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Research Article

COST-BENEFIT ANALYSIS OF A TWO SIMILAR COLD STANDBY SYSTEM WITH FAILURE DUE TO CORROSIVE ATMOSPHERE AND HUMAN ERRORS

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ABSTRACT

Atmospheric corrosion is the deterioration and destruction of a material and its vital properties due to electrochemical as well as the other reactions of its surface with the constituents of the atmosphere surrounding the material. Different atmospheric substances cause corrosion and erosion of metals and nonmetals. Earth's natural environment of oxygen and condensed water vapor is itself sufficient to cause gradual corrosion of iron and steel surfaces, producing iron oxide, more commonly known as rust. Corrosion alters the micro structure and drastically reduces the mechanical strength and useful life of the metals. The study of atmospheric corrosion is essential because this type of damage is the most prevalent among the different types of corrosion damage. This type of deterioration is widespread, as it affects outdoor as well as indoor installations such as utilities, industries, vehicles and residential structures. We have taken units failure due to atmospheric corrosion and due to Human Errors with failure time distribution as exponential and repair time distribution as General. We have find out MTSF, Availability analysis, the expected busy period of the server for repair when the failure caused due to atmospheric corrosion in (0,t], expected busy period of the server for repair in(0,t], the expected busy period of the server for repair when failure caused due to Human Errors in (0,t], the expected number of visits by the repairman for failure of units due to atmospheric corrosion in (0,t], the expected number of visits by the repairman for Human Errors in (0,t] and Cost-Benefit analysis using regenerative point technique. A special case using failure and repair distributions as exponential is derived and graphs have been drawn.

Keywords: Cold Standby, atmospheric corrosion, human errors, MTSF, Availability, Busy period, Cost-Benefit Analysis

INTRODUCTION

Atmospheric corrosion refers to the corrosive action that occurs on the surface of a metal in an atmospheric environment[1-3]. It occurs when the surface is wet by moisture formed due to rain, atmospheric corrosion and condensation. Atmospheric corrosion is a complex process involving a large number of interacting and constantly varying factors, such as weather conditions[4,5], air pollutants, material conditions, etc. The combined effect of these factors results in a great variations in corrosion rates.

In this paper, we have failure due to atmospheric corrosion and failure due to human errors which are non-instantaneous in nature.. Here, we investigate a two identical cold standby –a system in which offline unit cannot fail. The failure is due to Human Errors and due to atmospheric corrosion. When there is atmospheric corrosion to less degree, that is, within specified limit, it operates as normal as before but if these are beyond the specified degree the operation of the unit is stopped to avoid excessive damage of the unit and as the atmospheric corrosion continues going on some characteristics of the unit change which we call failure of the unit. After failure due to atmospheric corrosion the failed unit undergoes repair immediately according to first come first served discipline.

ASSUMPTIONS

1. The system consists of two similar cold standby units. The failure time distributions of the operation of the unit stopped automatically, the atmospheric corrosion and human errors are exponential with rates λ_1, λ_2 and λ_3 whereas the repairing rates for repairing the failed system due to atmospheric corrosion and due to Human Errors are arbitrary with CDF $G_1(t)$ & $G_2(t)$ respectively.
2. When there is atmospheric corrosion to less degree that is within specified limit , it operates as normal as before but if these are beyond the specified degree the operation of the unit is avoided and as the

atmospheric corrosion continues goes on some characteristics of the unit change which we call failure of the unit.

3. The atmospheric corrosion actually failed the units. The atmospheric corrosion is non-instantaneous and it cannot occur simultaneously in both the units.
4. The repair facility works on the first fail first repaired (FCFS) basis.
5. The switches are perfect and instantaneous.
6. All random variables are mutually independent.

Symbols for states of the System

Superscripts O, CS, SO, FAC, FHE

Operative, cold Standby, Stops the operation, Failed due to atmospheric corrosion, failed due to human errors respectively

Subscripts nac, uac, he, ur, wr, uR

No atmospheric corrosion, under atmospheric corrosion, human errors, under repair, waiting for repair, under repair continued respectively

Up states – 0, 1, 3; Down states – 2,4,5,6,7

States of the System

0(O_{nac} , CS_{nac})

One unit is operative and the other unit is cold standby and there is no atmospheric corrosion in both the units.

1(SO_{uac} , O_{nac})

The operation of the first unit stops automatically due to atmospheric corrosion and cold standby unit starts operating with no atmospheric corrosion.

2(SO_{uac} , $FHE_{nac,he,ur}$)

The operation of the first unit stops automatically due to atmospheric corrosion and the other unit fails due to human errors and undergoes repair..

3(FAC_{ur} , O_{uac})

The first unit fails due to atmospheric corrosion and undergoes repair and the other unit continues to be operative with no atmospheric corrosion.

4(FAC_{uR} , SO_{uac})

The one unit fails due to atmospheric corrosion and continues to be undergoes repair and the other unit also stops automatically due to atmospheric corrosion.

5(FAC_{uR} , FAC_{wr})

The repair of the first unit is continued from state 4 and the other unit failed due to atmospheric corrosion is waiting for repair.

6(FAC_{uR} , SO_{ac})

The repair of the first unit is continued from state 3 and unit fails due to atmospheric corrosion and operation of other unit stops automatically due to atmospheric corrosion.

7(FAC_{wr} , $FHE_{he, uR}$)

The repair of failed unit due to human errors is continued from state 2 and the first unit is failed due to atmospheric corrosion is waiting for repair.

Transition Probabilities

Simple probabilistic considerations yield the following expressions:

$$p_{01} = \frac{\lambda 1}{\lambda 1+ \lambda 3} \quad , \quad p_{02} = \frac{\lambda 3}{\lambda 1+ \lambda 3}$$

$$p_{13} = \frac{\lambda 2}{\lambda 1+ \lambda 2} \quad , \quad p_{14} = \frac{\lambda 1}{\lambda 1+ \lambda 2}$$

$$p_{23} = \lambda_1 G_2^*(\lambda_2) , \quad p_{23}^{(7)} = \lambda_2 G_2^*(\lambda_2) , \; p_{24} = \overline{G}_2^*(\lambda_2) ,$$

$$p_{30} = G_1^*(\lambda_1) , \; p_{33}^{(6)} = \overline{G}_1^*(\lambda_1)$$

$$p_{43} = G_1^*(\lambda_2) \; , \quad p_{43}^{(5)} = G_1^*(\lambda_2) \qquad (1)$$

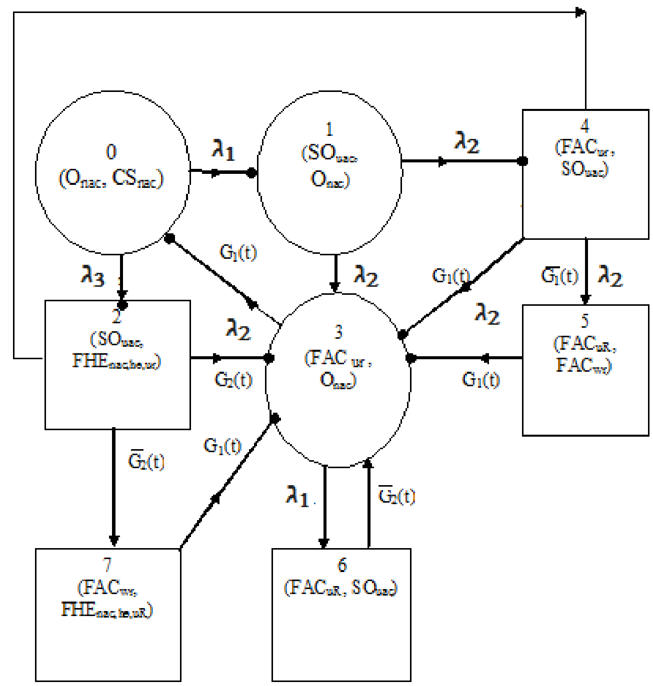

Figure 1: The State Transition Diagram

Regeneration point

Up State

Down State

We can easily verify that

$$p_{01} + p_{02} = 1, \; p_{13} + p_{14} = 1, \; p_{23} + p_{23}^{(7)} + p_{24} = 1,$$

$$p_{30} + p_{33}^{(6)} = 1, \; p_{43} + P_{43}^{(5)} = 1 \qquad (2)$$

And mean sojourn time are

$$\mu_0 = E(T) = \int_0^{\infty} P[T > t]dt = -1/\lambda_1$$

Similarly

$$\mu_1 = 1/\lambda_2 \quad , \quad \mu_2 = \int_0^{\infty} e^{-\lambda 1 \overline{G}1(t)} dt \quad ,$$

$$\mu_4 = \int_0^{\infty} e^{-\lambda 2 \overline{G}1(t)} dt \quad (3)$$

Mean Time to System Failure

We can regard the failed state as absorbing

$$\theta_0(t) = Q_{01}(t)[s]\theta_1(t) + Q_{02}(t)$$

$$\theta_1(t) = Q_{13}(t)[s]\theta_3(t) + Q_{14}(t),$$

$$\theta_3(t) = Q_{30}(t)[s]\theta_0(t) + Q_{33}^{(6)}(t) \qquad (4\text{-}6)$$

Taking Laplace-Stieltjes transforms of eq. (4-6) and solving for

$$\theta_0^*(0) = N_1(s) \; / \; D_1(s) \qquad (7)$$

Where

$$N_1(s) = Q_{01}^*(s) \; \{ \; Q_{13}^*(s) \, Q_{33}^{(6)*}(s) \; + \; Q_{14}^*(s) \} + \; Q_{02}^*(s)$$

$$D_1(s) = 1 \; - Q_{01}^*(s) \quad Q_{13}^*(s) \, Q_{30}^*(s)$$

Making use of relations (1) & (2) it can be shown that $\theta_0^*(0)$ =1, which implies that $\theta_0(t)$ is a proper distribution.

$$MTSF = E[T] = \left. \frac{d}{ds}\theta_0(s) \right|_{s=0} = (D_1'(0) - N_1'(0)) \; / \; D_1(0)$$

$$= \; (\mu_0 + p_{01} \; \mu_1 + p_{01} \; p_{13} \; \mu_3) \, / \, (1 \; - p_{01} \, p_{13} \, p_{30}) \quad (8)$$

Where

$\mu_0 = \mu_{01} + \mu_{02}$, $\mu_1 = \mu_{13} + \mu_{14}$, $\mu_2 = \mu_{23} + \mu_{23}^{(1)} + \mu_{24}$, $\mu_3 = \mu_{30} + \mu_{33}^{(6)}$; $\mu_3 = \mu_{43} + \mu_{43}^{(5)}$

Availability analysis

Let $M_i(t)$ be the probability of the system having started from state i is up at time t without making any other regenerative state . By probabilistic arguments, we have

The value of $M_0(t)= e^{-\lambda_1 t} e^{-\lambda_3 t}$, $M_1(t)= e^{-\lambda_1 t} e^{-\lambda_2 t}$,

$$M_3(t)= e^{-\lambda_1 t}\bar{G}_1(t) \quad (9)$$

The point wise availability $A_i(t)$ have the following recursive relations

$$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{02}(t)[c]A_2(t)$$
$$A_1(t) = M_1(t) + q_{13}(t)[c]A_3(t) + q_{14}(t)[c]A_4(t) ,$$
$$A_2(t) = \{q_{23}(t) + q_{23}^{(7)}(t)\}[c]A_3(t) + q_{33}^{(6)}(t) [c]A_3(t)$$
$$A_4(t) = \{q_{43}(t) + q_{43}^{(5)}(t)[c]A_3(t) \quad (10 - 14)$$

Taking Laplace Transform of eq. (10-14) and solving for $\hat{A}_0(s)$

$$\hat{A}_0(s) = N_2(s) / D_2(s) \quad (15)$$

where

$N_2(s) = (1 - \hat{q}_{33}^{(6)}(s))\ \hat{M}_0(s) +[\ \hat{q}_{01}(s)\{\hat{M}_1(s) + (\hat{q}_{13}(s)+ \hat{q}_{14}(s)(\hat{q}_{43}(s) + \hat{q}_{43}^{(5)}(s)))\} + \hat{q}_{02}(s)\{\hat{q}_{23}(s)) + \hat{q}_{23}^{(1)}(s)) + \hat{q}_{24}(s)(\hat{q}_{43}(s) +\hat{q}_{43}^{(5)}(s))\}]\ \hat{M}_3(s)$

$D_2(s) = (1 - \hat{q}_{33}^{(6)}(s)) - \hat{q}_{30}(s)\ [\hat{q}_{01}(s)\{\ \hat{q}_{13}(s)+ \hat{q}_{14}(s)(\hat{q}_{43}(s) + \hat{q}_{43}^{(5)}(s))\}+ \hat{q}_{20}(s)\{\ \hat{q}_{23}(s)+\hat{q}_{23}^{(7)}(s)+\ \hat{q}_{24}(s)(\hat{q}_{43}(s)) + \hat{q}_{43}^{(5)}(s))\}]$

The steady state availability

$$A_0 = \lim_{t\to\infty}[A_0(t)] = \lim_{s\to 0}[s\,\hat{A}_0(s)] = \lim_{s\to 0}\frac{s\,N_2(s)}{D_2(s)}$$

Using L' Hospitals rule, we get

$$A_0 = \lim_{s\to 0}\frac{N_2(s)+s\ N_2'(s)}{D_2'(s)} = \frac{N_2(0)}{D_2'(0)} \quad (16)$$

Where

$$N_2(0)= p_{30}\,\hat{M}_0(0) + p_{01}\hat{M}_1(0)\ \ \hat{M}_3(0)\ )$$

$D_2'(0) = \mu_3 + [\ \mu_0 + p_{01}(\ \mu_1 + p_{14}\ \mu_4 + p_{02}(\ \mu_2 + p_{24}\,\mu_4\ )]\ p_{30}$

The expected up time of the system in (0,t] is

$$\lambda_u(t) = \int_0^{\infty} A_0(z)dz \ \text{ So that } \widehat{\lambda_u}(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{SD_2(S)} \quad (17)$$

The expected down time of the system in (0,t] is

$$\lambda_d(t) = t - \lambda_u(t) \ \text{ So that } \widehat{\lambda_d}(s) = \frac{1}{s^2} - \widehat{\lambda_u}(s) \quad (18)$$

The expected busy period of the server when the operation of the unit stops automatically failed unit under atmospheric corrosion in (0,t]

$$R_0(t) = q_{01}(t)[c]R_1(t) + q_{02}(t)[c]R_2(t)$$
$$R_1(t) = S_1(t) + q_{13}(t)[c]R_3(t) + q_{14}(t)[c]R_4(t) ,$$
$$R_2(t) = S_2(t) + q_{23}(t)[c]R_3(t) + q_{23}^{(7)}(t)[c]R_3(t) + q_{24}(t)[c]R_4(t)$$
$$R_3(t) = q_{30}(t)[c]R_0(t) + q_{33}^{(6)}(t)[c]R_3(t),$$
$$R_4(t) = S_4(t) + (q_{43}(t)+ q_{43}^{(5)}(t))\ [c]R_3(t) \quad (19-23)$$

Where

$$S_1(t)= e^{-\lambda_1 t} e^{-\lambda_2 t},\ S_2(t) = e^{-\lambda_1 t}\bar{G}_2(t) ,$$
$$S_4(t) = e^{-\lambda_1 t}\bar{G}_1(t) \quad (24)$$

Taking Laplace Transform of eq. (19-23) and solving for $\widehat{R_0}(s)$

$$\widehat{R_0}(s) = N_3(s) / D_2(s) \quad (25)$$

where

$N_3(s) = (1 - \hat{q}_{33}^{(6)}(s))\ [\ \hat{q}_{01}(s)(\hat{S}_1(s) + \hat{q}_{14}(s)\,\hat{S}_4(s)+ \hat{q}_{02}(s)(\hat{S}_2(s) + \hat{q}_{24}(s)\,\hat{S}_4(s))]$ and $D_2(s)$ is already defined.

In the long run,

$$R_0 = \frac{N_3(0)}{D_2'(0)} \quad (26)$$

where $N_3(0)= p_{30}\ [\ p_{01}\ (\hat{S}_1(0) + p_{14}\,\hat{S}_4(0)\ ) + p_{02}\ (\hat{S}_2(0) + p_{24}\,\hat{S}_4(0)\ )$ and $D_2'(0)$ is already defined.

The expected period of the system under atmospheric corrosion in (0,t] is

$$\lambda_{rv}(t) = \int_0^{\infty} R_0(z)dz \ \text{ So that } \widehat{\lambda_{rv}}(s) = \frac{\hat{R}_0(s)}{s} \quad (27)$$

The expected Busy period of the server for repair when failure is caused due to atmospheric corrosion in (0,t]

$$B_0(t) = q_{01}(t)[c]B_1(t) + q_{02}(t)[c]B_2(t)$$
$$B_1(t) = q_{13}(t)[c]B_3(t) + q_{14}(t)[c]B_4(t) ,$$
$$B_2(t) = q_{23}(t)[c]\ B_3(t) + q_{23}^{(7)}(t)[c]B_3(t) + q_{24}(t)[c]\ B_4(t)$$
$$B_3(t) = T_3(t)+ q_{30}(t)[c]\ B_0(t) + q_{33}^{(6)}(t)[c]B_3(t)$$
$$B_4(t) = T_4(t)+ \{\ q_{43}(t) + q_{43}^{(5)}(t)\}\ [c]B_3(t) \quad (28-32)$$

Where

$$T_3(t) = e^{-\lambda_2 t}\bar{G}_1(t) \qquad T_4(t) = e^{-\lambda_1 t}\bar{G}_1(t) \quad (33)$$

Taking Laplace Transform of eq. (28-32) and solving for $\widehat{B_0}(s)$

$$\widehat{B_0}(s) = N_4(s) / D_2(s) \quad (34)$$

Where

$N_4(s) = \hat{T}_3(s)\ [\ \hat{q}_{01}(s)\{\ \hat{q}_{13}(s)+ \hat{q}_{14}(s)(\hat{q}_{43}(s) + \hat{q}_{43}^{(5)}(s))\}+ \hat{q}_{02}(s)\{\ \hat{q}_{23}(s)+\ \hat{q}_{23}^{(7)}(s)+ \hat{q}_{24}(s)(\hat{q}_{43}(s) +\hat{q}_{43}^{(5)}(s))\}]+\ \hat{T}_4(s)$
$[\hat{q}_{01}(s)\ \hat{q}_{44}(s)(1 - \hat{q}_{33}^{(6)}(s)) +$
$(\hat{q}_{02}(s)\ \ \hat{q}_{24}(s)(1- \hat{q}_{33}^{(6)}(s))]$

And $D_2(s)$ is already defined.

In steady state, $\quad B_0 = \frac{N_4(0)}{D_2'(0)} \quad (35)$

where $N_4(0)= \hat{T}_3(0)+ \hat{T}_4(0)\ \{\ p_{30}\ (p_{01}p_{14} + p_{02}\ p_{24})\ \}$ and $D_2'(0)$ is already defined.

The expected busy period of the server for repair in (0,t] is

$$\lambda_{ru}(t) = \int_0^{\infty} B_0(z)dz \ \text{ So that } \widehat{\lambda_{ru}}(s) = \frac{\hat{B}_0(s)}{s} \quad (36)$$

The expected Busy period of the server for repair when failure caused due to human errors in (o,t]

$$P_0(t) = q_{01}(t)[c]P_1(t) + q_{02}(t)[c]P_2(t)$$
$$P_1(t) = q_{13}(t)[c]P_3(t) + q_{14}(t)[c]P_4(t) ,$$
$$P_2(t) = L_2(t)+ q_{23}(t)[c]P_3(t) + q_{23}^{(7)}(t)[c]P_3(t)+ q_{24}(t)[c]P_4(t)$$
$$P_3(t) = q_{30}(t)[c]P_0(t) + q_{33}^{(6)}(t)[c]P_3(t),$$
$$P_4(t) = (q_{43}(t)+ q_{43}^{(5)}(t))\ [c]P_3(t) \quad (37-41)$$

Where $\quad L_2(t) = e^{-\lambda_1 t}\bar{G}_2(t)$

Taking Laplace Transform of eq. (37-41) and solving for $\widehat{P_0}(s)$

$$\widehat{P_0}(s) = N_5(s) / D_2(s) \quad (43)$$

where $N_5(s) = \hat{q}_{02}(s)\ \hat{L}_2(s)\ (1 - \hat{q}_{33}^{(6)}(s))$ and $D_2(s)$ is defined earlier.

In the long run , $\quad P_0 = \frac{N_5(0)}{D_2'(0)} \quad (44)$

where $N_5(0)= p_{30}\,p_{02}\,\hat{L}_2(0)$ and $D_2'(0)$ is already defined.

The expected busy period of the server for repair of the switch in (0,t] is

$$\lambda_{rs}(t) = \int_0^{\infty} P_0(z)dz \ \text{ So that } \widehat{\lambda_{rs}}(s) = \frac{\hat{P}_0(s)}{s} \quad (45)$$

The expected number of visits by the repairman for repairing the when faiure due to atmospheric corrosion in (0,t]

$$H_0(t) = Q_{01}(t)[s]H_1(t) + Q_{02}(t)[s]H_2(t)$$
$$H_1(t) = Q_{13}(t)[s][1+H_3(t)] + Q_{14}(t)[s][1+H_4(t)] ,$$
$$H_2(t) = [Q_{23}(t) + Q_{23}^{(7)}(t)]\ [s][1+H_3(t)] + Q_{24}(t)[s][1+ H_4(t)]$$

$H_3(t) = Q_{30}(t)[s]H_0(t) + Q_{33}^{(6)}(t)[s]H_3(t),$

$H_4(t) = (Q_{43}(t) + Q_{43}^{(5)}(t))\ [s]H_3(t)$ (46-50)

Taking Laplace Transform of eq. (46-50) and solving for $H_0^*(s)$

$$H_0^*(s) = N_6(s) / D_3(s) \quad (51)$$

where

$N_6(s) = (1 - Q_{33}^{(6)*}(s))\{Q^*_{01}(s)(Q^*_{13}(s) + Q^*_{14}(s)) + Q^*_{02}(s)(Q^*_{24}(s) + Q^*_{23}(s) + Q^*_{23}{}^{(7)}(s))\}$

$D_3(s) = (1 - Q_{33}^{(6)*}(s)) - Q^*_{30}(s)[Q^*_{01}(s)\{Q^*_{13}(s) + Q^*_{14}(s)(Q_{43}^*(s) + Q^*_{43}{}^{(5)}(s))\} + Q^*_{02}(s)\{Q^*_{23}(s) + Q^*_{23}{}^{(7)}(s)) + Q^*_{24}(s)(Q^*_{43}(s)) + Q^*_{43}{}^{(5)}(s))\}]$

In the long run, $H_0 = \frac{N_6(0)}{D_3'(0)}$ (52)

where $N_6(0) = p_{30}$ and $D'_3(0)$ is already defined.

The expected number of visits by the repairman for repairing when failure is caused due to human errors in (0,t]

$V_0(t) = Q_{01}(t)[s]V_1(t) + Q_{02}(t)[s][1+V_2(t)]$

$V_1(t) = Q_{13}(t)[s]V_3(t) + Q_{14}(t)[s]V_4(t),$

$V_2(t) = Q_{24}(t)[s][1+V_4(t)] + [Q_{23}(t) + Q_{23}^{(7)}(t)[s][1+V_3(t)]$

$V_3(t) = Q_{30}(t)[s]V_0(t) + Q_{33}^{(6)}(t)[s]V_3(t)$ (53-57)

Taking Laplace-Stieltjes transform of eq. (53-57) and solving for $V_0{}^*(s)$

$$V_0{}^*(s) = N_7(s) / D_4(s) \quad (58)$$

where $N_7(s) = (1 - Q_{33}^{(6)*}(s))\{Q^*_{01}(s)(Q^*_{14}(s) + Q^*_{43}(s)) + Q^*_{02}(s)(Q^*_{24}(s) + Q^*_{02}(s)(Q^*_{23}(s) + Q^*_{23}{}^{(7)}(s))\}$

and $D_4(s)$ is the same as $D_3(s)$

In the long run, $V_0 = \frac{N_7(0)}{D_4'(0)}$ (59)

where $N_7(0) = p_{30}\ [p_{01}\ p_{14}\ p_{43} + p_{02}]$ and $D'_3(0)$ is already defined.

Cost Benefit Analysis

The cost-benefit function of the system considering mean up-time, expected busy period of the system under atmospheric corrosion when the units stops automatically, expected busy period of the server for repair when failure due to human errors , expected number of visits by the repairman when failure is caused due to atmospheric corrosion, expected number of visits by the repairman for Human Errors.

The expected total cost-benefit incurred in (0,t] is C(t) = Expected total revenue in (0,t]

- Expected total repair cost for failure due to human errors in (0,t]
- Expected total repair cost for repairing the units when failure is caused due to human errors in (0,t]
- Expected busy period of the system under atmospheric corrosion when the units automatically stop in (0,t]
- Expected number of visits by the repairman for repairing when failure caused due to human errors in (0,t]
- Expected number of visits by the repairman for repairing the units when failure is due to atmospheric corrosion in (0,t]

The expected total cost per unit time in steady state is

$$C = \lim_{t\to\infty}(C(t)/t) = \lim_{s\to 0}(s^2 C(s))$$

$$= K_1A_0 - K_2P_0 - K_3B_0 - K_4R_0 - K_5V_0 - K_6H_0$$

Where

$K_1 \rightarrow$ Revenue per unit up-time,

$K_2 \rightarrow$ Cost per unit time for which the system failure due to human errors

$K_3 \rightarrow$ Cost per unit time for which the system is under unit repair failure due to atmospheric corrosion

$K_4 \rightarrow$ Cost per unit time for which the system is under atmospheric corrosion when units automatically stop.

$K_5 \rightarrow$ Cost per visit by the repairman for which switch repair,

$K_6 \rightarrow$ Cost per visit by the repairman for units repair.

CONCLUSION

After studying the system, we have analyzed graphically that when the failure rate due to operation of the unit stops automatically, due to human errors and , atmospheric corrosion rate increases, the MTSF and steady state availability decreases and the cost function decreased as the failure increases.

REFERENCES

1. Barlow RE and Proschan F. Mathematical theory of Reliability, John Wiley, New York, 1965.
2. Dhillon BS and Natesen J, Stochastic Anaysis of outdoor Power Systems in fluctuating environment, Microelectron. Reliab. 1983; 23: 867-881.
3. Gnedanke BV, Belyayar YK and Soloyer AD, Mathematical Methods of Relability Theory, Academic Press, New York, 1969.
4. Goel LR, Sharma GC and Gupta Rakesh. Cost Analysis of a Two-Unit standby system with different weather conditions, Microelectron. Reliab., 1985; 25: 665-659.
5. Goel LR, Sharma GC and Gupta Parveen, Stochastic Behavior and Profit Anaysis of a redundant system with slow switching device, Microelectron Reliab., 1986; 26: 215-219.

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