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Reliability and Profit Analysis of Some System Working Under Extreme Cold Weather Situation

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ABSTRACT

The present paper deals with the study of a reliability model for a system in which operation is affected by unstable weather conditions. This model consist two units which are non-identical in nature. This situation was observed by the authors in a manufacturing company wherein the working of the system needs to be shut down when the weather conditions rises beyond a certain limit. Present model is based on this situation. The problem of stopping the working of the system does not come in the winter for the location considered for the model. However, during summer, there is possibility when the system gets stopped due to dipping down in the temperature below a certain level. Various measures of the system effectiveness like MTSF, steady state availability, busy period, expected number of visit of the repairman, expected down time have been obtained making use regenerative point technique. In this article we have computed mean time, cost analysis and system failure with the help of reliability.

1. INTRODUCTION

In the fast moving world, it is realized globally that a rapid development in technology is taking place day by day to cater to the need of the society and industries. There is now a sea change m technology [1]. More and more complex and sophisticated systems are becoming a significant part of our modem society. It's practically impossible to conduct a lot of day-to-day tasks without the help of such methods [2]. As much more reliance is positioned on these devices, it's crucial they operate in a dependable fashion [3]. For a business to be successful in present day very competitive and highly advanced atmosphere, it's crucial it understands the dependability of its product and can manage it to be able to create items at an optimum reliability level [4]. This produces the minimum life cycle price of the person and reduces the manufacturer's expense of such a solution without compromising the product's quality and reliability [5].

$$R(t) = P[T > t] = 1 - P[T \le t] = 1 - F(t) .$$

The qualitative and quantitative performance measurement of a component or a machine can be measured by reliability modeling [6]. Concept of reliability contains a rich blend of basic and practical problems from the real world. The main aim of reliability modeling is optimization of available resources under all possible system performances including the economic forecasting of the profit [7]. A ream of probe effort has been done on reliability modeling of systems considering different forms on failure and repair policies [8]. We cannot ignore the effect of various failures such as major, minor and so on. Study of reliability furnishes lot of work on the reliability and cost benefit analysis of various systems [9].

2. MODEL ASSUMPTIONS

- The chosen system has two non-identical operative units
- We consider summer as a starting state of system while working
- There are arbitrary distributions for random variables
- each system is consider as a new system after repairing
- The failure of open mode Is due to some human errors.
- In winter, the working of the system in not affected by variation in temperature as it cannot increase beyond the required upper limit.
- Distribution of occurrence and disappearance of bad weather conditions and time required for activation are also taken as exponential.

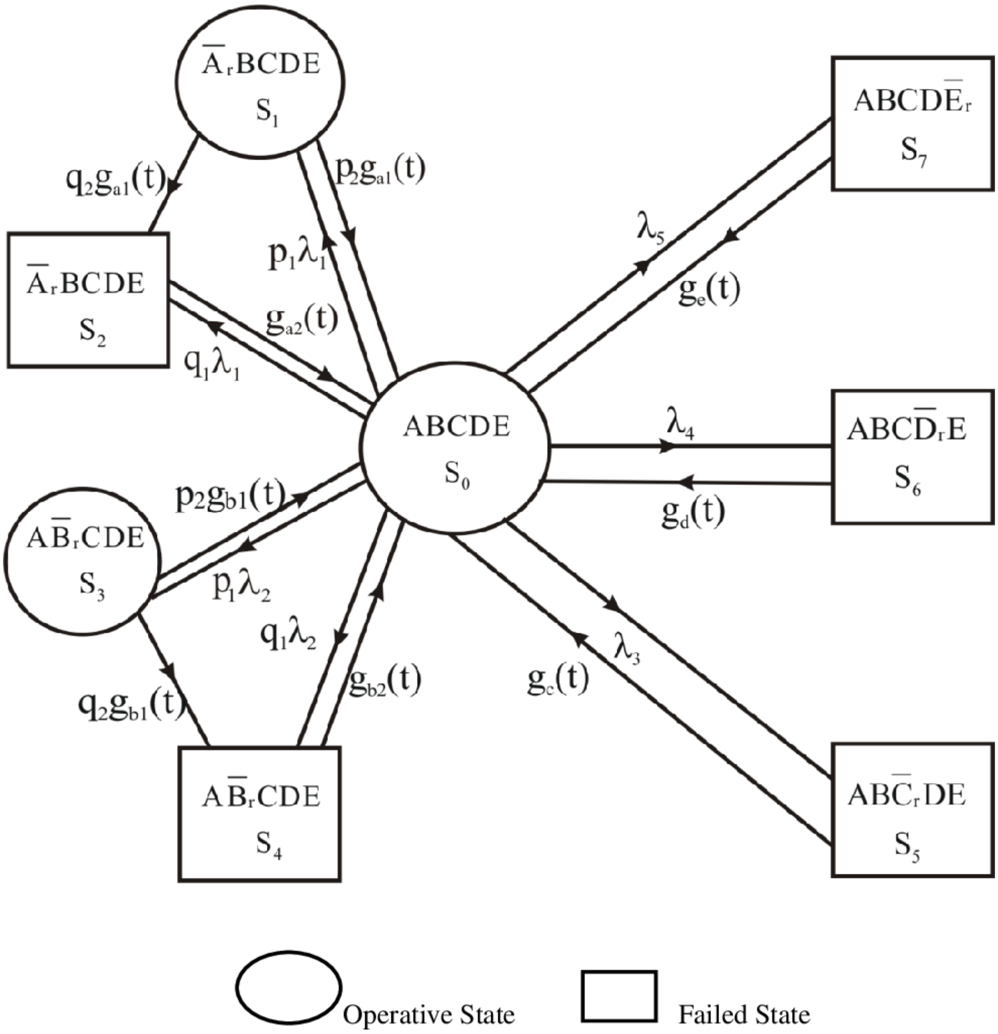

Figure 1

3. NOTATIONS

- λ: failure rate unit
- G(t): cumulative density function of both the units
- g(t): probability density function of both units

4. MEAN TIME TO SYSTEM FAILURE

For regenerative process, We have considered failed 6 failed sates (3,4,6,7,8,10) in MTSF.

$$\pi_0(t) = Q_{01}(t) \circledS \pi_1(t),$$

$$\pi_1(t) = Q_{13}(t) + Q_{12}(t) \circledS \pi_2(t)$$

$$\pi_2(t) = Q_{26}(t) + Q_{20}(t) \circledS \pi_0(t).$$

The MTSF at the point of where system starts from 0 state is

$$T_0 = \lim_{s \to 0} \frac{1 - \phi_0^{**}(s)}{s} = \lim_{s \to 0} \frac{1 - \frac{N(S)}{D(S)}}{s}$$

$$= \lim_{s \to 0} \frac{D(s) - N(s)}{sD(s)} = \frac{D'(0) - N'(0)}{D(0)} = \frac{N}{D}$$

Where $N = \mu_0 + p_{12}\mu_2 + \mu_1$

5. AVAILABILITY ANALYSIS

System availability means the state where system is always ready to provide services when requires.

$$A_0(t) = M_0(t) + q_{01}(t) © A_1(t)$$

$$A_1(t) = M_1(t) + q_{12}(t) © A_2(t) + q_{15}^4(t) © A_5(t)$$

$$A_2(t) = M_2(t) + q_{20}(t) © A_0(t) + q_{25}^6(t) © A_5(t)$$

$$A_4(t) = q_{45}(t) © A_5(t)$$

$$A_5(t) = M_5(t) + q_{59}(t) © A_9(t) + q_{58}^7(t) © A_8(t)$$

$$A_8(t) = q_{81}(t) © A_1(t)$$

$$A_9(t) = M_9(t) + q_{90}(t) © A_0(t) + q_{91}^{10}(t) © A_1(t)$$

Where $M_0(t) = e^{-\lambda_1 t} dt$, $M_1(t) = e^{-\lambda_2 t}\overline{G_1}(t)dt$, $M_2(t) = e^{-\lambda_2 t}\overline{G_2}(t)dt$, $M_5(t) = e^{-\lambda_1 t}\overline{G_3}(t)dt$ and $M_9(t) = e^{-\lambda_1 t}\overline{G_4}(t)dt$.

for $A_0^*(s)$ with the help of Laplace-Transformations we generally receive steady state is

$$A_0^*(s) = \frac{N_1(s)}{D_1(s)}$$

$$A_0 = \lim_{s \to 0}\left(sA_0^*(s)\right) = \lim_{s \to 0}\left(s\frac{N_1(s)}{D_1(s)}\right) = \frac{N_1(0)}{D_1'(0)} = \frac{N_1}{D_1}$$

$$N_1 = \mu_0(1 - p_{12}p_{25}^6p_{91}^{10} - p_{12}p_{25}^6p_{58}^7 - p_{14}^3p_{91}^{10} - p_{14}^3p_{58}^7)$$
$$+\mu_1 + \mu_2 p_{12} + (\mu_5 + \mu_5)(p_{12}p_{25}^6 + p_{14}^3)$$

$$D_1 = k_1 + k_2 + \mu_0(p_{12}p_{20} + p_{12}p_{25}^6p_{59}p_{90} + p_{14}^3p_{59}p_{90})$$
$$+(k_3 + k_4)\left(p_{12}p_{25}^6 + p_{14}^3\right)$$

Where, k_1, k_2, k_3 and k_4 is already defined.

6. PROFIT ANALYSIS

When the system is in constant state, the overall profit is considered as

$$P = C_0A_0 - C_{11}B_0^D - C_{12}B_0^H - C_2V_0$$

C_0 =Expected revenue in up time(o,t]

C_{11} =Expected total repair cost when repairman is busy under digging out.

C_{12} =Expected total repair cost when repairman is busy under hospitalization.

C_2 = Per visit cost of the repairman.

7. NUMERICAL EXAMPLES

We have considered some specific examples for calculating system reliability are:

$$g_1(t) = \alpha_1 e^{-\alpha_1 t}, g_2(t) = \alpha_2 e^{-\alpha_2 t},$$

$$g_3(t) = \alpha_3 e^{-\alpha_3 t}, \text{ and } g_4(t) = \alpha_4 e^{-\alpha_4 t}$$

$$p_{01} = 1, p_{12} = \frac{\alpha_1}{\lambda_2 + \alpha_1}, p_{14} = \lambda_2/(\lambda_2 + \alpha_1), p_{14}^{(3)} = \frac{\lambda_2}{\lambda_2 + \alpha_1}$$

$$p_{20} = \alpha_2/(\lambda_2 + \alpha_2), p_{26} = \lambda_2/(\lambda_2 + \alpha_2),$$

$$p_{25}^{(6)} = \frac{\lambda_2}{\lambda_2 + \alpha_2}, p_{45} = 1. p_{59} = \alpha_3 / (\lambda_1 + \alpha_3), p_{58}^{(7)} = \frac{\lambda_1}{\lambda_1 + \alpha_2},$$

$$p_{81} = 1, p_{90} = \alpha_4 / (\lambda_1 + \alpha_4), p_{91}^{(10)} = \frac{\lambda_1}{\lambda_1 + \alpha_4}$$

7. RESULTS

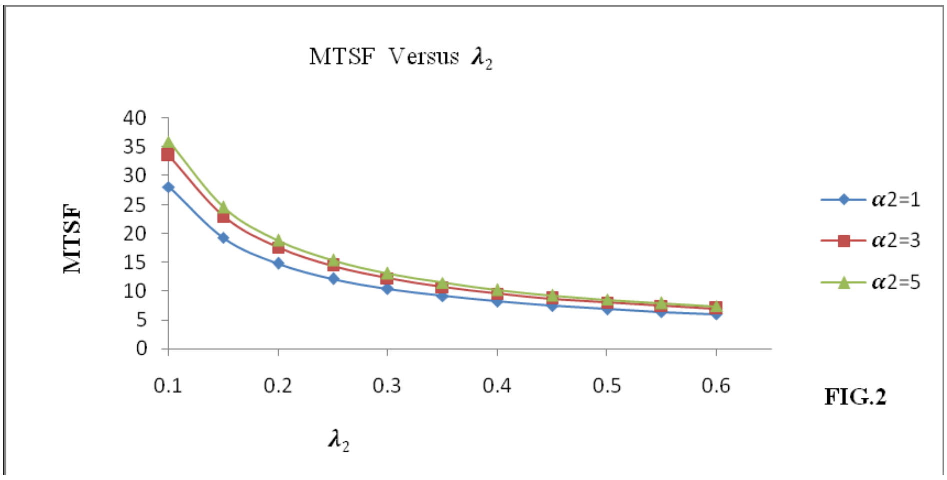

FIG.2

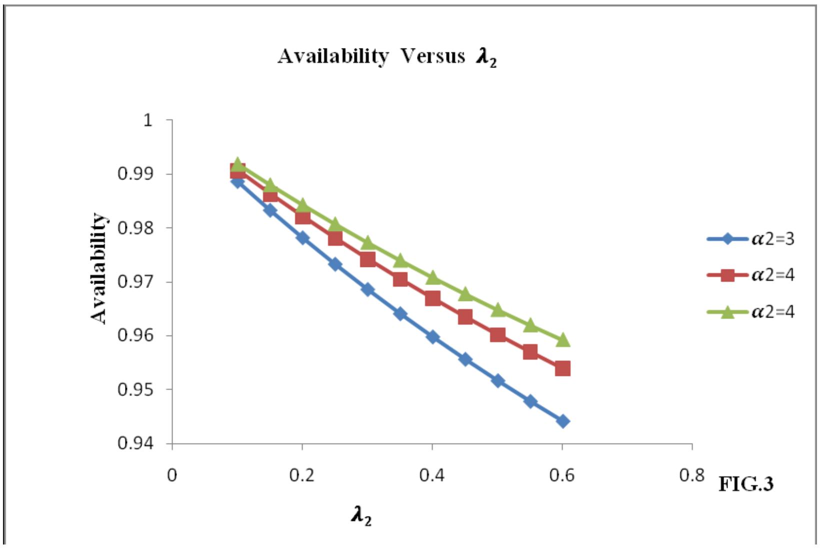

FIG.3

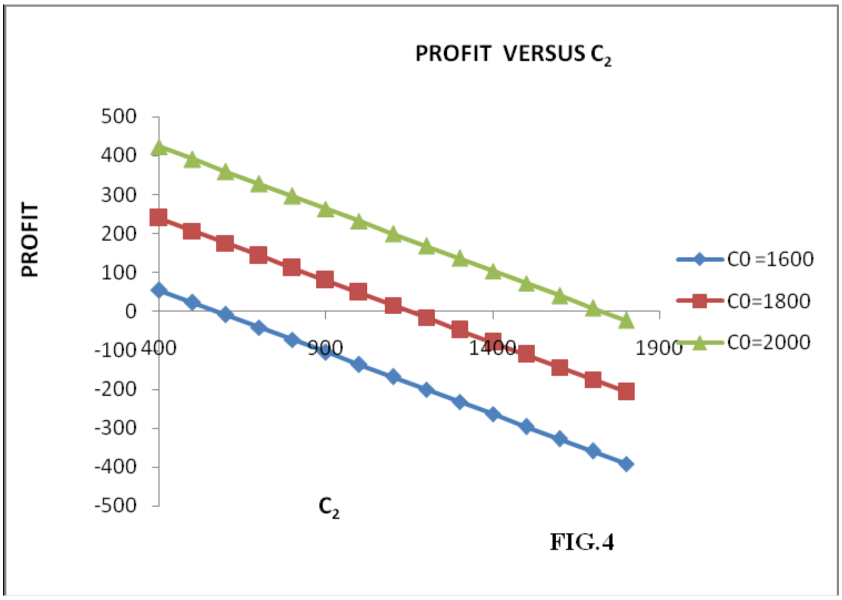

FIG.4

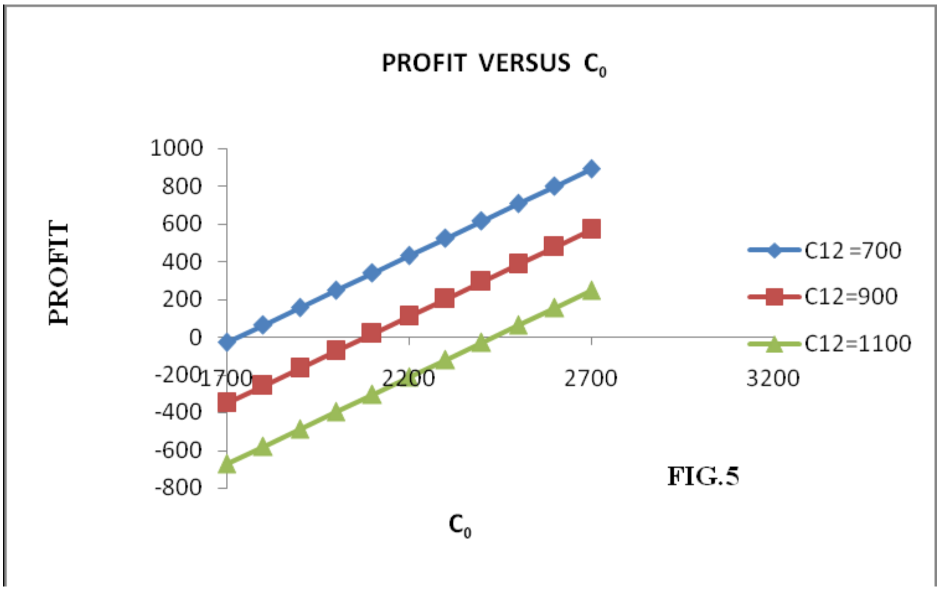

FIG.5

8. CONCLUSION

With the help of respected figures 2 and 3 it can be seen that MTSF and availability decreases as the failure rate increases respectively. Apart from that, it can be also seen that profit is decreases as per visit repair price on the repairman is increases in figure 4 and profit is raises as the revenue expense of the per device is increases which can be easily shown in figure 5. A reliability design based on a manufacturing device has been created in which repair is impacted by the time and performance is impacted by the unstable environmental conditions. Nevertheless, the owners of such methods might discover the impact on the actions of effectiveness with regard to details of attention as per the necessity of theirs as well as on the foundation of the information out there to them after which bring crucial conclusions concerning profitability of the product.

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