A two-storage model for deteriorating items with holding cost under inflation and Genetic Algorithms

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***Abstract*— *A deterministic inventory model has been developed for deteriorating items and Genetic Algorithms (GA) having a ramp type demands with the effects of inflation with two-storage facilities. The owned warehouse (OW) has a fixed capacity of W units; the rented warehouse (RW) has unlimited capacity. Here, we assumed that the inventory holding cost in RW is higher than those in OW. Shortages in inventory are allowed and partially backlogged and Genetic Algorithms (GA) it is assumed that the inventory deteriorates over time at a variable deterioration rate. The effect of inflation has also been considered for various costs associated with the inventory system and Genetic Algorithms (GA). Numerical example is also used to study the behaviour of the model. Cost minimization technique is used to get the expressions for total cost and other parameters.*

Keywords*— Genetic Algorithms, EOQ model, Rented warehouse (RW), Owned warehouse (OW).

I. INTRODUCTION

Many researchers extended the EOQ model to time-varying demand patterns. Some researchers discussed of inventory models with linear trend in demand. The main limitations in linear-time varying demand rate is that it implies a uniform change in the demand rate per unit time. This rarely happens in the case of any commodity in the market. In recent years, some models have been developed with a demand rate that changes exponentially with time. For seasonal products like clothes, Air conditions etc. at the end of their seasons the demand of these items is observed to be exponentially decreasing for some initial period. Afterwards, the demand for the products becomes steady rather than decreasing exponentially. It is believed that such type of demand is quite realistic. Such type situation can be represented by ramp type demand rate.

An important issue in the inventory theory is related to how to deal with the unfulfilled demands which occur during shortages or stock outs. In most of the developed models researchers assumed that the shortages are either completely backlogged or completely lost. The first case, known as backordered or backlogging case, represent a situation where the unfulfilled demand is completely back ordered. In the second case, also known as lost sale case, we assume that the unfulfilled demand is completely lost.

Furthermore, when the shortages occur, some customers are willing to wait for backorder and others would turn to buy from other sellers. In many cases customers are conditioned to a shipping delay and may be willing to wait for a short time in order to get their first choice. For instance, for fashionable commodities and high-tech products with short product life cycle, the willingness of a customer to wait for backlogging is diminishing with the length of the waiting time. Thus the length of the waiting time for the next replenishment would determine whether the backlogging would be accepted or not. In many real life situations, during a shortage period, the longer the waiting time is, the smaller is the backlogging rate would be. Therefore, for realistic business situations the backlogging rate should be variable and dependent on the waiting time for the next replenishment. Many researchers have modified inventory policies by considering the "time proportional partial backlogging rate".

II. GENETIC ALGORITHM

The principles of Genetic Algorithms (GA) and the mathematical framework underlying it were developed in the late 1960s (Holland, 1962; Kristinson and Dumont, 1992; Koppen et al., 2006). GA is normally discussed in the context of Evolutionary Computing (EC). The core methodologies of EC are Genetic Algorithms (GA), Evolutionary Programming (EP), Evolution Strategies (ES) and Genetic Programming (GP) (Oduguwa et al., 2005). In GA, attempt is made to model the processes underlying population genetic theory by using random search. GAs uses the survival-of-the-fittest strategy, where stronger individuals in a population have a higher chance of creating an offspring. To achieve this, the current input (population) is used to create a new and better population based on specified constraints. The inputs are normally represented as string and they model chromosome in human genetics. In materials engineering, for example, the input string will represent some properties of materials that are of interest.

One iteration of the algorithm is referred to as a generation. The basic GA is very generic and there are many aspects that can be implemented differently according to the problem (for instance, representation of solution or chromosomes, type of encoding, selection strategy, type of crossover and mutation operators, etc.) in practice, GA are implemented by having arrays of bits or characters to represent the chromosomes. The individuals in the population then go through a process of simulated evolution. Simple bit manipulation operations allow the implementation of crossover, mutation and other operations. The number of bits for every gene (parameter) and the decimal range in which they decode are usually the same but precludes the utilization of a different number of bits or range.

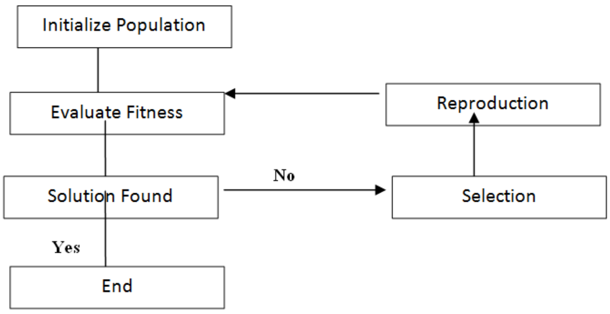

Fig.1:Flow chart of basic genetic algorithm

Zangwill (1966) developed a production multi period production scheduling model with backlogging. Inventory models with a mixture of backorders and lost sales were formulated by Montgomery et al. (1973). Economic production lot size model for deteriorating items with partial backordering was suggested by Wee (1993). A comparison of two replenishment strategies for the lost sales inventory model was presented by Donselaar et al. (1996). Time-limited free back-orders EOQ model was formulated by Abbound and Sfairy (1997).Chang and Dye (1999) developed an inventory model in which the proportion of customers who would like to accept backlogging is the reciprocal of a linear function of the waiting time. Papachristos and Skouri (2000) established a partially backlogged inventory model in which the backlogging rate decreases exponentially as the waiting time increases. An EOQ inventory model for items with Weibull distribution deterioration rate and ramp type demand was formulated by Wu (2001). Shortages in inventory were allowed and assumed to be partially backlogged. Teng et al. (2002) presented an optimal replenishment policy for deteriorating items with time-varying demand and partial backlogging. An EOQ model for deteriorating items with time-varying demand and partial backlogging was suggested by Teng et al. (2003). Chu and Chung (2004) discussed the sensitivity of the inventory model with partial backorders. An EOQ model with time varying deterioration and linear time varying demand over finite time horizon was proposed by Ghosh and Chaudhuri (2005). Shortages in inventory were allowed and partially backlogged with waiting time dependent backlogging rate. Optimal ordering policy for deteriorating items with partial backlogging was formulated by Ouyang et al. (2006) when delay in payment was permissible. Dye (2007) proposed joint pricing and ordering policy for deteriorating inventory. Shortages in inventory were allowed and partial backlogged. An inventory lot-size model for deteriorating items with partial backlogging was formulated by Chern et al. (2008). Authors have taken time value of money in to consideration. The demand was assumed to fluctuating function of time and the backlogging rate of unsatisfied demand was a decreasing function of the waiting time.

The analysis of deteriorating inventory began with Ghare and Schrader (1963), who established the classical no-shortage inventory model with a constant rate of decay. However, it has been empirically observed that failure and life expectancy of many items can be expressed in terms of Weibull distribution. This empirical observation has prompted researchers to represent the time to deterioration of a product by a Weibull distribution. Covert and Philip (1973) extended Ghare and Schrader's (1963) model and obtain an economic order quantity model for a variable rate of deterioration by assuming a two-parameter Weibull distribution. Philip (1974) presented an EOQ model for items with Weibull distribution deterioration rate.

An order level inventory model for a system with constant rate of deterioration was presented by Shah and Jaiswal (1977). Roychowdhury and Chaudhuri (1983) formulated an order level inventory model for deteriorating items with finite rate of replenishment. Hollier and Mak (1983) developed inventory replenishment policies for deteriorating item with demand rate decreases negative exponentially and constant rate of deterioration. Dutta and Pal (1988) investigated an order level inventory model with power demand pattern with a special form of Weibull function for deterioration rate, considering deterministic demand as well as probabilistic demand. An EOQ model for deteriorating items with a linear trend in demand was formulated by Goswami and Chaudhuri (1991). Inventory models for perishable items with stock dependent selling rate were suggested by Padmanabhan and Vrat (1995). The selling rate was assumed to be a function of current inventory level and rate of deterioration was taken to be constant with complete, partial backlogging and without backlogging. Su et al. (1999) formulated a deterministic production inventory model for deteriorating items with an exponential declining demand over a fix time horizon. A production inventory model for deteriorating items with exponential declining demand was discussed by Kumar and Sharma (2000). Time horizon was fixed and the production rate at any instant was taken as the linear combination of on hand inventory and demand. A single-vender and multiple-buyers production-inventory policy for a deteriorating item was formulated by Yang and Wee (2002). Production and demand rates were taken to be constant. A mathematical model incorporating the costs of both the vender and the buyers was developed. Goyal and Giri (2003) considered the production-inventory problem in which the demand, production and deterioration rates of a product were assumed to vary with time. Shortages of a cycle were allowed to be partially backlogged. An order-level inventory model for a deteriorating item with Weibull distribution deterioration, time-quadratic demand and shortages was suggested by Ghosh and Chaudhuri (2004). An economic production quantity model for deteriorating items was discussed by Teng and Chang (2005). Demand rate was taken as dependent on the display stock level and the selling price per unit. An order level inventory system for deteriorating items has been discussed by Manna and Chaudhuri (2006). The demand rate was taken as ramp type function of time and the finite production rate was proportional to the demand rate at any instant. The deterioration rate was time proportional and the unit production cost was inversely proportional to the demand rate. A note on the inventory models for deteriorating items with ramp type demand was developed by Deng et al. (2007). They have proposed an extended inventory model with ramp type demand rate and its optimal feasible solution. Seyed Hamid Reza Pasandideh, Seyed Taghi Akhavan Niaki, (2011) presented A genetic algorithm for vendor managed inventory control system of multi-product multi-constraint economic order quantity model. Ilkay Saracoglu, Seyda Topaloglu, Timur Keskinturk (2014) Extended A genetic algorithm approach for multi-product multi-period continuous review inventory models. R.K. Gupta, A.K. Bhunia, S.K. Goyal (2009) suggested An application of Genetic Algorithm in solving an inventory model with advance payment and interval valuedinventory costs. R.K. Gupta, A.K. Bhunia, S.K. Goya (2007) discussed An application of genetic algorithm in a marketing oriented inventory model with interval valued inventory costs and three-component demand rate dependent on displayed stock level. M.J. Li, D.S. Chen, S.Y. Cheng, F. Wang, Y. Li, Y. Zhou, J.L. Lang (2010) presented Optimizing emission inventory for chemical transport models by using genetic algorithm . Seyed Hamid Reza Pasandideh, Seyed Taghi Akhavan Niaki, Nafiseh Tokhmehchi (2011) Extended A parameter-tuned genetic algorithm to optimize two-echelon continuous review inventory systems. Masao Yokoyama (2000) suggested Integrated optimization of inventory-distribution systems by random local search and a genetic algorithm. K.L. Mak, et. al. (1999) presented Optimal inventory control of lumpy demand items using genetic algorithms. A.K. Maiti, et. al. (2006) discussed An application of real-coded genetic algorithm (RCGA) for mixed integer non-linear programming in two-storage multi-iteminventory model with discount policy. Sung-Pil Hong and Yong-Hyuk Kim (2009) discussed A genetic algorithm for joint replenishment based on the exact inventory cost. S.M. Disney et. al. (2000) Extended Genetic algorithm optimisation of a class of inventory control systems. S.P. Nachiappan and N. Jawahar (2007) developed A genetic algorithm for optimal operating parameters of VMI system in a two-echelon supply chain. Chi Kin Chan et. al. (2003) presented Solving the multi-buyer joint replenishment problem with a modified genetic algorithm. N. Jawahar and N. Balaji (2012) suggested A genetic algorithm based heuristic to the multi-period fixed charge distribution problem. Seyed Hamid Reza Pasandideh et. al. (2010) developed A parameter-tuned genetic algorithm for multi-product economic production quantity model with space constraint, discrete delivery orders and shortages. Faicel Hnaien et. al. (2009) suggested Genetic algorithm for supply planning in two-level assembly systems with random lead times Ata Allah Taleizadeh et. al. (2012) presented Multi-product multi-chance-constraint stochastic inventory control problem with dynamic demand and partial back-ordering: A harmony search algorithm. Amir Hamidinia et. al. (2012) Extended A genetic algorithm for minimizing total tardiness/earliness of weighted jobs in a batched delivery system. Jason Chao-Hsien Pan et. al. (2015) developed A storage assignment heuristic method based on genetic algorithm for a pick-and-pass warehousing system. Seyed Hamid Reza Pasandideh et. al. (2008) presented a genetic algorithm approach to optimize a multi-products EPQ model with discrete delivery orders and constrained space. Leopoldo Eduardo Cárdenas-Barrón (2010) developed adaptive genetic algorithm for lot-sizing problem with self-adjustment operation rate: a discussion. Jayanta Kumar Dey et. al. (2008) extended Two storage inventory problem with dynamic demand and interval valued lead-time over finite time horizon under inflation and time-value of money. Claudio Fabiano Motta Toledo et. al. (2014) presented A genetic algorithm/mathematical programming approach to solve a two-level soft drink production problem.

In this chapter a deterministic inventory model has been developed for deteriorating items having a ramp type demand with the effects of inflation with two-storage facilities. The owned warehouse (OW) has a fixed capacity of W units; the rented warehouse (RW) has unlimited capacity. Here, we assumed that the inventory holding cost in RW is higher than those in OW. Shortages in inventory are allowed and partially backlogged and it is assumed that the inventory deteriorates over time at a variable deterioration rate. The effect of inflation has also been considered for various costs associated with the inventory system. Numerical example is also used to study the behaviour of the model. Cost minimization technique is used to get the expressions for total cost and other parameters.

III. ASSUMPTION AND NOTATIONS

The mathematical model of two warehouse inventory model for deteriorating items is based on the following notation and assumptions

Notations:

O_c: Cost of Ordering per Order

φ: Capacity of OW.

T : The length of replenishment cycle.

M: Maximum inventory level per cycle to be ordered.

$t_{1:}$ the time up to which product has no deterioration.

t_2: The time at which inventory level reaches to zero in RW.

t_3: The time at which inventory level reaches to zero in OW.

H^{OW}: The holding cost per unit time in OW i.e. $H^{OW}=(a+b+1)_1 t$;where $(a+b+1)_1$ is positive constant.

H^{RW}: The holding cost per unit time in RW i.e. $H^{RW}=(a+b+1)_2$where $(a+b+1)_2>0$ and $H^{RW}>H^{OW}$.

S_c: The shortages cost per unit per unit time.

$\Psi^{1RW}(t)$: The level of inventory in RW at time $[0 \ \ t_1]$ in which the product has no deterioration.

$\Psi^{2RW}(t)$: The level of inventory in RW at time $[t_1 \ \ t_2]$in which the product has deterioration.

$\Psi^{1OW}(t)$: The level of inventory in OW at time $[0 \ \ t_1]$ in which the product has no Deterioration.

$\Psi^{2OW}(t)$: The level of inventory in OW at time $[t_1 \ t_2]$ in which only Deterioration takes place.

$\Psi^{3OW}(t)$: The level of inventory in OW at time $[t_2 \ t_3]$ in which Deterioration takes place.

Ψs(t): Determine the inventory level at time t in which the product has shortages.

$(\alpha+\omega+\nu)$: Deterioration rate in RW Such that $0<(\alpha+\omega+\nu)<1$;

$(\beta+\omega)$: Deterioration rate in OW such that $0<(\beta+\omega)<1$;

R_d: Deterioration cost per unit in RW.

O_d: Deterioration cost per unit in OW.

C_t: Cost of transportation per unit per cycle

r : (Discount rate – inflation i.e., r=d-i)

$T^{\Psi C}(t_{2,}t_{3,}\ T)$: The total relevant inventory cost per unit time of inventory system.

Assumption

1. Replenishment rate is infinite and lead time is negligible i.e. zero.
2. Holding cost is variable and is linear function of time.
3. The time horizon of the inventory system is infinite.
4. Goods of OW are consumed only after the consumption of goods kept in RW due to the more holding cost in RW than in OW.
5. The OW has the limited capacity of storage and RW has unlimited capacity.
6. Demand vary with time and is linear function of time and given by $D(t)=(ab+u)t$; where $(ab+u)>0$;
7. For deteriorating items a fraction of on hand inventory deteriorates per unit time in both the warehouse with different rate of Deterioration.
8. Shortages are allowed and demand is fully backlogged at the beginning of next replenishment.
9. The unit inventory cost (Holding cost + Deterioration cost) in RW>OW.

IV. MATHEMATICAL FORMULATION OF MODEL AND ANALYSIS

In the beginning of the cycle at t=0 a lot size of M units of inventory enters into the system in which backlogged (M-R) units are cleared and the remaining units R is kept into two storage as W units in OW and RW units in RW.

$$\frac{d\Psi^{1RW}(t)}{dt}= -\ (ab+u)\ t \quad ; \qquad 0\le t\le t_1 \qquad (1)$$

$$\frac{d\Psi^{2RW}(t)}{dt}= -\ (\alpha+\omega+\nu)\ \Psi^{2RW}(t)\ -\ (ab+u)t \quad ; \qquad t_1\le t\le t_2 \qquad (2)$$

$$\frac{d\Psi^{1W}(t)}{dt}= 0\ ; \qquad 0\le t\le t_1 \qquad (3)$$

$$\frac{d\Psi^{2W}(t)}{dt}= -\ (\beta+\omega)\ \Psi^{2W}(t)\ ; \qquad t_1\le t\le t_2 \qquad (4)$$

$\frac{d\Psi^{3W}(t)}{dt}$= - (β+ω) Ψ^{3W}(t) – (ab+u)t ; $t_2 \le t \le t_3$ (5)

$\frac{d\Psi^{4S}(t)}{dt}$= -(ab+u)t ; $t_3 \le t \le T$ (6)

Now inventory level at different time intervals is given by solving the above differential equations (1) to (6) with boundary conditions as follows:

At t=0, Ψ^{1RW}(t)=R-W ; therefore Differential eq. (1) gives

$\Psi^{1RW}(t)=R-W - \frac{(ab+u)t^2}{2}$; $0 \le t \le t_1$ (7)

Differential eq. (2) is solved at t=$t_2$and boundary condition $\Psi^{2RW}(t_2)=0$, which yields

$\Psi^{2RW}(t)=\frac{(ab+u)}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t)}-((\alpha+\omega+\nu)t-1)\}$; $t_1 \le t \le t_2$ (8)

Solution of differential eq. (3) with boundary condition at t=0 and $\Psi^{1OW}(0)=W$

$\Psi^{1OW}(t)=\varphi$; $0 \le t \le t_1$ (9)

Differential eq. (4) yields at t=$t_1$and $\Psi^{2OW}(t_1)=\varphi$

$\Psi^{2OW}(t)=\varphi e^{(\beta+\omega)(t_1-t)}$ $t_1 \le t \le t_2$ (10)

Solution of eq. (5) at t= t_3 and $\Psi^{3OW}(t_3)$ = 0 gives

$\Psi^{3OW}(t)=\frac{(ab+u)}{(\beta+\omega)^2}\{(\beta t_3-1)e^{(\beta+\omega)(t_3-t)}-((\beta+\omega)t-1)\}$; $t_2 \le t \le t_3$ (11)

Lastly the solution of eq. (6) at t=t_3 and $\Psi^{4S}(t_3)=0$, is given as

$\Psi^{4S}(t)=\frac{(ab+u)}{2}\{t_3^2-t^2\}$; $t_3 \le t \le T$ (12)

Now considering the continuity of $\Psi^{1R}(t_1)=\Psi^{2R}(t_1)$, at t=$t_1$ from eq. (7) & (8) we have

$R=\varphi+\frac{(ab+u)t_1^2}{2}+\frac{(ab+u)}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}$; (13)

Substituting eq.(13) into eq. (7) we have

$\Psi^{1RW}(t)=\frac{b}{2}(t_1^2-t^2)+\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}$; (14)

Cost of inventory shortages during time interval [t_3 T] is given (a+b+1)y

$IS=\int_{t_3}^{T}[-\Psi_s(t)]dt$

$= -\frac{(ab+u)}{2}\int_{t_3}^{T}(t_3^2-t^2)dt$

$=\frac{b}{6}\{T^3+2t_3^3-3t_3^2T\}$ $t_3 \le t \le T$ (15)

The maximum Inventory to be ordered is

M= R+IS

$=\varphi+\frac{bt_1^2}{2}+\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}+\frac{b}{6}\{T^3-2t_3^3-3t_3^2T\}$; (16)

Next the total relevant inventory cost per cycle consists of the following elements:

O_c: Cost of ordering (17)

Inventory holding cost in RW denoted by Ψ^{HR} and is given as

$\Psi^{HRW}=\int_0^{t_1}\Psi^{1RW}(t)(a+b+1)_2dt+\int_{t_1}^{t_2}\Psi^{2RW}(t)(a+b+1)_2dt]$

$=\frac{bb_2}{8}t_1^4+\frac{(ab+u)(a+b+1)_2}{2(\alpha+\omega+\nu)^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}\}t_1^2+\frac{(ab+u)(a+b+1)_2}{(\alpha+\omega+\nu)^4}(\alpha t_2-1)\{(e^{\alpha(t_2-t_1)}-1)-(\alpha+\omega+\nu)(t_2-t_1e^{\alpha(t_2-t_1)})\}-\frac{(ab+u)(a+b+1)_2}{6(\alpha+\omega+\nu)^2}\{2(\alpha+\omega+\nu)(t_2^3-t_1^3)-3(t_2^2-t_1^2)\}$

(18)

Inventory holding cost in OW denoted by Ψ^{HOW} and is given by

$\Psi^{HOW}=\int_0^{t_1}\Psi^{1OW}(t)(a+b+1)_1t\,dt+\int_{t_1}^{t_2}\Psi^{2OW}(t)dt+\int_{t_2}^{t_3}\Psi^{3OW}(t)(a+b+1)_1tdt$

$=\frac{\varphi(a+b+1)_1t_1^2}{2}+\frac{(a+b+1)_1\varphi}{(\beta+\omega)^2}\{(1-e^{-(\beta+\omega)(t_2-t_1)})-(\beta+\omega)(t_2e^{-(\beta+\omega)(t_2-t_1)}-t_1)\}$

$+\frac{bb_1}{\beta^4}((\beta+\omega)t_3-1)\{(e^{(\beta+\omega)(t_3-t_2)}-1)-(\beta+\omega)(t_3-t_2e^{(\beta+\omega)(t_3-t_2)})\}$

$-\frac{(ab+u)(a+b+1)_1}{6\beta^2}\{2(\beta+\omega)(t_3^3-t_2^3)-3(t_3^2-t_2^2)\}$ (19)

Cost of inventory deteriorated in RW is denoted and given by

$\Psi^{DRW}=(R-W)-\int_{t_1}^{t_2}(ab+u)t\,dt$

$=\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}-\frac{(a+b+1)}{2}(t_2^2-2t_1^2)$

Cost of deteriorated inventory in RW is given by

$$C\Psi^{DRW}=D_R\ \{\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}-\frac{(ab+u)}{2}(t_2^2-2t_1^2)\ \} \quad (20)$$

Cost of inventory deteriorated in OW is denoted and given (a+b+1)y

$\Psi^{DOW}=\varphi-\int_{t_2}^{t_3}(ab+u)t\,dt$

$=\varphi-\frac{b}{2}(t_3^2-t_2^2)$

Cost of deteriorated inventory in OW is given by

$$C\Psi^{DOW}=O_d\ \{\ \varphi-\frac{(ab+u)}{2}(t_3^2-t_2^2)\} \quad (21)$$

Inventory Shortages Cost per cycle is denoted and given by

$$CIS=S_c[\ \frac{(ab+u)}{6}\{T^3+2t_3^3-3t_3^2T\}] \quad (22)$$

$\mathbf{T^{\Psi C}\ (t_2, t_3\ T)}=\frac{1}{T}$ [Ordering cost + Inventory holding cost per cycle in RW + Inventory holding cost per cycle in OW +Deterioration cost per cycle in RW+ Deterioration cost per cycle in OW + Shortage cost]

$$T^{\Psi C}(t_2, t_3, T)=\frac{1}{T}[O_c+\Psi^{HRW}+\Psi^{HOW}+C\Psi^{DRW}+C\Psi^{DOW}+CIS] \quad (23)$$

Substituting equations (17) to (22) in equation (24) we get

$$\mathbf{T^{\Psi C}(t_2, t_3, T)}=\frac{1}{T}[O_c+\frac{bb_2}{8}t_1^4+\frac{(ab+u)(a+b+1)_2}{2(\alpha+\omega+\nu)^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}t_1^2+\frac{(ab+u)(a+b+1)_2}{(\alpha+\omega+\nu)^4}(\alpha t_2-1)\{(e^{\alpha(t_2-t_1)}-1)-(\alpha+\omega+\nu)(t_2-t_1e^{\alpha(t_2-t_1)})\}-\frac{(ab+u)(a+b+1)_2}{6(\alpha+\omega+\nu)^2}\{2(\alpha+\omega+\nu)(t_2^3\text{-}t_1^3)\text{-}3(t_2^2\text{-}t_1^2)\}+\frac{\varphi(a+b+1)_1t_1^2}{2}+\frac{(a+b+1)_1\varphi}{\beta^2}\{(1-e^{-(\beta+\omega)(t_2-t_1)})-(\beta+\omega)(t_2e^{-(\beta+\omega)(t_2-t_1)}-t_1)\}+\frac{bb_1}{\beta^4}((\beta+\omega)t_3-1)\{(e^{(\beta+\omega)(t_3-t_2)}-1)-(\beta+\omega)(t_3-t_2e^{(\beta+\omega)(t_3-t_2)})\}-\frac{(a+b+1)(a+b+1)_1}{6\beta^2}\{2(\beta+\omega)(t_3^3\text{-}t_2^3)\text{-}3(t_3^2\text{-}t_2^2)\}+R_d\{\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}+\frac{(a+b+1)}{2}(t_2^2-t_1^2)\}+O_d\{\varphi-\frac{b}{2}(t_3^2-t_2^2)\}+S_c\{\frac{b}{6}\{T^3+2t_3^3-3t_3^2T\}\} \quad (25)$$

The total relevant inventory cost is minimum if

$$\frac{\partial T^{\Psi C}}{\partial t_2}=0\ ;\ \frac{\partial T^{\Psi C}}{\partial t_3}=0\ ;\ \frac{\partial T^{\Psi C}}{\partial T}=0 \quad (26)$$

Present worth of Total cost for entire horizon

Present worth of total variable cost of the system during the entire planning horizon H is given by

$$TC_H=\sum_{i=0}^{n-1}(\mathbf{T^{\Psi C}(t_2, t_3, T)})e^{-riT}$$

$$=\{\ \frac{1}{T}[O_c+\Psi^{HRW}+\Psi^{HOW}+C\Psi^{DRW}+C\Psi^{DOW}+CIS]\}\ e^{-riT}$$

$$TC_H=[\frac{1}{T}[O_c+\frac{bb_2}{8}t_1^4+\frac{(ab+u)(a+b+1)_2}{2(\alpha+\omega+\nu)^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}t_1^2+\frac{(ab+u)(a+b+1)_2}{(\alpha+\omega+\nu)^4}(\alpha t_2-1)\{(e^{\alpha(t_2-t_1)}-1)-(\alpha+\omega+\nu)(t_2-t_1e^{\alpha(t_2-t_1)})\}-\frac{(ab+u)(a+b+1)_2}{6(\alpha+\omega+\nu)^2}\{2(\alpha+\omega+\nu)(t_2^3\text{-}t_1^3)\text{-}3(t_2^2\text{-}t_1^2)\}+\frac{\varphi(a+b+1)_1t_1^2}{2}+\frac{(a+b+1)_1\varphi}{\beta^2}\{(1-e^{-(\beta+\omega)(t_2-t_1)})-(\beta+\omega)(t_2e^{-(\beta+\omega)(t_2-t_1)}-t_1)\}+\frac{bb_1}{\beta^4}((\beta+\omega)t_3-1)\{(e^{(\beta+\omega)(t_3-t_2)}-1)-(\beta+\omega)(t_3-t_2e^{(\beta+\omega)(t_3-t_2)})\}-\frac{(a+b+1)(a+b+1)_1}{6\beta^2}\{2(\beta+\omega)(t_3^3\text{-}t_2^3)\text{-}3(t_3^2\text{-}t_2^2)\}+R_d\{\frac{b}{\alpha^2}\{((\alpha+\omega+\nu)t_2-1)e^{(\alpha+\omega+\nu)(t_2-t_1)}-((\alpha+\omega+\nu)t_1-1)\}+\frac{(a+b+1)}{2}(t_2^2-t_1^2)\}+O_d\{\varphi-\frac{b}{2}(t_3^2-t_2^2)\}+S_c\{\frac{b}{6}\{T^3+2t_3^3-3t_3^2T\}\}]\ e^{-riT} \quad (27)$$

V. GENETIC ALGORITHM

When compared to other evolutionary algorithms one of the most important GA feature is its focus on fixed length character strings although variable length strings and other structures have been used.

Step 1: Start

(Randomly generate population of n chromosomes as per population size.)

Step 2: Fitness

(Evaluate the fitness f(y) of each chromosome y in the population)

Step 3: New population

(Create new population by repeating following steps until the new population is complete.)

a. Selection

(Select two parent chromosomes from a population.)

b. Crossover

(With a crossover probability, crossover the parents to form a new offspring. If no crossover was performed, offspring is the exact copy of parents.)

c. Mutation

(With a mutation probability, mutate new offspring at each locus.)

d. Accepting

(Place new offspring in the new population.)

Step 4: Replace

(Use new generated population for a future run of the algorithm.)

Step 5: Test

(If the end condition is satisfied, stop, and return the best solution in current population.)

Step 6: Loop

Go to step 2

Step 7: Stop

(Stop when the fittest value is obtained.)

We are using those basic steps for finding the optimal resources for an organization in Medium range prospective using MATLAB software package.

VI. NUMERICAL EXAMPLE

In order to illustrate the above solution procedure, consider an inventory system with the following data in appropriate units: C=3500, φ =2500, (ab+u)=16, $(a+b+1)_1=3.7$, $(a+b+1)_2=3.4$, $t_1=0.3$, $(\alpha+\omega+\nu)=0.25$, $(\beta+\omega)=0.52$, $C_s=5.3$, and $C_t=5.3$.The values of decision variables are computed for the model and also for the models of special cases. The computational optimal solutions of the models are shown in Table-1.

There are not rules. The actual values are to be tuned to the specific GA through experience and trial-and-error. However some standard settings are reported in literature. It was proposed by Osyczka and Kundu in 1995 in which the Pareto-optimal solutions are updated gradually using the fitness information with respect to the objective function as given below.

Population Size = 80, Number of generations = 250, Crossover type = two Point, Crossover rate = 9.3, Mutation types = Bit flip, Mutation rate = 0.9 per bit

If single cut-point crossover instead of two cut-point crossover is employed the crossover rate can be lowered to a maximum of 9.75. The genetic algorithm is coded in MATLAB R2011b to solve the problem formulated in section3.

Table-1:

Cost function	t_2^*	t_3^*	T^*	**Total relevant cost**	**Genetic algorithm**
$T^{\Psi C}(t_2,t_3,T)$	0.325856	5.14757	27.1285	1219.27	987.72

VII. CONCLUSION

In this study, we have future a deterministic two-storage facilities inventory model for two-storage inventory model deteriorating items time varying demand and two-storage inventory model holding cost varying with respect to ordering cycle length with the objective of minimizing the total inventory cost and Genetic Algorithms (GA). Genetic Algorithms (GA) Two-storage inventory model Shortages are allowed and two-storage inventory model partially backlogged and Genetic Algorithms (GA). Furthermore the proposed model is very useful for two-storage inventory model deteriorating items. This model can be further extended by incorporation with other deterioration rate probabilistic demand pattern and Genetic Algorithms (GA).

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