International Journal of Electronic Engineering Research
ISSN 0975- 6450 Volume 1 Number 2 (2009) pp. 127–133

http://www.ripublication.com/ijeer.htm

Reliability Analysis of Pharmaceutical Plant Using Matlab-Tool

Deepika Garg[1] and Kuldeep Kumar[2]

[1,2]Reasearch scholar, Dept of Mathematics, N.I.T Kurukshetra, Haryana, 136118, India
[1]E-mail: deepikanit@yahoo.in
[2]E-mail: kuldeepnitk@yahoo.com

Abstract

Purpose: The purpose of paper is to compute reliability of a Pharmaceutical plant .A Pharmaceutical plant consists of nine sub-systems working in series. One subsystem namely Rotary Compression Machine is supported by stand-by units having perfect switch over devices and remaining eight subsystems are subjected to major failure only.

Methodology/approach- The mathematical model of Pharmaceutical plant has been developed using Markov birth – death Process. Equations are solved with the help of matlab-program.

Findings- The study of analysis of reliability can help in increasing the quality and production of Pharmaceutical plant. To ensure the system performance throughout its service life, it is necessary to set up proper maintenance planning and control which can be done after studying the variation of reliability with respect to time.

Originality/value- Industrial implications of the results have been discussed.

Key Words: Reliability, Differential Equations, Markov Process, Matlab-Tool.

Introduction

Modern engineering systems like process and energy systems, transport systems, offshore structures, bridges, pipelines are design to ensure the successful operation throughout the anticipated service life. Unfortunately there is a threat of deterioration of processes, so it is necessary to study the variation of reliability with respect to time. The objective of the present paper is to study the reliability of Pharmaceutical plant. A Pharmaceutical plant mainly consists of nine subsystems namely Weighing Machine, Sifter Machine, Mass Mixer, Granulator, Fluid Bed Dryer, Octagonal Blender, Rotary Compression Machine, Coating Machine, Strip Packing Machine .These units are arranged in series. Failure and repair rates of each machine are assumed to be constant. The mathematical model of Pharmaceutical plant has been developed using Markov birth – death Process. The differential equations have been developed on the basis of probabilistic approach using transition diagram and equations are solved with the help of matlab program .The findings of the present paper can be considered to be useful for the analysis of reliability and for determining the best possible maintenance strategies for a Pharmaceutical plant concerned.

Literature survey

The last decades has witnessed a growing interest in the development and application of reliability/availability methods in the field of various industrial sectors related with maintenance engineering and management. Recently, many researchers have discussed reliability of different process industries using different techniques. Chakraborty .and Dutta[2] discussed economics of sugar production.Malik[3] disscussed Reliable preventive maintenance scheduling .Kumar and Singh [4] analyzed the Availability of a washing system of paper industry. Singh, Kumar and Pandey [5] discussed the reliability and availability of fertilizer industry.Dayal and singh [6] studied reliability analysis of a system in a fluctuating environment. Zaho[8]developed a generalized availability model for repairable component and series system including perfect and imperfect repair.Michelson [9] discussed the use of reliability technology in process industry. Singh and Mahajan [10] examined the reliability and long run availability of a Utensils Manufacturing Plant using Laplace transforms. Günes and Deveci[11] have studied the reliability of service systems and its application in student office and Habchi[12] discussed and improved the method of reliability assessment for suspended test . Jain [13] discussed N-Policy for redundant repairable system with additional repairman. Gupta, Lal, Sharma and Singh [14] discussed the reliability, long term availability and MTBF of cement industry with the help of Runga – Kutta method. Kiureghian and Ditlevson [15] analyzed the availability, reliability & downtime of system with repairable components. Kumar, Singh and Sharma[17] discussed the availability of an automobile system namely “scooty”. Tewari, Kumar, Kajal and Khanduja [18] discussed the availability of a Crystallization unit of a sugar plant. In these papers, authors used either Laplace transforms method , Lagrange’s or runge-kutta method to solve differential associated with particular problem. Jussi K.Vaurio[19] discussed current research and application related to the modeling , optimization and application of maintenance procedures for ageing and deteriorating engineering and structural systems. Panagiotis [20]had Classified and calculated primary failure modes in bread production line. Garg,Kumar,Sigh [21]discussed the availability of cattle feed plant using matrix method. Panagiotis Tsarouhas, Ioannis Arvanitoyannis, Theodoros and Varzakas[22] discussed reliability and maintainability analysis of cheese (feta) production line in a Greek medium-size. It has been observed that these methods involve complex computations and it is very difficult to calculate availability/reliability of the system by these methods. In fact, problem of calculating variation of reliability with time has not satisfactorily been tackled till now. This leads to the development of matlab program in order to calculate reliability of the system .The variation in the reliability of Pharmaceutical plant is also shown with the help of graph

The System

The Pharmaceutical Plant mainly consists of nine subsystems namely Weighing Machine, Sifter Machine, Mass Mixer, Granulator, Fluid Bed Dryer, Octagonal Blender, Rotary Compression Machine, Coating Machine, Strip Packing Machine . These units are arranged in series. One subsystem namely Rotary Compression Machine is supported by stand-by units with perfect switch over devices and the remaining eight subsystems are prone to failure. The mathematical modeling is done by using Markov birth – death Process and differential equations has been developed on the basis of probabilistic approach using transition diagram. To solve these equations matrix method is developed and calculations are done with the help of c-program. Kang ,Song and Gardoni [18] discussed the matrix based system reliability method. The findings of this paper are considered to be useful for the analysis of reliability and determination of the best possible maintenance strategies for a pharmaceutical plant concerned

The Pharmaceutical consists of the following nine main subsystems:

- (i) Weighing Machine (A) consists of one unit. The system fails when this subsystem fails.
- (ii) Sifter Machine (B), consists of one unit. It is subjected to major failure only.
- (iii) Mass Mixer (C) consists of one unit. The system fails when this subsystem fails
- (iv) Granulator (D) consists of one unit. It is subjected to major failure only.
- (v) Fluid Bed Dryer (E) consists of one unit. It is subjected to major failure only.
- (vi) Octagonal Blender (F) consists of one unit. The system fails when this subsystem fails
- (vii) Rotary Compression Machine (G) consists of two units, one working and the other is in cold standby. The cold standby unit is of lower capacity. The system works on standby unit in reduced capacity. Complete failure occurs when both units fail..
- (viii) Coating Machine (H) consists of one unit. The system fails when this subsystem fails.
- (ix) Strip packing machine (I), consists of one unit. It is subjected to major failure only

Assumptions and Notations

(i) Repair rates and failure rates are negative exponential and independent of each other.
(ii) Not more than one failure occurs at a time.
(iii) A repaired unit is, performance wise, as good as new.
(iv) The subsystem G fail through reduced states.
(v) Switch-over devices are perfect.

A, B, C, D, E, F,H,I	: Capital letters are used for good states.
G	: Denotes the reduced capacity states.
a, b, c, d, e, f,g,h,i	: Denotes the respective failed states.
λ_i	: Indicates the respective mean failure rates of Weighing Machine, Sifter Machine, Mass Mixer, Granulator, Fluid Bed Dryer, Octagonal Blender, Rotary Compression Machine, Coating Machine, Strip Packing Machine,i =1,2,3,4,5,6,7,8,9,10. i = 8 stands for failure rates of reduced states of G , respectively.
μ_i	: Indicates the respective repair rates Weighing Machine, Sifter Machine, Mass Mixer, Granulator, Fluid Bed Dryer, Octagonal Blender, Rotary Compression Machine, Coating Machine, Strip Packing Machine,i =1,2,3,4,5,6,7,8,9,10. i = 8 stands for failure rates of reduced states of G , respectively.
$P_i(t)$	: Probability that the system is in i^{th} state at time t.
$P_i'(t)$	: Derivative of probability function $P_i(t)$.

Mathematical Modeling

Probabilistic considerations give the following differential equations, associated with the transition diagram as given by figure 1.

$$p_1'(t) = a_1 p_1(t) + \mu_1 p_3(t) + \mu_7 p_2(t) + \mu_2 p_4(t) + \mu_3 p_5(t) + \mu_4 p_6(t) + \mu_5 p_7(t) + \mu_6 p_8(t) + \mu_9 p_9(t) + \mu_{10} p_{10}(t)$$

$$p_2'(t) = a_2 p_2(t) + \mu_1 p_{11}(t) + \mu_2 p_{12}(t) + \mu_3 p_{13}(t) + \mu_4 p_{14}(t) + \mu_5 p_{15}(t) + \mu_6 p_{16}(t) + \mu_8 p_{17}(t) + \mu_9 p_{18}(t) + \mu_{10} p_{19}(t) + \lambda_7 p_1(t)$$

Where $a_1 = -(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6 + \lambda_9 + \lambda_{10} + \lambda_7)$

$$a_2 = -(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6 + \lambda_8 + \lambda_9 + \lambda_{10} + \mu_7)$$

$$p_i'(t) + \mu_j p_i(t) = \lambda_j p_1(t)$$

$i = 3,4,5,6,7,8,9,10;\ j = 1,2,3,4,5,6,9,10;$

$$p_i'(t) + \mu_j p_i(t) = \lambda_j p_2(t)$$

$i = 11,12,13,14,15,16,17,18,19;\ j = 1,2,3,4,5,6,8,9,10;$

With initial conditions $P_1(0) = 1$, otherwise zero.

Reliability Analysis

Equations are solved using the Matlab-program, for details of program see the appendix and results are shown below

Table 1: Variation of Reliability With Respect To Time.

Time	0	20	40	60	80	100	120	140
Reliability	1	0.93977	0.9135	0.89819	0.88764	0.87979	0.87375	0.86903
Time	160	180	200	220	240	260	280	300
Reliability	0.86531	0.86237	0.86003	0.85818	0.85671	0.85553	0.8546	0.85385

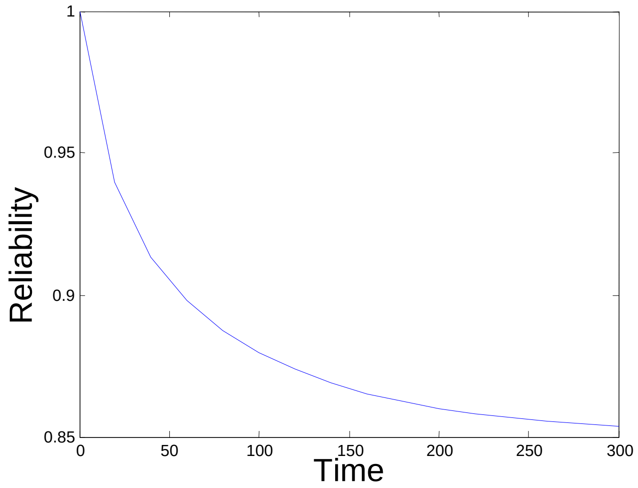

Figure 1: Variation of Reliability With Respect To Time.

Conclusion and Future Work

In this paper reliability computer program have been described. There are several advantages in comparison to use of other methods

(1) Reliability calculations are simplified.
(2) Computational of extensive system is possible.
(3) Results are more accurate and more precise.

The present paper can help in increasing the quality and production of pharmaceutical plant. The proposed method can be applied to complex systems that include a large system of differential equations. Using this method, we can easily study the variation of reliability with respect to time. Table 1 and figure 1 shows the variation of reliability with respect to time. Initially reliability decreases sharply with respect to time and become almost stable after long duration of time. The same methodology can be applied in other industries so that the management can get maximum benefit from the same.

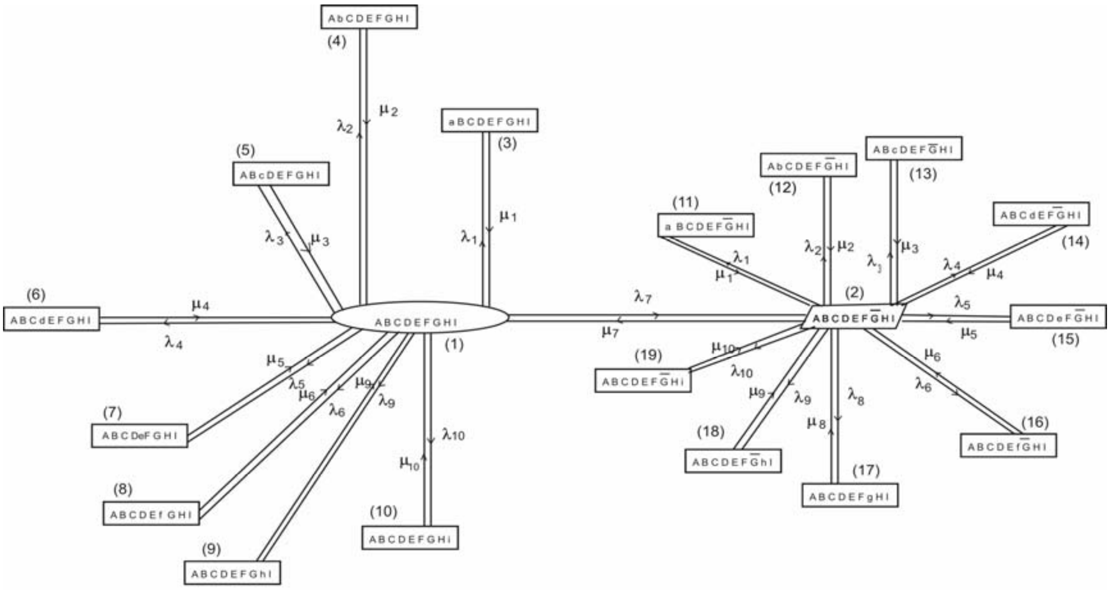

Figure 2: Transition diagram of pharmaceutical plant.

References

[1] B.S. Dhillon, and C.Singh, “Engineering Reliability New Techniques and Applications”, John Wiley and sons., 1981

[2] Chakraborty S.and S.A. Dutta, “Economics of sugar production:A case study”, international journal of production research ,vol 21,num 5,1983.

[3] Malik M.A.K.,“Reliable preventive maintenance scheduling“,AIIEE Trans. vol.11, no.1 , pp.221-228,1987.

[4] D.Kumar, and J.Singh,.“Availability of a Washing System in the Paper Industry”, Microelectron. Reliability, Vol. 29, pp.775-778,1989

[5] J.Singh, P.C.Pandey and D.Kumar, “Designing for Reliable Operation of Urea Synthesis in the Fertilizer Industry”, Microelectron. Reliability, Vol. 30, pp.1021-1024.,1990

[6] B.Dayal and J.Singh, “Reliability analysis of a system in a fluctuating envioronment”,Microelectron Reliability,Vol.32,pp.601-603,1992.

[7] D.Kumar, J.Singh, and P.C.Pandey “Availability of the Crystallization System in the Sugar Industry under Common – Cause Failure”, IEEE Transactions on Reliability, Vol. 41, No.1, pp 85-91.,1992

[8] M.Zhao, “Availability for Repairable components and series systems”,IEEE Transactions On Reliability,Vol-43,No.2,1994

[9] Q. Michelson, “Use of Reliability Technology in The Process Industry”,Reliability Engineering and system safety ,60,pp.179-181,1998

[10] J.Singh, and P Mahajan, “Reliability of Utensils Manufacturing Plant – A Case Study”, Opsearch, Vol. 36, No.3, pp 260-269.,1999.

[11] M.Güines and I. Deveci, “ Reliability of service system and an application in

student office",International Journal of Quality & Reliability Management, Vol.19,pp.206-211,2002

[12] G. Habchi, "An improved method of reliability assessment for suspended tests",International Journal of Quality & Reliability Management ,vol.19,pp.454-470,2002

[13] Madhu Jain,"N-Policy for redundant repairable system with additional repairmen",Opsearch, vol 4, 97-114,2003

[14] P Gupta., A.K.Lal, R.K.Sharma and J.Singh "Behavioral Study of the Cement manufacturing Plant – A Numerical Approach" , Journal of Mathematics and Systems Sciences, Vol. 1, No. 1,pp.50-69.,2005

[15] A.D.Kiureghian and O.D.Ditlevson, "Availability, Reliability & downtime of system with repairable components", Reliability Engineering and System Safety, Volume 92, Issue 2, pp. 66-72.,2007

[16] Jai Singh Gurjar,"Reliability Technology – Theory And Applications"; I.K. International Publishing House Pvt. Ltd. New Delhi (I ndia).,2007

[17] J.Singh, K Kumar,A.Sharma, "Availability Evaluation of an Automobile System",Journal of mathematics and system sciences, Vol. 4, No.2 ,pp.95-102.,2008

[18] P.C Tewari,D.Kumar,S.Kajal,R.Khanduja,"Decision support system for the Crystallization unit of a sugar plant", Icfai J. of Science and Technology, Vol-4, No.3,pp.7-16.,2008.

[19] Enrio Zio and Jussi K.Vaurio "Maitenance modeling and applications",Reliability Enginering And System safety,vol-94,Issue 1,Page 1.

[20] Panagiotis H. Tsarouhas," Classification and calculation of primary failure modes in bread production line", Reliability Engineering & System Safety,Volume 94, Issue 2, February 2009,Pages 551- 557.

[21] Garg,D.,Singh J.,Kumar K.,2009, "Availability analysis of cattle feed plant using matrix method" ,Computer science journals",vol-3,issue-2,pp.201-219.

[22] Panagiotis H.Tsarouhas,Ioannis S.Arvanitoyannis,Theodoros H.Varzakas Reli ability and maintainability analysis of cheese (feta) production line in a Greek medium-size company: A case study , Journal of Food Engineering, Volume 94, Issues 3-4, 2009, Pages 233-240