INTRODUCTION:

In the present scenario of competitive market to cut down production costs and improve productivity and delivery performance of manufacturing systems of processing industries are the key objectives of Industry. Process Industries must provide continuous and long term production to meet the ever increasing demand at lower costs. The Reliability and Availability Analysis of Process Industries can benefit in terms of higher production, lower maintenance costs. The Availability of complex systems and continuous process industries can be enhanced by considering maintenance, inspection, repairs and replacements of the parts of the failed units.

Since we are living in probabilistic environment, so we need the knowledge of probability. Probability is necessary for mathematical study of reliability. Thus before proceeding further, we introduce first the basic idea of reliability.

RELIABILITY:

Introduction to reliability contains rich blend of basic concepts and practical problems from the real world. In the most wider sense, the word ‘reliability’ has a very important meaning: Re and liability. It simply means that it is the liability, not once but again and again.

The concept of reliability has been interpreted in many different ways in numerous works out of which a few are listed below :-

(i) Reliability is the integral of the distribution of probabilities of failure free operation from the instant of switch on to first failure.

(ii) Reliability is the probability that the device will operate without failures for a given time under given operating conditions.

One of the definitions which has been accepted by most contemporary reliability authorities is given by the Electronics Industries Association (EIA) U.S.A. which states, “Reliability is the probability of an item
performing its intended function over a given period of time under the operating conditions encountered;

**AVAILABILITY:** [extracts from Goel(1997)]

Availability is the combination of two elements reliability and maintainability. This means that poor reliability can be offset by correspondingly improved maintainability and faster than maintenance-action rate, the better is the resulting availability. If down time is low then availability will be high. Reliability is a particular case of availability in which no maintainance activity is practiced.

**Forms Of Availability**

The most important forms of availability are;

(i) **Availability Inherent**

The probability that a system, when used stated conditions, without consideration for any preventive action, in an ideal support facilities (i.e. it is assumed that tools, spares, manpower, data etc. are available) shall operate satisfactorily at a given point in time.

\[ \text{Availability (Inherent)} = \frac{MTBF}{MTBF+MTTR} \]

(ii) **Availability Operational**

The **Availability Operational** is computed as;

\[ \text{Availability Operational} = \frac{MTBF}{MTBF+MTTR+\text{Mean administrative time}+\text{Mean time waiting for spares}} \]

(iii) **Use Availability**

The **Use Availability** can be calculated by the use of the following relation;

\[ \text{Use Availability} = \frac{\text{Operate Time}+\text{Off Time}}{\text{Operate Time}+\text{Off Time}+\text{Total Down Time}} \]

In practice the problem faced is to achieve maximum availability (for a given cost or to achieve a required availability at least cost).

**Applications of Reliability Technology:**

a) Electrical and electronics engineering maximum work has been done which may be seen in the literature. Analysis of systems and reliability optimization are given in the literature.
b) Mechanical engineering applications are contained in Dhillon and Singh’s book. It may be seen in literature. Singh applied the technology to process industries which may be seen in this book.

c) The agricultural application may be seen in the literature.

d) Applications to non-conventional energy systems.

e) The software reliability is given in literature.

f) In civil and chemical engineering some work has been done on reliability but not very much. There is scope for work in these fields.

g) In the fields of robotics there is scope for work.

h) In biological sciences, there is good scope for the work.

LITERATURE REVIEW:

1, Chander(1996), The paper discusses the availability and optimization of two single unit model. Model is discussed by taking different types of repair policies of a single repairman. Various parameters are evaluated.

2, Chander and Bansal(2005), The paper discusses the availability and optimization of a single unit model. Various reliability parameters of the model having different failure and repair are evaluated.

3, Dhankar and Malik(2011), Two reliability models for a single-unit system are proposed considering the idea of server failure while performing inspection and repair of the unit which may fail completely either directly from normal mode via partial failure. The expressions for several reliability characteristics are derived by making use of semi-Markov processes and regenerative point technique.

4, Giri, Goyal and Singh(2009), The paper examines the Industry based on agriculture to discuss the availability of a practical plant of liquid milk plant. A shortcut approach is used to evaluate the various parameters.

5, Goel and Singh(1998), This paper discusses the main part known as butter manufacturing system of a dairy plant consisting of five subsystems working in series having a standby for pumping subsystem. The switching process is controlled by an imperfect switch. The repair and failure rates are taken constant. Various reliability parameters are evaluated.

6, Goel and Singh(1996), The paper discusses the availability of a chemical plant where there are four subsystem A,B,D and E working in series. Taking constant failure and repair rates for each subsystem, the problem is formulated using Markov-method. The availability of the system followed by an illustration and special cases is given.

7, Goel and Singh(1997), The paper discusses the availability and optimization of a thermal power plant having two imperfect switches. Taking constant failure and repair rates for each subsystem, the mathematical formulation of the problem is done using Markov-method. The governing differential equations are solved recursively for a steady-state.
8, Goel and Singh (1995), The paper discusses the reliability and availability optimization of a standby complex system controlled by imperfect switch over device. Taking various constant failure rates and repair rates, the problem is done using supplementary variable technique.

9, Goel and Singh (1996), The Paper discusses the availability of a heating system in the sugar industry where there are furnaces in working and warm standby position and controlled by an imperfect switch over device. Taking the various constant failure rates and arbitrary repair times, the problem is formulated using supplementary variable technique.

10, Goel (1997), Complex system controlled by imperfect switch are discussed by using various technique, Markov-method and supplementary variable method. Taking constant failure and repair rates. Various parameters for reliability and availability optimization are evaluated.

11, Goyal and Kumar (2006), The paper discusses the reliability optimization of a model under different conditions. Three types of repair policy, replacement and instruction are used as the condition for evaluated various parameters of the model to discuss reliability and optimization.

12, Gupta, Singh and Singh (2001), The paper discusses the availability for a neat soap production system. The system is discussed under steady-state condition. Various parameters of availability are evaluated to established realistic result by taking practical example of soap plant.

13, Gupta, Singh and Singh (2004), The paper discusses the soap plant for availability and optimization. Here a part of soap plant, production of soap cakes is discussed to evaluate various parameters of availability of the system.

14, Gupta, Singh and Singh (2005), The expressions for mission reliability and steady state availability of flexible and complex polymer powder production system a part of acrylic fiber mill are derived. This practical paper explains mathematical formulation of the problem with more realistic and practical assumptions.

15, Gupta, Lal, Sharma and Singh (2005), In this paper reliability, long run availability and mean time before failure of a process industry, namely, cement manufacturing plant have been studied. Reliability of the serial process can be analysed by forming differential equations with the help of mnemonic rule and the transition diagram. These differential equations can be solved either by Laplace transform method or by some numerical method.

16, Gupta, Sharma, Goyal and Vikas (2009), This paper explains a methodology to study the transient behavior of repairable mechanical Yarn production System pertaining to a carded Yarn Manufacturing Plant. The methodology for determining the availability of the system is based on Markov Modelling.

17, Gupta and Singh (2007), The paper discusses a new method to evaluate various parameters of availability under steady-state condition. Calculations are avoided, the work can done easily and quickly by using this technique. Failure and Repair rates are constant.
18, Gupta and Singh (2007), The paper discusses the availability and optimization of a redundant system controlled by imperfect switch over device. The analysis of the system is carried out using the new approach introduced and applied by Gupta.

19, Gupta and Singh (2008), This paper presents the behavior and profit analysis of a mechanical system pertaining to laundry soap cakes manufacturing plant. The analysis of the system is carried out using the new approach introduced and applied by Gupta.

20, Gupta and Singh (2008), The paper investigates the three unit redundant system of which two are in operating mode and one is in cold stand-by mode with imperfect switch over device. The state of the system is expressed in term of fuzziness measure.

21, Gupta, Kumar and Singh (2008), This paper presents the behavior and profit analysis of a mechanical system pertaining to soft drink Industry. The analysis of the system is carried out using the new approach introduced and applied by Gupta.

22, Gupta (2008), This presents the behavior and profit analysis of a various process Industries. The analysis of the system is carried out using the new approach introduced and applied by Gupta. Calculations are avoided, the work can done easily and quickly by using this technique. Failure and Repair rates are constant.

23, Gupta, Kumar and Singh (2009), This paper presents ‘A New Approach’ for the analysis of a stochastic system under the steady-state conditions. The new approach provides only four formulae in the closed form to find the key parameters of a semi-Markov process with underlying Markov renewal process which is a finite irreducible aperiodic Markov chain.

24, Gupta, Kumar, Singh and Goel (2009), This paper analyses a single unit system of which two probabilistic operating Model 1 and Model 2 are considered with a capacity factor ‘C’. The system undergoes degradation after first repairs and replacement is done if degraded system is found to be unrepaired after inspection.

25, Gupta, Singh and Vanita (2010), For the analysis of a system, the time factor is very important. The key parameters used for analysis should be easily and quickly evaluated. This paper has to introduce the concept of a ‘base-state’ which is useful for finding quickly and easily, all the key parameters of the system are evaluated under steady state conditions.

26, Gurjar (2007), This book discusses the applications of reliability theory/technology to process industries and other systems. It provides system modelling and solution techniques in systemic and understandable manner for complex systems. Maximum types of systems are covered for analysis and maximum techniques are demonstrated by solving complex problems.

27, Kadayan, Kumar and Malik (2010), The paper discusses the probability analysis of two unit model system. Different units can be arranged in different ways, here we analysis them in parallel with the conditions of degradation and repair after inspection.
28, Kumar and Singh (1990), The paper discusses the availability and optimization of a process industry by taking the practical example of sugar industry. Refining system of sugar industry is used to evaluate various parameters of mathematical model using different technique.

29, Kumar and Singh (1991), The paper discusses the availability and optimization of a process industry by taking the practical example of paper industry. Production unit of paper industry having different repair policies used to evaluate various parameters of availability and discuss the cost optimization of the system.

30, Mahajan and Singh (1996), The paper discusses the reliability of a practical system taking constant failure and repair times for various equipments of the system. The differential equations associated with the system are evolved using Laplace transforms.

31, Mahajan and Singh (1996), The paper discusses a packers manufacturing plant, consisting of six subsystems, is analysed for evaluation of reliability of the system for a long period. The plant process is mathematically formulated using Markov method. The governing differential equations are solved for a long period.

32, Malik, Chand and Singh (2008), Two probabilistic models for a single unit system are developed considering the concept of degradation of unit after repair. Unit does not work as new after repair. Reliability and some economic measures are derived by using semi-Markov process and regenerative point technique.

33, Malik (2009), This paper explains the basic concepts of Reliability of a system, various technique used for mathematical modeling of a system. This also explain the Economic Measures to carry out Cost-Benefit Analysis.

34, Malik and Anand (2011), In this paper, a reliability model of a computer system consisting of two identical units—one is operative and the other is kept as standby is developed considering independent hardware and software failures. The expressions for several reliability characteristics are derived by making use of semi-Markov processes and regenerative point technique.

35, Reddy, Babu and Madhubala (2011), One of the most decision problems in marketing is determination of optimum sales allocation as a part among sales of report. This paper is to develop a goal programming model for the determination of sales policy which covers all exclusive product line sold in numerous sales territory.

36, Singh, Yadav and Singh (1996), The paper discusses the reliability analysis and optimization of steam generating system in a thermal power plant. Taking constant failure and repair rates the availability of the system and optimization are discussed followed by an example.

37, Singh and Mahajan (1999), The paper examines the reliability and availability of an utensils manufacturing plant assuming constant failure and repair rates for various machines in the manufacturing plant. The differential equations associated with the system are solved using Laplace transforms.
The paper discusses the reliability of an ash handling plant. System is discussed having three pumps to evaluate various parameters of availability and reliability of the system.

We, generally, use the word “reliable” for a person, equipment or the statement of a person in our daily life. Showing this property of a person or equipment the word ‘reliability’ is used. This paper is to explain the current applications of Reliability in Daily life.

The paper discusses the reliability and optimization analysis of a system. System is taken with hot standby condition. Various parameters are evaluated to analyze the cost effectiveness of the system.

**OBJECTIVE OF THE PRESENT WORK:**

An analysis of a problem requires the formulation first. The earlier authors did the mathematically modeling of reliability problems using Markov property of some distributions, while the problems having non-Markovian properties were formulated by supplementary variable technique. The next step is how to solve the problem? Initially, problems are solved using statistical methods. Later on, Laplace transform technique was used to solve the problems. Singh used direct integration technique where integral equations are obtained which may be solved using mathematically methods. Hence, there are many techniques of predicting the reliability of a system. The following methods may be used to analyse and predict the reliability of a system.

- Regenerative Point Technique.
- Supplementary Variable Technique.
- Renewal Theoretic Approach.
- Markow Method.
- Laplace Transform Technique.

Problems solving using all these techniques required very lengthy mathematical calculations, which are very much time and energy consuming. Recently, Gupta developed a graphical technique i.e. Regenerative Point Graphical Technique, which is used by author in this work, where various valuable results may be found without doing lengthy calculations.

This work is used to analyze the various Industry by taking practical example of Fertilizer plant, Button manufacturing plant and lots more, to evaluate the various parameters of systems by using the ‘Regenerative Point Graphical Technique (RPGT)’ i.e. the Mean Time to System Failure (MTSF), Availability, Busy period of Server, number of Server’s visits and number of Replacement etc. (under steady state conditions), which is helpful as stated below,
RPGT is very useful as;

1) Valuable results may be found without doing lengthy calculations.
2) Time is saved.
3) Energy is also saved.
4) Various parameters of system can evaluate quickly and easily.

The objective of present work is;

1) To obtain the Mean Time to System Failure (MTSF), Availability, Busy period of Server, number of Server’s visits and number of Replacement.
2) To analyze the optimization of the system for cost effectiveness.
3) Using RPGT the work become easily and done quickly.
4) Discuss Availability and Reliability of the system that helps to get continuous production from various industry.

HYPOTHESIS:

RPGT is introduced by Gupta and later on, he introduced the concept of Base-state which can be used to find all the key statistical parameters such as the Mean Time to System Failure (MTSF), Availability, Busy period of Server, number of Server’s visits and number of Replacement etc. (under steady state conditions) of a system more quickly and easily as explained below;

Base-State of the System: The calculation work can be economically minimized and simplified by locating a regenerative state (preferably an un-failed regenerative state) in the transition diagram which is associated with a largest number of primary circuits and the least/minimum number of secondary, tertiary circuits and circuits of higher dimensions at that regenerative state. Such a state is defined as a ‘base-state’ of the system.

A ‘base-state’ may also be defined as that regenerative state which is such that all the paths from it to the other regenerative states are associated with a minimum number of Primary, Secondary and Circuits of higher dimensions. A base-state may also be called a ‘key-state’ of the system. There may be one or more base-states of a given stochastic system. Thus, while determining a base state of a system, only the states which are associated with a large number of primary circuits be considered as the possible base-states. This will minimize the whole exercise of determining a base-state of the system. Further, if ‘ξ’ be a ‘base-state’ of a system then the formulae/algorithms of RPGT are as under:
**Regenerative Point Graphical Technique (RPGT):** [introduced by Gupta (2008)]

a). **Mean Time To System Failure:** The mean time to system’s failure being a positional measure, therefore, it depends upon the initial state of the system from which it is measured. MTSF is measured w.r.t. the un-failed initial state ‘ξ’ (at t=0).

\[
MTSF = \left[ \sum_{s_t} \left\{ \frac{pr(\xi^{(tf)}_{s_t})}{\Pi_{k_1 \neq \xi(1-V_{k_1, k_1})}} \right\} \mu_t \right] + \left[ 1 - \sum_{s_t} \left\{ \frac{pr(\xi^{(ff)}_{s_t})}{\Pi_{k_2 \neq \xi(1-V_{k_2, k_2})}} \right\} \right] \quad ...(1)
\]

b). **Total fraction of time for which the system is available:**

\[
A_\xi = \left[ \sum_{j,s_t} \left\{ \frac{pr(\xi^{(r)}_{j,s_t})f_j}{\Pi_{k_1 \neq \xi(1-V_{k_1, k_1})}} \right\} \right] \div \left[ \sum_{s_t} \left\{ \frac{pr(\xi^{(u)}_{s_t})}{\Pi_{k_2 \neq \xi(1-V_{k_2, k_2})}} \right\} \right] \quad ...(2)
\]

c). **The busy period of the Server doing any given job:**

\[
B_\xi = \left[ \sum_{j,s_t} \left\{ \frac{pr(\xi^{(r)}_{j,s_t})\eta_j}{\Pi_{k_1 \neq \xi(1-V_{k_1, k_1})}} \right\} \right] \div \left[ \sum_{s_t} \left\{ \frac{pr(\xi^{(u)}_{s_t})}{\Pi_{k_2 \neq \xi(1-V_{k_2, k_2})}} \right\} \right] \quad ...(3)
\]

d). **The number of the Server’s visits/Replacements:**

\[
V_\xi = \left[ \sum_{j,s_t} \left\{ \frac{pr(\xi^{(r)}_{j,s_t})}{\Pi_{k_1 \neq \xi(1-V_{k_1, k_1})}} \right\} \right] \div \left[ \sum_{s_t} \left\{ \frac{pr(\xi^{(u)}_{s_t})}{\Pi_{k_2 \neq \xi(1-V_{k_2, k_2})}} \right\} \right] \quad ...(4)
\]

**WORK PLAN AND METHODOLOGY:**

In the present scenario of competitive market to cut down production costs and improve productivity and delivery performance of manufacturing systems of processing industries are the key objectives of Industry. Reliability and its related issues have therefore become very relevant for manufacturing systems to meet the mission success. Keeping these concepts in mind, I will apply reliability technology to analyze the sugar, paper, fertilizer, non-conventional energy production, cement, rice mill, utensils, heavy machine manufacturing, soap manufacturing, plywood industry, soft drink industry etc. Moreover, I have also cited Journals like IEEE, Opsearch, Microelectronics and Reliability, International journal of statistics and Journal of the operational research society for analyzing the basic concept of reliability and availability. I have also taken extracts from the internet.