International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Analysis of the Reliability of the Butter-Oil Processing Plant using CAS Mathematica and Maxima

Shalini Jindal, Reena Garg, Tarun Garg

Abstract: ***The aim of the present paper is to analysis the reliability of the system by using CAS Mathematica and also, it's comparative study with CAS Maxima. The butter oil manufacturing plant consists of seven units i.e. separator, pasteurizer, continuous butter making, melting vats, butter oil clarifier, packaging and standby state. Model is developed by using Markov birth-death process. The first order differential equations are derived by using model and then solved for comparative study of reliability to give accuracy in result. By using Mathematica, we calculate probability of each state, which is beneficial to plant owners because better accuracy in result enhance reliability of the plant Graphs are plotted and tables are developed with the help of CAS Mathematica and Maxima, graphs show the variation and tables shows the fluctuations in reliability in comparative manner.***

Keywords: ***Reliability, Chapman Kolmogorov Differential Equations, Markov Process, Mathematica, Maxima, Butter-oil Processing Plant.***

I. Introduction

In industry, issue of system reliable becomes major term because of production of system are not affected with this issue, with increasing demand of this era so to overcome this issue from past, now and in future there are many techniques But to consider the value of time and accuracy in result, now there are also some software available to find the reliability of the system .In this research paper , we have not only evaluated the reliability of the system but also analyses the comparative study for its justification and improvement in results, by utilizing time. The overall concern is to increase the reliability of the system and decrease its failure rate so our system becomes more reliable. In present research paper, we have compared the reliability of the system by using CAS Mathematica and CAS Maxima.

Manuscript received on February 27, 2020.
Revised Manuscript received on March 14, 2020.
Manuscript published on March 30, 2020.
* Correspondence Author
Shalini Jindal*, Research Scholar, Department of Mathematics, J. C. Bose University of Science and Technology, YMCA-121006, Faridabad (Haryana-India). Email: shalinijindal91@gmail.com
Dr. Reena Garg, Assistant Professor, Faculty of Sciences (Department of Mathematics), J. C. Bose University of Science and Technology, YMCA-121006, Faridabad (Haryana)-India. Email: reenagargymca@gmail.com
Dr. Tarun Kumar Garg, Associate Professor, Satyawati college, University of Delhi, Delhi-India. Email: tkgarg@satyawati.du.ac.in

The butter oil manufacturing plant consists of seven units and System is working in standby state, to increase the redundancy of the system. we also analyses variation of the failure and repair rates on the reliability of system. In [1] Jai Singh, Arvind Kumar Lal, Rajendra Kumar Sharma and Pawan Kumar have analyses the "Reliability of butter oil processing plant by using R-K Method". In present paper we will analyses the "Reliability of butter oil processing plant using Mathematica" So we take the System, its transition diagram from [1].

In [2] Tarun Kumar Garg has analysed the "Reliability of skimmed milk power production by using CAS Mathematica". In [3] G. S. Tuteja has analyses the "Practical Mathematics Using Maxima". In [4] B. Dayal and Jai Singh have analysed the "Reliability analysis of a system in a fluctuating environment". [5] B.S. Dhillon and J. Natesan have analysed the "Stochastic analysis of outdoor power system in fluctuating environment". In [6] P. Goel and J. Singh have analysed the "Reliability analysis of a standby complex system having imperfect switch-over device".

In [7] D. Kumar, J. Singh and I.P. Singh have analysed the "Reliability analysis of the feeding system in paper industry".

The model is converted into set of differential equations by using chapman – Kolmogorov differential equations. These equations are solved by using CAS Mathematica and by using CAS Maxima. Maxima is method of approximation so these values are approximating values.

II. System Configuration

Butter oil manufacturing plant consist of following seven units:

(1) ***Unit A (Separator)*****:** In this unit, the fat from chilled milk (chilled by using chiller) is separated in form of cream & remaining skimmed milk is stored in milk silos.

(2) ***Unit B (Pasteuriser)*****:** In this unit, separated cream is pasteurised. When the pasteurised milk goes out of this unit some particles in form of sludge stuck around the outlet, which block the flow of milk resulting in failure of unit.

(3) ***Unit C (Continuous Butter Making)*****:** Cream is pumped into the CBM to form homogenous butter in this unit. The buttermilk produced in this process pumped back to the milk silos.

(4) ***Unit $\overline{C}$ (Continuous Butter Making)*****:** In this unit, unit C is working in standby state.

(5) ***Unit D (Melting Vats)*:** In this unit, butter is melted to evaporate water at 107 degree.

(6) ***Unit E (Butter-Oil Clarifier)*:** In this unit, butter oil is allowed to settle down few hours to remove fine particle of butter oil residue.

(7) ***Unit F (Packaging)*:** Packets filling machine produce the packets of butter oil in this unit.

III. NOTATIONS AND ASSUMPTIONS

Notations:

- **a, b, c, d, e, f:** Represent the failed state of the sub-systems A, B, C, D, E and F respectively.
- $\bar{B}$:Represents that sub-system B is working in reduced state.
- **αi (i=1,2, ...7):** represents the constant failure rates of sub-systems A, C, D, E, F, $\bar{B}$ and B.
- **βi;(i=1,2 ...6):** represents, respectively, the constant repair rates of sub-systems A, C, D, E, F and $\bar{B}$.
- **P_j(t) (j=1, 2, 3, ..., 13):** Represents the probability that the system is in jth state at time t.
- **P_j'(t):** Represents derivative of P_j(t) with respect to t.

Assumptions:

- Repair and failure rates are independent of each other.
- There are no simultaneous failures among the sub-systems.
- Sub-system B fails through reduced state only.
- Repaired unit is as good as new one.
- System is failed when either of unit is completely failed.

IV. FLOW DIAGRAM OF THE SYSTEM

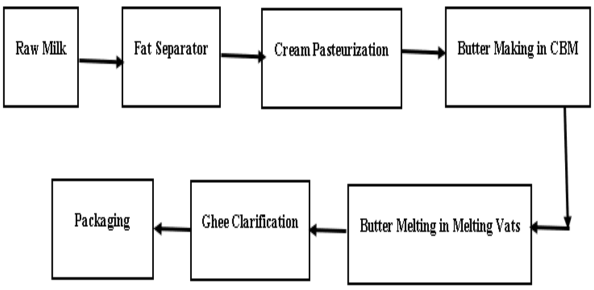

Fig.-1

V. MATHEMATICAL FORMULATION OF THE SYSTEM

The mathematical modelling of the system is carried out with the help of Fig.-1, to determine the reliability of butter oil processing plant and following chapman Kolmogorov differential equations are developed on basis of Markov birth-death process are given as:

$P_1'(t)=-H_1P_1(t)+b_6P_{13}(t)+b_2P_4(t)+b_3P_5(t)+b_5P_7(t)+b_4P_6(t)+b_1P_3(t)$ ………………..... (1)

$P_2'(t)=-H_2P_2(t)+b_1P_8(t)+b_2P_9(t)+b_3P_{10}(t)+b_4P_{11}(t)+b_5P_{12}(t)+a_6P_1(t)$ …………………. (2)

Where, $H_1=(a_1+a_2+a_3+a_4+a_5+a_6)$

$H_2=(a_1+a_2+a_3+a_4+a_5+a_7)$

Similarly, we get

$P'_{i+2}(t)+\beta_iP_{i+2}(t)=\alpha_iP_1(t)$, Where,i=1,2,...5 ……………….... (3)

$P'_{i+7}(t)+\beta_iP_{i+7}(t)=\alpha_iP_2(t)$, Where,i=1,2,...5 …………………. (4)

$P'_{13}(t)+\beta_6P_{13}(t)=\alpha_7P_2(t)$ ………………….(5)

With initial conditions at time t = 0

$$Pi(t)=\begin{cases}1 \text{ for } i=1\\ 0 \text{ for } i\neq 1\end{cases}$$ …………………. (6)

The system of differential equations with initial conditions are solved by using CAS Mathematica and Runge kutta method using maxima.

Values of P_0, P_1, P_2………. P_{13} given by Mathematica at point 't':

P_1[t] = 0.6419695170869428 exp (-6.011199999999998) t (-0.00010873876123088067 exp (5.011266880652618) t + 0.005829038084812744 + 0.008012134847461149 exp (5.335604731401927) t + 7.781170119844699 * 10 $^{-30}$ + 0.014304666420200689 exp (5.592596086255493) t + 0.022027008786365106 + 0.0018681727716482193 exp (5.608411654317564) t + 0.0031061226353421983 + 0.0012367208892571 94 exp (5.680388295668373) t + 0.0019847779852556558 + 0.49944645681994554 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

P_2[t] = 0.3180930039620148 exp (-6.011199999999998) t (0.000001267031886509244 exp (5.011266880652618) t – 0.005773745186247931 exp (5.335353928254821) t 0.00529338488758683 exp (5.335604731401927) t - 1.180070616429496 * 10 $^{-29}$ exp (5.341199999999998) t – 0.0202970674193962 exp (5.592596086255493) t + 0.018220922125274613 exp (5.593097971588801) t – 00.002696165111056674 exp (5.608411654317564) t + 0.0025941534661828255 exp (5.64084789955229875) t – 0.0019190350539238276 exp (5.680388295668373) t + 0.0017275040717069402 exp (5.680430024268092) t - 0.9971512179394846 exp (5.995171432069307) t + 1. exp (6.011199999999998) t,

$P_3[t]$ = (935 exp (5.680430024268092) t + 0.5197662333550848 exp (5.995171432069307) t + 1. exp (6.011199999999998) t)0.009394675859809094 exp (−6.011199999999998t) t (0.00007557279061392627 exp (5.011266880652618) t – 0.008989809776328033 exp (5.335353928254821) t -0.01236835017731519 exp (5.335604731401927) t -1.456814338237868 * 10^{-29} exp (5.341199999999998) t -0.6816564422241125 exp (5.592596086255493) t) -1.1146682218404302 exp (5.593097971588801) t + 0.1062101430056183 exp (5.608411654317564) t + 0.1749568709677201 exp (5.6084789955229875) t +0.006403162996699549 exp (5.680388295668373) t +0.01027084090244,

$P_4[t]$ = 0.008024618963586812 exp (-6.011199999999998) t (0.00007250058896509521 exp (5.011266880652618) t - 0.008452595388340315 exp (5.335353928254821) t - 0.01162884237921518 exp (5.335604731401927) t + 3.368900245713027 * 10^{-30} exp (5.341199999999998) t - 0.30756251865392714 exp (5.592596086255493) t) - 0.48673017821009745 exp (5.593097971588801) t - 0.2679972979558911 exp (5.608411654317564) t - 0.4566141160862603 exp (5.6084789955229875) t +0.007149884975834088 exp (5.680388295668373) t +0.011467729536361942 exp (5.680430024268092) t + 0.5202954335725708 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_5[t]$ = 0.002587041337514591 exp (-6.011199999999998) t (0.00022081738919935913 exp (5.011266880652618) t -0.6680478254558675 exp (5.335353928254821) t -0.9594052999794643 exp (5.335604731401927) t -5.217359777035152 * 10^{-14} exp (5.341199999999998) t + 0.03812361061100181 exp (5.592596086255493) t + 0.058587593198070845 exp (5.593097971588801) t + 0.004684210949559735 exp (5.608411654317564) t +0.0077862540661196595 exp (5.6084789955229875) t + 0.0024428997296901023 exp (5.680388295668373) t + 0.0039200576452230185 exp (5.680430024268092) t + 0.5116876818465194 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_6[t]$ = 0.0017508259556916475 exp (-6.011199999999998) t (0.000053563244105841953 exp (5.011266880652618) t – 0.005561961592570733 exp (5.335353928254821) t – 0.007650580722322234 exp (5.335604731401927) t – 2.964941443749204 * 10^{-29} exp (5.341199999999998) t – 0.053276878178071245 exp (5.592596086255493) t – 0.08250562479191517 exp (5.593097971588801) t -0.008469721476204515 exp (5.608411654317564) t – 0.01409524630517287 exp (5.6084789955229875) t -0.5027913213641085 exp (5.680388295668373) t – 0.8506459463498574 exp (5.680430024268092) t + 0.5249437175361165 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_7[t]$ = 0.0025870413375145484 exp (-6.011199999999998) t (0.00022081738919936132 exp (5.011266880652618) t – 0.6680478254558782 exp (5.335353928254821) t – 0.9594052999794804 exp (5.335604731401927) t + 5.217359777035065 * 10^{-14} exp (5.341199999999998) t + 0.03812361061100203 exp (5.592596086255493) t + 0.058587593198075924 exp (5.593097971588801) t +0.004684210949559612 exp (5.608411654317564) t + 0.007786254066119939 exp (5.6084789955229875) t + 0.0024428997296901704 exp (5.680388295668373) t – 0.003920057645222786 exp (5.680430024268092) t + 0.5116876818464366 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_8[t]$ = 0.004655019570175862 exp (-6.011199999999998) t (-8.805796054369779 * 10^{-7} exp (5.011266880652618) t + 0.008904534533166697 exp (5.335353928254821) t – 0.008171409887557065 exp (5.335604731401927) t + 4.037929713205988 * 10^{-29} exp (5.341199999999998) t + 0.9672107239879959 exp (5.592596086255493) t - 0.9220626409186428 exp (5.593097971588801) t - 0.15328351122441483 exp (5.608411654317564) t + 0.14611946356825412 exp (5.6084789955229875) t - 0.009935866979682916 exp (5.680388295668373) t + 0.008939498327088938 exp (5.680430024268092) t – 1.037719910826603 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_9[t]$ = 0.003976162549525261 exp (-6.011199999999998) t (-8.447820903019958 * 10^{-7} exp (5.011266880652618) t + 0.008372416035826929 exp (5.335353928254821) t – 0.007682838554541941 exp (5.335604731401927) t - 4.618301847458813 * 10^{-29} exp (5.341199999999998) t + 0.4364042469373774 exp (5.592596086255493) t - 0.4026271716925535 exp (5.593097971588801) t +0.3867763065450604 exp (5.608411654317564) t – 0.3813523260399902 exp (5.6084789955229875) t - 0.011094564682569422 exp (5.680388295668373) t + 0.00998124204040212 exp (5.680430024268092) t – 1.0387764658069212 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_{10}[t]$ = 0.0012818673293992896 exp (-6.011199999999998) t (--0.000002572980141099256 exp (5.011266880652618) t + 0.6617108792715553 exp (5.335353928254821) t – 0.6338512285012731 exp (5.335604731401927) t - 6.655070831674069 * 10^{-14} exp (5.341199999999998) t - 0.05409406078491351 exp (5.592596086255493) t + 0.04846413475399856 exp (5.593097971588801) t -0.0067602987939327595 exp (5.608411654317564) t + 0.006502878458298527 exp (5.6084789955229875) t - 0.0037906776340711212 exp (5.680388295668373) t + 0.003411925965400408 exp (5.680430024268092) t – 1.021590979754854 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_{11}[t]$ = 0.0008675263744419387 exp (-5.341199999999998) t (-6.241227825143336 * 10^{-7} exp (4.3412668806526185) t + 0.00550920211944931 exp (4.66535392825482) t – 0.005054516573648309 exp (4.665604731401926) t + 4.680698417532325 * 10^{-29} exp (4.671199999999997) t + 0.07559521882650061 exp (4.922596086255492) t - 0.06824932549046274 exp (4.9230979715888) t +0.01222358439811809 exp

(4.938411654317563) t - 0.011771985961922353 exp (5.6084789955229875) t + 0.7801874933037223 exp (5.010388295668372) t - 0.7403822225030903 exp (5.010430024268091) t – 1.048056823995884 exp (5.325171432069306) t + 1. exp (5.341199999999998) t),

$P_{12}[t]$ = 0.0012818673293991762 exp (-6.011199999999998) t (-0.000002572980141045838 exp (5.011266880652618) t + 0.66171087927163 exp (5.335353928254821) t – 0.6338512285013291 exp (5.335604731401927) t + 6.655070831674937 * 10^{-14} exp (5.341199999999998) t - 0.054094060784917304 exp (5.592596086255493) t + 0.048464134754002845 exp (5.593097971588801) t -0.006760298793933183 exp (5.608411654317564) t + 0.006502878458298912 exp (5.6084789955229875) t - 0.003790677634071463 exp (5.680388295668373) t + 0.003411925965399894 exp (5.680430024268092) t – 1.021590979755006 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

$P_{13}[t]$ = 0.003530832343978448 exp (-6.011199999999998) t (0.018944669899202148 exp (5.011266880652618) t - 0.01781173906277327 exp (5.335353928254821) t + 0.016317224673977886 exp (5.335604731401927) t - 5.200790368759902 * 10^{-29} exp (5.341199999999998) t - 0.03491091168177615 exp (5.592596086255493) t + 0.03131291419180629 exp (5.593097971588801) t -0.004514588909249599 exp (5.608411654317564) t + 0.004343285944470949 exp (5.6084789955229875) t - 0.002867705646296635 exp (5.680388295668373) t + 0.002581330796681178 exp (5.680430024268092) t – 1.013394480206043 exp (5.995171432069307) t + 1. exp (6.011199999999998) t),

The reliability of the system can be computed by

$$R(t) = P_1(t) + P_2(t) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

VI. COMPARATIVE ANALYSIS OF THE PERFORMANCE OF SYSTEM BY VICTIMIZATION CAS MAXIMA & MATHEMATICA

The reliability of system is calculated by using equation (7) for various values of failure and repair rates and given in tables as:

1.Effect of failure rate of Separator (α_1) on reliability of the system:

In Table-1, The reliability of the system is calculated by varying their values as a_1=0.006,.007,.008,.009,.010 and all other values a_2=0.0050, a_3=0.0027, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_1=0.41, b_2=0.40, b_3=0.67, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table1: Effect of failure rate of separator (α_1) on reliability of the system.

t \ a1	0.006	0.007	0.008	0.009	0.01
30	0.957253	0.954211	0.951188	0.948184	0.945199
60	0.956449	0.953413	0.950396	0.947398	0.944419
90	0.955953	0.95292	0.949906	0.946911	0.943935
120	0.955645	0.952613	0.949601	0.946607	0.943632
150	0.955454	0.952423	0.949411	0.946418	0.943444
180	0.955335	0.952304	0.949293	0.9463	0.943326
210	0.955262	0.952231	0.949219	0.946227	0.943253
240	0.955216	0.952185	0.949174	0.946181	0.943207
270	0.955188	0.952157	0.949145	0.946152	0.943178
300	0.955171	0.95214	0.949128	0.946135	0.943161
330	0.95516	0.952129	0.949117	0.946124	0.94315
360	0.955153	0.952122	0.94911	0.946117	0.943143

t \ a1	0.006	0.007	0.008	0.009	0.01
30	0.962191	0.95994	0.9577	0.95547	0.95325
60	0.961378	0.959132	0.956896	0.954671	0.952456
90	0.960876	0.958632	0.956398	0.954175	0.951962
120	0.960565	0.958323	0.95609	0.953868	0.951656
150	0.960373	0.958131	0.955899	0.953677	0.951466
180	0.960255	0.958012	0.95578	0.953559	0.951347
210	0.960181	0.957939	0.955707	0.953485	0.951274
240	0.960136	0.957893	0.955661	0.95344	0.951228
270	0.960108	0.957865	0.955633	0.953411	0.9512
300	0.960091	0.957848	0.955616	0.953394	0.951182
330	0.96008	0.957837	0.955605	0.953383	0.951171
360	0.960073	0.957831	0.955598	0.953376	0.951165

2. Effect of failure rate of CBM (α_2) on reliability of the system:

In Table-2, The reliability of the system is calculated by varying their values as a_2=0.0050,.0055,.0060,.0065,.0070 and other values a_1=0.006, a_3=0.0027, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_1=0.41, b_2=0.40, b_3=0.67, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table2: Effect of failure rate of CBM (α_2) on reliability of the system.

t \ a2	0.0050	0.0052	0.0054	0.0056	0.0058
30	0.957253	0.95611	0.954969	0.953832	0.952697
60	0.956449	0.955309	0.954171	0.953035	0.951903
90	0.955953	0.954813	0.953676	0.952542	0.95141
120	0.955645	0.954505	0.953369	0.952235	0.951104
150	0.955454	0.954315	0.953179	0.952045	0.950914
180	0.955335	0.954196	0.95306	0.951927	0.950796
210	0.955262	0.954123	0.952987	0.951853	0.950723
240	0.955216	0.954077	0.952941	0.951808	0.950677
270	0.955188	0.954049	0.952913	0.95178	0.950649
300	0.955171	0.954032	0.952895	0.951762	0.950631
330	0.95516	0.954021	0.952885	0.951751	0.95062
360	0.955153	0.954014	0.952878	0.951744	0.950613

t \ a2	0.005	0.0052	0.0054	0.0056	0.0058
30	0.962191	0.961729	0.961267	0.960806	0.960345
60	0.961378	0.960917	0.960456	0.959996	0.959536
90	0.960876	0.960415	0.959955	0.959495	0.959035
120	0.960565	0.960105	0.959645	0.959185	0.958725
150	0.960373	0.959912	0.959453	0.958993	0.958534
180	0.960255	0.959794	0.959334	0.958874	0.958415
210	0.960181	0.959721	0.959261	0.958801	0.958342
240	0.960136	0.959675	0.959215	0.958756	0.958296
270	0.960108	0.959647	0.959187	0.958727	0.958268
300	0.960091	0.95963	0.95917	0.95871	0.958251
330	0.96008	0.959619	0.959159	0.958699	0.95824
360	0.960073	0.959613	0.959152	0.958692	0.958233

3. Effect of failure rate of Melting vats (α_3) on reliability of the system:

In Table-3, The reliability of the system is calculated by varying their values as a_3=0.0022,.0024,.0026,.0028,.0030 and all other values a_1=0.006, a_2=0.0050, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_1=0.41, b_2=0.40, b_3=0.67, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table3: Effect of failure rate of Melting vats (α_3) on reliability of the system

t \ a3	0.0022	0.0024	0.0026	0.0028	0.0030
30	0.962882	0.962605	0.962329	0.962053	0.961777
60	0.962068	0.961792	0.961516	0.961241	0.960965
90	0.961565	0.961289	0.961014	0.960738	0.960463
120	0.961254	0.960978	0.960703	0.960428	0.960153
150	0.961062	0.960786	0.960511	0.960236	0.959961
180	0.960943	0.960668	0.960392	0.960117	0.959842
210	0.96087	0.960594	0.960319	0.960044	0.959769
240	0.960824	0.960549	0.960274	0.959998	0.959724
270	0.960796	0.960521	0.960246	0.95997	0.959695
300	0.960779	0.960503	0.960228	0.959953	0.959678
330	0.960768	0.960493	0.960217	0.959942	0.959667
360	0.960762	0.960486	0.960211	0.959936	0.959661

t \ a3	0.0022	0.0024	0.0026	0.0028	0.003
30	0.962882	0.962605	0.962329	0.962053	0.961777
60	0.962068	0.961792	0.961516	0.961241	0.960965
90	0.961565	0.961289	0.961014	0.960738	0.960463
120	0.961254	0.960978	0.960703	0.960428	0.960153
150	0.961062	0.960786	0.960511	0.960236	0.959961
180	0.960943	0.960667	0.960392	0.960117	0.959842
210	0.96087	0.960594	0.960319	0.960044	0.959769
240	0.960824	0.960549	0.960273	0.959998	0.959723
270	0.960796	0.960521	0.960245	0.95997	0.959695
300	0.960779	0.960503	0.960228	0.959953	0.959678
330	0.960768	0.960493	0.960217	0.959942	0.959667
360	0.960761	0.960486	0.960211	0.959936	0.959661

Retrieval Number: F9161038620/2020©BEIESP
DOI: 10.35940/ijrte.F9161.038620
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

4. Effect of repair rate of Separator (β_1) on reliability of the system:

In Table-4, The reliability of the system is calculated by varying their values as b_1=0.30,0.35,0.40,0.45,0.50 and all other values a_1=0.006, a_2=0.0050, a_3=0.0027, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_2=0.40, b_3=0.67, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table4: Effect of repair rate of separator (β_1) on reliability of the system.

t \ b1	0.30	0.35	0.40	0.45	0.50
30	0.957253	0.959876	0.961853	0.963396	0.964634
60	0.956449	0.959068	0.961041	0.962581	0.963817
90	0.955953	0.958568	0.960539	0.962077	0.963312
120	0.955645	0.958259	0.960228	0.961766	0.963
150	0.955454	0.958067	0.960036	0.961574	0.962807
180	0.955335	0.957948	0.959918	0.961455	0.962688
210	0.955262	0.957875	0.959844	0.961382	0.962615
240	0.955216	0.95783	0.959799	0.961336	0.96257
270	0.955188	0.957801	0.959771	0.961308	0.962542
300	0.955171	0.957784	0.959754	0.961291	0.962525
330	0.95516	0.957773	0.959743	0.96128	0.962514
360	0.955153	0.957767	0.959736	0.961274	0.962507

t \ b1	0.3	0.35	0.4	0.45	0.5
30	0.957253	0.959876	0.961853	0.963396	0.964634
60	0.956449	0.959068	0.961041	0.962581	0.963817
90	0.955953	0.958568	0.960539	0.962077	0.963312
120	0.955645	0.958259	0.960228	0.961766	0.963
150	0.955453	0.958067	0.960036	0.961574	0.962807
180	0.955335	0.957948	0.959918	0.961455	0.962688
210	0.955262	0.957875	0.959844	0.961382	0.962615
240	0.955216	0.957829	0.959799	0.961336	0.96257
270	0.955188	0.957801	0.959771	0.961308	0.962542
300	0.95517	0.957784	0.959753	0.961291	0.962524
330	0.95516	0.957773	0.959743	0.96128	0.962514
360	0.955153	0.957766	0.959736	0.961274	0.962507

5. Effect of repair rate of CBM (β_2) on reliability of the system:

In Table-5, The reliability of the system is calculated by varying their values as b_2=0.30,0.35,0.40,0.45,0.50 and all other values a_1=0.006, a_2=0.0050, a_3=0.0027, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_1=0.41, b_3=0.67, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table5: Effect of repair rate of CBM (β_2) on reliability of the system.

t \ b2	0.3	0.35	0.4	0.45	0.5
30	0.957921	0.960427	0.962351	0.963877	0.965119
60	0.957116	0.959618	0.961538	0.96306	0.9643
90	0.956619	0.959118	0.961035	0.962556	0.963794
120	0.95631	0.958808	0.960725	0.962245	0.963482
150	0.956119	0.958617	0.960533	0.962052	0.96329
180	0.956001	0.958498	0.960414	0.961934	0.963171
210	0.955927	0.958425	0.96034	0.96186	0.963098
240	0.955882	0.958379	0.960295	0.961815	0.963052
270	0.955853	0.958351	0.960267	0.961787	0.963024
300	0.955836	0.958333	0.96025	0.96177	0.963007
330	0.955825	0.958323	0.960239	0.961759	0.962996
360	0.955818	0.958316	0.960232	0.961752	0.96299

t \ b2	0.3	0.35	0.4	0.45
30	0.957921	0.960427	0.962351	0.963877
60	0.957116	0.959618	0.961538	0.96306
90	0.956619	0.959118	0.961035	0.962556
120	0.95631	0.958808	0.960725	0.962245
150	0.956119	0.958617	0.960533	0.962052
180	0.956001	0.958498	0.960414	0.961934
210	0.955927	0.958425	0.96034	0.96186
240	0.955882	0.958379	0.960295	0.961815
270	0.955853	0.958351	0.960267	0.961787
300	0.955836	0.958333	0.96025	0.96177
330	0.955825	0.958323	0.960239	0.961759
360	0.955818	0.958316	0.960232	0.961752

6. Effect of repair rate of Melting vats (β_3) on reliability of the system:

In Table-6, The reliability of the system is calculated by varying their values as b_3=0.60,0.65,0.70,0.75,0.80 and all other values a_1=0.006, a_2=0.0050, a_3=0.0027, a_4=0.0009, a_5=0.0027, a_6=0.0055, a_7=0.0111; b_1=0.41, b_2=0.40, b_4=0.33, b_5=0.67, b_6=1.0 are kept fixed.

Table6: Effect of repair rate of Melting vats (β_3) on reliability of the system.

t \ b3	0.6	0.65	0.7	0.75	0.8
30	0.961756	0.962076	0.962351	0.962589	0.962797
60	0.960945	0.961264	0.961538	0.961775	0.961983
90	0.960443	0.960762	0.961035	0.961273	0.96148
120	0.960132	0.960451	0.960725	0.960962	0.96117
150	0.95994	0.960259	0.960533	0.96077	0.960977
180	0.959822	0.960141	0.960414	0.960651	0.960859
210	0.959748	0.960067	0.960341	0.960578	0.960785
240	0.959703	0.960022	0.960295	0.960532	0.96074
270	0.959675	0.959994	0.960267	0.960504	0.960712
300	0.959657	0.959976	0.96025	0.960487	0.960695
330	0.959647	0.959966	0.960239	0.960476	0.960684
360	0.95964	0.959959	0.960232	0.96047	0.960677

t \ b3	0.6	0.65	0.7	0.75	0.8
30	0.961756	0.962076	0.962351	0.962589	0.962797
60	0.960945	0.961264	0.961538	0.961775	0.961983
90	0.960443	0.960762	0.961035	0.961273	0.96148
120	0.960132	0.960451	0.960725	0.960962	0.96117
150	0.95994	0.960259	0.960533	0.96077	0.960977
180	0.959822	0.96014	0.960414	0.960651	0.960859
210	0.959748	0.960067	0.96034	0.960578	0.960785
240	0.959703	0.960022	0.960295	0.960532	0.96074
270	0.959675	0.959994	0.960267	0.960504	0.960712
300	0.959657	0.959976	0.96025	0.960487	0.960694
330	0.959647	0.959966	0.960239	0.960476	0.960684
360	0.95964	0.959959	0.960232	0.96047	0.960677

VII. GRAPHICAL STUDY

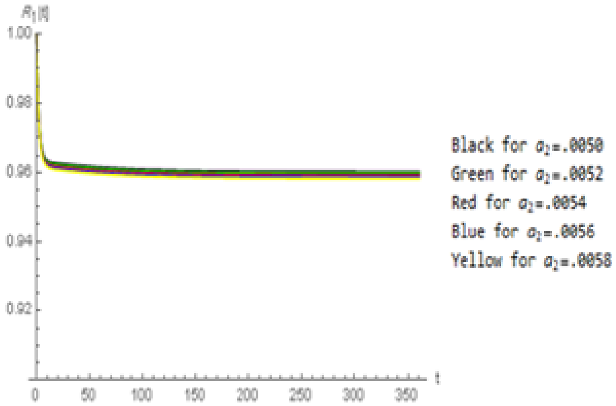

Fig.-2

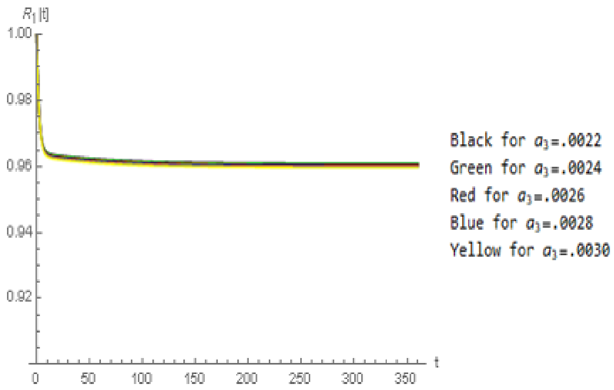

Fig.-3

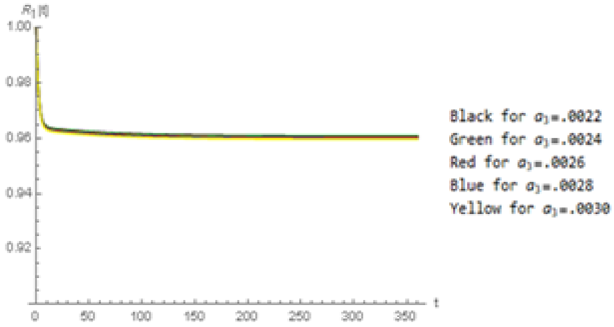

Fig.-4

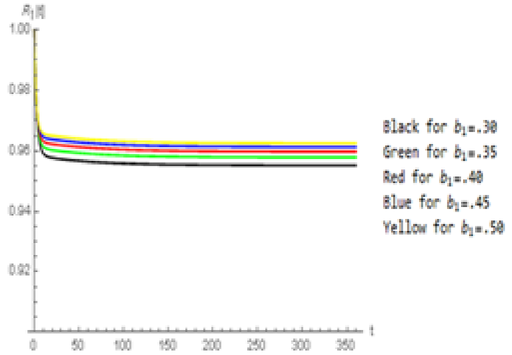

Fig.-5

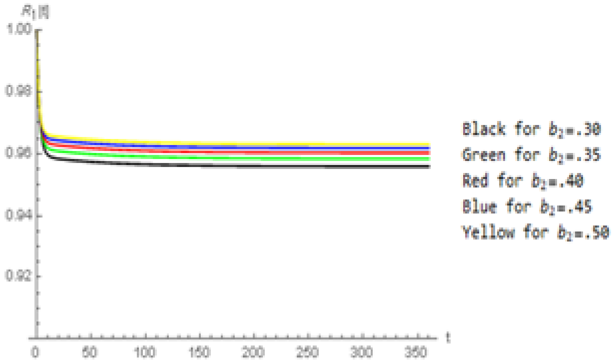

Fig.-6

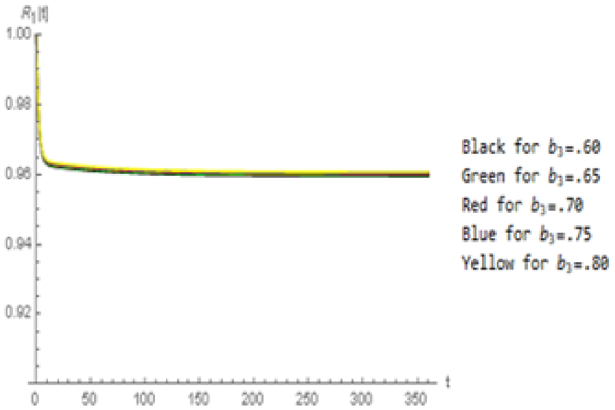

Fig.-7

VIII. DISCUSSION AND CONCLUSION

Analysis of reliability of butter-oil manufacturing plant can help in increasing the production of the butter-oil. The tables and graphs show the variation of reliability with change in failure rates (α_i) and repair rates (β_i) of separator, pasteuriser, continuous butter making, melting vats, butter oil clarifier and packaging.we observed that reliability of the system decrease with increase in failure rate and with passage of time it approches the steady state. Graphical study respective to their tables such as graph-2 represent table-1, graph-3 represents table-2 and so on clears the variation with different values of failure rate on reliability of system. We analysed from the tables that reliability of the system decrease with increase in failure rate but increase with increase in repair rate, also with passage of time reliability is decreased slightly and after that it reaches steady state.In comparative study, Mathematica is method of better accuracy than Maxima. Values given by Mathematica are exact than approximates values given by Maxima. Also, Mathematica gives individual values of P_1, P_2………P_{13} at point t which is not possible in Maxima.In Mathematica, P1, P2 …., P13 are continuous functions of time so R(T) is also continuous function of time not discrete. Mathematica gives exact values closer to the solution rather than approximates values given by Maxima. This software not only gives accuracy in results but also save computation time. such results might be useful for optimization in performance of butter-oil processing plant.

REFERENCES:

1. Jai Singh, Arvind Kumar Lal, Rajendra Kumar Sharma and Pawan Kumar Gupta (2005), "Numerical analysis of reliability and availability of the serial processes in butter-oil processing plant", Article in International Journal of Quality & Reliability Management
2. Tarun Garg (2015), "Application of CAS Maxima to the Availability Analysis of Screening Unit in a paper plant".
3. Practical Mathematics Using Maxima, G. S. Tuteja, International Book House Pvt. Ltd., Delhi.
4. Dayal, B. and Singh, J. (1992), "Reliability analysis of a system in a fluctuating environment", Microelectron Reliability, Vol. 32, pp. 601-3.
5. Dhillon, B.S. and Natesan, J. (1983), "Stochastic analysis of outdoor power system in fluctuating environment", Microelectron Reliability, Vol. 23, pp. 867-81.
6. Goel, P. and Singh, J. (1995b), "Reliability analysis of a standby complex system having imperfect switch-over device", Microelectron Reliability, Vol. 35, pp. 285-8.
7. Kumar, D., Singh, J. and Singh, I.P. (1988a), "Reliability analysis of the feeding system in paper industry", Microelectron Reliability, Vol. 28, pp. 213-15.
8. Kumar, D., Singh, J. and Singh, I.P. (1988b), "Availability of the feeding system in the sugar industry", Microelectron Reliability, Vol. 28, pp. 867-71.
9. Mahajan, P. and Singh, J. (1999), "Reliability of utensils manufacturing plant – a case study", Operation research, Vol. 36, pp. 260-71.
10. Singh, J. (1984), "Reliability of a fertilizer production supply problem", Proceedings of ISPTA, Wiley Eastern Ltd, New Delhi, pp. 95-8. Singh, J. (1989a), "A warm stand-by redundant system with common cause failures", Reliability Engineering and System Safety, Vol. 26, pp. 135-41.
11. Singh, J. (1989b), "Reliability analysis of a biogas plant having two dissimilar units", Microelectron Reliability, Vol. 29, pp. 779-81.

12. Olga Burukhina1, Anna Bushinskaya, Irina Maltceva1 and Svyatoslav Timashev (2018), "Mechanical system reliability analysis using reliability matrix method", : Materials Science and Engineering.
13. Khanduja, R., Tewari,P.C., and Chauhan, R.S.(2012), "Performance Modeling and Optimization for the Stock Preparation Unit of a Paper Plant using Genetic Algorithm", International Journal of Quality and reliability Management, Vol. 28, No. 6, pp. 688-703.
14. Kumar, S. and Tewari, P.C.(2011), "Mathematical Modeling and Performance Optimization of CO2 Cooling System of a Fertilizer Plant " , International Journal of Industrial Engineering Computations , vol. 2, pp. 689-695.

AUTHOR PROFILE

I am **Shalini Jindal** Research Scholar in Department of mathematics , currently pursuing PhD in mathematics in J. C. Bose University of Science and Technology , YMCA Faridabad. E mail: shalinijindal91@gmail.com

Dr. Reena Garg, M.Sc Mathematics (GOLD MEDALIST) M.Phil, Ph.D is an Assistant Professor (Sr Scale) Mathematics in J.C. BOSE UNIVERSITY OF SCIENCE And TECHNOLOGY, YMCA FARIDABAD , HARYANA(NAAC "A' GRADE STATE UNIVERSITY). Three Ph.D scholars are pursuing Ph.D under her kind supervision. She is working in University for the last twelve years. Her teaching experience of more than a decade in the University has made this book more valuable for the knowledge seekers. She has published / presented more than 80 research papers in various International Journals / International conferences / national conferences.

Dr. Tarun Kumar Garg tkgarg@satyawati.du.ac.in has been working as an associate professor since last 20 years in the department of Mathematics, Satyawati College, University of Delhi, Delhi. His field of research is Wavelet Analysis, Reliability and availability of Mechanical systems and Optimization. He has published many research papers in international journals.