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EVALUATION OF RELIABILITY PARAMETER OF RICE MILL

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Abstract: In this paper, the object is to improve the reliability and overall performances of Rice Mill. When a more complexities increase in the system, the reliability evaluations become more difficult. Therefore, the derivation of symbolic reliability expression is simplified and a general system in compact form is helpful. Before this, the techniques executed earlier to solve such reliability models are very time consuming and very tedious calculations. Therefore, in this study Boolean function technique and algebra is used to evaluate systems, overall performance. Reliability of considered system has been computed by using Weibull and Exponential time distributions. M.T.T.F. of the considered system an important reliability parameter has been evaluated to develop practical utility of the model. A mathematical model has been developed with the help of Boolean function technique to measuring reliability.

KEYWORDS: Boolean Function Technique, Reliability, Failure Rate, M.T.T.F, Rice Mill

I INTRODUCTION

Rice is considered to be staple food diet in most parts of India including east and south parts of the country. Paddy is the most important agricultural commodity in Manipur and the total area under cultivation is estimated to be 2.25 lac hectares with annual production of close to 5 lac tons. Rice is one of the chief grains of India. Thus, rice mills play very important role for human. Rice-grains consists of husk and brown rice. Brown rice in turn contain bran which comprises the outer layer and edible portion. Rice mill is removal of husk and bran to obtain edible portion for consumption .Rice mill is a crucial steps in post-production of rice. It producers edible white rice that is sufficiently milled and free form impurities. In this paper, an effort has been made to carry out the performance analysis of a rice manufacturing plant.

Reliability of a unit (or product) is the probability that the unit performs its intended function adequately for a given period of time under the given stated operating conditions or environment. Reliability definition stresses four element: probability, intended function, time and operating conditions [1]. Gupta P.P, Agarwal S.C have considered a Boolean Algebra Method for Reliability calculations and again Gupta P.P Kumar Arvind, Reliability and M.T.T.F Analysis of Power Plant. Sharma, Deepankar Sharma, Neelam, Evaluation of some Reliability Parameters for Tele-communication system by Boolean Function Technique [2][3][4][5]. [6][7][8][9] The reliability of several electronic equipments by using various techniques has been calculated, but the method adopted by them lead to cumbersome and tedious calculation. Keeping this fact in view, for the evaluation of various factors of reliability of Rice mill, the authors have applied Boolean function technique.

The block diagram of a rice mill is shown in figure 1. The work of cleaner is to remove all impurities and unfilled grains from paddy. Two identical units are working in parallel. This unit can work with one unit in reduced capacity. Husking section removes husk from paddy. Failure of this subsection causes the complete failure of the system. The separation subsystem separates the unhusked paddy from bran rice. Failure of the subsystem causes the complete failure of the system. The work of Whitening unit is to remove all or part of the bran layer and germ from brown rice. The two identical units are functioning in parallel. This unit can work with one subsystem in reduced capacity. This subsystem improves the appearance of milled rice by removing the remaining bran particles and by polishing the exterior of the milled kernel. These are two identical units. Failure of any one unit causes complete failure of the system.

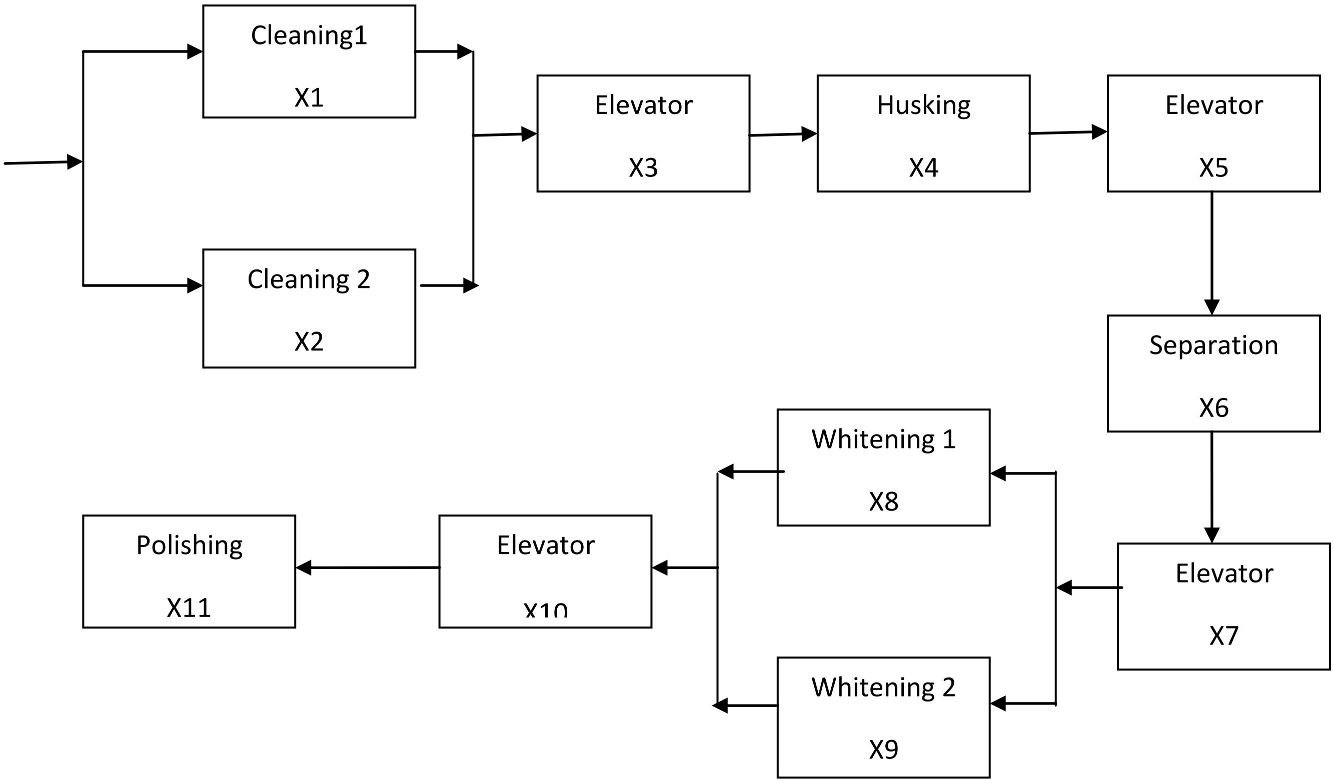

Figure 1: Block Diagram Representation of Rice Mill

II. RELIABILITY BY BOOLEAN FUNCTION TECHNIQUE

The reliability of substation is determine, a mathematical model is developed as shown in figure1. Following assumptions are made for applying Boolean function technique:

1. First of all , ensure all the equipments are good and operable.
2. The state of all components of the system is statistically independent.
3. The state of each component and as whole system operable, workable, good or fail.
4. There is no repair facility.
5. Supply between any two component of the system is hundred percent reliable and ok.
6. The failure times of all components are arbitrary.
7. The reliability of each component is to be known in advance.

Notations

X1, X2 = State of both Cleaning section

X3, X5, X7, X10 = State of elevator

X4 = State of husking section

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X6 = State of separation of paddy from rice

X8, X9 = State of cleaners

X11 = State of polishing section

$X_i(i = 1,2,\ldots 11)$ = 1 in good state and 0 in bad state

X_i' = negation of X_i

^ = Conjunction

| | = Logical Matrix

R_i = Reliability of i^{th} part of the system

$Q_i = 1-R_i$

R_s = Reliability of Whole System

$R_{SW}(t)/R_{SE}(t)$ = Reliability of the system as a whole when failures follow Weibull /Exponential time distribution.

III. FORMULATION OF MATHEMATICAL MODEL

The successful operation of the system in terms of logical matrix is expressed as:

$$F(X_1, X_2 \ldots\ldots X_{11}) = \begin{vmatrix} X_1 & X_3 & X_4 & X_5 & X_6 & X_7 & X_8 & X_{10} & X_{11} \\ X_1 & X_3 & X_4 & X_5 & X_6 & X_7 & X_9 & X_{10} & X_{11} \\ X_2 & X_3 & X_4 & X_5 & X_6 & X_7 & X_8 & X_{10} & X_{11} \\ X_2 & X_3 & X_4 & X_5 & X_6 & X_7 & X_9 & X_{10} & X_{11} \end{vmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$= (X_1 X_2 X_8 X_9) \wedge \begin{vmatrix} X_1 & X8 \\ X_1 & X_9 \\ X_2 & X_8 \\ X_2 & X_9 \end{vmatrix} = (X_1 X_2 X_8 X_9) \wedge B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$B = \begin{vmatrix} X_1 & X8 \\ X_1 & X_9 \\ X_2 & X_8 \\ X_2 & X_9 \end{vmatrix} = \begin{vmatrix} M_1 \\ M_2 \\ M_3 \\ M_4 \end{vmatrix}$$

By Orthogonalisation algorithm, above equation can be written as

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$$B = \left| \begin{array}{llll} M_1 & & & \\ M_1' & M_2 & & \\ M_1' & M_2' & M_3 & \\ M_1' & M_2' & M_3' & M_4 \end{array} \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Now using algebra of logics

$$M_1' M_2 = \left| X_1 \quad X_8' \quad X_9 \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$M_1' M_2' M_3 = \left| X_1' \quad X_2 \quad X_8 \quad X_9' \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$M_1' M_2' M_3' M_4 = \left| X_1' \quad X_2 \quad X_8' \quad X_9 \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

By using equation 3-6

$$B = \left| \begin{array}{llll} X_1 & X_8 & & \\ X_1 & X_8' & X_9 & \\ X_1' & X_2 & X_8 & X_9' \\ X_1' & X_2 & X_8' & X_9 \end{array} \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

By using equation 7 and equation 2

$$F = \left| \begin{array}{lllllllllll} X_3 & X4 & X_5 & X_6 & X_7 & X_{10} & X_{11} & X_1 & X_8 & & \\ X_3 & X4 & X_5 & X_6 & X_7 & X_{10} & X_{11} & X_1 & X_8' & X_9 & \\ X_3 & X4 & X_5 & X_6 & X_7 & X_{10} & X_{11} & X_1' & X_2 & X_8 & X_9' \\ X_3 & X4 & X_5 & X_6 & X_7 & X_{10} & X_{11} & X_1' & X_2 & X_8' & X_9 \end{array} \right| \qquad \ldots\ldots\ldots\ldots\ldots\ldots(12)$$

Finally the probability of successful operation i.e. reliability of the system as a whole is given by

$$R_S = R_3 R_4 R_5 R_6 R_7 R_{10} R_{11} [R_1 R_8 + R_1 R_9 (1-R_8) + R_2 R_8 (1-R_1)(1-R_9) + R_2 R_9 (1-R_1)(1-R_8)]$$

$$\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

A. Some Particular Cases

Case1: When all failures follow Weibull's Criteria

Let λ_i will be the failure rate of components corresponding to system state X_i and it follows weibull time distribution. Then reliability function of considered system at time't' is given as:

$$R = e^{-(\lambda_3+\lambda_4+\lambda_5+\lambda_6+\lambda_7+\lambda_{10}+\lambda_{11})t^{\alpha}} [e^{-(\lambda_1+\lambda_8)t^{\alpha}} + e^{-(\lambda_1+\lambda_9)t^{\alpha}} (1- e^{-\lambda_8 t^{\alpha}}) + e^{-(\lambda_2+\lambda_8)t^{\alpha}}$$

$$(1- e^{-\lambda_1 t^{\alpha}})(1- e^{-\lambda_9 t^{\alpha}}) + e^{-(\lambda_2+\lambda_9)t^{\alpha}}(1- e^{-\lambda_1 t^{\alpha}})(1- e^{-\lambda_8 t^{\alpha}})] \qquad \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

When $\lambda_1 = \lambda_2 =$ ------------- $\lambda_{11} = \lambda$ then from above equation

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$R_{sw}(t) = e^{-(7\lambda)t^{\alpha}}[4e^{-(2\lambda)t^{\alpha}} - 5e^{-(3\lambda)t^{\alpha}} + 2e^{-(4\lambda)t^{\alpha}}]$ ……………………..(15)

Case –II: When all failures follow Exponential time distribution

Exponential distribution is a particular case of weibull distribution for $\alpha = 1$. Hence the reliability of a whole system at an instant't' is given by

$R_{se}(t) = e^{-(7\lambda)t}[4e^{-(2\lambda)t} - 5e^{-(3\lambda)t} + 2e^{-(4\lambda)t}]$

……………………..(16)

and the expression for M.T.T.F in this case is

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

$$= \frac{4}{9\lambda} - \frac{1}{2\lambda} + \frac{2}{11\lambda}$$ ……………………..(17)

IV. NUMERICAL COMPUTATIONS

For a numerical computation, let us consider the values

i. Setting $\lambda_i(i = 1,2,3....11) = 0.001$ and $\alpha = 2$ in equation 15
ii. Setting $\lambda_i(i = 1,2,3....11) = 0.001$ in equation 16
iii. Setting $\lambda_i(i = 1,2,3....11) = 0.001.......0.012$ in equation 17 table 1 and table 2 has been computed and corresponding graphs are shown in figure 2 and 3 respectively.

Table 1: Reliability values showing for $R_{sw}(t)$, $R_{se}(t)$ with time

S. No.	t	$R_{sw}(t)$	$R_{se}(t)$
1	1	0.992032903896432	0.992032903896432
2	2	0.968521893116969	0.984131233001847
3	3	0.930604255469389	0.976294417532871
4	4	0.880068014079911	0.968521893116969
5	5	0.819205206130421	0.960813100735798
6	6	0.750632731038987	0.953167486669187
7	7	0.677101439565022	0.945584502439783
8	8	0.601313520506161	0.938063604758295

Table 2: M.T.T.F vs λ

S. No.	λ	M.T.T.F
1	0.001	126.262626262626
2	0.002	63.1313131313131
3	0.003	42.0875420875421
4	0.004	31.5656565656566
5	0.005	25.2525252525253
6	0.006	21.0437710437711
7	0.007	18.0375180375180
8	0.008	15.7828282828283
9	0.009	14.0291806958474
10	0.010	12.6262626262626
11	0.011	11.4784205693297
12	0.012	10.5218855218855

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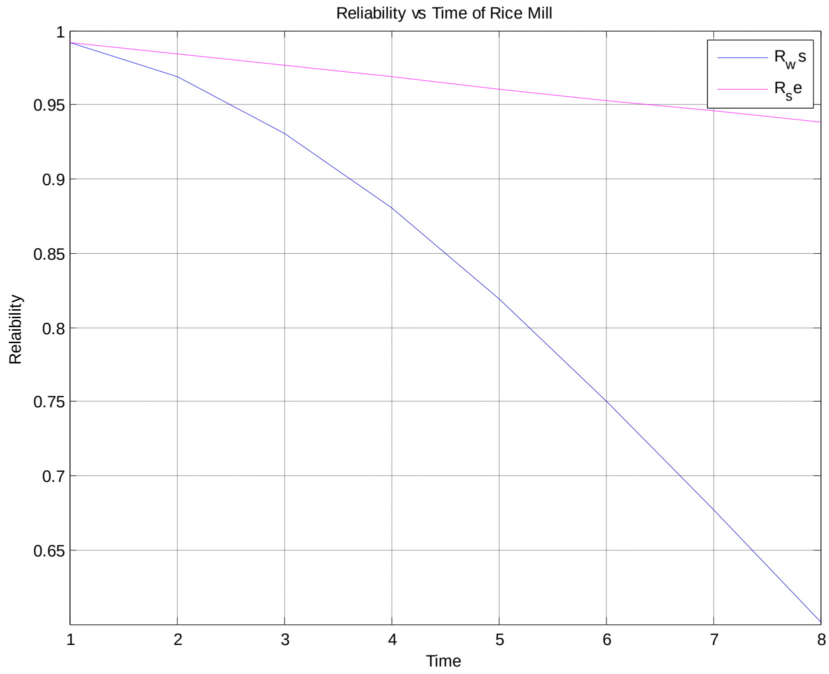

Figure 2: Graph showing Weibull distribution and exponential distribution with time

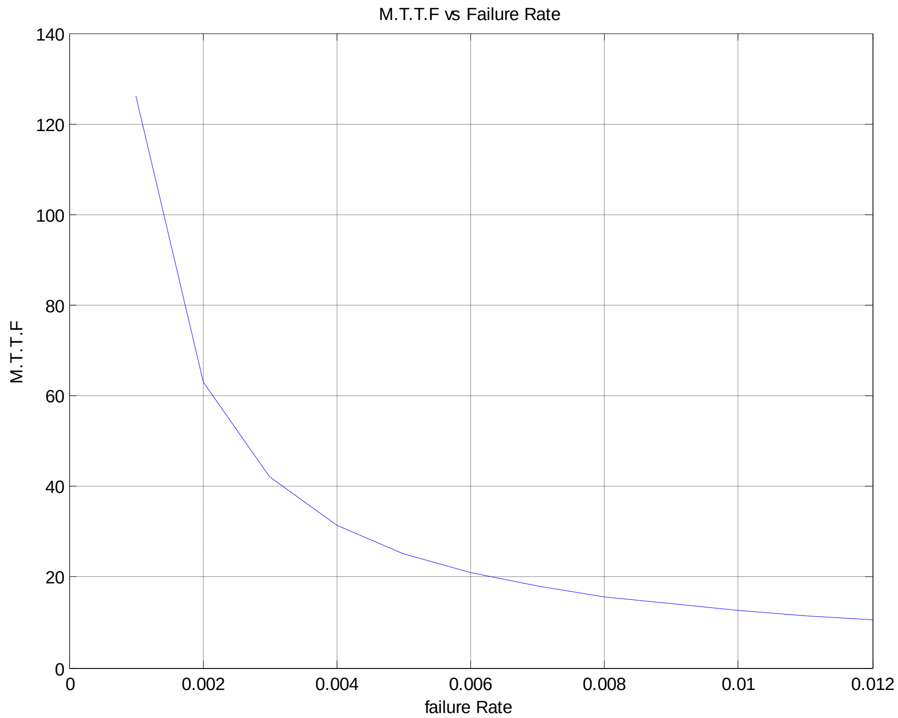

Figure 3: Graph showing M.T.T.F with failure rate

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V. CONCLUSION

In this paper, we have considered a rice mill for analysis of various reliability parameters by employing the Boolean function technique & algebra of logics. Table 1 computes the reliability of the system with respect to time when failures rates follow exponential and Weibull time distributions. An inspection of graph "Reliability Vs Time" (fig2) reveals that the reliability of the complex system decreases approximately at a uniformly rate in case of exponential time distribution, but decreases very rapidly when failure rates follow Weibull distributions. Table 2 and graph "MTTF V/S Failure Rate"(fig-3) yields that MTTF of the system decreases catastrophically in the beginning but later it decreases approximately at a uniform rate.

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