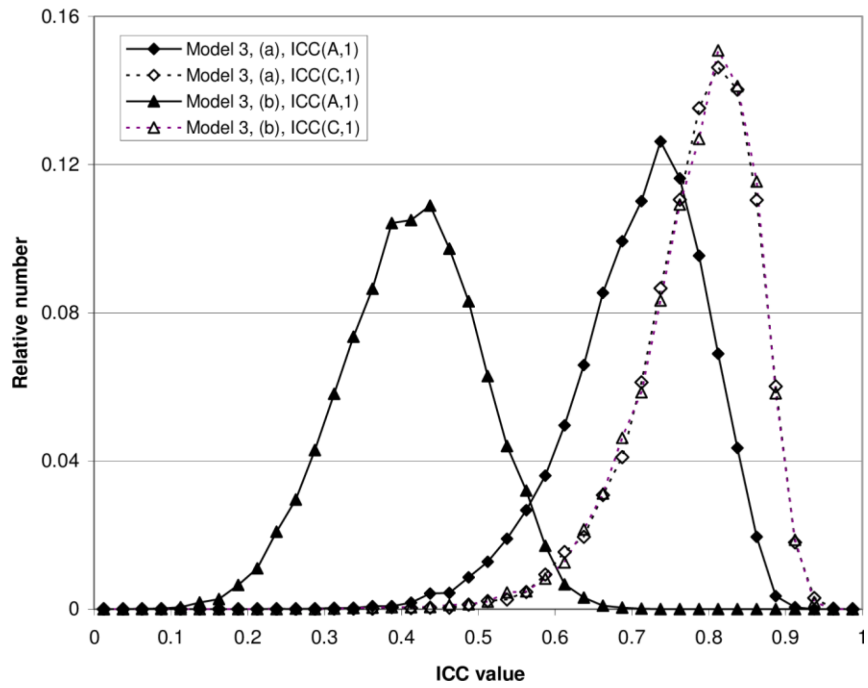
Reliability Modeling Analysis



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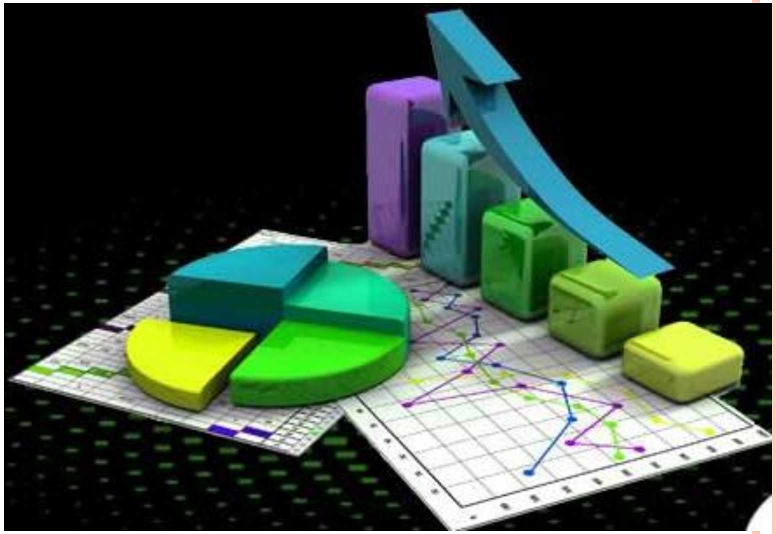
INTRODUCTION

Society's growing expectations always demand rapid technological advance. Can not allow failures during system operation. That facts making the theme of this theory of reliability much more essential and has brought it to the forefront of research.



Now this reliability element has become a subject of repeated discussion amongst researchers from various fields. Infect, the reliability case has gained momentum especially after World War I. US defence department formed a reliability committee. This was later renamed the Electronic Equipment Reliability Advisory Group (AGREE).Since then, many other organizations, both manufacturers and users, have been formed to promote the reliability aspect. Robert Lusser gave the basic definition of reliability atesymposeium held at San-Deigo. According to him "Reliability is a broad term which focuses on a system (or product)'s ability to perform it as extended function"

WHAT IS RELIABILITY ?

- Reliability is a characteristic of an item expressed by the probability that a device will perform its intended function during a specified period of time under stated operating conditions or environment.
- Mathematically: If T is time to the failure of a product occurs, then the probability that it will not fail in a given environment before time 't' is given by

$$R(t) = \Pr.[T > t] = \int_t^{\infty} f(x)dx$$

Where, f (x) is the failure probability density function. Thus, reliability is always a function of time which depends on environment conditions which may or may not vary with time. Since it is a probability, therefore it lies between 0 and 1 and R(0) = 1, R(∞) = 0.

Consists of 4 key elements

- First, reliability is a probability.
- Second, reliability is predicated on intended function.
- Third, reliability applies to a specified period of time.
- Fourth, reliability is restricted to operation under stated conditions

Failure Rate

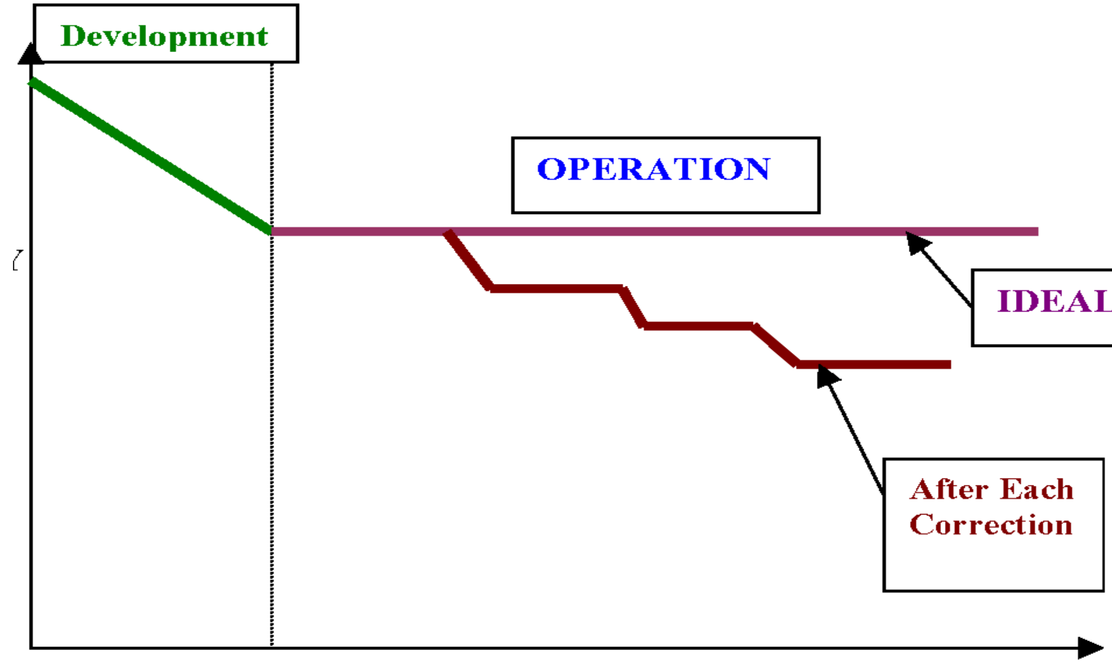
- Failure rate is the frequency with which an engineered system or component fails, expressed for example in failures per hour. It is often denoted by the Greek letter λ (Lamda) and is important in reliability theory
- It is usually time dependent, for example, as an automobile grows older, the failure rate in its fifth year of service may be many times greater than its failure rate during its first year of service

REPAIR RATE

A different approach is used for modeling the rate of occurrence of failure incidences for a repairable system. These rates are called repair rates, one which can be restored to satisfactory operation by any action. Failures occur and the system is repaired to a state that may be the same as new, or better, or worse. Examples are computers, automobiles, and airplanes.

Reliability Modeling

- A model explains the design idea in a presentable form and also explains the system at different levels of abstraction. Reliability modeling is the process of predicting or understanding the reliability of a component or system prior to its implementation. A system's overall reliability can be determined by the development of reliability models.



Series Configuration

A system having n-units is said to have series configuration if the failure of an arbitrary unit, say ith unit causes the entire system failure.

Example: Deepawali or Christmas glow bulb, where if one bulb fails the whole lead fails. The block diagram of a series system

Parallel Configuration

In this configuration, all the units are connected in parallel i.e. the failure of the system occurs only when all the units of system fail.

For example, four engine aircraft which is still able to fly with only two engines working.

Maintainability

Maintainability is the probability that the system will be restored to operational effectiveness within a specified time when the action is taken in accordance with specified conditions. Maintenance is one of the effective ways of increasing the reliability of a system.

Several categories:

Preventive maintenance(done before a unit actually fails),

Corrective maintenance(deals with the system performance when it gives wrong result) and **R**epair maintenance(two types).

Repeat repair policy

Resume repair policy

PROFIT ANALYSIS

Profit is an excess of revenue over expenses for an activity over a period of time. Every organization, company, firm or enterprise should earn sufficient profits to survive and grow over a long period. The main objective of the industrialists is to earn maximum profit by selling their produces by financing a minimum on production. There must be an optimal balance between the reliability aspect of a product and its cost. This can be achieved by contributing major cost to research and development, production, spares and maintenance.In order to increase the reliability of the products, we would require a correspondingly high investment in the research and development activities.

Profit per unit time = total revenue per unit time –total cost per unit time.

E ;: of regenerative states

E ;: of non-regenerative states

λ ;: Constant failure rate

$\alpha 0$;: The rate by which system undergoes for preventive maintenance (called maximum constant rate of operation time)

$\beta 0$;: The rate by which system undergoes for replacement (called maximum constant rate of repair time)

FUr /FWr ;: The unit is failed and under repair/waiting for repair

FURp ;: The unit is failed and under replacement

UPm ;: The unit is under preventive maintenance

WPm ;: The unit is waiting for preventive maintenance

FUR/FWR ;: The unit is failed and under repair / waiting for repair continuously from previous state

FURP ;: The unit is failed and under replacement continuously from previous state

UPM ;: The unit is under preventive maintenance continuously from previous state

WPM ;: The unit is waiting for preventive maintenance continuously from previous state

g(t)/G(t) ;: pdf/cdf of repair time of the unit f(t)/F(t) :: pdf/cdf of preventive maintenance time of the unit

r(t)/R(t) :: pdf/cdf of replacement time of the unit

qij (t)/ Qij(t) :: i pdf /cdf of passage time from regenerative state Si to a regenerative state Sj or to a failed state Sj without visiting any other regenerative state in (0, t]

qij.kr (t)/Qij.kr(t) :: pdf/cdf of direct transition time from regenerative state Si to a regenerative state Sj or to a failed state Sj visiting state Sk, Sr once in (0, t]

$M_i(t)$ :: Probability that the system up initially in state S_i E is up at time t without visiting to any regenerative state

$W_i(t)$ :: Probability that the server is busy in the state S_i up to time 't' without making any transition to any other regenerative state or returning to the same state via one or more non-regenerative states.

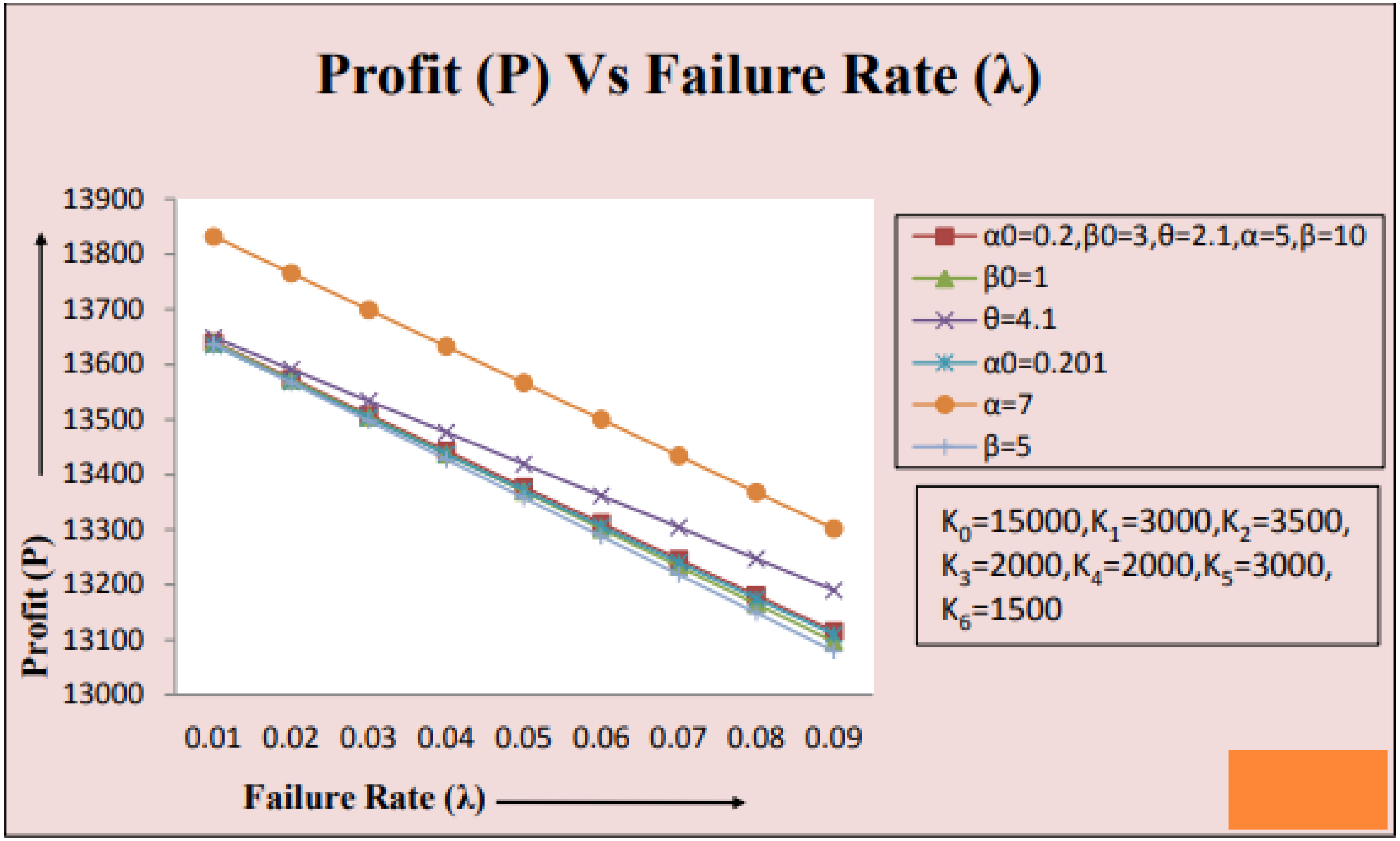
μ_i :: The mean sojourn time in state S_i which is given by
$\mu_i = E(T) = \int_0^{\infty} P(T > t)\, dt = \sum_j m_{ij}$,where T denotes the time to system failure.

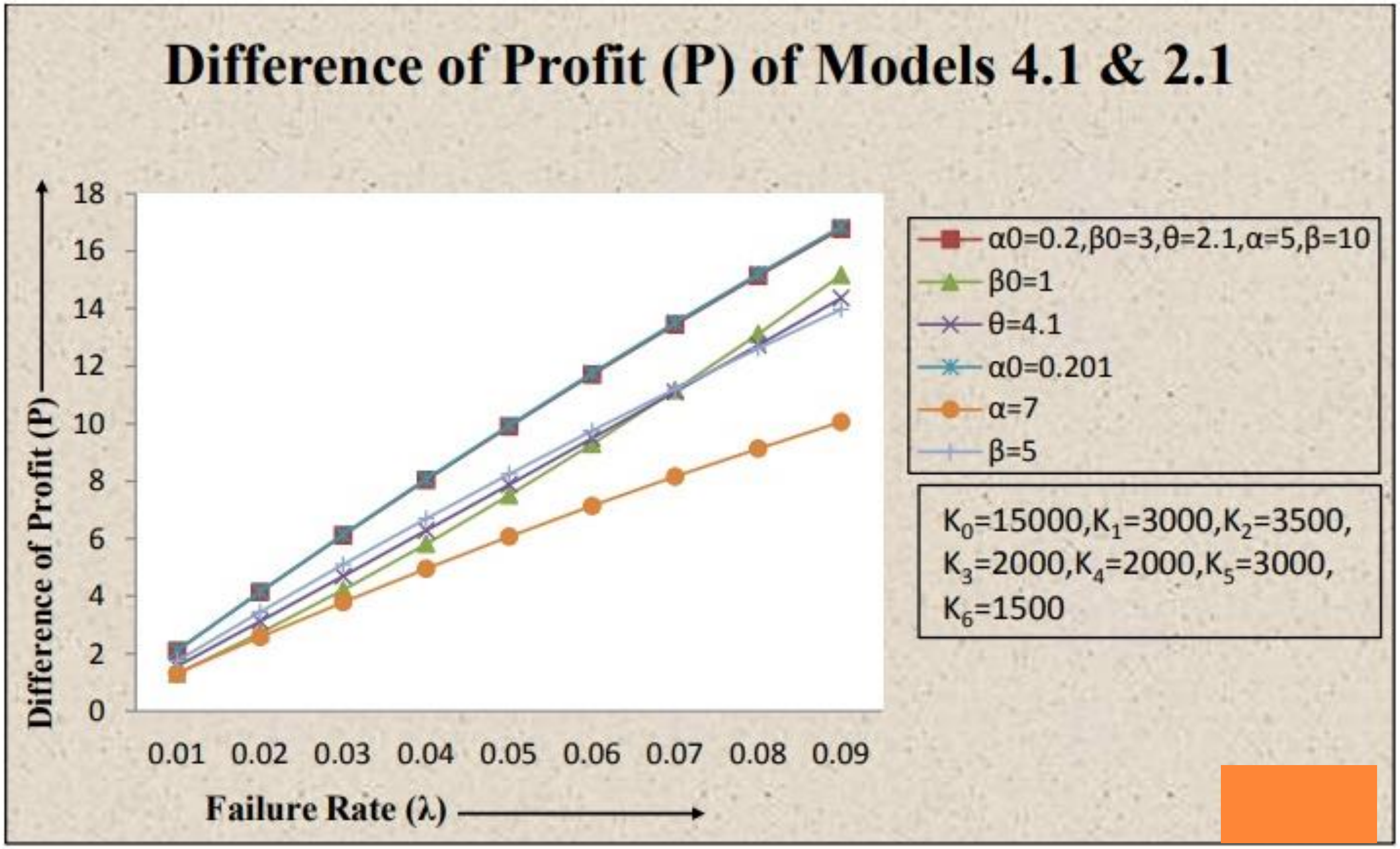
Ⓢ/© :: Symbol for Laplace-Stieltjes convolution/Laplace convolution

*/** :: Symbol for Laplace Transformation /Laplace Stieltjes Transformation

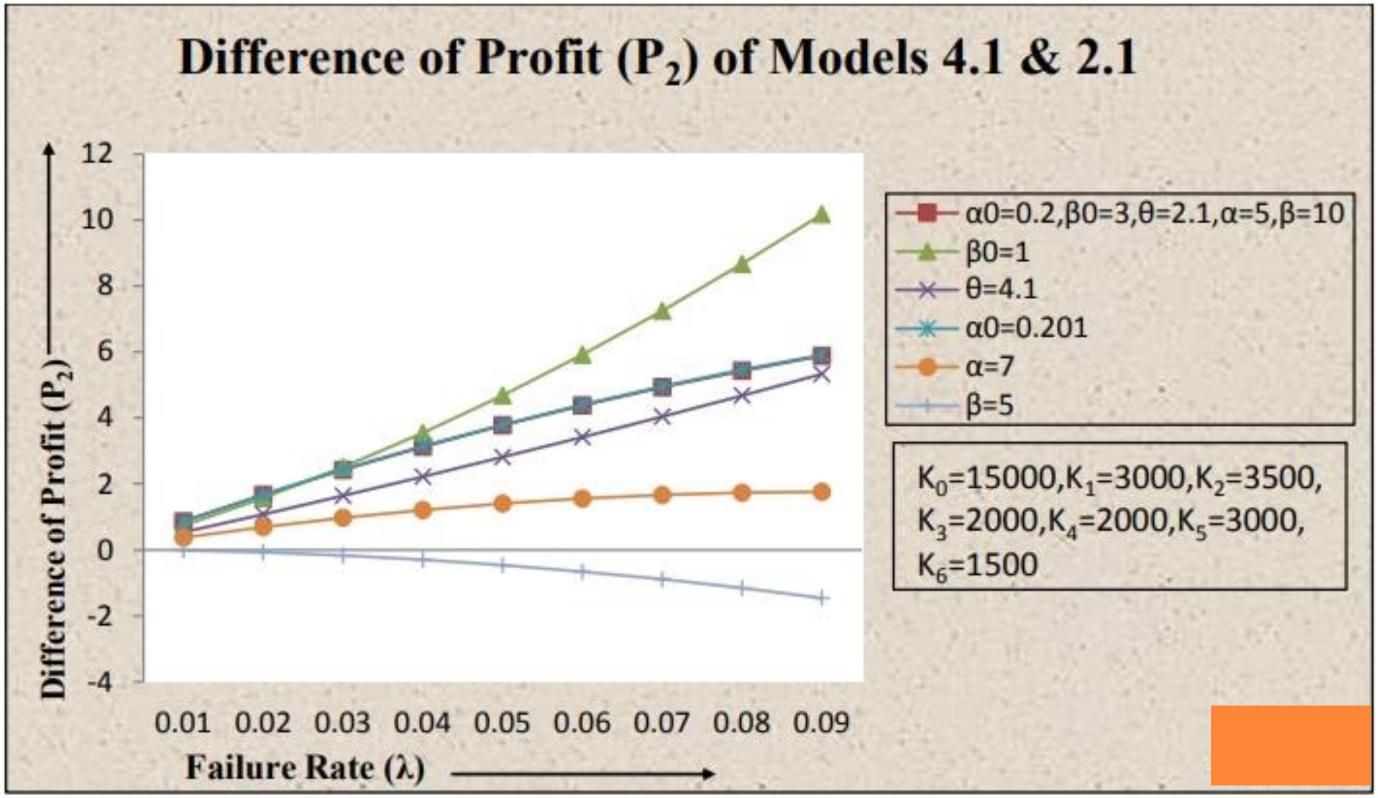
The states S_0, S_1, S_2, S_4 and S_6 are regenerative while the states S_3, S_5, S_7, S_8, S_9, S_{10}, S_{11} and S_{12} are non-regenerative.

RESULTS & INTERPRETATION

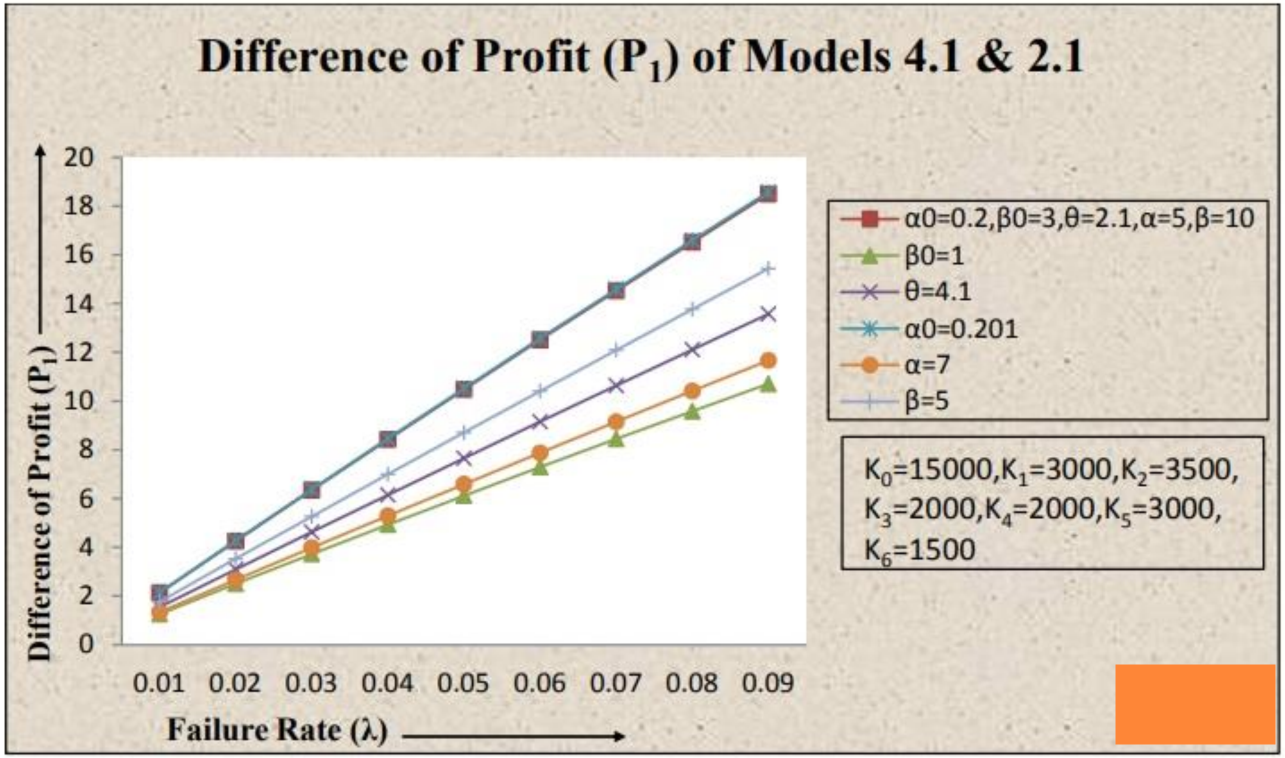




Difference of Profit (P) of Models 4.1 & 2.1
Difference of Profit (P)
18
16
14
12
10
8
6
4
2
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
Failure Rate (λ)
α0=0.2,β0=3,θ=2.1,α=5,β=10
β0=1
θ=4.1
α0=0.201
α=7
β=5
K0=15000,K1=3000,K2=3500,
K3=2000,K4=2000,K5=3000,
K6=1500



Difference of Profit (P_2) of Models 4.1 & 2.1
12
10
8
6
4
2
0
-2
-4
Difference of Profit (P_2)
0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09
Failure Rate (λ)
α0=0.2,β0=3,θ=2.1,α=5,β=10
β0=1
θ=4.1
α0=0.201
α=7
β=5
K_0=15000,K_1=3000,K_2=3500,
K_3=2000,K_4=2000,K_5=3000,
K_6=1500



Difference of Profit (P1) of Models 4.1 & 2.1
Difference of Profit (P1)
20
18
16
14
12
10
8
6
4
2
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
Failure Rate (λ)
α0=0.2,β0=3,θ=2.1,α=5,β=10
β0=1
θ=4.1
α0=0.201
α=7
β=5
K0=15000,K1=3000,K2=3500,
K3=2000,K4=2000,K5=3000,
K6=1500

Profit comparison

While considering the particular case $g(t) = \theta e^{-\theta t}$, $r(t) = \beta e^{-\beta t}$ and $f(t) = \alpha e^{-\alpha t}$ the results indicate that MTSF, availability and profit of the system model go on decreasing with the increase of failure rate (λ) and the rate (α_0) by which unit under goes for preventive maintenance. But, their values increase with the increase of repair rate (θ), the rate (β_0) by which system under goes for replacement and replacement rate (β). Again, if we increase the preventive maintenance rate (α), the system becomes more profitable.

(a) Under Cost Policy (i)

(b) Under Cost Policy (ii)

(c) Under Cost Policy (iii)

CONCLUSION

- Priority's given to one unit being maintained preventively over replacing the other failed unit.
- some reliability measured is extracted into steadystate, while considering these assumptions Giving arbietrary valued to different parameters and the costs, profited functions with respect to failure rate is observed.

The systems model profit was obtained by considering the 3 types of cost policies that follow:

(a) "Excess revenue per unit time consumed by the system and expense per unit time maintenance operation" .

(b) "Excess revenue for maintenance activities over cost per unit time the server is busy" .

(c) "Excess often revenue over cost per repair activity per unit times by the servers".

Thank you