IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

M.T.T.F. AND RELIABILITY VS TIME FOR A MILK MANUFACTURING AND PROCESSING UNIT USING BFT

Dr. Reena Garg

Assistant Professor(Mathematics), Department of Humanities and Sciences YMCA University of Science and Technology, Faridabad

DOI: 10.5281/zenodo.1161709

ABSTRACT

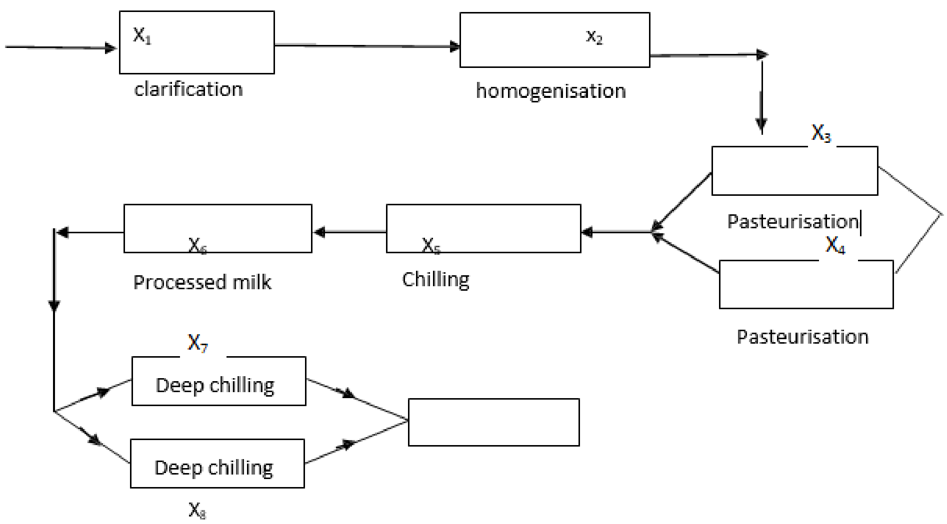
For systems of multistate elements, the problem of developing Boolean reliability models was considered on the basic of logic. The objective of this paper is to find the reliability of milk manufacture plant using Boolean function technique. Milk consists the process of clarification, homogenisation , pasteurisation , chilling, processed milk and the deep chilling. The failure rate is exponentially distributed and Weibull distributed . The reliability factor and MTTF have been evaluated by using Boolean function technique. We reveal our technique by solving of examples and insert numerical results to show the effects of system reliability.

Keywords: M.T.T.F.,Milk manufacturing plant, BFT, Exponential distribution, weibull distribution

I. INTRODUCTION

Dairy sector is one of the main subsidiary activities of most of the former in India . The demand for milk and the milk products is at its peak , in order to meet the demand the milk need to be converted to various milk product Industries are trying to introduce more reliability in their industrial process to fulfil the needs of future demand. The industrial system and as well as their product complexibility is increasing day by day. To reduce this complexibility , the author introduce the basic Boolean function technique.

In the beginning the whole power plant is in operating state and there is no repair facility to repair andfailed component of the power plant. The author obtained the reliability function in two cases that is when the failure rate follow Weibull Time Distribution and exponential time distribution and the mean time to failure (MTTF) has been calculated in both cases. The paper is sum up with numerical computation and graphical representation to highlight the important result .



Transition state diagram of milk plant

II. ASSUMPTIONS

The following assumptions have been associated with this model:

a) Initially, the whole system is good and operable.
b) Every component of the system remains either in good or bad state.
c) There is no repair facility to repair a failed component.
d) The reliability of each part moreover each section is in advance.
e) The whole system can fail due to failure of any one of its units.
f) Failures are statistically- independent.

III. NOTATIONS

X_1 : State of Clarification

X_2 : State of homogenisation

X_3 , X_4 : State of pasteurisation

X_5 : State of chilling

X_6 : State of processed milk

X_7 ,X_8 : State of deep chilling

X_i (i=1,2,...8) : 1 in good state; 0 in bad state

X_i' : Negation for X_i' all i

$\wedge / \vee$: Conjunction / Disjunction

| | : This notation has used to represent logical matrix. R_i :
Reliability of i^{th} part of the system, $\forall$ i=1,2....8

Q_i : 1-R_i

R_S : Reliability of the whole system

$R_{SW}(t)/R_{SE}(t)$: Reliability of the system as the whole when failure follow Weibull / Exponential time distribution

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IV. FORMULATION OF MATHEMATICAL MODEL

By making use of Boolean function technique , the condition of capability of successful operation of the system in terms of logical matrix are expressed as shown :\

$$f(x_1, \ldots\ldots x_8) = \begin{vmatrix} x_1 & x_2 & x_3 & x_5 & x_6 & x_7 \\ x_1 & x_2 & x_4 & x_5 & x_6 & x_7 \\ x_1 & x_2 & x_3 & x_5 & x_6 & x_8 \\ x_1 & x_2 & x_4 & x_5 & x_6 & x_8 \end{vmatrix} \qquad \ldots\ldots(1)$$

$$= \begin{vmatrix} x_1 & x_2 & x_5 & x_6 \end{vmatrix} \wedge \begin{vmatrix} x_3 & x_7 \\ x_4 & x_7 \\ x_3 & x_8 \\ x_4 & x_8 \end{vmatrix} \qquad \ldots\ldots(2)$$

$$= \begin{vmatrix} x_1 & x_2 & x_5 & x_6 \end{vmatrix} \wedge \begin{vmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{vmatrix} \qquad \ldots\ldots(3)$$

$B_1 = | x_3 \quad x_7 |$, $B_2 = | x_4 \quad x_7 |$

$B_3 = | x_3 \quad x_8 |$, $B_4 = | x_4 \quad x_8 |$

By orthogonalization algorithm (3) may be written as

$$f(x_1, \ldots x_8) = \begin{vmatrix} B_1 & & & \\ B_1' & B_2 & & \\ B_1' & B_2' & B_3 & \\ B_1' & B_2' & B_3' & B_4 \end{vmatrix} \qquad \ldots\ldots(4)$$

Now we $B_1' B_2 = \begin{vmatrix} x_3' & \\ x_3 & x_7' \end{vmatrix} \wedge | x_4 \quad x_7 |$

$$= | x_3' \quad x_4 \quad x_7 | \qquad \ldots\ldots(5)$$

$B_1' B_2' B_3 = \begin{vmatrix} x_3' & \\ x_3 & x_7' \end{vmatrix} \wedge \begin{vmatrix} x_4' & \\ x_4 & x_7' \end{vmatrix} \wedge | x_3 \quad x_8 |$

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

$$= \begin{vmatrix} x_3' & x_4 & x_7 & x_8 \\ x_3 & x_4 & x_7' & x_8 \end{vmatrix} \qquad ....(6)$$

$$B_1' B_2' B_3' B_4 = \begin{vmatrix} x_3' & \\ x_3 & x_7' \end{vmatrix} \wedge \begin{vmatrix} x_4' & \\ x_4 & x_7' \end{vmatrix} \wedge \begin{vmatrix} x_3' & \\ x_3 & x_8' \end{vmatrix} \wedge \begin{vmatrix} x_4 & x_8 \end{vmatrix}$$

$$= \begin{vmatrix} x_3' & x_4 & x_7' & x_8 \end{vmatrix} \qquad ....(7)$$

$$= \begin{vmatrix} x_3 & x_7 & & \\ x_3' & x_4 & x_7 & \\ x_3 & x_4' & x_7' & x_8 \\ x_3 & x_4 & x_7' & x_8 \\ x_3' & x_4 & x_7' & x_8 \end{vmatrix} \qquad ......(8)$$

Using equation (4) in equation (8)

$$f(x_1, ...x_8) = \begin{vmatrix} x_1 & x_2 & x_3 & x_5 & x_6 & x_7 & & \\ x_1 & x_2 & x_3 & x_4 & x_5 & x_6 & x_7 & \\ x_1 & x_2 & x_3 & x_4' & x_5 & x_7' & x_8 & \\ x_1 & x_2 & x_3 & x_4 & x_5 & x_6 & x_7' & x_8 \\ x_1 & x_2 & x_3' & x_4 & x_5 & x_6 & x_7' & x_8 \end{vmatrix} \qquad .....(9)$$

Since equation (8) is the disjunction of disjoint conjunctions, therefore the reliability of the whole system is given by

$R_S = P_r\{ f(x_1, ...x_8)=1\}$

$= R_1R_2R_5R_6[R_3R_7+Q_3R_4R_7+R_3Q_4Q_7R_8+R_3R_4Q_7R_8+Q_3R_4Q_7R_8]$

Where R_i is the reliability corresponding to system state x_i

And $Q_i = 1-R_i$ □ $i= 1,2.....8$

Thus

$R_S = R_1R_2R_5R_6$ [$R_3R_7+R_4R_7-R_3R_4R_7+R_3R_8-R_3R_4R_8-R_3R_7R_8+R_3R_4R_7R_8+R_3R_4R_8-R_3R_4R_7R_8+R_4R_8-R_3R_4R_8-R_4R_7R_8+R_3R_4R_7R_8$ (10)

Where $R_i(i=1,2,................8)$ is the reliability of the section state $x_i(i=1,2,..........,8)$ respectively.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

V. SOME PARTICULAR CASE

Case 1: When reliability of each component

Then equation (10) yields

$$R_S = 4R^7 - 6R^7 + R^8 \tag{11}$$

Case 2: When failure rates follow Weibull Time Distribution :

Let λ_i be the failure rate corresponding to the system state x_i, $\forall$ i=1,2,..........8, then reliability of considered system at an instant 't', is given by

$$R_{SW}(t) = \sum_{i=1}^{7} e^{-a_i t^{\alpha}} - \sum_{i=1}^{6} e^{-b_j t^{\alpha}} \quad ....(12)$$

where α is a positive parameter and

$a_1 = c + \lambda_3 + \lambda_7$

$a_2 = c + \lambda_4 + \lambda_7$

$a_3 = c + \lambda_3 + \lambda_8$

$a_4 = c + \lambda_3 + \lambda_4 + \lambda_7 + \lambda_8$

$a_5 = c + \lambda_3 + \lambda_4 + \lambda_8$

$a_6 = c + \lambda_4 + \lambda_8$

$a_7 = c + \lambda_3 + \lambda_4 + \lambda_7 + \lambda_8$

and

$b_1 = c + \lambda_3 + \lambda_4 + \lambda_7$

$b_2 = c + \lambda_3 + \lambda_4 + \lambda_8$

$b_3 = c + \lambda_3 + \lambda_7 + \lambda_8$

$b_4 = c + \lambda_3 + \lambda_4 + \lambda_7 + \lambda_8$

$b_5 = c + \lambda_3 + \lambda_4 + \lambda_8$

$b_6 = c + \lambda_4 + \lambda_7 + \lambda_8$

Case 3: When failure rate follow exponential time distribution

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Exponential distribution is nothing but a particular case of Weibull distribution for α=1 and it is very useful for practical problems purpose. Therefore, the reliability of consider system as a whole at any instant 's' is expressed as:

$$R_{SE}(t)=\sum_{i=1}^{7} e^{-a_i t} - \sum_{i=1}^{6} e^{-b_j t} \quad \text{........(13)}$$

Where a_i and b_j mentioned earlier

Also an important reliability parameter, viz ; M.T.T.F. ,in this case given by

$$\text{M.T.T.F} = \int_0^{\infty} R_{SE}(t)\,dt$$

$$=\sum_{i=1}^{7}\left(\frac{1}{\alpha_i}\right) - \sum_{i=1}^{7}\left(\frac{1}{\beta_i}\right) \quad \text{.......(14)}$$

VI. NUMERICAL EXAMPLE

For numerical computation

(A) λ_i (i=1,2,.......8) =0.001, α=2 and t=0,1,2.......in equation (12)

(B) λ_i (i=1,2,........8)=0.001, and t=0,1,2............ in equation(13)

(C) λ_i (i=1,2,........8)=0,0.1,0.2..........1.0 in equation (14)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Table -1

T	$R_{sw}(t)$	$R_{se}(t)$
0	1	1
1	0.996005	0.996005
2	0.984095	0.992023
3	0.964485	0.990037
4	0.937532	0.981347
5	0.903734	0.980452
6	0.863723	0.974459
7	0.818257	0.972027
8	0.768202	0.978542
9	0.714519	0.964095
10	0.658234	0.969562

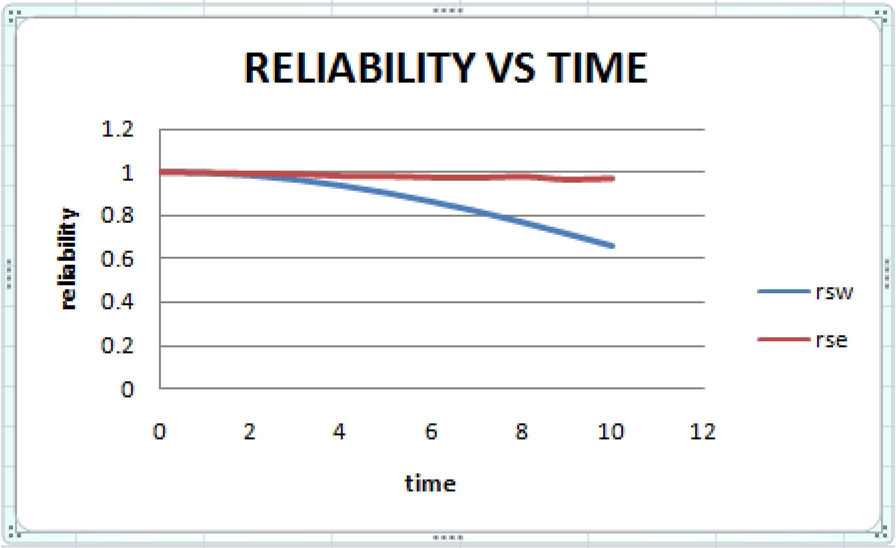


Fig-I

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

TABLE - 2

λ	MTTF
0	2.202380
0.1	0.988253
0.2	0.787301
0.3	0.656084
0.4	0.562358
0.5	0.492063
0.6	0.393657
0.7	0.286349
0.8	0.252324
0.9	0.223249

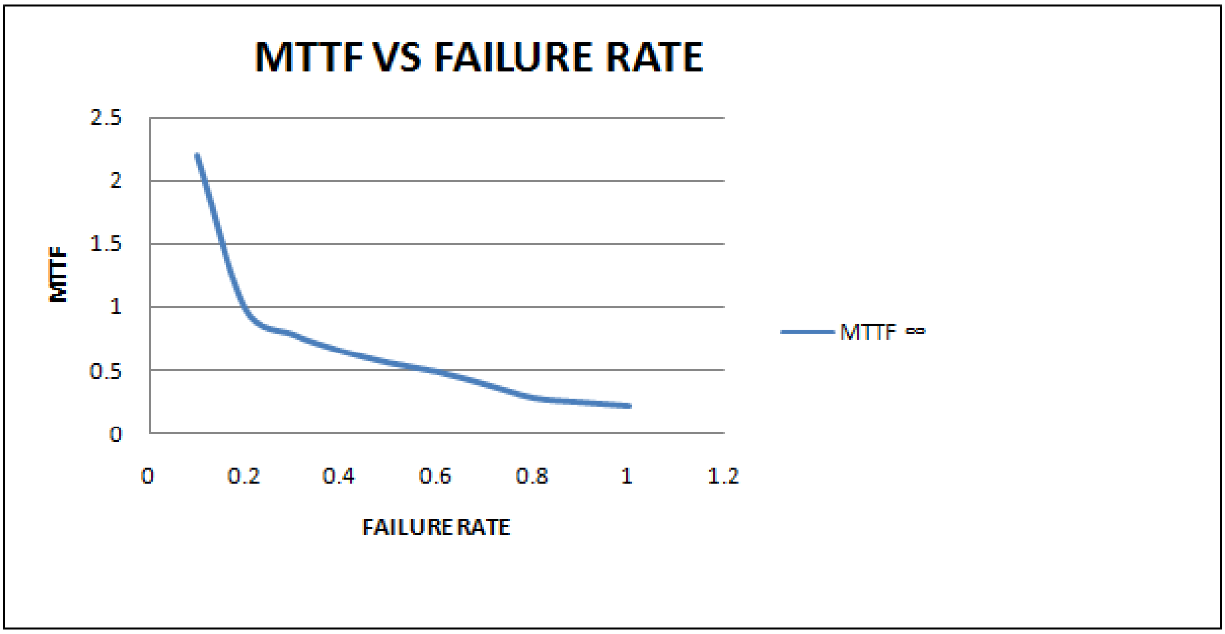


Fig-2

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

VII. RESULTS AND DISCUSSION

In this paper the author has considered a milk plant for analysis of various reliability parameter by using Boolean function technique and logics.

Table 1 show that the reliability of the system with respect to time when the failure rates follows the Weibull and Exponential time distribution. The graph of' reliability Vs time' computes the reliability of complex system decreases approximately at a uniformly rate in case exponential time distribution but in case of Weibull Time Distribution decreases rapidly .

In table 2 and graph MTTF V/S Failure rate ' yields that MTTF of the system has been decreases catastrophically in the beginning after that it decreases approximately at a uniform rate '.

VIII. REFERENCES

[1] D R Prescott , R. Remenyte -Prescott, S Reed, J D Andrews and C G Downes, "A Reliabilty analysis method using binary decision diagrams in phased mission planning " Journal of risk and relaibilty". Vol 223, 2009
[2] S.C. Aggarwal , Mamta Sahani and Shikha Bansal ."reliability characteristics of cold stand by redundant system" IJRRAS 3 (2) May 2010
[3] Nagraja, H.N ; Kannan , N. Krishann, N.B ; "Reliability" Springer publication 2004.
[4] Dhillon ,B.S; Reliability, quality and safety engineers ",Taylor Francis 2004.
[5] Rao,S; Parulekar ,B.B; energy technology ," Khanna publishers New Delhi, 2002.
[6] Osaki ,S,; " Stochastic Models in Reliability and maintainence ," Springer publications 2002.