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Performance Optimization for Skim Milk Powder Unit of a Dairy Plant Using Genetic Algorithm

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ABSTRACT

The paper deals with the performance optimization for skim milk powder unit of a dairy plant at National Dairy Research Institute (N. D. R. I.), Karnal using Genetic Algorithm (G. A.). The skim milk powder unit comprises of six subsystems working in series. The failure and repair rates of the subsystems are taken from maintenance history sheets, which follow the exponential distribution. The mathematical formulation is carried out using probabilistic approach and the Markov birth – death process is used to develop the difference differential equations. The steady state availability expression has been derived using normalizing conditions. The optimal values of failure/repair rates of each subsystem of the skim milk powder unit have been evaluated using Matlab 7.1 G. A. tool. The steady state availability obtained from Markov analysis is also compared with the optimal availability calculated through G. A. tool. So, the findings of the present paper will be highly useful to the plant management for developing proper maintenance strategies which can be implemented in order to enhance system performance.

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1. INTRODUCTION

NDRI was established in 1996 and is commercially active research institute at Karnal (India). The plant has the capacity to handle 60,000 liters of milk per day. The supply of raw milk is from the model dairy plant and institute dairy farm. The fat content in the raw milk is weighed and assessed for the SNF (Solid Not Fat) and fat contents. Thereafter, the milk undergoes pasteurization and then cooled to refrigeration temperature (4-5 °C) before it is sent to storage tank. Further processing involves separation of cream by cream separator and its standardization for various purposes. Continuous churning of cream separates butter in a butter making machine. Lassi and Flavored milk is made in this section. In the second section, production of condensed and dried milk products are carried out. Fine powder is made with the help of roller drier machine. The milk is fed into the rotating steam-heating drums or rollers. As the drums revolve, a thin film of milk is adhered to it and dried by the time, a complete revolution is made and then scrapped by a blade. This material is collected and fed into pulverized machine which converts it in the fine powder form. This fine powder is then packed and stored. Skim milk powder contains calcium chloride, curic acid and sodium citrate not exceeding 0.3% by weight of the end product. The products made in the plant are tested in quality control section by different methods. These products are then finally packed in hygienic conditions in packaging section by means of computerized machine.

1. 1. History Availability of a system can be improved by several methods like using large safety factors, structural redundancy, reducing system complexities, practicing a planned maintenance schedule and repair schedule. Availability optimization problems concentrate on optimal allocation of redundancy components and optimal selection of alternative design to meet system requirement. Efforts were made by some researchers in the direction of availability optimization and cost analysis. Goldberg [1] made a systematic study of G. A. mechanism and

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identified three basic operators: reproduction, crossover and mutation for obtaining near optimal solutions. Srinivas [2] discussed various optimization techniques and their implementation in the engineering problems. Ishii et al. [3] applied the reliability optimization as the last step in their six step heuristic procedure. Sung et al. [4,5] applied branch and bound approach for reliability optimization. Mettas [6] derived a general model to estimate the minimum reliability requirement for multiple components within a system that would yield the goal reliability value for the system. Kuo et al. [7] discussed the reliability redundancy allocation problem for finding simultaneously optimal redundancy levels and optimal component reliabilities that maximize system reliability subject to resource constraints. Coit et al. [8] proposed a multiple objective formulation for maximizing the system availability. Nahas et al. [9] studied the reliability optimization problem for a series system with multiple choice constraints, to maximize the system reliability. Gen et al. [10] studied the G. A. approach for various reliability optimization problems. Castro et al. [11] proposed a maintenance optimization model for an Engineering system assembled in a series configuration. Dai et al. [12] developed an optimization model for the grid service allocation using G. A.. Taboada et al. [13] studied the reliability optimization of the complex systems. Juang et al. [14] proposed a G. A. based optimization model to optimize the availability of a series parallel system. Gupta et al. [15,16,17] dealt with the development of decision support system and performance modeling of feed water unit,coal handling unit and feed water system of a thermal power plant. They derived the availability expression for feed water and coal handling unit with elements exhibiting independent failures and repairs. Amir Azaron et al. [18] developed a new methodology for reliability evaluation and optimization of non repairable dissimilar component with cold standby redundant systems. Nakagawa et al. [19] analyzed the reliability optimization problem by using the concept of the reversed failure rate. Garg et al. [20] developed a reliability model of a block-board manufacturing system in the plywood industry using time dependent and steady state availability under idealized and faulty Preventive Maintenance (PM). Singh et al. [21] analyzed the mathematical model with the application of cupola. The transition state probabilities, reliability, availability and M.T.T.F. were determined using supplementary variable technique. Khanduja et al. [22] developed a mathematical model and did performance optimization for the digesting system of a paper plant using G. A.. Asha and Nair [23] developed the relationship between mean time to failure in an age replacement model with hazard rate and mean residual life functions. Vasili et al. [24] presented a brief review of existing maintenance optimization models. Several reliable models and methods in this area were discussed and future prospects were investigated. Khanduja et al.[25] discussed the steady state behavior and maintenance planning of the bleaching system in a paper plant. The development of mathematical modeling was carried out using Markov birth-death process. The literature review discussed here reflects that G. A. has been applied successfully in various complex industries consisting of series and series-parallel system. The approach of performance modeling and development of decision support system has also been discussed by many researchers. Therefore, in order to bridge the gap, G. A. is being proposed in the present paper for performance optimization in dairy industry. The analysis will definitely help the plant management to adopt the strategic maintenance planning and scheduling.

2. SYSTEM CONFIGURATION

The skim milk powder unit of the dairy plant at N.D.R.I consists of the following six subsystems:

1. Pumping subsystem: It is used for unloading the milk brought from milk collection centers. The system consists of two pumps, one in standby having perfect switch-over device. This system never fails.
2. Preheating subsystem (B_1): The subsystem is used to heat the roller. The steam is allowed to move onto the rollers. After drum's surface achieve a temperature high enough to dry the milk film, the flow is allowed over the entire drum length. This subsystem is subjected to major failure only.
3. Agitator (B_2): It works on the centrifugal force principle. Chilled milk from the chiller is taken to the agitator where fat is separated from the milk in the form of cream containing 40 to 50% fats. The skimmed milk is stored in milk silos for preparing milk powder. It consists of three components working in series – motor, bearings and high speed gear box. Failure of any component causes complete failure of the subsystem.
4. Pasteurizer (B_3): It pasteurizes the milk coming from pumping system. Here the cream is heated up to 80 to 82˚C with no holding time. The purpose is to destroy pathogenic and undesirable organisms, inactivate the enzymes present, make possible removal of volatile flavors and removal of tanning substances. Failure of machine causes the complete failure of the unit.
5. Drum drier and scraping machine (B_4): The drum revolves and a thin film of milk adhered to it which is dried by the time of a complete revolution of drum. The film is made and then is scrapped by a blade. Partial failure of machine can set the system

to reduced working capacity while major failure causes complete failure of the unit.

6. Pulverized machine (B_5): The above material is collected and fed into pulverized machine which converts it to fine powder form. This fine powder is then packed and stored. Partial failure of machine can set the unit to reduced working capacity while major failure causes complete failure of the unit.

The pumping system, as mentioned above, never fails. So, working of the unit is affected by rest of the five subsystems. All the above mentioned subsystems, except subsystem B_4 and B_5 are subjected to major failures while B_4 and B_5 can work in reduced state also (Figure 1).

3. ASSUMTIONS AND NOTATIONS

I. Failure and repair rates for each subsystem are constant and statistically independent [26, 27].
II. There are simultaneous failures occurring at a time.
III. Performance wise a repaired unit as good as new one.

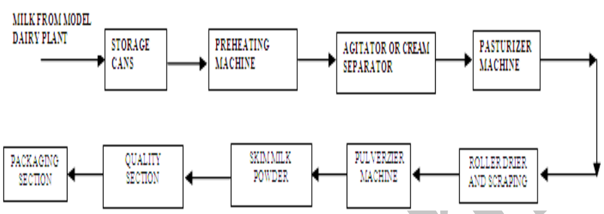

Figure 1. Schematic flow diagram of skim milk powder unit

TABLE 1. Notations of skim milk powder unit

Transition diagram	Figure 2
‘(t)	d/dt
Full capacity states (without standby)	B_1, B_2, B_3, B_4, B_5
Failed states	b_1, b_2, b_3, b_4 ,b_5
Reduced capacity	B'٤ B and'٥
Failure rates	λ_i, i = 7 to 13 from B_1, B_2, B_3, B_4, B_5, B'_4,B'_5 to b_1,b_2,b_3, B'_4,B'_5,b_4,b_5
Repair rates	μ_i, i = 7 to 11 from b_1,b_2,b_3, b_4,b_5 to B_1, B_2, B_3, B_4, B_5,
Probability of full capacity working states (without standby unit)	P_0
Probability of reduced capacity working states	P١ , P٢ P and٣
Probability of failed states	P_4 to P_{19}

IV. The standby units are of the same nature and capacity as the active units.

The notations associated with the transition diagram are as summarized in Table 1.

4. MATHEMATICAL ANALYSIS OF THE UNIT

The transition diagram (Figure 2) depicts a simulation model showing all the possible states for skim milk powder unit. The model helps to develop the Chapman-Kolmogorov differential equations using mnemonic rule [22]. This rule states that the derivative of the probability of every state is equal to the sum of all probability flows which comes from other states to the given state minus the sum of all probability flows which goes out from the given state to the other states. Probability considerations give the following differential equations associated with the transition diagram:

$$P_0'(t)+\left(\sum_{i=7}^{11}\lambda_i\right)P_0(t)=\sum_{i=7}^{9}\mu_i P_{i-3}(t)+\mu_{10}P_{10}(t)+\mu_{11}P_{14}(t) \quad (1)$$

$$P_1'(t)+\left(\sum_{i=7}^{9}\lambda_i+\lambda_{11}+\lambda_{12}\right)P_1(t)=\sum_{i=7}^{9}\mu_i P_i(t)+\lambda_{10}P_0(t)+\mu_{11}P_{18}(t) \quad (2)$$

$$P_2'(t)+\left(\sum_{i=7}^{10}\lambda_i+\lambda_{13}\right)P_2(t)=\sum_{i=7}^{9}\mu_i P_{4+i}(t)+\mu_{10}P_{19}(t)+\lambda_{11}P_0(t) \quad (3)$$

$$P_3'(t)+\left(\sum_{i=7}^{9}\lambda_i+\lambda_{12}+\lambda_{13}\right)P_3(t)=\sum_{i=7}^{9}\mu_i P_{8+i}(t)+\lambda_{10}P_2(t)+\lambda_{11}P_1(t) \quad (4)$$

$$P_i'(t)+\mu_7 P_i(t)=\lambda_7 P_j(t) \quad (5)$$

for i = 4, j=0; i = 7, j=1; i = 11, j=2; i = 15, j=3;

$$P_i'(t)+\mu_8 P_i(t)=\lambda_8 P_j(t) \quad (6)$$

for i = 5, j=0; i = 8, j=1; i = 12, j=2; i = 16, j=3;

$$P_i'(t)+\mu_9 P_i(t)=\lambda_9 P_j(t) \quad (7)$$

for i = 6, j=0; i = 9, j=1; i = 13, j=2; i = 17, j=3;

$$P_i'(t)+\mu_{10} P_i(t)=\lambda_j P_k(t) \quad (8)$$

for i = 10, j =6,k=1; i =19,j=6, k =3;

$$P_i'(t)+\mu_{11} P_i(t)=\lambda_j P_k(t) \quad (9)$$

for i = 14, j =7,k=2; i =18,j=7, k =3;

Initial conditions at time t = 0 are:

$P_i(t)=1$ for i = 0 $\qquad P_i(t)=0$ for $i\neq 0$

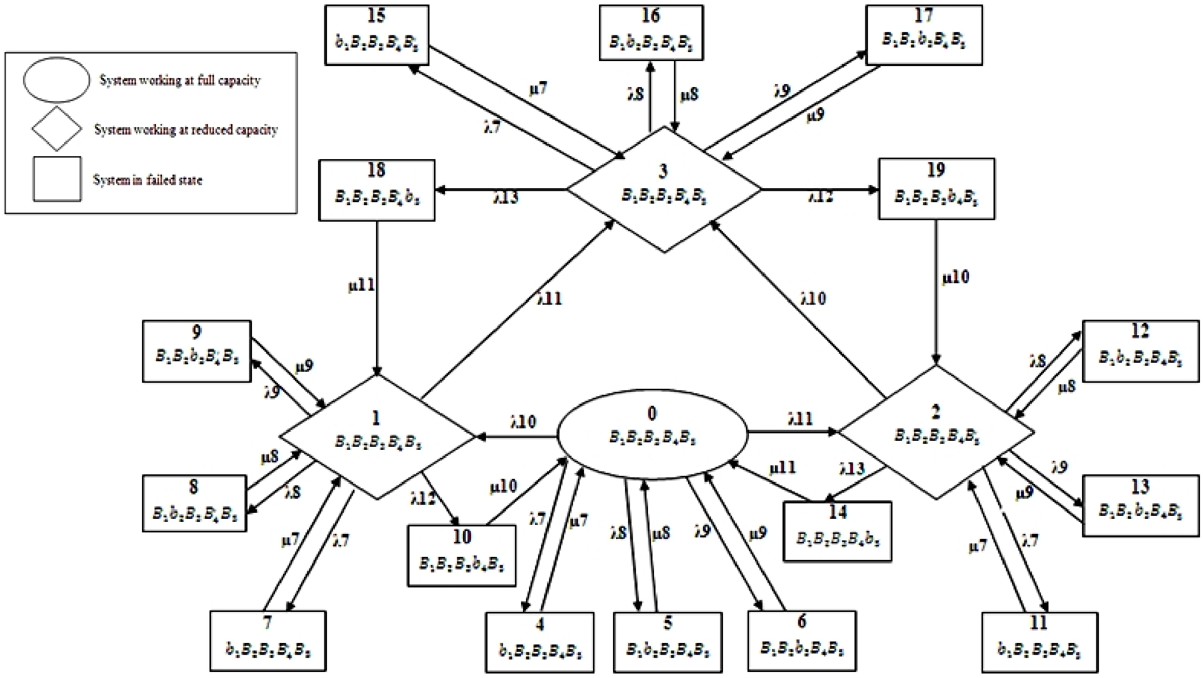

Figure 2. Transition diagram of skim milk powder system

4. 1. Steady State Availability The skim milk powder unit is required to be available for long duration of time. So, the long run or steady state availability of the skim milk powder unit is obtained by putting $d/dt = 0$ as $t \to \infty$ into differential Equations (1) to (9) and solving these equations recursively, we get:

$P_1 = L_1 P_0$ $P_2 = L_2 P_0$ $P_3 = L_3 P_0$

$P_4 = H_1 P_0$ $P_5 = H_2 P_0$ $P_6 = H_3 P_0$

$P_7 = H_1 L_1 P_0$ $P_8 = H_2 L_1 P_0$ $P_9 = H_3 L_1 P_0$

$P_{10} = H_4 L_1 P_0$ $P_{11} = H_1 L_2 P_0$ $P_{12} = H_2 L_2 P_0$

$P_{13} = H_3 L_2 P_0$ $P_{14} = H_5 L_2 P_0$ $P_{15} = H_1 L_3 P_0$

$P_{16} = H_2 L_3 P_0$ $P_{17} = H_3 L_3 P_0$ $P_{18} = H_5 L_3 P_0$

$P_{19} = H_4 L_3 P_0$

where

$H_i = \frac{\lambda_j}{\mu_j}$; $i = 1, 2, 3$; $j = 7, 8, 9$

$H_4 = \frac{\lambda_{12}}{\mu_{10}}$ $H_5 = \frac{\lambda_{13}}{\mu_{11}}$

$L_1 = \frac{\mu_{11} H_5 L_3 + \lambda_{10}}{C_1}$ $L_2 = \frac{\mu_{10} H_4 L_3 + \lambda_{11}}{C_2}$

$$L_3 = \frac{\lambda_{10}\lambda_{11}(C_1 + C_2)}{C_1 C_2 C_3 - \mu_{11} H_5 (C_1 \lambda_{10} + C_2 \lambda_{11})}$$

$$C_1 = T_2 - \mu_7 H_1 - -\mu_8 H_2 - \mu_9 H_3$$

$$C_2 = T_3 - \mu_7 H_1 - -\mu_8 H_2 - \mu_9 H_3$$

$$C_3 = T_4 - \mu_7 H_1 - -\mu_8 H_2 - \mu_9 H_3$$

$$T_1 = \sum_{i=7}^{11} \lambda_i \qquad T_2 = \sum_{i=7}^{9} \lambda_i + \lambda_{11} + \lambda_{12}$$

$$T_3 = \sum_{i=7}^{10} \lambda_i + \lambda_{13} \qquad T_4 = \sum_{i=7}^{9} \lambda_i + \lambda_{12} + \lambda_{13}$$

Now, using normalizing conditions i.e. sum of all the probabilities is equal to one, we get:

$$\sum_{i=0}^{19} P_i = 1$$

$$P_0 = \begin{bmatrix} 1 + L_1 + L_2 + L_3 + H_1 + H_2 + H_3 + H_1 L_1 + H_2 L_1 + \\ H_3 L_1 + H_4 L_1 + H_1 L_2 + H_2 L_2 + H_3 L_2 \\ + H_5 L_2 + H_1 L_3 + H_2 L_3 + H_3 L_3 + H_5 L_3 + H_4 L_3 \end{bmatrix}^{-1}$$

The maximum steady state availability of skim milk powder unit (A_{v1}) may be obtained as summation of probabilities of all working and reduced capacity states i.e.:

$$A_{v1} = P_0 + P_1 + P_2 + P_3 = [1 + L_1 + L_2 + L_3]P_0 \quad (10)$$

A_{v1} = 92.82 %

Taking λ_7=0.00007, μ_7=0.009, λ_8=0.008, μ_8=0.55, λ_9=0.008, μ_9=0.05, λ_{10}=0.005, μ_{10}=0.08, λ_{11}=0.00009, μ_{11}=0.008, λ_{12}=0.005, λ_{13}=0.0002

(Data taken from maintenance history sheets)

The availability (A_{v1}) as given by Equation (10) includes all possible failure events (λ_i) and the identification of all the courses of action i.e. repair priorities (μ_i). This model can be used to adopt strategic maintenance policies for skim milk powder unit. Similarly, the various availability levels may be computed for different combinations of failure and repair rates. The optimal availability value for skim milk powder unit is further evaluated using G. A. technique.

4. 2. Performance Optimization Using Genetic Algorithm G. A. is a powerful computerized tool for search and optimization problems. The G. A. optimizes the results using the following steps:

1) Identify all the constraints of the G. A. tool.
2) Randomly generate the initial population and prepare the coded strings.
3) Compute the fitness of each individual and form the mating pool from the old population.
4) Divide the population repeatedly into random tournaments.
5) Determine the new generation pool and select two parents from the mating pool randomly.
6) Perform the crossover of the parents to produce two off springs.
7) Mutate, if required.
8) Place the child strings to new population and compute the fitness of each individual.
9) Replace old population with new population.
10) Repeat the steps 3 to 6 until the best individuals in new population represent the optimum value of the performance function.

The performance optimization of the skim milk powder unit is influenced by the failure and repair rates of each subsystem. The designed range of failure and repair rates are taken from the maintenance history sheets. In order to optimize the availability, G. A. tool in Matlab 7.1 is being used in the present paper. The following G. A. operators along with permissible range of failure and repair rates are used for the performance optimization.

TABLE 2. G. A. operators for skim milk powder unit

Population type: Double vector	Reproduction (elite count):2
Population size: 20 to 160 in step size of 20	Reproduction (crossover fraction):0.80
Creation function: Uniform	**Mutation probability: 0.01**
Fitness scaling: Rank	**Crossover probabilities: Heuristic-0.80**
Selection: Stochastic	Migration: Direction- forward
Stopping criteria: Generation-50 to 450 in step size 50	Number of variables:12
Variable	Range (Min. to Max.)
λ_7	0.00007 to 0.00011
μ_7	0.009 to 0.045
λ_8	0.008 to 0.016
μ_8	0.11 to 0.55
λ_9	0.0008 to 0.0012
μ_9	0.05 to 0.25
λ_{10}	0.005 to 0.009
μ_{10}	0.08 to 0.40
λ_{11}	0.00009 to 0.00013
μ_{11}	0.008 to 0.04
λ_{12}	0.005 to 0.009
λ_{13}	0.0002 to 0.001

5. RESULTS AND DISCUSSION

The maximum steady state availability as calculated by Markov analysis comes out to be 92.82% by using the failure and repair rates available through maintenance history sheets. A G. A. is a search strategy that employs random selection to guide a highly exploitative search, striking a balance between explorating of feasible domain and exploting of good solutions. The performance optimization is carried out by varying the number of generations from 50 to 450 in step size 50 as shown in Table 3. It is observed that the optimum availability of skim milk powder unit of an N.D.R.I. plant comes out to be 97.52 % at 350 number of generation. The corresponding values of failure and repair rates are λ_7 = 0.00007 (once in 14286 h), μ_7 = 0.0449 (once in 22.2 h), λ_8 = 0.008 (once in 125 h), μ_8 = 0.5461 (once in 1.83 h), λ_9 = 0.0008 (once in 1250 h), μ_9 = 0.2448 (once in 4.08 h), λ_{10} = 0.005 (once in 200 h), μ_{10} = 0. 3989 (once in 2.5 h), $\lambda_{11=}$ 0.00012 (once in 8333.3 h), μ_{11}=0.029 (once in 34.48 h),λ_{12} = 0.005(once in 200 h), λ_{13} = 0.0002 (once in 5000 h), which is the best possible combination of failure and repair rates of different subsystems. The effect of number of generations on the availability of skim milk powder unit is shown in Figure 3.

Now the performance optimization is carried out by varying the population size from 20 to 160 in step size of 20, as shown in Table 4.

It is evident that the best possible combination of failure and repair parameters are λ_7 = 0.00007, μ_7 =0.0401, λ_8 = 0.008, μ_8 = 0.5409, λ_9 = 0.0008, μ_9 =0.2426, λ_{10} = 0.005, μ_{10} = 0. 3913, λ_{11}= 0.0001, μ_{11}=0.039, λ_{12} = 0.005, λ_{13} = 0.0002, at which optimum value of system availability is 97.49% with population size 100. The effect of population size on system availability is shown in Figure 4.

TABLE 3. Effect of number of generations on the availability of skim milk powder unit

No. of Generation	Availability	λ_7	μ_7	λ_8	μ_8	λ_9	μ_9	λ_{10}	μ_{10}	λ_{11}	μ_{11}	λ_{12}	λ_{13}
50	0.954015	0.00007	0.0242	0.0121	0.3912	0.0009	0.1120	0.005	0.3298	0.00013	0.04	0.005	0.0002
100	0.957964	0.00007	0.0442	0.0121	0.3673	0.0008	0.2453	0.005	0.3871	0.0001	0.031	0.005	0.0002
150	0.961755	0.00008	0.0443	0.0122	0.4248	0.0008	0.2431	0.005	0.3969	0.00013	0.029	0.005	0.0002
200	0.970146	0.00009	0.0445	0.0105	0.5443	0.0008	0.2498	0.005	0.3652	0.00009	0.038	0.005	0.0002
250	0.974781	0.00008	0.0429	0.008	0.5386	0.0008	0.2453	0.005	0.3959	0.00012	0.033	0.005	0.0002
300	0.975051	0.00007	0.0415	0.008	0.5474	0.0008	0.2434	0.005	0.3968	0.00012	0.029	0.005	0.0002
350	**0.975198**	**0.00007**	**0.0449**	**0.008**	**0.5461**	**0.0008**	**0.2448**	**0.005**	**0.3989**	**0.00012**	**0.029**	**0.005**	**0.0002**
400	0.975033	0.00007	0.0405	0.008	0.5447	0.0008	0.2373	0.005	0.3892	0.00013	0.039	0.005	0.0002
450	0.973506	0.00007	0.0426	0.009	0.5499	0.0008	0.2487	0.005	0.3987	0.00013	0.039	0.005	0.0002

TABLE 4. Effect of population size on availability of skim milk powder unit

Population size	Availability	λ_7	μ_7	λ_8	μ_8	λ_9	μ_9	λ_{10}	μ_{10}	λ_{11}	μ_{11}	λ_{12}	λ_{13}
20	0.957964	0.00007	0.0442	0.01209	0.3673	0.0008	0.24531	0.005	0.38712	0.0001	0.0314	0.005	0.0002
40	0.966385	0.00009	0.0324	0.01209	0.5307	0.0008	0.23471	0.005	0.39249	0.0001	0.0399	0.005	0.0002
60	0.967774	0.00007	0.0449	0.01232	0.5499	0.0008	0.24999	0.005	0.39639	0.0001	0.0265	0.005	0.0002
80	0.971859	0.00008	0.0246	0.00801	0.5162	0.0008	0.17137	0.005	0.39875	0.0001	0.0399	0.005	0.0002
100	**0.974991**	**0.00007**	**0.0401**	**0.008**	**0.5409**	**0.0008**	**0.24261**	**0.005**	**0.39132**	**0.0001**	**0.0399**	**0.005**	**0.0002**
120	0.974673	0.00007	0.0402	0.008	0.5489	0.0008	0.24824	0.005	0.34219	0.00013	0.0382	0.005	0.0002
140	0.973881	0.00011	0.0402	0.008	0.5418	0.0008	0.24984	0.005	0.39248	0.00013	0.0371	0.005	0.0002
160	0.973428	0.00007	0.0402	0.008	0.5499	0.0008	0.17359	0.005	0.34538	0.00012	0.0399	0.005	0.0002

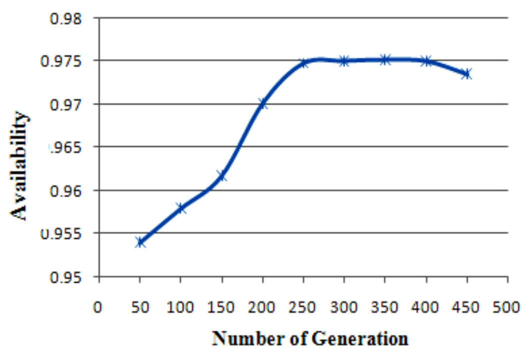

Figure 3. Effect of number of generation on the availability of skim milk powder system

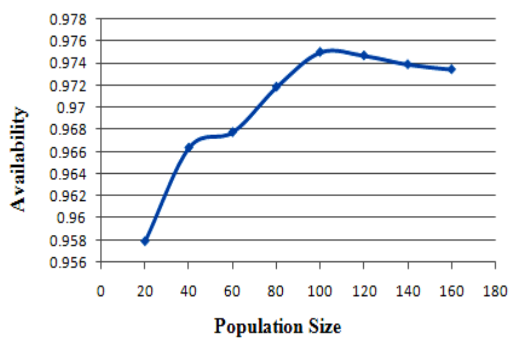

Figure 4. Effect of population size on the availability of skim milk powder system

TABLE 5. Comparison in steady state availability and optimized availability using genetic algorithm

System	Steady state availability	Optimized availability using genetic algorithm
Milk skim powder unit	92.82% λ_7=0.00007, μ_7=0.009, λ_8=0.008, μ_8=0.55, λ_9=0.008, μ_9=0.05, λ_{10}=0.005, μ_{10}=0.08, λ_{11}=0.00009, μ_{11}=0.008, λ_{12}=0.005, λ_{13}=0.0002	97.52% λ_7 = 0.00007, μ_7 = 0.0449, λ_8 = 0.008, μ_8 = 0.5461, λ_9 = 0.0008, μ_9 = 0.2448, λ_{10} = 0.005, μ_{10} = 0. 3989, $\lambda_{11=}$ 0.00012, μ_{11}=0.029, λ_{12} = 0.005, λ_{13} = 0.0002

6. CONCLUSION

The mathematical formulation has been carried out using probabilistic approach and Markov birth–death process is used to develop the system performance model in terms of availability expression. Then, the system availability of the skim milk powder unit is being optimized in the paper. The derived results from the analysis were discussed with plant management and found to be useful for the management in the following ways:

- The steady state availability can be determined at any instant for different combinations of failure and repair rates of each subsystem taken from maintenance history sheets.
- The optimized availability value comes out to be 97.52% by selecting various feasible values of failure and repair rates. The selected values of these parameters must be maintained by the plant management.
- The corresponding failure rates can be maintained by using redundancy, scheduled preventive maintenance and good inherent design etc.
- The optimal repair rates can be achieved by enhancing the skill of maintenance personnel through training, employing sufficient workers and motivating them to attain the target.
- The availability has been increased by 10.95% using G. A. This implies that mean time between failures of the unit has been increased from 339 days to 356 days.
- The effect of number of generation and population size on unit availability is also discussed in the paper.
- The comparision between steady state availability and optimized availability using G. A. is shown in Table 5.

The major implication lies in the fact that the failure and repair rates are assumed to be constant which follow the exponential distribution in order to simplify the problems.

7. ACKNOWLEDGEMENT

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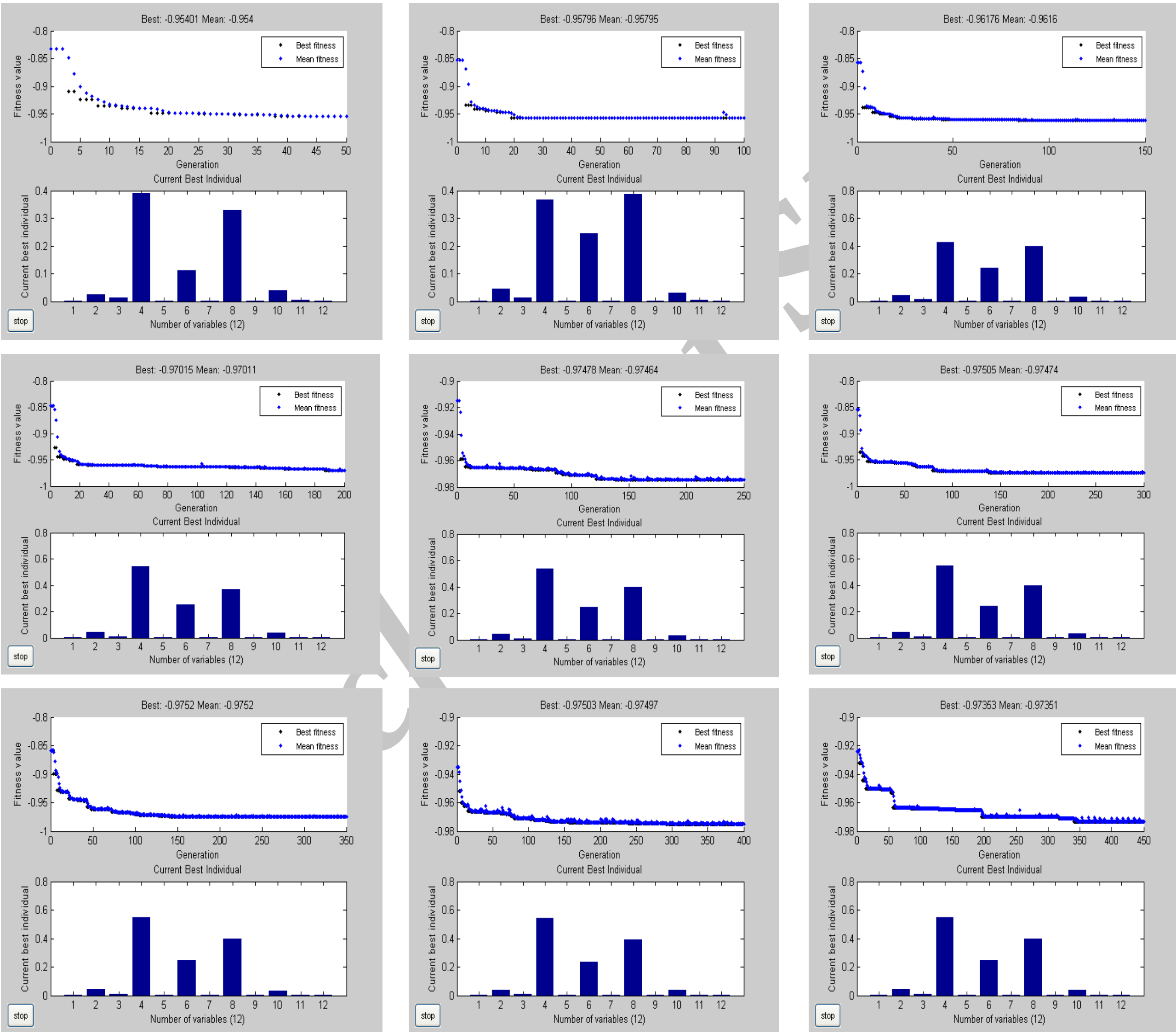
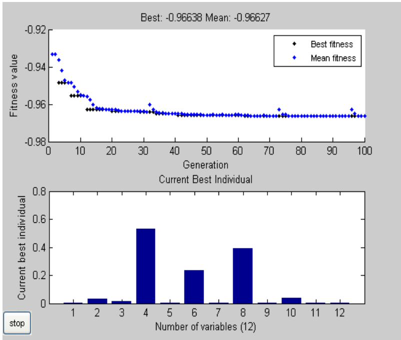
APPENDIXES

Effect of number of generations on the availability of skim milk powder unit



Effect of population size on the availability of skim milk powder unit



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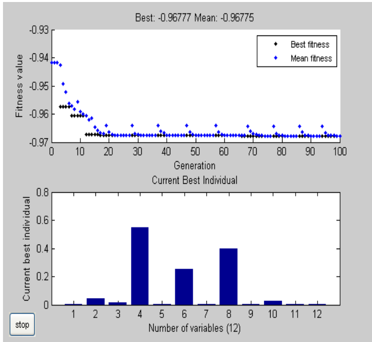

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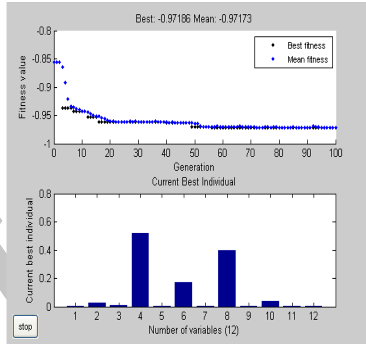

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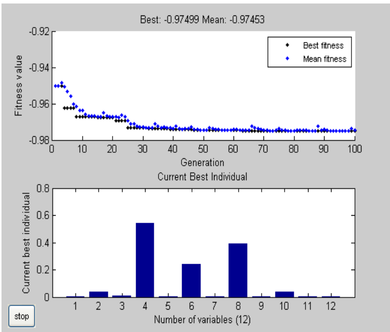

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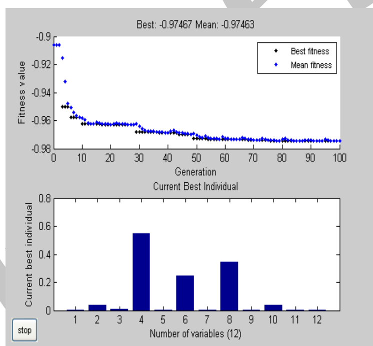

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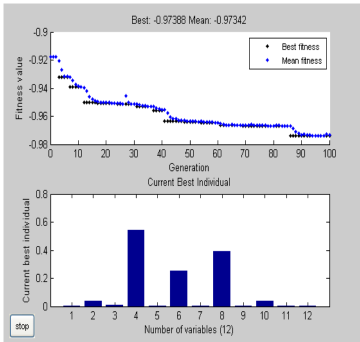
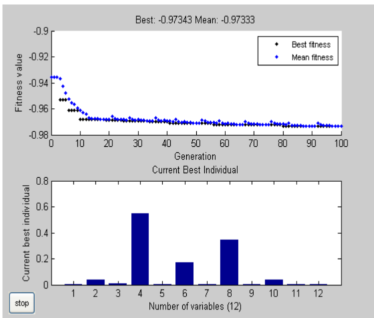


Population Size =140



Population Size =160

Performance Optimization for Skim Milk Powder Unit of a Dairy Plant Using Genetic Algorithm

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چکیده

این مقاله، بهینه سازی عملکرد واحد شیر خشک بدون چربی از کارخانه های لبنی با استفاده از الگوریتم ژنتیک (G. A.) در موسسه ملی تحقیقات لبنی (N.D.R.I) را مورد بررسی قرار می دهد. کارخانه به بخش های زیادی از جمله واحد بازاریابی، واحد تغلیظ و خشک کردن، واحد پنیر و کره، واحد کنترل کیفیت، واحد پودر شیر و واحد بسته بندی تقسیم می شود. واحد پودر شیر بدون چربی، شامل شش زیر مجموعه است. نرخ شکست و ترمیم از این زیر مجموعه ها از تاریخ های تعمیر و نگهداری که به دنبال توزیع نمایی گرفته شده است تبعیت می کند. به منظور توسعه تفاوت معادلات دیفرانسیل، فرمول ریاضی با استفاده از روش احتمالاتی و تولد مارکف – فرآیند مرگ به دست می آید. این معادلات با استفاده از شرایط عادی حل شد تا فرموله کردن شرایط پایدار تدوین گردد. نتایج بهینه نرخ شکست / تعمیر هر یک از زیر مجموعه های واحد شیر خشک بدون چربی با استفاده از نرم افزار MATLAB 7.1 و ابزار الگوریتم ژنتیک مورد بررسی قرار گرفته است. شرایط پایدار به دست آمده از تجزیه و تحلیل مارکف نیز با در دسترس بودن بهینه محاسبه شده از طریق ابزار G.A. مقایسه شده است. بنابراین، یافته های این مقاله برای مدیریت کارخانه و توسعه استراتژی های نگهداری مناسب بسیار مفید می باشد و موجب افزایش عملکرد سیستم می گردد.

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