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REVIEW ARTICLE

ESTIMATION OF SYSTEM RELIABILITY (NOT REPAIRABLE) WITH SUDDEN FAILURE

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ABSTRACT

The probability theory of reliability has grown out of the demand of modern technology which says the probability of a system or unit giving satisfactory performance for a specific period unit specified operating condition when a system or unit does not perform satisfactorily, it said to have failed. In the study, the standby unit can work for a certain time period and come to downstate even without failure. It's working due to some failure. This failure of the units causes the failure of the complete systems due to some unknown reasons. They studied the system and designed a model for its reliability. In this present study, we considered a system with two non-similar and non-identical units causes sudden failure due to unknown reason. This sudden failure can occur in the system, causes the total system failure. The model is analyzed various measures reliability of the system.

INTRODUCTION

Every new system is an improvement of its predecessor in the sense that it is more different and more durable. Generally all physical system such as Computer System, Water Pump, Electric Fan, Mixer Grinder, Television Set, Vehicles, Nuclear Power Station, Refrigerator, Washing Machine, Power Station of State Electric Board and many such type of system may fail after some duration of time. Due to failure of the system, system reliability has become very important.

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Reliability is an inherent of system just as the system capacity or power rating. The probability theory of reliability has grown out of the demand of modern technology which says the probability of a system or unit giving satisfactory performance for a specific period unit specified operating condition when a system or unit does not perform satisfactorily, it said to have failed. Dhillon (1978), Tuteja (2001), Pajankar *et al.* (2006), Satyavati *et al*. (2008) and some other researchers studied the failed systems and try out reliability models. Tuteja (2001) considered the system with two dissimilar units, one operate and other in standby mode. In the study, the standby unit can work for a certain time period and come to downstate even without failure. Pajankar *et al.* (2006) assumed a system, stop it's working due to some failure. This failure of the units causes the failure of the complete systems due to some unknown reasons. They studied the system and designed a model for its reliability.

In this study, we considered a system with two non-similar and non-identical units causes sudden failure due to an unknown reason and which is not repairable. Such type of situations generally happened in daily life where a working equipments, for eg. mixer grinder, oven, washing machine, refrigerator, television etc and in industries, manufacturing plants/units/machineries etc. stopped functioning suddenly. The system may be failed due to improper handling, improper design, unskilled manpower, poor machinery etc. This sudden failure can occur in the system, causes the total system failure. This sudden failure may be defined as the failure of a system or unit due to known reasons, which are not known in advanced. These failures may occur due to (i) unskilled manpower i.e. improper handling of the system, inadequate training and skill of the concerned manpower etc., (ii) poor machinery i.e. by using old outdated and rusted machinery, which works very slowly, (iii) voltage fluctuation i.e. improper supply of electricity and not availability of standby equipments (generator, invertors etc.), (iv) environmental condition i.e. due to temperature humidity, moisture, dust, water etc., (v) old technology i.e. due to using outdated equipment and machinery which needs to replaced by new one. The models are analyzed various measures of system effectiveness such as reliability of the system, mean time to system failure are determined.

Description of system

The system contains two non-similar parallel units. Initially, at time t = 0, both units start functioning (operating) simultaneously. The system will continue its functioning until both units will get failure i.e. when both units are working the system gives good performance and continues even if one of unit gets failed. If both the units will get fail then only system will stop working. The sudden failure of the system will happened due to some unknown reasons. This sudden failure can occur when both units are functioning or one unit has functioning and other failed. This failure can cause the total system failure. There is no regeneration or repair facility available i.e. once a unit gets failed, it cannot be repair at any circumstances.

Assumptions

- The both units of the system are non-similar and start working simultaneously.
- The failure rate of both units at each stage is constant.
- The failed unit(s) in the systems is(are) not repairable
- The sudden failure (SF) occurs due to unknown reasons is stochastically independent.
- There is a stage where unit(s) or system can stop working due to some unknown reason which is non-repairable.
- The sudden failure (SF) can occur when both units are functioning or one unit is functioning and another failed.
- The sudden failure rate is constant.
- The failure rates of the system or units are constant.
- The system is in rest when both the units are not working.
- The system is said to be failure when both the units are failure and system stopped working.

Notation

$\lambda_{01}, \lambda_{02}$	Constant failure rate of unit 'a' and 'b' from stage 0 to1 and 0 to 2 respectively
λ_{04}	Failure rate of both unit 'a' and 'b' from stage 0 to 4 due to unknown reason when both units are working.
$\lambda_{13}, \lambda_{23}$	Constant failure rate of unit 'b' and 'a' from stage 1 to 3 and 2 to 3 respectively
$\lambda_{14}, \lambda_{24}$	Failure rate of unit 'b' and 'a' from stage 1 to 4 and 2 to 4 due to sudden failure (SF) when only unit 'b' and 'a' is working respectively
SF	sudden failure causes due to some unknown reason.
$P_n(t)$	Probability that redundant system is in state ' n ' at time t
t	time constant.
n	stage of the system (n = 0, 1, 2, 3, 4)
R(t)	Reliability of the system.
MTSF	Mean Time to System Failure of the System (MTSF)

$P_n(t)'$ $\frac{dP_n(t)}{dt}$; Derivative of $P_n(t)$ with respect to time t (n = 0, 1, 2, 3, 4)

$$P_0(t) = e^{-A_1 t}$$

$$P_1(t) = a\left(\frac{e^{-A_1 t} - e^{-A_2 t}}{A_2 - A_1}\right)$$

$$P_2(t) = b\left(\frac{e^{-A_1 t} - e^{-A_3 t}}{A_3 - A_1}\right)$$

$$P_3(t) = \left(\frac{f.a}{A_1(A_2 - A_1)} + \frac{i.b}{A_1(A_3 - A_1)}\right)(1 - e^{-A_1 t}) - \frac{(1 - e^{-A_2 t})(f.a)}{A_2(A_2 - A_1)} - \frac{(1 - e^{-A_3 t})(i.b)}{A_3(A_3 - A_1)}$$

$$P_4(t) = -\left(\frac{d}{A_1} + \frac{f.a}{A_1(A_2 - A_1)} - \frac{i.b}{A_1(A_3 - A_1)}\right)(1 - e^{-A_1 t}) - \frac{(1 - e^{-A_2 t})(g.a)}{A_1(A_2 - A_1)} - \frac{(1 - e^{-A_3 t})(j.b)}{A_1(A_3 - A_1)}$$

Reliability of the System

Pajankar (2004) defined the reliability is the integration of the probabilities measured at functioning units of a functioning system. Therefore on solving the equations, the reliability of the system analyzed and described here as –

$$R(t) = e^{-A_1 t}\left(1 + \frac{a}{(A_2 - A_1)} - \frac{b}{(A_3 - A_1)}\right) - \frac{ae^{-A_2 t}}{(A_2 - A_1)} - \frac{b(1 - e^{-A_3 t})}{(A_3 - A_1)}$$

Mean Time to System failure

To determine the mean time to system failure (MTSF) of the system, we regard the fouled states of the system absorbing. Therefore the mean time to system failure (MTSF) is obtained as-

$$M(t) = \frac{A_2 A_3 + a.A_3 + b.A_2}{A_1.A_2.A_3}$$

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