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PERFORMANCE ANALYSIS OF STOCHASTIC MODEL OF A SEED PROCESSING PLANT WHEN SYSTEM BROUGHT TO HALT AND PERIODIC REST

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ABSTRACT

The paper deals with a model of a seed processing plant which has centrifuge system situated at Yunick Agro, Hisar, Haryana (India) on the basis of real data collected. Depending on time of repair and cost of repairs, faults are classified as minor, major or neglected faults.The occurrence of a minor fault leads to degradation whereas occurrence of a major fault leads to failure of the system. Some minor faults are repairable on-line by regular maintenance and others either converted into neglected faults which are being repaired during periodic rest or system brought to forcefully stop/halt in case of unavoidable fault and further inspection is carried out. Whenever there is major fault/periodic rest/during halt, inspection is carried out, repair being done according to fault is repairable or non repairable. Replacement or labour redundancy is used in case of non-repairable faults. Neglected faults are repaired during rest period. Considering all these aspects and using the real data collected from the plant, various measures of system effectiveness such as MTSF, Reliability, Availability and Busy period etc. are derived by using Semi-Markov process and Regenerative Point technique. The functioning of the plant's machine is examined using numerical results and graphs derived thereof. From the plots so obtained, we get cut-off points of profit for different values of rates of major faults/ revenue of per unit Uptime.

Index Terms: *Reliability, Labour redundancy, Semi-Markov Process, Mean Time To System Failure(MTSF), Availability, Regenerative Point technique*

I.INTRODUCTION

In field of agriculture, seed processing is essential process for higher quality of seed I.e higher genetically purity,possession of good shape, size, colour, etc.,higher physical soundness and weight, higher germination, higher physiological vigour and stamina. The basic aim of seed processing is to attain the greatest percentage of ideal seed with higher germination potential. The order of operations in seed processing are based on characteristics of seed such as shape, size, weight, length, surface structure, colour and moisture content. The foremost functioning in a seed processing plant are receiving; pre-cleaning; conditioning; drying; cleaning and grading; treatment; and weighing, packaging and storage. Using good quality seed, development of root system will be more productive that helps absorption of nutrients efficiently and result in higher yield. The leading function of the seed industry in India is to improve in the expansion of agriculture, providing access to superior quality seeds and planting materials for the farmers in India. In the present scenario of competitive market, improvement in performance of the machines with minimum operating cost is the main objective of each industry. In the present paper, actual data relating to a seed processing plant machine, situated in Yunick Agro Seed, Hisar(Haryana) has been gathered personally by visiting the said plant premises from time to time and a stochastic model is developed considering its various types of faults using Semi-Markov Process and Regenerative Point Technique. The plant machine is a single unit complex system with various sub systems wherein different faults occur during operation. The faults are categorized as minor, major and neglected faults on the basis of down time and cost which are repairable as well as non-repairable. Since the machine is operative round the clock, therefore, power failures/ degradation are also considered as faults. It is observed that on occurrence of a minor fault, machine partially stopped and some faults can be corrected by regular maintenance/repair and other faults either converted into neglected faults which will be corrected during periodic rest time or sometimes due to some unavoidable minor fault system has to forcefully stop/brought to halt and then inspection carried out , whereas in case of major fault,when system goes to failure labour redundancy and

replacement is used. Whereas neglected faults are repairable during periodic rest time. Inspection is being done by a single repairman who visits the plant in negligible time and inspects whether the fault is repairable or non-repairable. In case of repairable fault, the defective part is repaired whereas in case of non-repairable fault, the defective part of the machine is replaced or work is done manually by labour. For numerical calculations, inspection rates, repair rates and replacement rates are assumed to follow Exponential Distributions. On the basis of so collected real data, by using Semi-Markov Process and Regenerative Point Technique, various measures of system effectiveness such as MTSF, Reliability, Availability (with full and reduced capacity) and Busy Period of repairman are obtained. Finally, numerical calculations and graphs drawn on the basis thereof have been used for evaluation of performance of the machine which is useful for smooth and better functioning of the seed Industry.

Researchers and Scientists are trying to improve the performance of industries using various reliability techniques. Kumar et al. (1989) analyzed the reliability and availability behaviour of subsystems of paper industry by using probabilistic approach [1]. Gupta et al. (2005) worked on the system reliability and availability in butter oil processing plant by using Markov Process and R-K method [2]. Kumar and Pooja Bhatia (2011) discussed reliability and cost analysis of a one unit centrifuge system with single repairman and Inspection [3]. Pooja Bhatia and Kumar (2013) studied Performance and Profit Evaluations of a Stochastic Model on Centrifuge System Working in Thermal Power Plant Considering Neglected Faults [4]. Sharma and Vishwakarma (2014) applied Markov Process in performance analysis of feeding system of sugar industry [5]. Renu and Pooja Bhatia (2017) dealt with reliability analysis for removing shortcomings using stochastic processes and applied for maintenance in industries [6]. A few of the Researchers have worked for real data of paper machine and footwear machine. Veena Rani and Pooja Bhatia discussed about Performance Evaluation of Stochastic Model of a Paper Machine Having Three Types of Faults [7]. Rinku and Pooja Bhatia, (2022) analyzed a study on a Study on Comparative Analysis of Two Stochastic Models for Single Unit footwear Machine [8].Pooja Bhatia and Deepal, (2023) analyzed a study on Profit Analysis of a Stochastic Model With Maintenance and Labour Redundancy [9].Pooja Bhatia and Deepal, (2023) analyzed a study on Reliability Examination of Stochastic Model of a Seed Processing plant having three types of faults [10].

For the purpose of performance evaluation, a stochastic model is developed by using Regenerative Point Technique and following measures of system effectiveness are obtained

◆ Transition Probabilities

◆ Mean Sojourn Time

◆ Mean Time to System Failure (MTSF)

◆ Expected up time/Expected down time

◆ Busy Period of repairman (Repair and Replacement time)

◆ Profit analysis

II. MODEL DESCRIPTIONS

(1) ASSUMPTIONS

◆ The system consists of a single unit.

◆ The system works with full efficiency after each repair and replacement.

◆ The Repair man reaches the system in negligible time.

◆ A single Repair man facility is provided to the system for repair and replacement of the components.

◆ Time distribution of various faults i.e. minor/major/neglected are Exponential while other distributions are general.

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◆ A minor fault leads to partial failure whereas major fault leads to complete failure.

◆ Some neglected faults and some minor faults are repairable during periodic rest time.

◆ Due to power failure/degradation the machine stops temporarily for few minutes.

(2) NOTATIONS

◆ λ_1/λ_2 : Rate of occurrence of minor/major faults.

◆ λ_3: Rate of occurrence of neglected faults.

◆ $a_1/b_1/c_1$: Probability that a minor fault is replaceable or repairable or work is done manually by labour.

◆ $a_2/b_2/c_2$: Probability that a major fault is replaceable or repairable or work is done manually by labour.

◆ $a_3/b_3/c_3$: Probability that a neglected fault is replaceable or repairable or work is done manually by labour during rest period.

◆ η_4: Rate with which system goes to rest.

◆ η_5: Rate with which system carried forcefully stop/halt.

◆ β_4: Rate with which system restarts after periodic rest.

◆ $i_1(t)/i_2(t)/i_3(t)$: p.d.f of time to inspection of the unit at down state/failed state/rest period.

◆ $I_1(t)/I_2(t)/I_3(t)$: c.d.f of time to inspection of the unit at down state/failed state/rest period.

◆ $h_1(t)/h_2(t)/h_3(t)$: p.d.f of time to replacement of the unit at down state/failed state/rest period.

◆ $H_1(t)/H_2(t)/H_3(t)$: c.d.f of time to replacement of the unit at down state/failed state/rest period.

◆ $k_1(t)/k_2(t)/k_3(t)$: p.d.f of time to maintenance of the unit at down state/failed state/rest period.

◆ $K_1(t)/K_2(t)/K_3(t)$: c.d.f of time to maintenance of the unit at down state/failed state/rest period.

◆ $l_1(t)/l_2(t)/l_3(t)$: p.d.f of time to labour redundancy of the unit at down state/failed state/rest period.

◆ $L_1(t)/L_2(t)/L_3(t)$: c.d.f of time to labour redundancy of the unit at down state/failed state/rest period.

◆ $p_1(t)/P_1(t)$: p.d.f/c.d.f of time to preventive maintenance of the unit at down state.

◆ $d_1(t)/d_3(t)$: p.d.f of time to delay in repairs during maintenance of the unit on occurrence of minor/neglected faults.

◆ $D_1(t)/D_3(t)$: c.d.f of time to delay in repairs during maintenance of the unit on occurrence of minor/neglected faults.

◆ ©: Laplace convolution.

◆ */**: Laplace transformation/Laplace stieltjes transformation.

◆ Q_{ij}/q_{ij}: cdf/pdf for the transition of the system from one regenerative state S_i to another regenerative state S_j or to a failed state S_j.

(3) TRANSITION STATES

Different states of the system model according to Semi Markov process and Regenerative Point Technique are as follows:

State 0: Initially state is operative.

State 1: Operative unit temporarily failed due to some minor faults.

State 2: Unit completely failed due to some major faults.

State 3: Operative unit temporarily failed due to some neglected faults.

State 4: System is carried to periodic rest.

State 5: System brought to forcefully stop/halt due to some unavoidable minor faults.

State 6: Neglected fault identified which will be rectified during rest period.

State 7: Major fault identified in inspection which is rectified by replacement of components/ parts and after this system is operative.

State 8: Major fault identified in inspection which is rectified by repair/maintenance of components/ parts and after this system is operative.

State 9: Major fault identified in inspection which is rectified by labour redundancy and after this system is operative.

State 10: Minor fault identified in inspection which is rectified by replacement of components/ parts and after this system is operative.

State 11: Minor fault identified in inspection which is rectified by repair/maintenance of components/ parts and after this system is operative.

State 12: Minor fault identified in inspection which is rectified by labour redundancy and after this system is operative.

State 13: Neglected fault identified in inspection which is rectified by replacement of components/ parts and after this system is operative.

State 14: Neglected fault identified in inspection which is rectified by repair/maintenance of components/ parts and after this system is operative.

State 15: Neglected fault identified in inspection which is rectified by labour redundancy and after this system is operative.

Here, state 0 is operative state with full capacity whereas 1,3,4,5,6,10,11,12,13,14,15 are operative states with reduced capacity,states 2,7,8,9 are failed states.

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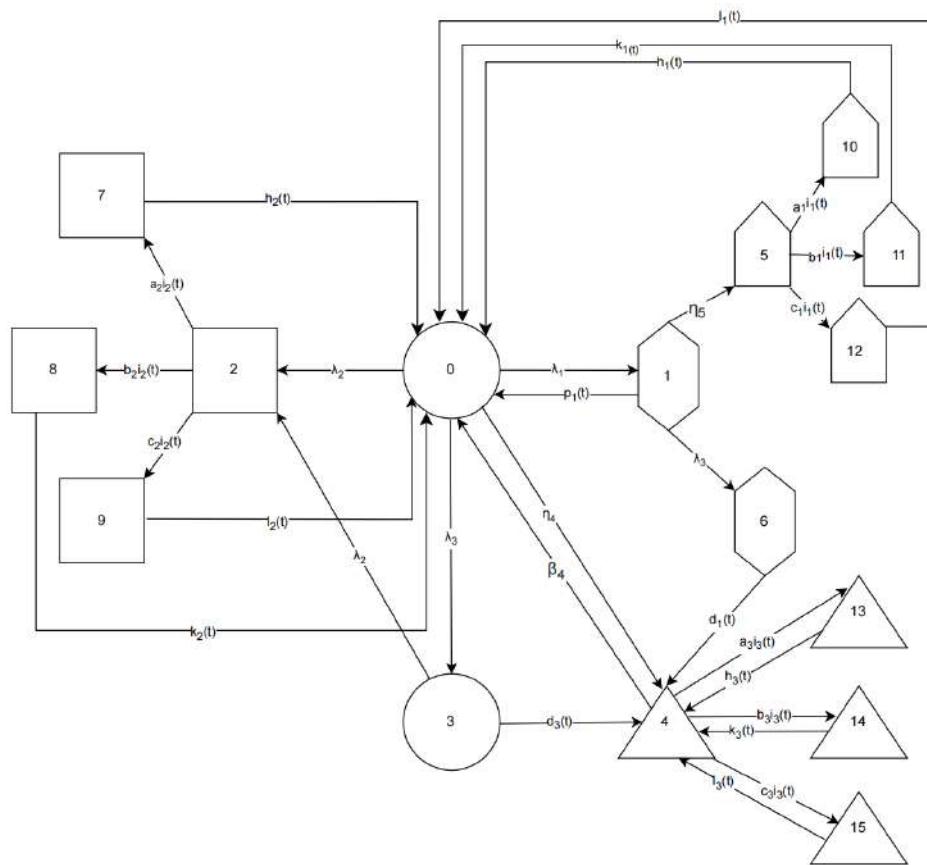
(4) TRANSITION DIAGRAM

Fig 7.7

III. RELIABILITY INDICATOR

(1) Transition probability

We can find transition probabilities by using simple probabilistic arguments and these are given by:

$$p_{ij} = \lim_{s \to 0} \int_0^\infty \exp(-st)\,dQ_{ij}\,dt$$

$p_{01} = \dfrac{\lambda_1}{\lambda_1 + \lambda_2 + \lambda_3 + \eta_4}$ $\qquad$ $p_{02} = \dfrac{\lambda_2}{\lambda_1 + \lambda_2 + \lambda_3 + \eta_4}$ $\qquad$ $p_{03} = \dfrac{\lambda_3}{\lambda_1 + \lambda_2 + \lambda_3 + \eta_4}$ $\qquad$ $p_{04} = \dfrac{\eta_4}{\lambda_1 + \lambda_2 + \lambda_3 + \eta_4}$ $\qquad$ $p_{15} = \dfrac{\eta_5(1 - p_1*(\eta_5 + \lambda_3))}{\eta_5 + \lambda_3}$

$p_{15} = \dfrac{\lambda_3(1 - p_1*(\eta_5 + \lambda_3))}{\eta_5 + \lambda_3}$ $\qquad$ $p_{50} = l_1^*(0)$ $\qquad$ $p_{27} = a_2 i_2^*(0)$

$p_{28} = b_2 i_2^*(0)$ $\quad$ $p_{29} = c_2 i_2^*(0)$ $\quad$ $p_{10} = p_1^*(\eta_5 + \lambda_3)$ $\quad$ $p_{40} = 1 - i_1^*(\beta_4)$

$p_{32} = 1 - d_3^*(\lambda_2)$ $\quad$ $p_{34} = d_3^*(\lambda_2)$ $\quad$ $p_{64} = d_1^*(0)$ $\quad$ $p_{70} = h_2^*(0)$

$p_{80} = k_2^*(0)$ $\quad$ $p_{30} = p_3*(0)$ $\quad$ $p_{90} = l_2^*(0)$ $\quad$ $p_{5,10} = a_1 i_1^*(0)$

$p_{5,11} = b_1 i_1^*(0)$ $\quad$ $p_{5,12} = c_1 i_1^*(0)$ $\quad$ $p_{10,0} = h_1^*(0)$ $\quad$ $p_{11,0} = k_1^*(0)$

$p_{12,0} = l_1^*(0)$ $\quad$ $p_{4,13} = a_3 i_3^*(\beta_4)$ $\quad$ $p_{4,14} = b_3 i_3^*(\beta_4)$ $\quad$ $p_{4,15} = c_3 i_3^*(\beta_4)$

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$p_{13,4}=h_3^{*}(0)$ $p_{14,4}=k_3^{*}(0)$ $p_{15,4}=l_3^{*}(0)$

It can be verified that

$p_{01}+p_{02}+p_{03}+p_{04}=1$, $p_{10}+p_{15}+p_{16}=1$, $p_{27}+p_{28}+p_{29}=1$, $p_{32}+p_{34=}1$

$p_{64}=p_{70}=p_{80}=p_{90}=p_{10,0}=p_{11,0}=p_{12,0}=p_{13,4}=p_{14,4}=p_{15,4}=1$ $p_{40}+p_{4,13}+p_{4,14}+p_{4,15}=1$ $p_{5,10}+p_{5,11}+p_{5,12}=1$

(2) *Mean sojourn times*

The unconditional mean time taken by the system to transit for any regenerative state j, when it is counted from epoch of entrance into that state i', is mathematically, stated as

$$mij=\int_0^{\infty} tdQ_{ij}(t)=-Q_{ij}^{*'}(s)$$

$m_{01}+m_{02}+m_{03}+m_{04}=\mu_0$, $m_{10}+m_{15}+m_{16}=\mu_1$, $m_{27}+m_{28}+m_{29}=\mu_2$, $m_{32}+m_{34}=\mu_3$, $m_{40}+m_{4,13}+m_{4,14}+m_{4.15}=\mu_4$ $m_{5,10}+m_{5,11}+m_{5,12}=\mu_5$, $m_{64}=\mu_6$, $m_{70}=\mu_7$

$m_{80}=\mu_8$ $m_{90}=\mu_9$ $m_{10,0}=\mu_{10}$ $m_{11,0}=\mu_{11}$

$m_{12,0}=\mu_{12}$ $m_{13,4}=\mu_{13}$ $m_{14,4}=\mu_{14}$ $m_{15,4}=\mu_{15}$

and the mean sojourn time in the regenerative states i are obtained as

$\mu_0=\dfrac{1}{\lambda_1+\lambda_2+\lambda_3+\eta_4}$, $\mu_1=\dfrac{1-p_1^{*'}(\eta_5+\lambda_3)}{\eta_5+\lambda_3}$, $\mu_2=-i_2^{*}(0)$, $\mu_3=\dfrac{1-d_3*(\lambda_2)}{\lambda_2}$, $\mu_4=\dfrac{1-i_3*(\beta_4)}{\beta_4}$, $\mu_5=-i_1^{*'}(0)$,

$\mu_6=-d_1^{*'}(0)$, $\mu_7=-h_2^{*'}(0)$, $\mu_8=-k_2^{*'}(0)$ $\mu_9=-l_2^{*'}(0)$ $\mu_{11}=-k_1^{*'}(0)$ $\mu_{12}=-l_1^{*'}(0)$ $\mu_{13}=-h_3^{*'}(0)$ $\mu_{14}=-k_3^{*'}(0)$ $\mu_{15}=-l_3^{*'}(0)$

(3) Measures of System Effectiveness

Using probabilistic arguments for regenerative processes, various recursive relations are obtained and are solved to find different measures of system effectiveness, which are as follows:

Mean Time to System Failure (MTSF) $T_{72}=\dfrac{N}{D}$

Where $N=p_{03}\mu_3+\mu_0+\mu_1p_{01}+p_{01}p_{16}\mu_6$ $D=1-p_{01}p_{10}$

Expected Uptime of the system $UT_{72}=N_1/D_1$

Expected Downtime of the system $DT_{72}=N_2/D_1$

Busy Period of Repairman (Repair time only) $BR_{72}=N_4/D_1$

Busy Period of Repairman (Replacement time only) $BRP_{72}=N_5/D_1$

Where

$N_1=\mu_0+p_{03}\mu_3$

$D_1=\mu_{0+}(p_{03}p_{32}+p_{02}+p_{4,13}p_{02}+p_{4,13}p_{03}p_{32}+p_{4,14}p_{02}+p_{4,14}p_{03}p_{32}+p_{4,15}p_{03}p_{32}+p_{4,15}p_{02})(\mu_2+\mu_7p_{27}+\mu_8p_{28}+\mu_9p_{29})+p_{01}+p_{02}\mu_4+\mu_4p_{03}p_{32}+p_{03}\mu_3+p_{03}p_{34}+(p_{5,10}\mu_{10}+p_{5,11}\mu_{11}+p_{5,12}\mu_{12})(p_{01}p_{15}+p_{4,13}p_{01}p_{15}+p_{4,14}p_{01}p_{15}+p_{4,15}p_{01}p_{15})+p_{4,13}p_{01}\mu_{13}(p_{10}+p_{15}p_{5,10}+p_{15}p_{5,11}+p_{15}p_{5,12})+(p_{4,13}\mu_{13}+p_{4,14}\mu_{14}+p_{4,15}\mu_{15})(p_{02}+p_{03}p_{32})+(p_{4,14}\mu_{14}p_{01}+p_{4,15}\mu_{15}p_{01})(p_{10}+p_{15})+p_{01}\mu_6 p_{40}p_{4,15}$

$N_2=p_{01}(\mu_1+p_{16}\mu_6)(1-p_{4,13}p_{13,4}-p_{4,14}p_{14,4}-p_{4,15}p_{15,4})$

$N_3=(\mu_4p_{04}+\mu_5p_{01}p_{15}+\mu_2(p_{02}+p_{03}p_{32}))(1-p_{4,13}p_{13,4}-p_{4,14}p_{14,4}-p_{4,15}p_{15,4})$ + $(p_{01}p_{16}p_{64}+p_{03}p_{32}+p_{04})\mu_4$

$N_4=\mu_{14}p_{4,14}(p_{01}p_{16}p_{64}+p_{03}p_{34}+p_{04})+(p_{01}\mu_1+\mu_8p_{28}(p_{02}+p_{03}p_{32})+\mu_{11}p_{01}p_{15}p_{5,11})(1-p_{4,13}p_{13,4}-p_{4,14}p_{14,4}-p_{4,15}p_{15,4})$
$N_5=(\mu_7p_{27}(p_{02}+p_{03}p_{32})+\mu_{10}p_{01}p_{15}p_{5,10})(1-p_{4,13}p_{13,4}-p_{4,14}p_{14,4}-p_{4,15}p_{15,4})+p_{4,13}\mu_{13}(p_{01}p_{16}p_{64}+p_{03}p_{34}+p_{04})$

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(4) Profit Analysis

The expected profit incurred of the system is given by

$$P_{72} = C_0 UT_{72} - C_1 DT_{72} - C_2 BI_{72} - C_3 BR_{72} - C_4 BRP_{72} - C_5$$

C_o = revenue per unit up time of the system

C_1 = revenue per unit down time of the system

C_2 = cost per unit time of inspection

C_4 = cost per unit time of replacement

C_5 = other fixed costs

Here other fixed costs (C_5) includes cost of installation of the system, wages of the repairman/operator etc.

(5) Numerical Study

Giving particular values to the parameters and considering

$$i_2(t)=\alpha_2 e^{-\alpha 2t} \quad h_2(t)=\gamma_2 e^{-\gamma 2t} \quad d_1(t)=\xi_1 e^{-\xi 1t} \quad k_2(t)=\beta_2 e^{-\beta 2t}$$

$$d_3(t)=\xi_3 e^{-\xi 3t} \quad l_1(t)=\eta_1 e^{-\eta 1t} \quad l_2(t)=\eta_2 e^{-\eta 2t} \quad p_1(t)=\delta_1 e^{-\delta 1t}$$

$$i_1(t)=\alpha_1 e^{-\alpha 1t} \, h_1(t)=\gamma_1 e^{-\gamma 1t} \, d_1(t)=\xi_1 e^{-\xi 1t} \, k_1(t)=\beta_1 e^{-\beta 1t} \, i_3(t)=\alpha_3 e^{-\alpha 3t} \, l_3(t)=\eta_3 e^{-\eta 3t} \, k_3(t)=\beta_3 e^{-\beta 3t} \, h_3(t)=\gamma_3 e^{-\gamma 3t}$$

We get

$$p_{01}=\frac{\lambda_1}{\lambda_1+\lambda_2+\lambda_3+\eta_4} \quad p_{02}=\frac{\lambda_2}{\lambda_1+\lambda_2+\lambda_3+\eta_4} \quad p_{03}=\frac{\lambda_3}{\lambda_1+\lambda_2+\lambda_3+\eta_4} \quad p_{04}=\frac{\eta_4}{\lambda_1+\lambda_2+\lambda_3+\eta_4} \quad p_{15}=\eta_5\left(\frac{1}{\eta_5+\lambda_3}-\frac{\delta_1}{\eta_5+\lambda_3+\delta_1}\right) \quad p_{16}=\lambda_3\left(\frac{1}{\eta_5+\lambda_3}-\frac{\delta_1}{\eta_5+\lambda_3+\delta_1}\right)$$

$$p_{40}=\frac{\beta_4}{\alpha_3+\beta_4}, \quad p_{50}=p_{64}=p_{70}=p_{80}=p_{90}=1 \quad p_{27}=a_2 \quad p_{28}=b_2 \quad p_{29}=c_2 \quad p_{32}=\frac{\lambda_2+\xi_3}{\lambda_2}$$

$$p_{34}=\frac{\xi_3}{\lambda_2+\xi_3} \quad p_{4,13}=a_3\left(\frac{\beta_4}{\alpha_3+\beta_4}\right) \quad p_{4,14}=b_3\left(\frac{\beta_4}{\alpha_3+\beta_4}\right) \quad p_{4,15}=c_3\left(\frac{\beta_4}{\alpha_3+\beta_4}\right) \quad p_{10}=\frac{\delta_1}{\eta_5+\lambda_3+\delta_1}$$

$$\mu_0=\frac{1}{\lambda_1+\lambda_2+\lambda_3+\eta_4} \quad \mu_1=\frac{1}{\eta_5+\lambda_3+\delta_1} \quad \mu_2=\frac{1}{\alpha_2} \quad \mu_3=\frac{1}{\xi_3+\lambda_2} \quad \mu_4=\frac{1}{\alpha_3+\beta_4} \quad \mu_5=\frac{1}{\alpha_1} \quad \mu_6=\frac{1}{\xi_1}$$

$$\mu_7=\frac{1}{\gamma_2} \quad \mu_8=\frac{1}{\beta_2} \quad \mu_9=\frac{1}{\eta_2} \quad \mu_{10}=\frac{1}{\gamma_1}$$

$$\mu_{11}=\frac{1}{\beta_1} \quad \mu_{12}=\frac{1}{\eta_1} \quad \mu_{13}=\frac{1}{\gamma_3} \quad \mu_{14}=\frac{1}{\beta_3}$$

$$\mu_{15}=\frac{1}{\eta_3}$$

For the particular cases, taking values from the collected data and assuming the values*(6) Mean time to system failure(T_{72})=7.32594*

(7) Expected Uptime of the system (UT_{72})=0.451602

(8) Expected Downtime of the system (DT_{72})=0.000578

(9) Busy period of Repairman (Inspection time only)BI_{72}=0.085426

(10) Busy period of Repairman (Repair time only)BR_{72}=0.0606

(11) Busy period of Repairman (Replacement time only)BRP_{72}=0.04988

(12) Expected profit P_{72}=28.2357

(13) Graphical analysis

Using above numerical values, various graphs are drawn for MTSF(T_{72}) and profit(P_{72}) of the system for different values of rate with which

system is brought to forcefully stop/halt(η_5), rates of minor, major and neglected faults($\lambda_1, \lambda_2, \lambda_3$), Repair rates($\beta_1, \beta_2, \beta_3$),replacement rates($\gamma_1, \gamma_2, \gamma_3$) ,inspection rates($\alpha_1, \alpha_2, \alpha_3$) and labour redundancy rate (η_1, η_2, η_3). From the plotted graphs following conclusion are drawn

Fig. 7.8 presents the graph between mean time to system failure (T_{72}) and the rate of occurrence of minor faults (λ_1) for the different values of rate of occurrence of major faults (λ_2). It can be concluded from the graph that the MTSF decreases with increase in the values of rate of occurrence of minor faults and has lower values for higher values of rate of occurrence of major faults.
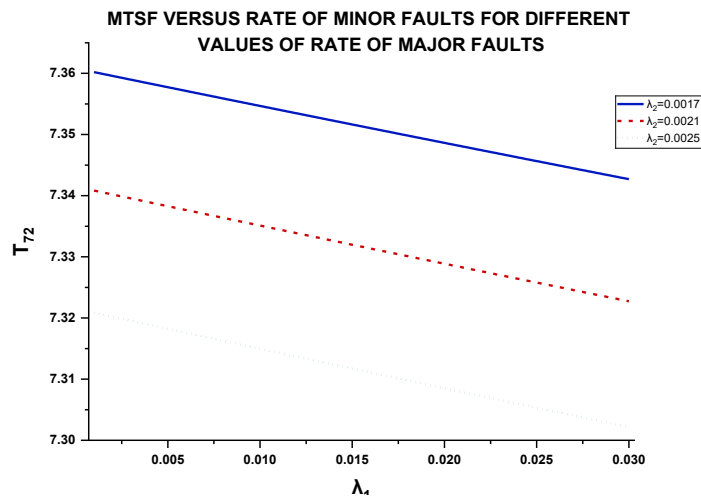

Fig 7.8

Fig 7.9 shows the graph between MTSF (T_{72}) and the rate of occurrence of neglected faults (λ_3) for the different values of rate with which is carried to halt(η_5). It is observed from the graph that the MTSF (T_{72}) increases with increase in the values of rate of occurrence of neglected faults that and has lower values for higher values of rate with which system is brought to halt(η_5).
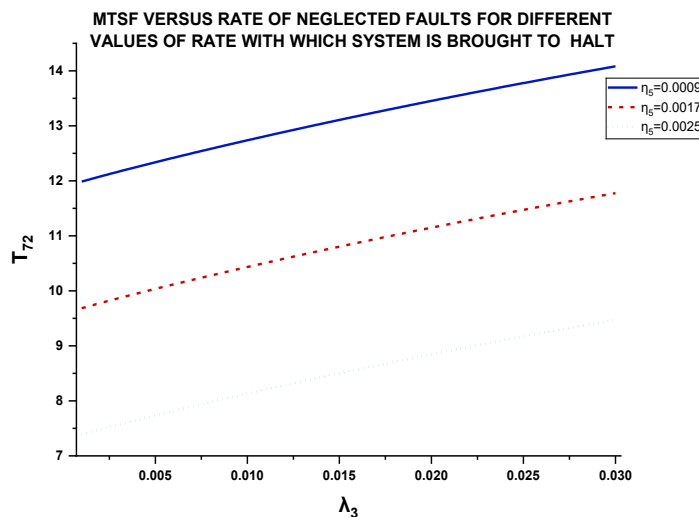

Fig 7.9

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Fig 7.10 represents the graph pattern of profit (P_{72}) with respect to the rate of occurrence of neglected faults (λ_3) for different values of rate of occurrence of major faults(λ_2). From the graph,we observe that the profit of the system decreases with the increase in the values of the rate of occurrence of neglected faults (λ_3) for different rate of major faults.
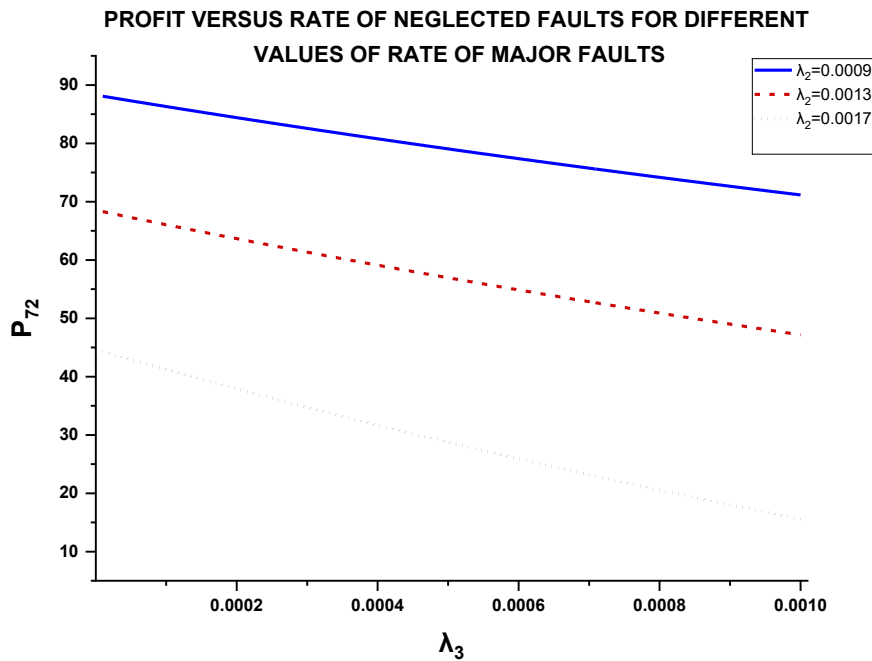

Fig 7.10

Fig. 7.11 represents the graph of profit (P_{72}) with respect to revenue per unit up time (C_0) of the system for the different values of rate of occurrence of neglected faults (λ_3). We conclude that:

   (i)   The profit increases with the increase in the values of revenue per unit up time and has greater values for higher values of rate of occurrence of major faults.

(ii) For λ_3= 0.0001, the profit is negative or zero or positive according as C0 is < or = or > 1085.31 and hence, in this case, for the system to be profitable, the revenue per unit up time of the system should be fixed greater than Rs.1085.31.

(iii) For λ_3 = 0.0010, the profit is negative or zero or positive according as C0 is < or = or > 1215.289 and hence, in this case, for the system to be profitable, the revenue per unit up time of the system should be fixed greater than Rs. 1215.289 .

(iv) For λ_3 = 0.1000, the profit is negative or zero or positive according as C0 is< or = or > 1292.451 and hence, in this case, for the system to be profitable, the revenue per unit up time of the system should be fixed greater than Rs. 1292.451.
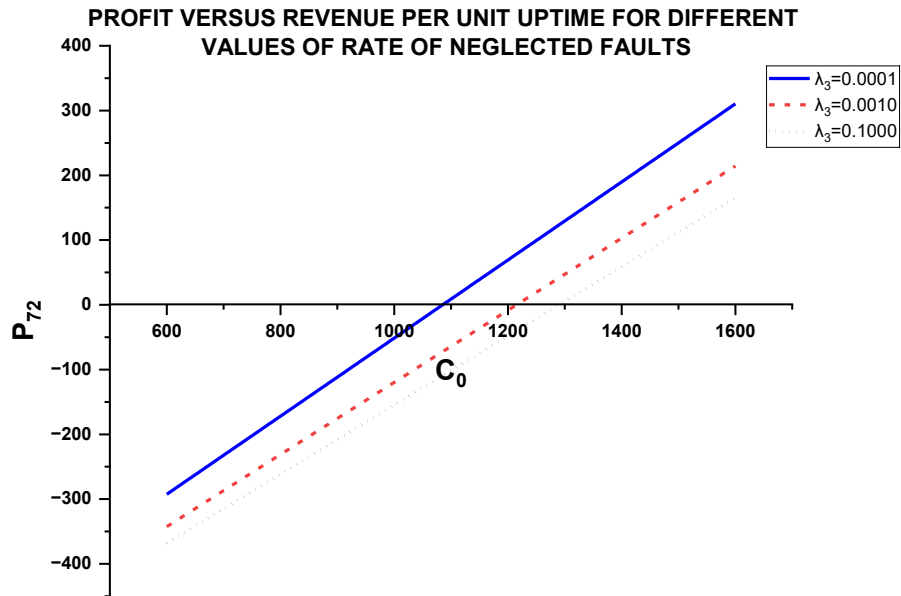
Fig 7.11

Fig 7.12 shows the graph between Profit (P_{72}) and the rate of occurrence of neglected faults (λ_3) for the different values of rate with which is carried to halt(η_5). It is observed from the graph that the Profit (P_{72}) decreases with increase in the values of rate of occurrence of neglected faults for different values of the rate with which system is brought to halt and has lower values for higher values of rate with which system is brought to halt(η_5).
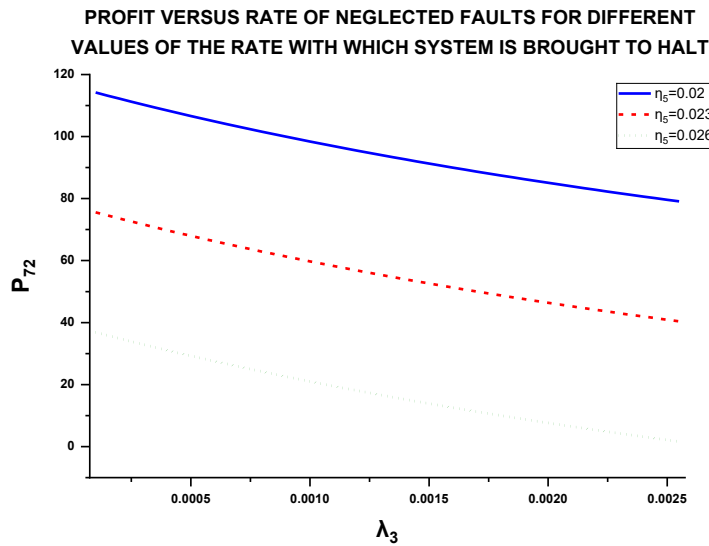

Fig 7.12

IV. CONCLUSION

From the graphical analysis done above, we conclude that MTSF decreases with increase in the values of rate of occurrence of minor faults and has lower values for higher values of rate of occurrence of major faults. Also MTSF increases with increase in the values of rate of occurrence of neglected faults that and has lower values for higher values of rate with which system is brought to halt(η_5). Profit of the system decreases with the increase in the values of the rate of occurrence of neglected faults (λ_3) for different rate of major faults and decreases with increase in the values of rate of occurrence of neglected faults for different values of the rate with which system is

brought to halt and has lower values for higher values of rate with which system is brought to halt(η_5).Further, we obtained cut off points of profit for different values of revenue per unit Uptime. We found that, for specific value of rate of minor/major fault what should be the greater value of revenue of per unit Uptime or lower value of miscellaneous costs to get positive profit. On the basis of these values, several suggestions can be given to the management team of the seed processing plant to make the overall profit.

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