International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.iaurasht.ac.ir
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)
Case Report

Production Planning Optimization Using Genetic Algorithm and Particle Swarm Optimization (Case Study: Soofi Tea Factory)

***Mansour Soofi* [1*] *and Maryam Mohseni* [2]**

Received: 09 November 2016,
Accepted: 05 September 2017

Abstract

Production planning includes complex topics of production and operation management that according to expansion of decision-making methods, have been considerably developed. Nowadays, managers use innovative approaches to solving problems of production planning. Given that the production plan is a type of prediction, models should be such that the slightest deviation from their reality. In order to minimize deviations from the values stated in the tea industry, two Particle Swarm optimization algorithm and genetic algorithm were used to solve the model. The data were obtained through interviews with Securities and Exchange Organization and those in financial units, industrial, commercial, and production. The results indicated the superiority of birds swarm optimization algorithm in the tea industry.

Keywords:
production planning, Genetic algorithm, Particle Swarm Optimization Algorithm, Securities and Exchange Organization

[1] *Department of Industrial Management, Rasht Branch, Islamic Azad University, Rasht, Iran*
[2] *PhD in Industrial Management, Tehran University*
** Corresponding author's email: msoufi@aol.com*

INTRODUCTION

One of the most important tasks of production management is production planning. Good planning can make the company competitive in a strategic position. Production planning, one of the principal duties of managers, aims to meet the demand for the product on the market in the shortest time and lowest cost. Operations management tries to achieve the organization's goals with the aim of minimizing the cost of production, without compromising other goals such as product quality (Vonderembse & White, 2014). Today, managers tend to have flexible organizations consistent with the accelerating changes in market demand and to reduce production costs, improve the quality of products or services, promote innovation and risk-taking is so important (Pavão & Ravagnani, 2016). Of course, to achieve these goals, managers must make decisions in areas such as production, warehousing, and levels in the workforce. To this end, managers who designed appropriate mathematical models, according to good demands such as reducing production costs and increasing the quality of products, can find appropriate decision variable set by finding an optimal solution to this model (Braune et al., 2000).

In production planning, it can be recognized how much production is needed in each course of planning to meet the demand for the goods. Planning methods that are used to solve production issues have changed due to improvements in operation research techniques. Classical and traditional optimization methods, long used in solving optimization problems, have been unsuccessful in solving complex problems, because they cannot solve problems with complex variables and objective functions. The managers are currently facing various goals for the future where these goals are not compatible with each other (Fatemi Qomi, 2004). Accordingly, nowadays, managers use heuristic methods to solve production planning problems where these methods aim to look for very justified answers. These include repetitive algorithms that any iteration includes the search for better answers that is better than the previous answer (Zha et al., 2016). It should be noted that the majority of companies still rely on the knowledge and experience of their experts for production planning and modeling, as well optimization of production planning. We should also know that optimization of any factory depends on the characteristics, needs, and constraints of the production system. In other words, optimization goals in each factory may vary from one factory to another and can include a variety of maximization or minimization (Naima et al., 2015).

The tea industry, like other industries, is faced with more objectives and constraints and its process is composed of many steps and a variety of stations. For this reason, to use the maximum capacity of machines and manpower, accurate production planning is needed. To have appropriate production program to meet fluctuations in demand in the tea industry, it is necessary to provide a snapshot of conditions for tea production in our model. This research trying to find a suitable mathematical model for Soofi Tea Factory to optimize production planning, determining the type and amount of product mix and production plan tailored to meet seasonal fluctuations in demand in the factory. For this purpose, a suitable model, due to limitations faced by factories, is introduced for tea industry using the production planning techniques and then using ideal planning and advanced techniques of operations research (Genetic Algorithm and Particle Swarm Optimization), the designed model is solved; and by these techniques, the optimal solution, that is the optimal amount of output per workstation and normal and overtime hours that they work per month within the industrial company Soofi Tea is obtained, so that all Tea manufacturing companies by slightly change can use the model to plan their production and maximize efficiency.

The model is presented in the form of multi-product, multi-stage, and multi-period production planning system which contains two target functions: the first function is to reduce the cost of company that in this study are non-linear. As mentioned earlier, it is better to use modeling to optimize production planning to overcome the

[1] *Recently, a fourth dimension has been added:– the institutional dimension of development*

modern change. Of course, finding the optimal point in the case when faced with a complex model is not easy. In fact, classical and traditional optimization methods have long been used to solve optimization problems; however, they have failed in solving complex problems. Because they have not the ability to obtain the global optimal point in optimization problems with high variables and complex target functions and to solve this problem, give us only one local optimum point. Most classical optimization methods use gradient or higher-order derivatives of target function and start from an initial point, gradually the answer found has been improved in ascending or descending order. In the gradient methods, local minimum risk of exposure is high (Modares, 2013). One of the ways to overcome this problem is to use intelligent population optimization methods such as genetic algorithms and Particle Swarm Optimization method that are designed to find the global optimal solution to complex problems. Production planning is to determine production targets for a period of time in the future that is called the planning horizon as well as optimal use of resources to meet the specified requirements (Wang et al., 2015). The purpose of production planning is to plan and arrange the order sequence based on strategic objectives and the actual conditions of the manufacturing plant. Production planning attempts to improve the material flow and efficient use of machinery in its production and includes different management goals such as reducing work in process, lead times and costs, as well as improving responsiveness to fluctuations in demand (Zolghadri et al., 2008). In some manufacturing units, the production process is such that the final product must pass several stages of production to complete. The sequence of production steps leads the input provide to each stage of previous output.

Goal programming was first created in 1960 by Charnes and Cooper and is employed by Lee in production planning in 1973. Lee pointed out that goal programming models allow disparate variables to be collected in a single objective function. The main problem of production planning is fluctuating demand over time. Fluctuations in product demand to be answered by adopting different strategies, such as changing the speed of production, changes in labor, overtime or negligence, side contract and change the warehouse level. So far several methods is used to solve such problems including the decision search programming and linear programming method, but these methods are not widely used in industry. The main reason for this is that these models greatly simplifying the fact and leaves no room to impose manager tastes or method to solve problems. In addition, solving production planning problem by any of the above methods involve actual items production costs, staffing and storage that access to real values of these costs is very difficult. Because most of these cost are not linear and are in grade two and above and they are not simple estimate. Since the objective function of each of the above methods has cost structure, perhaps the use of excessive approximation cause that the answer obtained is not be reasonable, although it may be optimized for used model. Each comprehensive production planning issue is trying to determine the optimal production staffing levels and warehouse, so that at the least cost to meet demand over the planning horizon. The main problem in determining these values is to contrast of the three targets (production, human resources, and warehouse) together. That means access to each of Purposes undermines other purposes.

Therefore, the above objectives cannot be gathered in a single objective function, such as would be used in linear programming. On the other hand, often for any of these purposes, certain amount to be levied by managers which makes full access is not possible yet with goals. Therefore the problem in terms of the above models is impossible. This problem can be solved by using goal programming models. In addition, it must be said that the three causes of the goal programming method to solve problems of production planning is recommended, 1) Non-retractable objectives, 2) Fluctuating demand and, 3) Lack of access to the real cost items. In goal programming, unwanted deviations from target values set by the decision making can be minimized in order to reach an acceptable solution. Unwanted distortions measured by positive and negative deviation variables that are defined for every goal. They show the supra and infra achieve to any goal (Liu, et al., 2016). Genetic Algorithm that highly influenced with natural phenomena had been provided by Charles Darwin in the mid-19th century (Nunez-Letamendia, 2015). Genetic algorithms first introduced by John Holland in 1962, then Goldberg expanded it in 1986 (Yand & Chiang, 1996). Due to the high potential in solving complex optimization problems much attention has been paid (Mitchell, 1996). In genetic algorithms, each chromosome represents a point in the search space and a possible solution to the problem. Chromosomes itself (solutions) are formed of a fixed number of genes (variable). Set of chromosomes make up a colony. With the impact of genetic operators on each population, the new population is formed of the same number of chromosomes. Steps of genetic algorithm can be stated as follows:

1. The initial population is composed of people who are usually randomly selected.
2. Current population estimates are based on the relative fitness.
3. If the final criterion that is considered to be meets, the ultimate solution is selected.
4. The new population is created based genetic operators.
5. Actions are repeated from step 2 again and until the end criterion is met, the repetition is continued (Asgarpour Khansary & Hallaji Sani, 2014).

Genetic Algorithm uses two different genetic operator named cutting (link) and mutation that the main operator in genetic algorithm is cutting action. This operator, by combining the two chromosomes as their parents creates two new chromosomes as children which are somewhat similar in terms of specifications to parents and inherit the properties of both. Through this inheritance is that the gradual evolution arises ultimately. The population will be modified over time. It should be noted that interbreeding usually does not apply on all chromosome pairs selected for crossover. Usually the probability of crossover is considered for each chromosome pair within 0.6 to 0.95. This number is called crossover rate or crossover probability. But the mutation operator create a sudden or random change on some of genes or chromosomes that cause firstly, the likelihood of algorithm engaging in a locally optimal would be less and secondly, new areas is search and new chromosomes are added to the cycle. The possibility of mutation action on each chromosome is called mutation rate mutation or mutations probability. Usually this number is considered very small (0.001) (Kuo et al., 2012).

To select members of the next generation from among the members of the current generation and offspring from operators, several selection methods have been proposed. The main idea in the selection methods is that good people prefer on bad people where the best and worst of people defined by the fitness function f.

In the present study, tournament method is used to select. In this way a few chromosomes are randomly selected and the best of them will go to the next generation (Depending on the size of the tournament, which is usually between 2 to 7). This work will continue to evolve the next generation. The number of chromosomes that are randomly selected called tournament size. Usually two people are randomly selected from the population. Then a random number r is chosen between 0 and 1. If $r < k$ (where k is a parameter, for example, 0.75), a more fitness person, and otherwise less fit person to be elected as a parent. The two then returned to the initial population and again place in the selection process (Liu et al., 2016). Usually, different stop criteria are considered to stopping the algorithm. For example, the end time of the algorithm, or the number of algorithm iteration are examples of the algorithm stop criteria.

Particle Swarm Optimization method (PSO) is one of the most recent population-based search methods (Giftson & Rajan, 2015). In PSO, each member of a community called a particle. These particles all are floating in multidimensional space and moving based on the exchange of information with other members. Change the position of each particle is based on his experience and knowledge and its neighbors. Thus, the particle in the search space is floating and moving. And while movement of particles, each of them during the way movement store a memory of their best value and its position. From now, Xi (t) is used to show the position of the particle Pi at time t.

In PSO, the best value and position of each particle is stored in the variable ip best and best position of the particles in all the repetitions stored on ig best (Kennedy, 1997). The new move of particles takes place based on the resultant p best i (The past experience of each particle) and g best (best past experience of all the particles) in the previous moving direction of particles (Mansour et al., 2008).

MATERIALS AND METHODS

The mathematical model designed for this study is called goal programming model. The model consists of 276 decision variables; two objectives functions that include minimizing the cost and maximizing sales; six categories of restrictions including restrictions on cars production capacity (indicating that each machine cannot produce more than its capacity), balancing limits (to create effective communication between the lines that in this limits the amount of each product at each station is balance with the required amount of it to product in the next step), demand restrictions (storage of one product in one specified month equal to the product storage in the previous month as well as production of that product in that month minus the projected demand for that product per month), restrictions of overtime hours and normal hours of work (number of hours that people work in the area that the company has set), restrictions of the number of people who work extra hours (the number of people who work extra hours cannot exceed the number of people in the factory) and restrictions of the amount of inventory (the amount of inventory that must be kept in stock cannot exceed the limit that has been set for it). To build capacity constraints and the balance, the production process should be considered and then presented the respective constraints for each station. The production process is shown in Figure 1.

In such systems of production, a balance between the various stages of the production sequence is very important (Jewski & Ritzman, 2001).

$$\min z = \sum_{k=1}^{k}\sum_{i=1}^{m}\sum_{j=1}^{n}\left[C_{ijk} X_{ijk}\right]$$

St:

$$\sum_{i=1}^{m}\sum_{k=1}^{k}\left[a_{ijkl} x_{ijk} \le b_{jl}\right] \quad (l=1, 2, \ldots, l)\ (j=1, 2, \ldots, n)$$

$$\sum_{k=1}^{k} X_{ijk} = \sum_{k=1}^{k} X_{i,j+1,k} \quad (i=1, 2, \ldots, m)\ (j=1, 2, \ldots, n-1)$$

$$\sum_{k=1}^{k} X_{imk} = Di \qquad i=1, 2, ..m$$

All variables≥0

where:

X_{ijk}: Product *i* which by the method *k* make in *j* stage

$a_{ijk\,l}$: The amount of product consumption *i* by method *k* in the process *j* in material balance stage 1

b_{jl}: amount of raw material 1 in the process *j*

k: Production methods.

The overall goal programming model is as follows.

$$Min \sum_{k=1}^{q}\sum_{i=1}^{m} P_k (d^-{}_i + d^+{}_i)$$

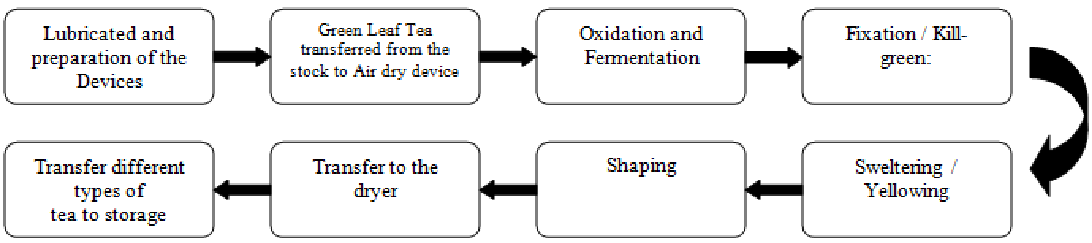

Figure 1. The production process in Soofi Tea Factory.

St:

$$\sum_{j=1}^{n} C_{ij} X_j + d^-_i + d^+_i = b_i \quad (J=1,2,\ldots,n)(I=1,2,\ldots,m)$$

$$\sum_{j=1}^{n} a_{rj} x_j \leq b'_r \quad (r=0,1,2,\ldots,s)\ (j=1,2,\ldots,n)$$

cXj , di+ , di- ≥0

X_j: Model decision variables that can adopt any non-negative number

D_i^+, d_i^-: Show Positive and negative deviations from the ideal variables

B_i: Express the right number or level of desire of its goal i

P_n: specifies the kth priorities (k=1,2, ..., N)of goal.

A_{rj}: Provides technical coefficients of the model

C_{ij}: Coefficients of the decision variables

b_r: The right numbers of functional limitations

To implement a fitness-proportionate selection, several sampling methods have been proposed such as roulette wheel. Fitness or the selection probability of each chromosome is calculated as follows:

$$P_k = \frac{f_k}{\sum_{j=1}^{pop-size} f_j}$$

where $f j$, is the value of chromosomes matching function.

The particles movement rate i is defined as follows:

$$\vec{v}_i(t) = \vec{x}_i(t) - \vec{x}_i(t-1)$$

The following steps are to be taken when employing the Particle Swarm Optimization method: (Karimi et al., 2010)

1. Choose the initial population (population of particles are randomly selected in the search space).

2. Calculate the value of particles using its present position (for every particles, its value is obtain according to the criterion function).

3. Compare the present value of the particles and best experience and the following conditional Green Leaf Tea ((In fact, the value of each particle compared with pi besti and if it's current value is pi pest, we replace the value of the current position by p best I and the position related it). If f (pi)≥ p best I , then:

$f(p_i)=p\ best_i$ (A

$p\ best_i = \vec{X}_I(t)$ (B

4. Compare the current value of each particle with the best previous experience on all Population particles and Green Leaf Tea of below: (In fact, the value of each particle compared with g besti and if the particles value is more than g besti, we replace the value of the position by g besti and the position related it). If f (pi) ≥ gi best, then:

$f(p_i)=p\ best_i$ (A

$g\ best_I = \vec{X}i(t)$ (B

5. Change the speed of the particles according to the following equation:

$$\vec{v}_i = \vec{v}i(t-1) + \rho 1\ (\vec{x}pbest_i - \vec{x}_i(t)) + \rho 2\ (\vec{x}gbest_i - \vec{x}_i(t))$$

where ρ_1 and ρ_2 are positive random numbers.

6. Move the particle to its new position

$$X_i(t) = \vec{x}_i(t-1) + \vec{v}_i(t)$$

7. Go to step 2 and repeat algorithm until convergence.

Decision variables

f_1: Values greater than the cost of products specified in October

f_2: Values greater than the cost of products specified in November

f_3: Values greater than the cost of products specified in December

f_4: Values greater than the cost of products specified in January

f_5: Values greater than the cost of products specified in February

f_6: Values greater than the cost of products specified in March

h_1: Values less than the sale of products specified in October

h_2: Values less than the sale of products specified in November

h_3: Values less than the sale of products specified in December

h_4: Values less than the sale of products specified in January

h_5: Values less than the sale of products specified in February

h_6: Values less than the sale of products specified in March

PC_{1ijt}: Oxidation and fermentation Tea that is generated in the band i with difficulty j in period t.

$PC2_{ijt}$: Product that is generated in the Fixation i with difficulty j in period t.

Ip_{tt}: The Green Leaf Tea that is stored in the warehouse of raw materials in band during the period t.

RM_{jt}: The oxidation Tea produced with difficulty j in period t.

RS_t: Oxidation Tea amount stored in the period t

Iot: The Natural flavors of tea is stored in the intermediate product warehouse in period t.

CM_{ijt}: The amount of tea which are produced by the mill i with the genus j in period t.

ZL_t: The additives for production in the period t

Il_t: The amount of tea stored in the period t in the warehouse number one.

IM_t: The amount of tea stored in the period t in the warehouse numbers two.

IS_t: The amount of tea stored in the period t in the warehouse number three.

S_{ijt}: The amount of tea are ready to sell from the final station with a label i with genus j in period t.

N_t: Normal hours of work per worker in period t

L_t: Number of employees who work extra hours during t

M_t: The number of hours of overtime work per worker in period t

IS_{ijt}: The final balance of the tea with label i and genus j in period t.

Model parameters

The model parameters include projected demand of different products according to the type of material and the period of maximum-band capacity and the efficiency of various devices and the beginning inventory of products with label i for genus j in period t. Goals amount of sales and the cost of the salary of regular working hours, overtime, the cost of one square meter warehousing product, the number of workers who work in overtime; minimum number of normal working hours and the maximum and minimum number of overtime hours per worker and the selling price and cost of production per Kg of product.

$C.cap1_{ijt}$: The maximum capacity of the circling to dry i to produce a production with difficulty j in period t.

$M.cap2_{ijt}$: The maximum capacity of each Oxidation and Fermentation device i to produce a production with difficulty j in period t.

$I.cap_t$: The maximum capacity of Green Leaf Tea warehouse to store raw materials crushed in the period t.

$RM.cap_{jt}$: The maximum capacity of the Oxidation and Fermentation batching machine to produce a production with difficulty j in period t.

$IO.cap_t$: The maximum capacity of the central warehouse to store the Shaping Tea in band in the period t.

$RS.cap_t$: Maximum capacity of the form in period t.

$K.cap_t$: The maximum capacity of the roasting i to produce a production with degree j in period t.

$CM.cap_{ijtt}$: The maximum capacity of Oxidation and Fermentation device to produce a production with degree j in period t.

$IL.cap_t$: The maximum capacity of the device number one to shaping tea in period t.

$IM.cap_t$: The maximum capacity of the device number two to shaping tea in period t.

$IS.cap_t$: The maximum capacity of the device number three to shaping tea in period t.

$S.cap_{ijt}$: The maximum capacity of the selling station of products with devices i with genus j in period t.

$N_{t\,min}$: Normal minimum number of hours each employee works in period t

$N_{t\,max}$: Normal maximum number of hours each employee works in period t

$L_{t\,max}$: Maximum employees who work in period t

$M_{t\,max}$: Maximum hours that each worker has overtime in the period t

$M_{t\,min}$: Minimum hours that each worker has overtime in the period t

IS_{ijt-1}: The amount of tea inventory with label i and genus j at the beginning of the first month.

D_{ijt}: The demand for teas with label i and genus j in period t.

C_{ijt}: The cost of one Kg tea with label i and genus j in period t.

P_{ijt}: Sale price of Kg products with label i and genus j in period t.

C_{RL}: The cost of one normal work hours per worker in period t

C_{RO}: The cost of one hour of overtime per worker in period t.

C_{IO}: The cost of inventory per square meter products in the period t.

gt: The goal set for maximizing sales revenue.

%X: The efficiency of Oxidation and fermentation unit

%Y: Efficiency of shaping devices

%A: Tea percent

% (1-A): % of additives

The mathematical model

$$Z1\,t = \sum_{i=1}^{m}\sum_{j=1}^{n} S\,ijt * C\,ijt + \sum_{t=1}^{t}(L\,tmax * N\,t * C\,rl) + \sum_{t=1}^{t}(M\,t * L\,t * C\,ro) + \sum_{i=1}^{m}\sum_{j=1}^{n}(IS\,ijt + S\,ijt - D\,ijt) * C\,io \le C\,t \quad (1)$$

$$Z2t = \sum_{i=1}^{m}\sum_{j=1}^{n}(P\,ijt * S\,ijt) \ge g\,t \quad (2)$$

N t min ≤ N t ≤ N t max (3)

L t ≤ L tmax (4)

S ijt + IS ijt-1 - Isijt ≥ D ijt (5)

M tmin ≤ M t ≤ M t max (6)

PC 1ijt ≤ C.cap 1ijt (7)

PC 2ijt ≤ C.cap 2ijt (8)

IP t ≤ I.cap t (9)

RM jt ≤ RM.cap jt (10)

RS t ≤ RS.cap t (11)

K ijt ≤ K.cap ijt (12)

IO t ≤ IO.cap t (13)

CM ijt ≤ CM.cap ijt (14)

IL t ≤ IL.cap t (15)

IM t ≤ IM.cap t (16)

IS t ≤ IS.cap t (17)

S ≤ S.cap ijt (18)

$$\sum_{i=1}^{m}\sum_{j=1}^{n} PC\,1ijt + \sum_{i=1}^{h}\sum_{j=1}^{n} PC\,2ijt = IP\,t \quad (19)$$

$$\sum_{j=1}^{n} RM\,jt = IP\,t \quad (20)$$

$$\%X \sum_{j=1}^{n} RM\,jt = RS\,t \quad (21)$$

$$RSt = \sum_{i=1}^{m}\sum_{j=1}^{n} K\,ijt \quad (22)$$

$$\%A[IO\,t] + (1 - \%A)(ZLt) = \sum_{i=1}^{m}\sum_{j=1}^{n} CM\,ijt \quad (23)$$

$$\%y \sum_{i=1}^{m}\sum_{j=1}^{n} K\,ijt = IO\,t \quad (24)$$

$$\sum_{i=1}^{m-2}\sum_{j=1}^{n} CM\,ijt = IL\,t \quad (25)$$

$$\sum_{i=m-1}^{m-1}\sum_{j=1}^{n} CM\,ijt = IM\,t \quad (26)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} CM\,ijt = IS\,t \quad (27)$$

$$IL\,t + IM\,t + IS\,t = \sum_{i=1}^{m}\sum_{j=1}^{n} S\,ijt \quad (28)$$

As mentioned, the study aimed to satisfied two objectives: Reducing costs and increasing sales that two equations (1) and (2) in the above model reflects the two objectives functions. Thus, the (1) relate to 4 group of cost includes cost of production, normal wage labor costs, the cost of overtime wage and factory storage cost and Ct represents the goal cost. Equation (2) is also refer to the second goal, that is the proceeds from the sale of tea products and gt refers to goal sale. Equation (3) ensures that normal hours of labor in the factory does not exceed from less than the minimum working hours and the maximum working hours.

Equation (5) ensures that labor overtime hours in the factory does not exceed from less than the minimum overtime hours and the maximum overtime hours. As equation (6) suggests, the amount of a product inventory in the previous month in addition to the amount of product in that month minus the amount of inventory in that month must be greater than anticipated demand for the product on the same month. Equation (7) indicates the capacity constraints of Oxidation and fermentation device and equation (8) indicates the form capacity constraints and ensures that the product produced by the mold for a given period and certain hardness cannot exceed the maximum capacity of Fixation / Kill-green devices. Equation (9) refers to raw material storage capacity constraints.

Equation (19) means that the products of different machines in the first station are equal to the input to the warehouse of Green Leaf Teas. Equation (10) states that the prepared oxidation Tea should not exceed the maximum amount of Fixation / Kill-green devices to produce production. Equation (20) means that the input Green Leaf Tea to oxidation Tea construction equipment is equal to the amount of material in the warehouse for raw materials. According to equation (11) the amount of material stored in each period cannot exceed the maximum capacity of vibrating table. Equation (21) means the amount of input material in the silo of raw materials is equal to manufactured products from raw mill minus waste moisture produced by the grinding of raw materials. The main part takes place when drying that according to (12) the product is not more than the maximum capacity of the Fixation / Kill-green devices.

Equation (22) indicates that total powdered material stored in the silo of raw materials is equal to imported materials to oxidation Tea machine building. This means that all materials go from silo of raw materials into the devices. Equation (13) ensures that the additive that is stored in the intermediate products stock in each period does not exceed the maximum storage capacity. Equation (24) states that all materials that are inserted into the machine is not converted into oxidation Tea, but depends to station efficiency (% y); So, the material leaves the device to the next round is not equal to the material inserted into the machine. Equation (13) refers to the limited capacity of oxidation tea shaping for the production. According to equation (23), a percentage of additives are added to the tea that is removed from the device to achieve oxidation tea in the next step. Equations (15), (16) and (17) refers o the limited capacity of three Oxidation Tea silos. And according to the equation (25), (26) and (27), all products will be imported to the warehouse where they are stored. Equation (19) refers to labels of produced oxidation Tea and limited capacity to a certain degree production. Equation (28) means that all products go to sales station.

RESULTS

After making the appropriate model, decision maker can act on any kind of experience and applied it. As described earlier, the present study with the help of Genetic Algorithm and Particle Swarm simulation algorithm sought to solve the proposed mathematical model. In the first step, the basic parameters of the algorithm should be determined. In Particle Swarm simulation algorithm, each particle is a potential answer. As such, each particle has 276 decision variables. In addition, in genetic algorithms, every chromosome is a potential answer that has 276 decision variables. Accordingly, the search space in each of these two algorithms will have 276 dimensions. In the studied factory, as mentioned the value of all objective function to manage all the same and rate the weighted factor for both functions is considered one. In the optimization model in genetic algorithm,

Table 1
Parameters of Genetic Algorithm

Parameters	Value
Mutation rate	0.1
Crossover rate	0.8
Initial population size	40
Number of generations	100

Table 2
PSO algorithm parameters

Parameters	Value
Number of particles	40
Number of generations	100
Acceleration coefficient g best (c2)	2
Acceleration coefficient p best (c1)	2

the extended sampling space is considered and selection method is tournament. Basic parameters of GA and PSO are shown in Tables 1 and 2.

Moreover, r1 and r2 random numbers in the period [0, 1] and , the inertia weight decreases linearly during the iterations of the algorithm. In the beginning, is considered equal to 1 and finally can reach 0.5 with trial and error to achieve better results (Soleimani & Kannan, 2014). Next, by collecting the necessary data from the Soofi Tea Factory and after importing the inputs to the model by the programming software called MATLAB, the obtained model using GA and PSO were solved and the optimum solutions were obtained. The answers of the model include the amount of output per workstation, the number of overtime hours and the normal number of hours that employees work per month and the number of employees who work extra hours per month, end inventory for each product per month, and the deviation rate of the objective functions from the goals assigned to them.

Data collection

It is noteworthy that before entering data and parameters into the model in the present study, the data were obtained through interviews with SEO and those in financial units, industrial, commercial and production. Storage cost per Kg of tea is 1000. The factory has 350 workers at its manufacturing plant in normal time work. The cost of each worker's salary for normal working hours is 2000 and the cost of wages per worker per hour of overtime is 3500.The collected information is shown in Tables 3 to 6.

Table 3
Data on Goals (IRR)

Goal	October	November	December	January	February	March
Cost	2210000000	2200000000	1900000000	1890000000	19650000000	2160000000
Sale	4210000000	4162000000	3580000000	3570000000	3710000000	4130000000

Table 4
Data on the Genus Product and Related Information (IRR)

Teas		cost of per Kg (to IRR)	selling price per Kg (to IRR)	Max inventory of end period (to kg)	Tea stock at the beginning of the first month planning (to kg)
Black	I	25000	50000	0	0
	II	30000	56500	3000	3000
Green	I	26000	51500	0	0
	II	315000	58000	3000	2000
Tea bag	I	25500	51000	0	0
	II	32500	57500	3500	3000

Table 5
Data on Projected Demand for the Next 6 Months (kg)

Tea Type		October	November	December	January	February	March
Black	I	25000	24000	20000	20000	22000	25000
	II	40000	38000	30000	30000	30000	40000
Green	I	4000	3000	3000	3000	4000	3000
	II	3000	2000	2000	2000	3000	3000
Tea bag	I	6000	5000	5000	5000	4000	3000
	II	3000	5000	6000	6000	6000	7000

Table 6
Other Data

	Specifications
Loading Place	Total: 2
	Power loading of Tea in months/ kg: 90000
Green leaf tea stock	Total: 3
	Capacity in kg: 20/180/160
Oxidation tea production	Monthly production capacity in kg: 2000
	For each ton of entries: 600 kg
Additives Stock	Monthly capacity in kg: 90000
	Scrap percentage: 40%
Fixation / Kill-green devices	Total capacity of mold in months: 264000
Number of shaping devices	Total: 12
	Power Monthly: 178000
Green Leaf tea storage	Capacity in Kg/ Month: 528000
Tea	Monthly production power/hours: 800
	Monthly production power/ kg: 70000
	Monthly production power/hours:200
Oxidation tea	Monthly production power/ kg: 40000
	-Additives for oxidation Tea capacity per month: 900000 kg ; Combined ratio: 95%
Products storage	-Capacity of oxidation Tea corrective materials/month: 300000Combined ratio: 5%

The answerers obtained from the model

To solve the problem in two ways Genetic Algorithm and Particle Swarm algorithm, the optimum amount of product on each workstation according to number of machine, genus, as well as tag of product and production rate in different months/Kg can be obtained. Tables 7 and 8 show the values obtained from the algorithm:

The regular working hours overtime and the

Table 7
Optimum Amount of Product in Each Station Using GA (kg)

Production station		Type of genus produce	Production October	Production November	Production December	Production/ January	Production February	Production March
Loading Place	Lot By Lot	Black	25000	24000	20000	20000	22000	25000
		Green	4000	3000	3000	3000	4000	3000
		Tea bag	6000	5000	5000	5000	4000	6000
	Quantity	Black	37000	38000	30010	33480	30000	36500
		Green	3500	2000	2000	1000	1500	3000
		Tea bag	2500	5000	6000	3500	7000	3000
Fixation Tea	Fixation IM1	All three	26000	25670	22010	21990	22830	25500
	Fixation IL2	All three	26000	25670	22010	21990	22830	25500
	Fixation IH3	All three	26000	25670	22010	21990	22830	25500
Shaping	i=1	All three	26010	25680	22020	21990	22830	25500
	i=2	All three	26010	25680	22020	21990	22830	25500
	i=3	All three	26010	25680	22020	21990	22830	25500
Stock intermediate products	i=1	All three	71580	70530	58970	58930	61580	70000
Amendments	i=1	All three	200000	200000	200000	200000	200000	200000
Dryer	i=1	All three	238590	235080	196560	196440	205260	233340
Raw materials Silo	i=1	All three	238600	235090	196560	196430	205260	233330
Raw Mill	i=1	All three	477180	470190	393120	392850	410520	466680
Raw material storage	i=1	All three	477190	470180	393110	392850	410530	466670
Circling 1	i=1	All three	178590	175080	136560	136440	145260	173340
Circling 2	i=2	All three	178590	175080	136560	136440	145260	173340
Additive	i=3	All three	120000	120000	120000	120000	120000	120000

Table 8
Optimum Amount of Product in Each Station Using PSO (kg)

Production station		Type of genus produce	Production October	Production November	Production December	Production/ January	Production February	Production March
Loading Place	Lot By Lot	Black	25000	24000	20000	20000	22000	25000
		Green	4000	3000	3000	3000	4000	3000
		Tea bag	600	5000	5000	5000	4000	6000
	Quantity	Black	37030	38000	30020	33450	30000	36500
		Green	3500	2000	2000	1500	1700	3100
		Tea bag	2500	5020	6080	3400	7000	3000
Fixation Tea	Fixation IM1	All three	26010	25675	22030	22115	22900	25530
	Fixation IL2	All three	26010	25675	22030	22115	22900	25530
	Fixation IH3	All three	26010	25675	22030	22115	22900	25530
Shaping	i=1	All three	26020	25685	22040	22125	22910	25530
	i=2	All three	26020	25685	22040	22125	22910	25530
	i=3	All three	26020	25685	22040	22125	22910	25530
Stock intermediate products	i=1	All three	71610	70580	59070	59240	61820	70094
Amendments	i=1	All three	200000	200000	200000	200000	200000	200000
Dryer	i=1	All three	238690	235270	196900	197800	206070	233650
Raw materials Silo	i=1	All three	238700	235280	196900	197800	206070	233660
Raw Mill	i=1	All three	477380	470540	393800	395600	412150	467300
Raw material storage	i=1	All three	477390	470550	393790	395600	412150	467310
Circling 1	i=1	All three	178695	175275	136895	137800	146070	173655
Circling 2	i=2	All three	178695	175275	136895	137800	146070	173655

Table 9
Number of Hours Worked and the Number of People Who Work Overtime Based on GA

Month	Regular hours	Overtime hours	number of people who work overtime
October	160	50	30
November	150	50	40
December	140	50	30
January	130	50	40
February	130	50	50
March	150	50	30

Table 10
Number of Hours Worked and the Number of People Who Work Overtime Based on PSO

Month	Regular hours	Overtime hours	number of people who work overtime
October	160	50	40
November	150	50	50
December	140	50	40
January	130	50	30
February	130	50	55
March	150	50	40

number of people who work overtime per month in studied plants are expressed in terms of variables and values obtained from using genetic algorithm and Particle Swarm algorithm shown in Tables 9 and 10.

The amount of each product must be in storage per month using Genetic Algorithm and Particle Swarm also shown in tables 11 and 12.

Tables 13 and 14 shows the deviation from the objective functions, each of which has been implemented five times by each of the algorithms. In different performances of the two algorithms, the amount of output per workstation was identical, while the number

Table 11
The Ending Inventory Based on GA (kg)

Month	Ending inventory					
	Black		Green		Tea bag	
	LBL i=1	Q i=2	LBL i=1	Q i=2	LBL i=1	Q i=2
October	0	0	0	2500	0	2500
November	0	0	0	2500	0	2500
December	0	20	0	2500	0	2500
January	0	3500	0	1500	0	0
February	0	3500	0	0	0	0
March	0	0	0	0	0	0

Table 12
The Ending Inventory Based on PSO (kg)

Month	Ending inventory					
	Black		Green		Tea bag	
	LBL i=1	Q i=2	LBL i=1	Q i=2	LBL i=1	Q i=2
October	0	30	0	2500	0	2500
November	0	30	0	2500	0	2520
December	0	50	0	2500	0	2600
January	0	3500	0	2000	0	0
February	0	3500	0	700	0	0
March	0	0	0	800	0	0

Table 13
The Deviations from GA with the Population Size 40

Performance	1	2	3	4	5
f1	1540000	6085000	34055000	6733000	4343000
f2	1266000	43698000	40000	27150000	37340000
f3	67526000	25256000	55888000	26525000	9921000
f4	5246000	17728000	5809000	22231000	28446000
f5	54050000	8435000	290000	33369000	12890000
f6	2540000	26258000	2540000	891000	11991000
h1	10750000	10750000	10750000	10750000	10750000
h2	2000000	2000000	2000000	2000000	2000000
h3	13441000	13441000	13441000	13441000	13441000
h4	9559000	9559000	9559000	9559000	9559000
h5	15500000	15500000	15500000	15500000	15500000
h6	10750000	10750000	750000	750000	750000
F	194168000	177180000	160622000	186918000	186931000

of overtime hours, the number of regular working hours and the number of designated people were fixed. Because the changes of overtime hours, regular hours, and the number of people work overtime per month affect only the costs objective function and will not affect the sales objective function.

The model was aimed at reducing the total distortions. According to the results that have been obtained by PSO, whole unwanted deviations from target values set by the experts participating in PSO is less than when the model is solved using GA. And from this, it can be concluded that the results obtained from of PSO are better than the ones that can be achieved by GA.

Table 13
The Deviations from PSO with the Population Size 40

Performance	1	2	3	4	5
f1	2440000	4194000	2440000	20940000	3443000
f2	690000	5895000	690000	42320000	56690000
f3	7021000	7021000	54601000	7021000	7021000
f4	16846000	16846000	25267000	16846000	16846000
f5	6590000	6590000	6590000	6590000	6590000
f6	49075000	5690000	5690000	8840000	5691000
h1	9055000	9055000	9055000	9055000	9055000
h2	850000	850000	850000	850000	850000
h3	8276000	8276000	8276000	8276000	8276000
h4	50000	50000	50000	50000	50000
h5	3900000	3900000	3900000	3900000	3900000
h6	4950000	4950000	4950000	4950000	4950000
F	109743000	73317000	122359000	129638000	123362000

CONCLUSION

According to the results and outputs of the model by the Genetic Algorithm and Particle Swarm optimization algorithm, it can be contended that the production rate by PSO is higher than that of GA. As we know, organizations are trying to produce more to gain further profit. In the answer obtained from Genetic Algorithm and Particle Swarm Optimization Algorithm (see Table 7), the total products that achieved in sales within the six months that the organization is planning using genetic algorithms is 433 990 (the sum of all values in station sales) and using Particle Swarm Optimization Algorithm is 434 800 (Table 8). This amount associated with an increase of 810 Kg of tea than to use genetic algorithms. Also compared to tables 7 and 8, it can be seen that the production in other production stations is more obtained by PSO algorithm. This means that the production stations capacity more used. As such, given that in any organization, management aims to increase production in view of the costs, we can argue that the answer obtained from birds swarm optimization algorithm is better than the one obtained from the genetic algorithm.

Moreover, given that the objective function in our model is to reduce the sum of cost and sales revenue deviations, in comparison to Table 13 and 14, it can be argued that the total target deviation (cost and sales revenue) in the values specified in Genetic Algorithm is higher in amount compared to Particle Swarm algorithm. According to what was explained it can be concluded that particle Swarm Optimization algorithm performance is better than genetic algorithm, and by using it, more satisfactory results can be achieved.

Given the results of the model using GA, the company is able to produce 433990Kg in 6 months for which production planning has taken place and launch it to the consumer market for sales. This amount is compared to the company's present production that is 367 788 Kg, which has increased to 18% over six months. It can, then, be contended that the obtained results from GA are satisfactory. On the other hand, according to the results yielded by the model, the company is able to produce 434800Kg in 6 months for which production planning has taken place and launch it to the consumer market for sales using PSO. This amount can be compared to the company's present production, which is 367 788 Kg and shows an increase by 18.2 percent. Values of, f, h, or deviation from the ideals means that the solutions obtained to what extent are different from the ideals set for an object. Values of suggest to what degree the obtained answers are different from the ideal of cost. For example, to solve model using PSO, the amount of 1 is corresponds to obtain 2440000. This number means that the cost obtained for the month of October in 2440000 is more than the ideal cost. The values h also indicated the extent to which the obtained answers are different from the ideal of sales. For example, to solve the model using PSO, the amount of h1 corresponds to 9055000. This number means that the sales revenue obtained for the month October in 9055000 is less than the ideal sales. The values F also represents the total difference in cost goal objective function and ideal sales from objective function. For example, to solve the model using PSO, the amount of F corresponds to obtained109750000. This number means that the total objective function is different from the cost ideals and sales ideals from the objective function is 109750000.

ACKNOWLEDGEMENT

We are thankful to Dr. Alireza Amirteimoori professor in Applied Mathematics and Operations Research, for his scientific comments on this study.

REFRENCES

Asgarpour Khansary, M., Hallaji Sani, A. (2014). Using genetic algorithm (GA) and particle swarm optimization (PSO) methods for determination of interaction parameters in multicomponent systems of liquid-liquid equilibria. *Fluid Phase Equilibria, 365*, 141–145.

Braune, R., Wanger, S., Affenzeller, M. (2000). Applying Genetic Algorithms to the optimization of production planning in a real world manufacturing environment. *Institute of Systems Theory and Simulation Johannes Kepler University, 69*.

Dilworth, J. (1989). *Production and Operation Management, Manufacturing and Non anufacturing*. Fourth Edition. London: Rondan House Inc.

Fatemi Qomi, M.T. (2004). *Planning and inventory control*. Amir Kabir Publications.

Giftson Samuel, G., & Christober Asir Rajan, C. (2015). Hybrid: Particle Swarm Optimization-Genetic Algorithm and Particle Swarm Optimization-Shuffled Frog Leaping Algorithm for long-term generator maintenance scheduling. *International Journal of Electrical Power and Energy Systems, 65*, 432–442.

Jewski, L.J.K., & Ritzman L.P. (2001). *Operation Management*. (Sixth Edit). Newjersy: Prentic Hall.

Karimi, H., Youssef, H., Omar, A. (2010). Adaptive fuzzy APSO based inverse tracking controller with an application DC motor. *Expert System with Application, 36,* 3454–3458.

Kennedy J. (1997). The Particle Swarm: Social Adaptation of knowledge. In *Proceeding of 1997 International Conference on Evolutionary Computing*. IEEE press.

Kuo, R.J., Syu, Y.J., Chen, Z.Y., Tien, F.C. (2012). Integration of particle swarm optimization and genetic algorithm for dynamic clustering. *Information Sciences, 195*, 124–140.

Liu, X., An, H., Wang, L., Lia, X. (2016). An integrated approach to optimize moving average rules in the EUA futures market based on particle swarm optimization and genetic algorithms. *Applied Energy, 185* (2017): 1778-1787.

Mansour, R., Bettayeb, M., Djamah, T., & Djnnoun, S. (2008). Fitting fractional System identification using Particle swarm optimization. *Applied Mathematics and Computation, 510–520*, 510–520.

Mitchell M. (1996). *An introduction to Genetic Algorithms*. MIT Press, Cambrige, MA.

Modares, H. (2013). *Controller design of noise cancellation by active method using algorithm based on particles colony.*

Naima, K., Fadela, B., Imene, C., & Abdelkader, C. (2015). USE of Genitic Algorithm and Particle Swarm Optimisation Methods for the Optimal Control of the Reactive Power in Western Algerian Power System. *Energy Procedia, 74*, 265–272.

Nunez-Letamendia, L. (2015). Fitting the control parameters of a genetic algorithm an application to technical trading systems design. European *Journal of Operational Research, 179*, 179 (847-868). 2007.

Pavão, L., Ravagnani, M. (2016). Heat Exchanger Network Synthesis using a Genetic Algorithms-Particle Swarm Optimization Hybrid Method and Parallel Processing. Computer Aided Chemical Engineering (Vol. 38). Elsevier Masson SAS.

Soleimani, H., Kannan, G. (2014). A hybrid particle swarm optimization and genetic algorithm for closed-loop supply chain network design in large-scale networks. *Applied Mathematical Modelling, 39*(14), 3990–4012.

Vonderembse, M. A., White, G. P. (2014). *Core Concepts of Operations Management.* West Publishing Company.

Wang, Y., Ma, X., Xu, M., Liu, Y., Wang, Y. (2015). Two-echelon logistics distribution region partitioning problem based on a hybrid particle swarm optimization-genetic algorithm. *Expert Systems with Applications, 42*(12), 5019–5031.

Yand, F., & Chiang, H.D. (1996). A Parallel genetic algorithm for generation expansion planning. IEEE Trans. *On Power System, 11*(3), 478–486.

Zha, Y., Liang, N., Wu, M., Bian, Y. (2016). Efficiency evaluation of banks in China: A dynamic two-stage slacks-based measure approach. *Omega, 60,* 60-72.

Zolghadri, M., Oliver, C., Bourriers., J. (2008). Close Optimal Production and Procurement Policy for a X-network of Added Value Using Lexicographic Linear Goal Programming. *Computers and Industrial Engineering, 54*, 821–839.

How to cite this article:

Soofi, M., & Mohseni, M. (2017). Production planning optimization using genetic algorithm and particle swarm optimization (case study: Soofi tea factory). *International Journal of Agricultural Management and Developmen, 7(3), 395-410.*

URL: http://ijamad.iaurasht.ac.ir/article_530260_c1d9cb79551007e80a0d0d2d24122d84.pdf