_i then mean sojourn time in that state is given by

$\psi_i = \int P[T_i > t]\,dt$

The conditional mean sojourn times are

$\psi_{1|x} = \int \bar{K}_1(u|x)e^{-(\theta_1+\theta_2)u}\,du = \frac{1}{\beta_1+\beta_2}\{1-k_1^*[(\theta_1+\theta_2)|x]\}$

$\psi_{2|x} = \frac{1}{\beta_1+\beta_2}\{1-k_2^*[(\theta_1+\theta_2)|x]\}$

$\psi_{4|x} = \psi_{5|x} = \int \bar{K}_1(u|x)du,$ $\psi_{6|x} = \psi_{7|x} = \int \bar{K}_2(u|x)du,$

and unconditional mean sojourn times are

$\psi_0 = [\alpha_1(1-\mathrm{r}_1)+\alpha_2(1-\mathrm{r}_2)]^{-1},$ $\psi_1 = [\beta_1(1-\mathrm{r}_1)+\theta_1+\theta_2]^{-1}$

$\psi_1 = [\beta_2(1-\mathrm{r}_2)+\theta_1+\theta_2]^{-1},$ $\psi_3 = [\alpha_1(1-\mathrm{r}_1)+\alpha_2(1-\mathrm{r}_2)+\theta_1]^{-1}$

$\psi_4 = \psi_5 = \frac{(1+\alpha_1 r_1 x)}{\beta_1},$ $\psi_6 = \psi_7 = \frac{(1+\alpha_2 r_2 x)}{\beta_2}$

5. ANALYSIS OF RELIABILITY AND MTSF

Let the random variable $T_i$denotes the time to system failure when the system starts from state $S_i \in E(i = 0,1,2)$. Then the reliability of the system according to its definition is given by

$R_i(t) = P[T_i > t]$

To determine $R_i(t)$,we regard the failed states of the system as absorbing. Using probabilistic arguments recursive relation among $R_i(t)$can be easily developed and taking L.T. of the relations and solving for $R_0^*(s)$,we get

$$R_0^*(s) = \frac{N_1(s)}{D_1(s)} \qquad (6)$$

where,

$N_1(s) = Z_0^* + q_{01}^* Z_1^* + q_{02}^* Z_2^*$

and

$D_1(s) = 1 - q_{01}^* q_{10}^* - q_{02}^* q_{20}^*$

where, Z_0^*, Z_1^* *and* Z_2^* are the L.T. of

$Z_0(t) = e^{-t[\alpha_1(1-r_1)+\alpha_2(1-r_2)]}$, $Z_1(t) = e^{-t(\theta_1+\theta_2)}\bar{K}_1(t|x)$

$Z_2(t) = e^{-t(\theta_1+\theta_2)}\bar{K}_2(t|x)$

Taking the inverse Laplace Transform of (7) we get the reliability of the system To get MTSF, we use the well known formula

$$E(T_0) = \lim_{s\to 0} R_0^*(s) = N_1(0)/D_1(0) \qquad (7)$$

where,

$N_1(0) = \psi_0 + p_{01}\psi_1 + p_{02}\psi_2$

and

$D_1(0) = 1 - p_{01}p_{10} - p_{02}p_{20}$

6. AVAILABILITY ANALYSIS

Let $A_i(t)$ denotes the probability that system is up at epoch t when it initially starts from regenerative state S_i .Using the definition of $A_i(t)$, the recursive relations among $A_i(t)$ (i = 0,1,2,3) can easily be developed, taking their L.T. and solving for$A_0^*(s)$ we get

$$A_0^*(s) = \frac{N_2(s)}{D_2(s)} \qquad (8)$$

where,

$N_2(s) = Z_0^*\left[1 - q_{32}^{*(9)}\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right) - q_{31}^{*(8)}\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right)\right] + Z_1^*\left[q_{01}^*\{1 - q_{31}^{*(9)}\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right)\}\right] + Z_2^*\left[q_{02}^*\{1 - q_{31}^{*(8)}\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right)\}\right]$
$+Z_3^*\left[q_{01}^*\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right)\right] + \left(Z_1^* q_{02}^* q_{31}^{*(8)} + Z_2^* q_{01}^* q_{31}^{*(9)} + Z_3^* q_{02}^*\right)\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right)$

and

$D_2(s) = 1 - q_{32}^{*(9)}\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right) - q_{31}^{*(8)}\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right) - q_{02}^* q_{10}^* q_{31}^{*(8)}\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right) - q_{02}^* q_{10}^*\left[1 - q_{31}^{*(9)}\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right)\right] - q_{01}^* q_{20}^* q_{32}^{*(9)}\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right)$
$-q_{02}^* q_{20}^*\left[1 - q_{31}^{*(8)}\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right)\right] - q_{01}^* q_{30}^*\left(q_{13}^{*(4)}+q_{13}^{*(5)}\right) - q_{02}^* q_{30}^*\left(q_{23}^{*(6)}+q_{23}^{*(7)}\right)$

The steady state probability that the system will be up is given by

$$A_0 = \lim_{t\to\infty} A_0(t) = \lim_{s\to 0} sA_0^*(s) = N_2(0)/D_2(0) \qquad (9)$$

It can be easily seen that $D_2(0) = 0$
so by using L'Hospital rule, we have
$A_0 = N_2(0)/D_2'(0) \quad = N_2/D_2$
where

$$N_2 = \psi_0[1 - p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)}) - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)})] + \psi_1[p_{01}\{1 - p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})\} + p_{02}p_{31}^{(8)}(p_{23}^{(6)} + p_{23}^{(7)})]$$
$$+\psi_2[p_{02}\{1 - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)})\} + p_{01}p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})] + \psi_3[p_{01}(p_{13}^{(4)} + p_{13}^{(5)}) + p_{02}(p_{23}^{(7)} + p_{23}^{(6)})]$$

and

$$D_2 = 1 - p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)}) - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)}) - p_{02}p_{10}p_{31}^{(8)}(p_{23}^{(6)} + p_{23}^{(7)})$$
$$-p_{01}p_{10}[1 - p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})] - p_{02}p_{20}[1 - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)})] - p_{01}p_{30}(p_{13}^{(4)} + p_{13}^{(5)}) - p_{02}p_{30}(p_{23}^{(6)} + p_{23}^{(7)})$$

The expected up time of the system during (0,t) is given by

$\mu_{up}(t) = \int_0^t A_0(u)du$ **(10)**

so that

$\mu_{up}^*(s) = A_0^*(s)/s$ **(11)**

7. BUSY PERIOD ANALYSIS

Define $B_i(t)$ as the probability that the repairman is busy in the repair of failed unit when the system initially starts from regenerative state S_i. Using probabilistic arguments, relations among $B_i(t)$can be set up, taking their L.T. and solving for $B_0^*(s)$, we have

$B_0^*(s) = N_2(s)/D_2(s)$ **(12)**

where,

$$N_3(s) = [q_{01}^*\{1 - q_{31}^{*(9)}(q_{23}^{*(6)} + q_{23}^{*(7)})\} + q_{02}^*q_{31}^{*(8)}(q_{23}^{*(6)} + q_{23}^{*(7)})] + Z_2^*[q_{01}^*q_{31}^{*(9)}(q_{13}^{*(4)} + q_{13}^{*(5)})\{1 - q_{31}^{*(8)}(q_{13}^{*(4)} + q_{13}^{*(5)})\}]$$
$$+Z_3^*[q_{01}^*(q_{13}^{*(4)} + q_{13}^{*(5)}) + q_{02}^*(q_{23}^{*(6)} + q_{23}^{*(7)})]$$

In the long run, the expected fraction of time for which the repairman is busy in the repair of the failed unit is given by

$B_0 = \lim_{t\to\infty} B_0(t) = \lim_{s\to 0} sB_0^*(s) = N_3/D_2$ (say) **(13)**

where,

$$N_3 = \psi_1[p_{01}\{1 - p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})\} + p_{02}p_{31}^{(8)}(p_{23}^{(6)} + p_{23}^{(7)})] + \psi_2[p_{02}\{1 - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)})\} + p_{01}p_{31}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})] +$$
$$\psi_3[p_{01}(p_{13}^{(4)} + p_{13}^{(5)}) + p_{02}(p_{23}^{(7)} + p_{23}^{(6)})]$$

The expected busy period of the repairman during (o, t) is given by

$\mu_b(t) = \int_0^t B_0(u)du$ **(14)**

So that

$\mu_b^*(s) = B_0^*(s)/s$ **(15)**

8. EXPECTED NUMBER OF REPAIRS

Define$V_i(t)$ as the expected number of repairs of the failed unit during the interval (0,t) when the system initially starts from the regenerative state S_i . Using elementary probabilistic arguments, recursive relations among$V_i(t)$ can be set up, taking their L.S.T.and solving for $\tilde{V}_0(s)$,we get

$\tilde{V}_0(s) = \frac{N_4(s)}{D_2(s)}$ **(16)**

Where,

$$N_4(s) = \tilde{Q}_{01}\tilde{Q}_{10}[1 - \tilde{Q}_{32}^{(9)}(\tilde{Q}_{23}^{(6)} + \tilde{Q}_{23}^{(7)})] + \check{Q}_{02}\tilde{Q}_{10}\tilde{Q}_{31}^{(9)}(\tilde{Q}_{23}^{(6)} + \tilde{Q}_{23}^{(7)}) + \tilde{Q}_{20}\tilde{Q}_{01}\tilde{Q}_{32}^{(9)}(\tilde{Q}_{13}^{(4)} + \tilde{Q}_{13}^{(5)}) + \tilde{Q}_{02}\tilde{Q}_{20}[1 - \tilde{Q}_{31}^{(8)}(\tilde{Q}_{13}^{(4)} + \tilde{Q}_{13}^{(5)})]$$
$$+\tilde{Q}_{30}\tilde{Q}_{01}(\tilde{Q}_{13}^{(4)} + \tilde{Q}_{13}^{(5)}) + \tilde{Q}_{30}\tilde{Q}_{02}(\tilde{Q}_{23}^{(6)} + \tilde{Q}_{23}^{(7)})$$

In steady state expected number of repairs per unit of time is given by

$V_0 = \lim_{t\to\infty}[V_0(t)/t] = \lim_{s\to\infty} s^2\,\tilde{V}_0(s) = N_4/D_2$ (say) **(17)**

Where,

$$N_4 = p_{01}p_{10}\{1 - p_{32}^{(9)}(p_{23}^{(6)} + p_{23}^{(7)})\} + p_{01}p_{02}\,p_{31}^{(8)}(p_{23}^{(6)} + p_{23}^{(7)}) + p_{01}p_{30}(p_{13}^{(4)} + p_{13}^{(5)})$$
$$+ p_{01}p_{20}\,p_{32}^{(9)}(p_{13}^{(4)} + p_{13}^{(5)}) + p_{02}p_{20}\{1 - p_{31}^{(8)}(p_{13}^{(4)} + p_{13}^{(5)})\} + p_{01}p_{20}\,p_{32}^{(9)}(p_{13}^{(4)} + p_{13}^{(5)})$$

9. PROFIT FUNCTION ANALYSIS

Considering the mean up time, expected busy period of the repairman and expected number of repairs per unit of time, the net expected profits in the interval (0,t) are

$P_1(t) = K_0\mu_{up}(t) - K_1\mu_b(t)$ **(18)**

$P_2(t) = K_0\mu_{up}(t) - K_2V_0(t)$ **(19)**

The expected total profits per unit time in steady state are

$P_1 = \lim_{t\to\infty}[P_1(t)/t] = \lim_{s\to 0} s^2\,P_1^*(s)$

$P_2 = \lim_{t\to\infty}[P_2(t)/t] = \lim_{s\to 0} s^2\,P_2^*(s)$

So that

$P_1 = K_0A_0 - K_1B_0$ **(20)**

$P_2 = K_0A_0 - K_2V_0$ **(21)**

Where K_0 is the revenue per unit up time and K_1 and K_2 are the costs of repair per unit time for the system and per unit repair cost of the system respectively.

10. GRAPHICAL STUDY OF THE SYSTEM MODEL

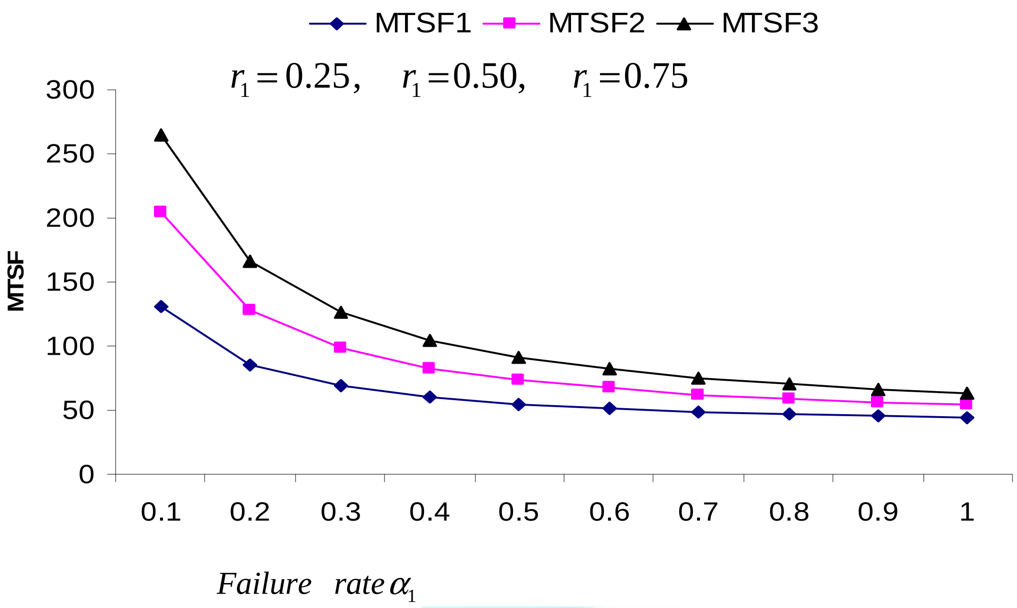
For a more concrete study of system behaviour, we plot the graphs of MTSF and profit functions w.r.t. the failure parameter α_1 for three different values of the correlation coefficient $r_1 = 0.25, r_2 = 0.50, r_3 = 0.75$ when the other parameters are kept fixed as $\alpha_2 = 0.04$, $\beta_1 = 0.04, \beta_2 = 0.03, \gamma_1 = 0.4, \gamma_2 = 0.4$, $\theta_1 = 0.05$, $\theta_2 = 0.03, K_0 = 1000$, $K_1 = 300$, $K_2 = 400$.

Fig.2, shows the variation in MTSF in respect of α_1 for three different values of correlation coefficient $r_1 = 0.25, r_2 = 0.50, r_3 = 0.75$.It is observed from the graph that MTSF decreases with the increase in the failure parameter α_1 and increases with the increase in the values of the correlation coefficient r_1.

Fig.3, represents the change in profit functions P_1 and P_2 w.r.t. varying values of α_1 for three different values of correlation coefficient $r_1 = 0.25, r_2 = 0.50, r_3 = 0.75$. From the graph it is seen that both the profit functions decrease with the increase in the failure rate α_1 and increase with the increase in r_1. It is also observed that profit function P_2 is always higher as compared to profit function P_1 for fixed values of α_1 and r_1.

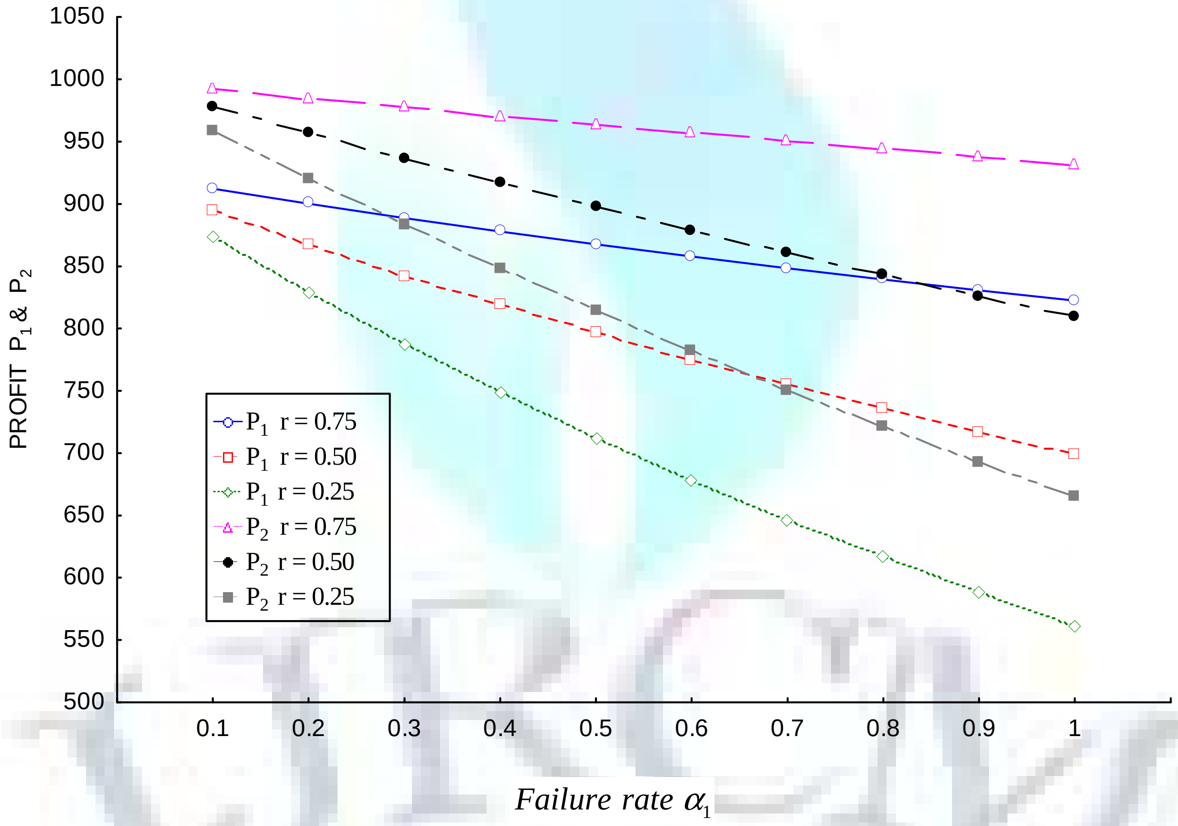
BEHAVIOUR OF MTSF W.R.T α_1 FOR DIFFERENT VALUES OF r_1

FIG. 2



BEHAVIOUR OF PROFIT FUNCTIONS P_1 and P_2 W.R.T. α_1 FOR DIFFERENT VALUES OF r_1

FIG. 3



11. CONCLUSION

In this paper a system model consisting of two subsystems has been considered for its analysis .Various reliability characteristics like mean time to system failure, availability, busy period of the repairman and profit incurred by the system have been obtained. The graphical behavior of some of the characteristics w.r.t. failure rate for different values of correlation coefficient between failure and repair has been studied.

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