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RESEARCH ARTICLE

Performance Analysis of Feeding System in Sugar Mill with Consideration of Bagasse Jamming

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Abstract

Objectives: The sugar industry comprises various units, including feeding, crushing, evaporation, refining, and crystallization. The feeding system is the most crucial aspect of the sugar mill as the sugar-making process starts from here. So faults which occur here are divided into four categories minor, major, cease faults and walkout faults. This paper sets out to showcase a comprehensive analysis of the system's performance, availability, and profit. The study takes into account how minor, major, and cease faults can potentially impact the system's overall effectiveness. The findings of this research hold significant importance for sugar mills that prioritize optimal performance and profit. **Methods:** Primary data regarding various failures is collected from Ch. Devilal Co-Operative Sugar Mills Limited, Ahulana, Gohana. To find MTSF, Reliability, Availability, Profit etc., a mathematical model has been created. This model is based on the Semi-Markov process and Regenerative Point Technique and equations are drawn using exponential distribution and solved with Cremer's rule and Laplace - Stieltjes transformation. **Findings:** A fault, Bagasse Jamming is considered a cease fault which occurs very frequently in the feeding system. Therefore, it is found that cease faults and major faults have more adverse impacts on the system's performance and availability than minor faults. MTSF, Availability and Profit are inversely proportional to these faults. When a major fault is 0.0035 and the cease fault is 0.0042, MTSF is nearly 100. So, to gain more profit we have to pay more attention to these faults. **Novelty:** The paper's results will aid in fault removal, increase availability, and optimize maintenance tactics in the sugar industry.

Keywords: MTSF; Performance Analysis; Availability; Reliability; Minor; Major; Cease Faults

1 Introduction

As technology evolves, technical hitches rise swiftly in industries. So, to keep development secure, the reliability of the industrial systems is essential. The task of any industry's management is to maximize their system's reliability. Several researchers have undertaken extensive efforts to enhance the performance metrics of industrial systems. The reliability theory is very important in industrial systems and that's why extensively studied. Sugar production in India has been a significant contributor to rural development in the country, with an inherent association between the two. The relationship between the sugar industry in India and rural development in India is an associated one, where the growth and development of one have positively held the other. The sugar industry of India has served as a vital source of income and employment for many rural communities. The sugar industry is also tangled in the making of other chemicals and generates 3.2 billion litres of alcohol and 4700 MW of power, with the potential to export around 3500 MW of power to the national grid. In this way, this industry plays a vital player in India's economy and rural development. A sugar mill is a blend of many subsystems. Here, the feeding system of a sugar mill is studied which plays a significant role in a sugar mill.

Many researchers have tried to improve the performance of various industries as well as sugar mills. Aman E, Mahna V K and Khanduja R[(1)] analysed the availability of the feeding system using the Markov birth-death process. Kumar A and Ram M[(2)] have discussed the performance of a sugar mill and found that performance is most affected by the failure of the evaporation and crystallization process. They considered all failures except the bagasse carrying system. Sharma G and Tewari P C[(3)] analysed maintenance priorities for various subsystems of the crushing unit of a sugar mill considering repair rete. Then Saini M, Kumar A, and Sinwar D[(4)] studied subsystems of a sugar mill and gave certain important reliability measures. Rinku and Bhatia P[(5)] studied the footwear machine having a permissiveness of neglected faults. Kushwaha K, Panchal D and Sachdeva A[(6)] provided a fuzzy modelling-based integrated framework for performance analysis of the juice clarification unit of a sugar mill. Bala R, Bhatia P and Garg M[(7)] have used the application of reliability modelling in the performance analysis of dentistry systems. Ayagi H I, Wan Z, Yusuf I, Sanusi A and Musa M[(8)] studied the performance of the series-parallel system with two subsystems each using k-out-of-n using Copula characteristics. Kumari A and Bhatia P[(9)] also analysed the feeding system of a sugar mill considering only the impact of major and minor faults. Saini M, Choudhary R and Kumar A[(10)] studied availability investigation and optimization of the crystallizer unit of a sugar mill using the Markov approach and Cuckoo Search Algorithm. Balaso F B and Jagtap H[(11)] analysed power generation in a sugar factory by steam turbine and gave reasons for steam turbine failure. They also provide tactics to enhance the availability of steam turbines in thermal power plants. Kushwaha D K, Panchal D and Sachdeva A[(12)] reviewed the analysis of power generation in a sugar mill by the steam turbine and the reasons for its failure. Kumar A, Sinwar D, Kumar N, and Saini M[(13)] studied the generator of a steam turbine power plant and investigated the availability, profit, and decision variables of the generator. Maan V S, Kumar A, Saini M, and Saini D K[(14)] developed a mathematical model for renewable energy sources like hydroelectric power plant (HPP) using Adaptive Neuro Fuzzy Inference System (ANFIS).

It has been observed that considerable attention has been given to both the sugar mill and its feeding system. But there is still a gap. Aman E, Mahna V K and Khanduja R[(1)] have provided the results related to availability considering only the repair rate. Also, they didn't categorise faults as minor, major etc. Results given by Kumar A and Ram M[(2)] are drawn by considering all failures except the bagasse carrying system. Sharma G and Tewari P C[(3)] analysed maintenance priorities decided for various subsystems of the crushing unit only which is a part of the feeding system. The study conducted by Saini M, Kumar A, and Sinwar D[(4)] analyzed six months of data from the entire system. Kumari A and Bhatia P[(9)] derived the results for the feeding system considering only minor and major faults. Other researchers such as[(6,10–12)] have worked with sugar mills but their work is not related to the feeding system.

The above analysis clearly defines the gap in the study of the feeding system which has great importance as all other subsystems of the sugar mill depend on it. The feeding system is a series configuration comprising a cane unloader, cane feeding table, cane kicker and cutter, fibrizer, cane leveller and chopper, cane carrier, mill roller, bagasse carrier, and RCB chain. Primary data regarding various failures has been collected for two years by visiting the mill premises Ch. Devilal Co-Operative Sugar Mills Limited, Ahulana, Gohana now and then. Then faults are categorised into various types of major, minor faults, and cease faults (bagasse jamming) that occur very frequently in the feeding system besides walkouts. For a minor fault and a cease fault, the system is degraded but not stopped. But at the occurrence of a major system is completely stopped which reduces the performance of the system. Repair rates as well as replacement rates are also considered for MTSF, availability and profit analysis which provided more realistic results. This paper sets out to showcase a comprehensive analysis of the system's performance, availability, and profit. The study takes into account how minor, major, and cease faults can potentially impact the system's overall effectiveness.

The findings presented in this paper are expected to provide valuable insights for decision-making related to the elimination of faults in the system, thereby enhancing the system's availability and enabling the implementation of the most effective maintenance strategies in the sugar industry. This research is likely to have a significant impact on the industry by contributing to the development of efficient and sustainable maintenance practices that can optimize the system's performance while minimizing downtime and associated costs.

2 Methodology

Primary data regarding various failures is collected from Ch. Devilal Co-Operative Sugar Mills Limited, Ahulana, Gohana. Maximizing performance is crucial for any organization. To achieve this, it's important to have accurate measures of key metrics such as MTSF, Reliability, Availability, Busy Period, etc. A mathematical model has been developed to help with this analysis, providing reliable and precise results that can inform decision-making and drive organizational success.

This paper describes a model that employs the Semi-Markov process and Regenerative Point Technique. These mathematical techniques are used to help understand complex systems that involve random events and transitions. The equations in the model are solved using a combination of Cremer's rule, Laplace transformation, and Laplace-Stieltjes transformation. These methods are commonly used in mathematical analysis to help solve equations that are difficult to solve with more traditional mathematical tools.

2.1 Assumptions

Assumptions for the models used in this chapter are as follows:

- The system is a complex configuration of various subsystems arranged in a series.
- The system will be new after every repair and replacement.
- The technician stretches to the system in minimal time.
- The exponential distribution is used for various faults such as major/minor/walkout/cease faults.
- Minor faults cause degradation/failure whereas major faults cause complete failure.
- Due to cease fault the machine stops temporarily for a few minutes.
- The walkout leads to a complete stoppage of the system.

2.2 Notations

- O: Operative unit.
- $\ddot{y}_1, \ddot{y}_2, \ddot{y}_3, \ddot{y}_4$: Rate of minor faults/major faults/walkouts/cease faults.
- a/b: Probability of minor fault to be repairable/non-repairable.
- $\dot{\alpha}/\dot{\beta}$: Probability of major fault to be repairable/non-repairable.
- $i_1(t)/I_1(t)$: p.d.f./c.d.f. of the inspection rate of a minor fault per unit time.
- $g_1(t)/G_1(t)$: p.d.f./c.d.f. of repairing rate of minor fault with per unit time.
- $h_1(t)/H_1(t)$: p.d.f./c.d.f. of replacement rate of minor fault per unit time.
- $i_2(t)/I_2(t)$: p.d.f./c.d.f. of the rate of inspection of a major fault per unit of time.
- $g_2(t)/G_2(t)$: p.d.f./c.d.f of repair rate of major faults per unit time.
- $h_2(t)/H_2(t)$: p.d.f./c.d.f. of replacement rate of major faults per unit time.
- $k_1(t)/K_1(t)$: p.d.f./c.d.f. of the rate of negotiations of walkout per unit time.
- $j_1(t)/J_1(t)$: p.d.f./c.d.f. of maintenance rate of cease faults per unit time.
- $\boxed{S}/\boxed{C}$: Laplace-Stieltjes convolution/Laplace convolution.
- $^{*}/^{**}$: Laplace transformation/Laplace - Stieltjes transformation.
- $q_{ij}(t)/Q_{ij}(t)$: p.d.f./c.d.f. of the conversion of the system from one regenerate state S_i into a new regenerate state S_j or a cut-out state S_j.
- p.d.f.: Probability distribution function.
- c.d.f.: Cumulative distribution function.

2.3 Model

Figure 1 gives the various state transition diagram of Model-I. The time of entry in the states 0, 1, 2, 3, 4, 5, 6,7 and 8 are regenerate points i.e. every state is regenerate state. 2, 3, 7, and 8 are cut-out states The epochs of entry into states 0, 1, 2, 3, 4, 5, 6, 7, 8 are regenerative points and so all states are regenerative states.

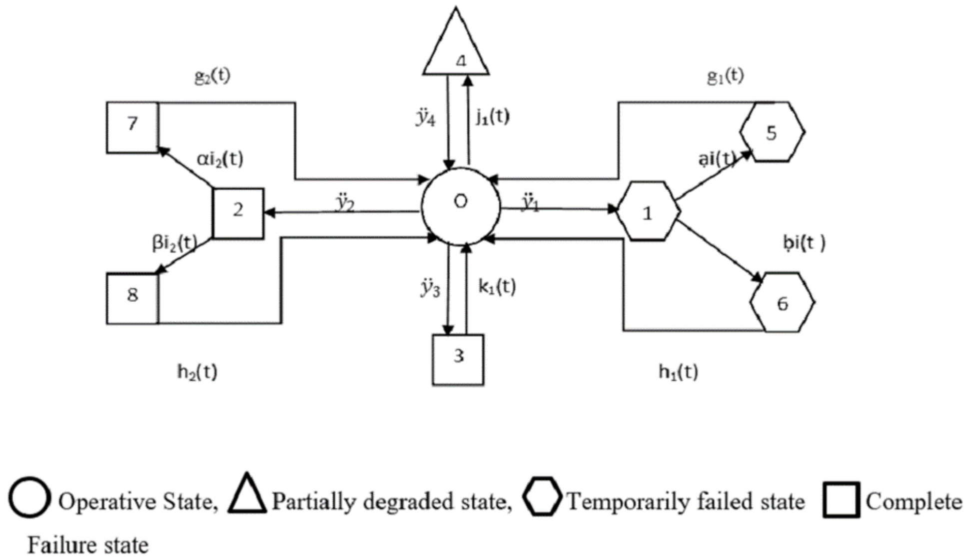

Fig 1. State Transition Diagram

2.4 Transition Probabilities

The transition probabilities dQ_{ij}(t) are given by:

$dQ_{01}(t) = \ddot{y}_1 e^{-(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)t}$
$dQ_{02}(t) = \ddot{y}_2 e^{-(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)t}$
$dQ_{03}(t) = \ddot{y}_3 e^{-(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)t}$
$dQ_{04}(t) = \ddot{y}_4 e^{-(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)t}$
$dQ_{15}(t) = ai_1(t)$
$dQd_{16}(t) = bi_1(t)$
$dQ_{27}(t) = \alpha ai_2(t)$
$dQ_{27}(t) = \beta i_2(t)$
$d_{30}(t) = k_1(t)$
$dQ_{40}(t) = j_1(t)$
$dQ_{50}(t) = g_1(t)$
$dQ_{60}(t) = h_1(t)$
$dQ_{70}(t) = g_2(t)$
$dQ_{80}(t) = h_2(t)$.

Taking L.S.T. $Q_{ij}^{**}(s)$ of Q_{ij}(t) i.e., $Q_{ij}^{**}(s) = \int_0^\infty e^{-st} dQ_{ij}(t)\,dt$ then the non-zero elements $p_{ij} = \lim_{s\to 0} Q_{ij}^{**}(s)$ are obtained as,

$p_{01} = \frac{\ddot{y}_1}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$ $\quad p_{02} = \frac{\ddot{y}_2}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$ $\quad p_{03} = \frac{\ddot{y}_3}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$
$p_{04} = \frac{\ddot{y}_4}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$ $\quad p_{15} = ai_1^*(0) = a$ $\quad p_{16} = bi_1^*(0) = b$
$p_{27} = \alpha i_2^*(0) = \alpha$ $\quad p_{28} = \beta i_2^*(0) = \beta$ $\quad p_{30} = k_1^*(0) = 1$
$p_{40} = j_1^*(0) = 1$ $\quad p_{50} = h_1^*(0) = 1$ $\quad p_{60} = g_1^*(0) = 1$
$p_{70} = g_2^*(0) = 1$ $\quad p_{80} = h_2^*(0) = 1$

Clearly,

$p_{01}+p_{02}+p_{03}+p_{04} = 1$ $\quad p15 + p16 = a + b = 1$ $\quad (b = 1 - a)$
$p_{27}+p_{28} = \alpha+\beta = 1$ $\quad (\beta = 1-\alpha)$
$P_{20} = p_{30} = p_{50} = p_{60} = p_{70} = p_{80} = 1$

2.5 Mean Sojourn Time

The mean time taken by the system to transition from a regenerative state Si to state Sj is unrestricted and is counted from the epoch of entrance.

$m_{ij} = \int_0^\infty t dQ_{ij}(t) = -Q_{ij}^{**'}(0).$

Thus, $m_{01} = \frac{\ddot{y}_1}{(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)^2}$ $m_{02} = \frac{\ddot{y}_2}{(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)^2}$ $m_{03} = \frac{\ddot{y}_3}{(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)^2}$

$m_{04} = \frac{\ddot{y}_4}{(\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4)^2}$ $m_{15} = -ai_1^{*'}(0)$ $m_{16} = -bi_1^{*'}(0)$ $m_{27} = -\alpha i_2^{*'}(0)$ $m_{28} = -\beta i_2^{*'}(0)$ $m_{30} = -k_1^{*'}(0)$

$m_{40} = -j_1^{*'}(0)$ $m_{50} = -g_1^{*'}(0)$ $m_{60} = -h_1^{*'}(0)$ $m_{70} = -g_2^{*'}(0)$ $m_{80} = -h_2^{*'}(0)$

Also, the Mean Sojourn Time in state S_i is given by:

$\mu_i = \int_0^\infty P(T > t)dt$

$\mu_0 = \frac{1}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$

$\mu_1 = -i_1^{*'}(0)$ $\mu_2 = -i_2^{*'}(0)$

$\mu_3 = -k_1^{*'}(0)$ $\mu_4 = -j_1^{*'}(0)$ $\mu_5 = -g_1^{*'}(0)$

$\mu_6 = -h_1^{*'}(0)$ $\mu_7 = -g_2^{*'}(0)$ $\mu_8 = -h_2^{*'}(0)$

Thus, we see that

$m_{01}+m_{02}+m_{03}+m_{04}=1$ $m_{15}+m_{16} = \mu_1$ $m_{27}+m_{28} = \mu_2$

$m_{30} = \mu_3$ $m_{40} = \mu_4$ $m_{50} = \mu_5$

$m_{60} = \mu_6$ $m_{70} = \mu_7$ $m_{80} = \mu_8$

2.6 Measures of System Effectiveness

We obtained numerous iterative relations and resolved to find the distinct parameters of system proficiency like Reliability and MTSF using probabilistic arguments given below:

$\therefore$ **Meantime to system failure (MTSF) (T_0)** = $\frac{N_1}{D_1}$ where, $N_1 = \mu_0 + p_{01}\mu_1 + p_{04}\mu_4 + p_{01}p_{15}\mu_5 + p_{01}p_{16}\mu_6$ and $D_1 = 1 - p_{04}\mu_4 - p_{01}p_{15}\mu_5 - p_{01}p_{16}\mu_6$.

Availability with full capacity per unit time (A_0) = $\frac{N_2}{D_2}$ Where, $N_2 = \mu_0$

And, $D_2 = \mu_0+\mu_1 p_{01}+\mu_2 p_{02}+\mu_3 p_{03}+\mu_4 p_{04}+\mu_5 p_{01}p_{15}+\mu_6 p_{01}p_{16}+p_{02}p_{27}\mu_7+p_{02}p_{28}\mu_8$.

Busy period of repairman during inspection (B_0^I) = $\frac{N_3}{D_2}$, where $N_3 = \mu_1 p_{01}+\mu_2 p_{02}$ and $D_2 = \mu_0+\mu_1 p_{01}+\mu_2 p_{02}+\mu_3 p_{03}+\mu_4 p_{04}+\mu_5 p_{01}p_{15}+\mu_6 p_{01}p_{16}+p_{02}p_{27}\mu_7+p_{02}p_{28}\mu_8$.

Busy period of repairman for repair (B_0^R) = $\frac{N_4}{D_2}$ where $N_4 = \mu_5 p_{01}p_{15}+p_{02}p_{27}\mu_7$ and D_2 is as above.

Busy period of repairman for replacement (B_0^{Rp}) = $\frac{N_5}{D_2}$, where, $N_5 = \mu_6 p_{01}p_{16}+\mu_8 p_{02}p_{28}$ and D_2 is above.

Expected walkout period due to strike of farmers and workers (S_0) = $\frac{N_6}{D_2}$, where $N_6 = \mu_3 p_{03}$ and D_2 is defined as above.

Profit Analysis: The profit of a system can be obtained as follows:

$P = C_0A_0 - C_1B_0^I - C_2B_0^R - C_3B_0^{Rp} - C_4S_0 - C_5$

Wherever C_0 = Profits per unit availability of a system;

C_1 = Cost of inspection per unit time;

C_2 = Cost of repair per unit time;

C_3 = Cost of replacement per unit time;

C_4 = Loss due to walkouts per unit time;

C_5 = Miscellaneous cost of machine.

3 Results and Discussion

If we assign specific values to the parameters and consider them,

$g_1(t) = \xi_1 e^{-\xi_1(t)}$, $h_1(t) = \xi_2 e^{-\xi_2(t)}$, $g_2(t) = \rho_1 e^{-\rho_1(t)}$, $h_2(t) = \rho_2 e^{-\rho_2(t)}$, $i(t) = \eta_1 e^{-\eta_1(t)}$, $k_1(t) = \nu e^{-\nu(t)}$, $l_1(t) = \tau e^{-\tau(t)}$,

we get, $p_{01} = \frac{\ddot{y}_1}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$, $p_{02} = \frac{\ddot{y}_2}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$, $p_{03} = \frac{\ddot{y}_3}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$, $p_{04} = \frac{\ddot{y}_4}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$, $p_{15} = a$, $p_{16} = b$, $p_{27} = \alpha$, $p_{28} = \beta$ $p_{30} = 1$, $p_{40} = 1$, $p_{50} = 1$, $p_{60} = 1$

and $\mu_0 = \frac{1}{\ddot{y}_1+\ddot{y}_2+\ddot{y}_3+\ddot{y}_4}$, $\mu_1 = \frac{1}{\eta_1}$, $\mu_2 = \frac{1}{\eta_2}$, $\mu_3 = \frac{1}{\nu}$, $\mu_4 = \frac{1}{\tau}$, $\mu_5 = \frac{1}{\xi_1}$, $\mu_6 = \frac{1}{\xi_2}$, $\mu_7 = \frac{1}{\rho_1}$, $\mu_8 = \frac{1}{\rho_2}$.

Assuming the values, take the values from collected data for the above particular cases

$\ddot{y}_1$=0.0095, $\ddot{y}_2$=0.0072, $\ddot{y}_3$=0.0014, $\ddot{y}_4$=0.0062, a=0.7, b=0.3, α=0.7, β=0.3, η_1=0.9, η_2=0.85, ν=0.02, ξ_1= 1.62, ξ_2= 1.31, τ= 2.06, ρ_1=0.532, ρ_2=0.47.

The resulting values of various parameters of system effectiveness are:

MTSF (Mean time to system failure) (T_0) = 67.9464

Availability per unit time (A_0) = 0.92083

Busy periods of Repairman (Inspection Time) (B_0^I) = 0.0149

Busy periods of Repairman (Repairing Time) (B_0^R) = 0.1773

Busy periods of Repairman (Replacement Time) (B_0^{Rp}) = 0.0936

Probable walkout epoch due to strike (S_0) = 0.0625.

Using the above arithmetical values, different graphs are designed to show the relation between MTSF, Availability, profit, numerous rates of minor/major faults, and cease faults as well as the rate of expected walkout period.

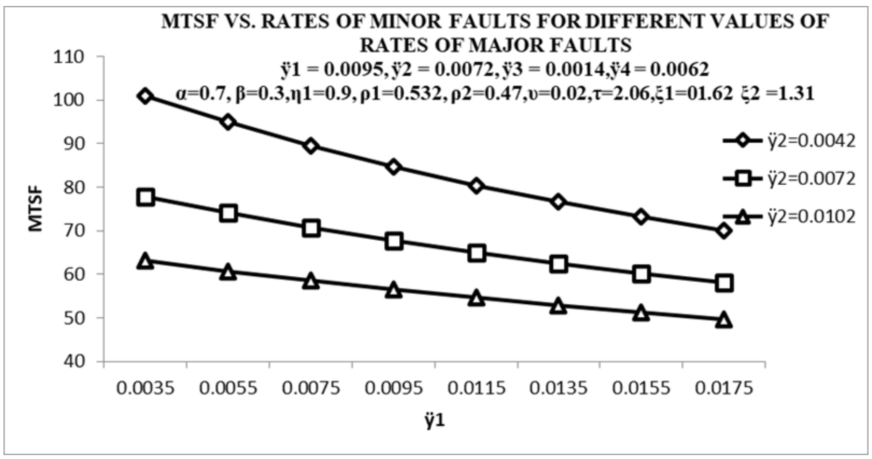

Fig 2. MTSF vs. rates of Minor Faults

Figure 2 shows the relationship between MTSF and minor faults for the various rates of major faults. MTSF and minor faults are inversely related. MTSF is decreased for higher values of $\ddot{y}_1$ and increased for lower values of $\ddot{y}_1$. When $\ddot{y}_1$ is 0.0035, MTSF is 101.0795; MTSF is 56.5065 for $\ddot{y}_1$ = 0.0095 and $\ddot{y}_2$ is 0.0072.

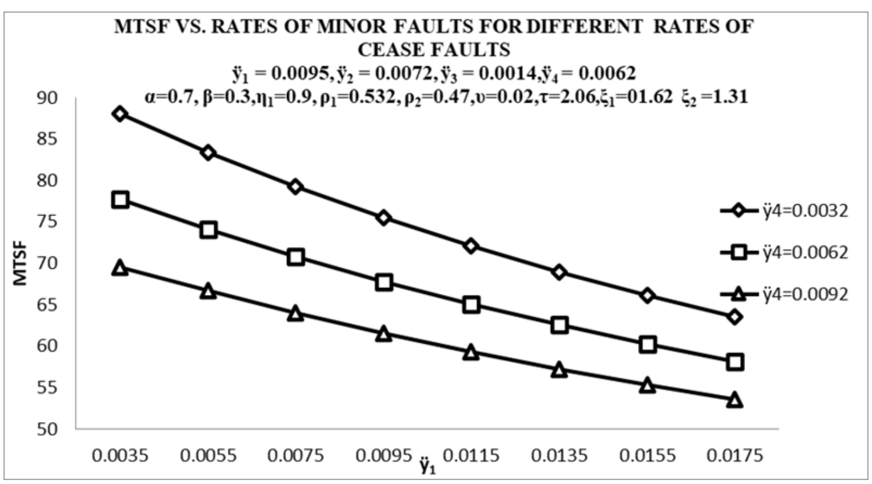

Fig 3. MTSF vs. Minor Faults for Various Rates of Cease Faults

This graph shows the relationship between MTSF and minor faults for various rates of cease faults (Bagasse jamming). These faults are also inversely comparable. For higher values of cease faults, MTSF is minimised. When the value of cease faults is 0.0032 then MTSF IS 65.7059; when it is 0.0062, MTSF is 59.8285 and for 0.0092, MTSF is 54.9291 (Figure 3).

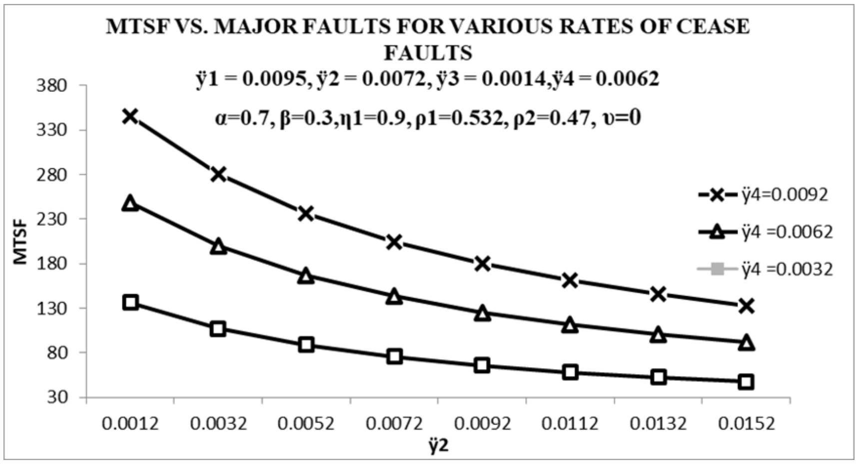

Fig 4. MTSF vs. Major Faults for Various Rates of Cease Faults

MTSF is decreasing for higher rates of major faults and cease faults. When the major fault is 0.0072, MTSF is 75.4646. When the major fault is 0.0152 and cease faults are 0.0092, MTSF is 41.5064 (Figure 4).

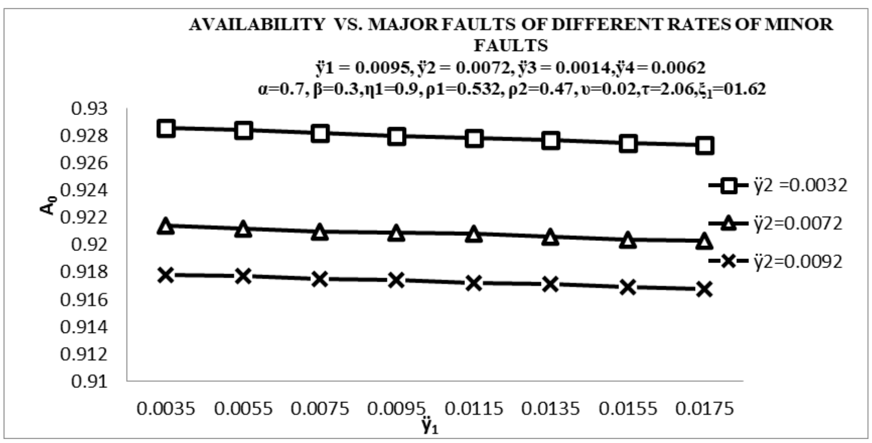

Fig 5. Availability vs. Minor Faults for Various Rates of Major Faults

Availability is also inversely proportional to major and minor faults. The System is less available for higher rates of these faults and availability increases for lower rates of minor, major and cease faults (Figure 5).

Figure 6 shows the graph of Profit and various rates of minor and major faults. Profit is maximising when $\ddot{y}_1$ 0.0035 and $\ddot{y}_2$ is 0.0042. It is lowest for minor faults 0.0175 and $\ddot{y}_2$ is 0.0102. Also, it is seen that the rates of major faults have more effect on profit than those of minor faults.

Figure 7 shows relation between profit, cease faults and major faults. This graph shows that when major faults are 0.0042, the profit is 2251.52 and when these faults are 0.0102, the profit is 1566.94.

So by the above discussion, it is found that MTSF is decreased for higher values of $\ddot{y}_1$ and increased for lower values of $\ddot{y}_1$ and $\ddot{y}_2$. When $\ddot{y}_1$ is 0.0035, MTSF is 101.0795 when $\ddot{y}_2$ is 0.0042. MTSF is 49.7089; $\ddot{y}_1$ is 0.0172 and $\ddot{y}_2$ is 0.0102. MTSF is maximising when $\ddot{y}_1$ is 0.0095, $\ddot{y}_2$ is 0.012 and $\ddot{y}_4$ is 0.0032 and for the same rate of $\ddot{y}_1$, MTSF has a minimum value 4105064 for $\ddot{y}_2$ is 0.0152 and $\ddot{y}_4$ is 0.0092.

Availability is also affected in the same way. A_0 is 0.09209 for $\ddot{y}_1$ = 0.0095, $\ddot{y}_2$= 0.0072 and $\ddot{y}_4$= 0.0062. But it minimises for $\ddot{y}_1$ = 0.0175 and $\ddot{y}_2$ = 0.0092. Profit is highest when $\ddot{y}_1$ =0.0035 and $\ddot{y}_2$=0.0042.

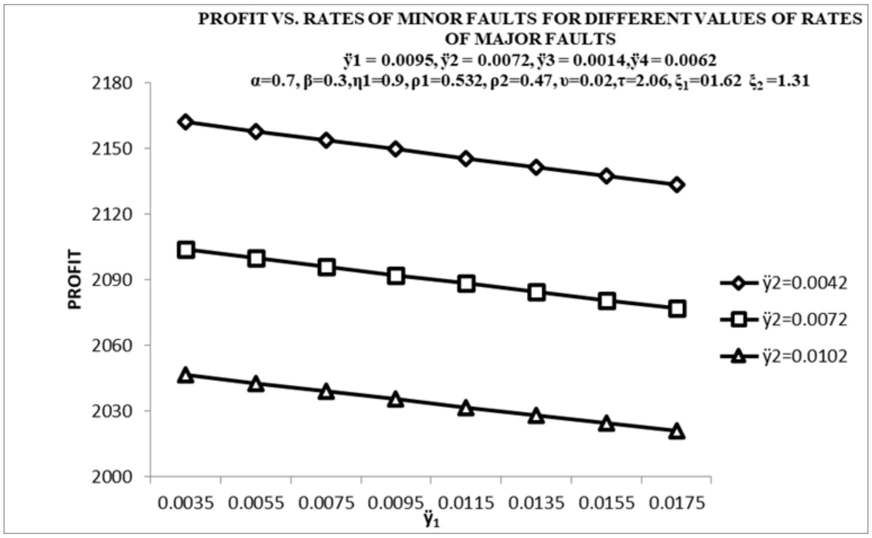

Fig 6. Profit Vs. Minor and Major Faults

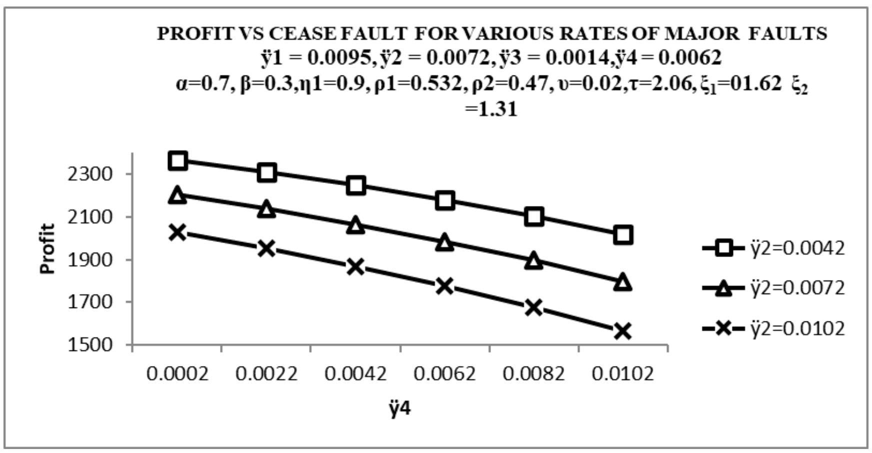

Fig 7. Profit Vs. Cease Faults and Major Faults

4 Conclusion

After analysing the above graphs, it is found that the Mean Time to System Failure (MTSF), Availability, and profit of sugar mill increase for the decreasing values of the rates of minor faults/major faults as well as for cease faults.

When $\ddot{y}_1$ is 0.0095, $\ddot{y}_2$ is 0.0072 and $\ddot{y}_4$ is 0.0062, MTSF is 67.8004. But when rates of these faults increased i.e. when $\ddot{y}_1$ is 0.0175 and $\ddot{y}_2$ is 0.0102, MTSF is 49.7089. It is also seen that Major faults have more effects on availability than minor and cease faults. A_0 is minimum when $\ddot{y}_1$ is 0.0175, $\ddot{y}_2$ is 0.0092 and $\ddot{y}_3$ is 0.0062.

Studies have revealed that faults classified as "cease faults" have a significantly greater detrimental effect on various aspects of a system's performance than those categorized as "minor" faults, but have less adverse effects compared to "major" faults. These cease faults can have a significant impact on the Mean Time Between System Failures (MTSF), which is a key metric used to assess a system's reliability, as well as on profitability and availability. Therefore, it is crucial to address these faults promptly and ensure that they are given the necessary attention and resources they require to prevent any further damage.

To enhance both profitability and availability, it is imperative to accord greater focus to the elimination of major faults and the cease faults, which have the potential to escalate into major faults. The aforementioned findings are of considerable value to the sugar mill's management team, as they help facilitate an analysis of the availability and profitability aspects of the mill's operations. Additionally, these findings aid in identifying priorities for repair and replacement of the feeding system in the sugar plant, thereby contributing to the optimization of system performance.

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