Supply Chain Inventory Model for Deteriorating Item with Warehouse & Distribution Centres Under Inflation

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Abstract - Inventory of Chemical Industry model is a method of balancing investment to achieve the service-level goal. Here consider Warehouse of Chemical Industry and Distribution centres of Inventory of Chemical Industry models. One is of finite capacity treated as Distribution centres of Chemical Industry which is at market place and other warehouse is of infinite capacity treated as Warehouse which is at some other place from the market PSO Algorithm and SA. Here the objective is to minimize the total cost .In this work Particle swarm optimization Algorithm and Simulated Annealing is used to optimize or to minimize the cost. The results produced from the Particle swarm optimization Algorithm and Simulated Annealing are compared with mathematical model and genetic algorithm. Results show that the PSO Algorithm and SA optimized the results more than traditional mathematical model and PSO Algorithm and SA.

Keywords: Inventory of Chemical Industry, Warehouse of Chemical Industry, Distribution centres of Chemical Industry, PSO Algorithm and SA

I. INTRODUCTION

As discusesed above the Warehouse of Chemical Industry and Distribution centres of Chemical Industry is an important place in the business entity and every businessman needed it during the business transaction of goods either finished or raw-materials. Now in the present market scenario and due to globalization of the market the business environment is highly competitive and no one wants to loss goodwill in the market and tries to fulfil the demand of their customer. For this, the distributors and retailers always stock the goods at their shop. In this cut-throat business environment suppliers offers some discount on bulk purchase during festival seasons and also they offers trade credit financing scheme to attract their retailers. To get benefited from these policies of the suppliers, retailers needed extra space to stock the products purchased in bulk during the offered period but due to small space in the busy market places, retailers faces problem of storage at their owned single warehouse and hence they required another storage space to stock their products purchased in excess. To resolve this problem they hire another storage space on rental basis for a short period. This rented warehouse becomes an additional storage space which is provided by private/public or government agencies and these spaces are used as secondary space for storing. The acquiring the space on rental basis for storing purposes brought the concept of Warehouse of Chemical Industry and Distribution centres of Chemical Industry in the inventory modelling. In Inventory of Chemical Industry modelling, the Warehouse of Chemical Industry and Distribution centres of Chemical Industry concept was first time introduced the concept of Ware-house of Chemical Industry and Distribution centres of Chemical Industry considering one with limited capacity (Distribution centres of Chemical Industry) and other with unlimited capacity (Ware-house of Chemical Industry). In this concept often it is assumed that the carrying cost of items in Ware-house of Chemical Industry is more than that of Distribution centres of Chemical Industry due to better preservation facilities provided by owner of additional warehouse, therefore it is economical to consume first the goods kept in Ware-house of Chemical Industry to reduce the holding cost incurred in Ware-house of Chemical Industry. Latter Here shall discusesed the advantages and limitations of the Ware-house of Chemical Industry and Distribution centres of Chemical Industry modelling over the single Warehouse of Chemical Industry modelling.

II. RELATED WORK

Yadav and Swami (2018) analyzed a integrated supply chain model for deteriorating items with linear stock dependent demand under imprecise and inflationary environment. Yadav and Swami (2018) discuses a partial backlogging production-inventory lot-size model with time-varying holding cost and weibull deterioration. Yadav, et., al. (2018) presented a supply chain inventory model for decaying items with two ware-house and partial ordering under inflation. Yadav, et., al. (2018) proposed an inventory model for deteriorating items with two warehouses and variable holding cost. Yadav, et., al. (2018) analyzed a inventory of electronic components model for deteriorating items with warehousing using genetic algorithm. Yadav, et., al. (2018) discuses a analysis of green supply chain inventory management for warehouse with environmental collaboration and sustainability performance using genetic algorithm. Yadav and kumar (2017) presented a electronic

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components supply chain management for warehouse with environmental collaboration & neural networks. Yadav, et., al. (2017) analyzed a effect of inflation on a two-warehouse inventory model for deteriorating items with time varying demand and shortages. Yadav, et., al. (2017) discuses an inflationary inventory model for deteriorating items under two storage systems. Yadav, et., al. (2017) proposed a fuzzy based two-warehouse inventory model for non instantaneous deteriorating items with conditionally permissible delay in payment. Yadav (2017) analyzed a analysis of supply chain management in inventory optimization for warehouse with logistics using genetic algorithm. Yadav, et., al. (2017) discuses a supply chain inventory model for two warehouses with soft computing optimization. Yadav, et., al. (2016) presented a multi objective optimization for electronic component inventory model & deteriorating items with two-warehouse using genetic algorithm. Yadav (2017) analyzed a modeling and analysis of supply chain inventory model with two-warehouses and economic load dispatch problem using genetic algorithm. Yadav, et., al. 2018 discuses a particle swarm optimization for inventory of auto industry model for two warehouses with deteriorating items. Yadav, et., al. (2018) analyzed a hybrid techniques of genetic algorithm for inventory of auto industry model for deteriorating items with two warehouses. Yadav, et., al. (2018) discuses a supply chain management of pharmaceutical for deteriorating items using genetic algorithm. Yadav, et., al. (2018) analyzed a particle swarm optimization of inventory model with two-warehouses. Yadav, et., al. (2018) presented a supply chain management of chemical industry for deteriorating items with warehouse using genetic algorithm. Yadav (2017) discuses a analysis of seven stages supply chain management in electronic component inventory optimization for warehouse with economic load dispatch using ga and PSO. Yadav, et., al. (2017) gives a multi-objective genetic algorithm optimization in inventory model for deteriorating items with shortages using supply chain management. Yadav, et., al. (2017) analyzed a supply chain management in inventory optimization for deteriorating items with genetic algorithm. Yadav, et., al. (2017) discuses a modeling & analysis of supply chain management in inventory optimization for deteriorating items with genetic algorithm and particle swarm optimization. Yadav, et., al. (2017) presented a multi-objective particle swarm optimization and genetic algorithm in inventory model for deteriorating items with shortages using supply chain management. Yadav, et., al. (2017) proposed soft computing optimization of two warehouse inventory model with genetic algorithm. Yadav, et., al. (2017) analyzed a multi-objective genetic algorithm involving green supply chain management. Yadav, et., al. (2017) presented a multi-objective particle swarm optimization algorithm involving green supply chain inventory management. Yadav, et., al. (2017) gives a green supply chain management for warehouse with particle swarm optimization algorithm. Yadav, et., al. (2017) analyzed a analysis of seven stages supply chain management in electronic component inventory optimization for warehouse with economic load dispatch using genetic algorithm. Yadav, et., al. (2017) discuses a analysis of six stages supply chain management in inventory optimization for warehouse with artificial bee colony algorithm using genetic algorithm. Yadav, et., al. (2016) presented a analysis of electronic component inventory optimization in six stages supply chain management for warehouse with abc using genetic algorithm and PSO. Yadav, et., al. (2016) analyzed a two-warehouse inventory model for deteriorating items with variable holding cost, time-dependent demand and shortages. Yadav, et., al. (2016) discuses a two warehouse inventory model with ramp type demand and partial backordering for weibull distribution deterioration. Yadav, et., al. (2016) proposed a two-storage model for deteriorating items with holding cost under inflation and genetic algorithms. Singh, et., al. (2016) analyzed a two-warehouse model for deteriorating items with holding cost under particle swarm optimization. Singh, et., al. (2016) presented a two-warehouse model for deteriorating items with holding cost under inflation and soft computing techniques. Sharma, et., al. (2016) gives an optimal ordering policy for non-instantaneous deteriorating items with conditionally permissible delay in payment under two storage management. Yadav, et., al. (2016) discuses a analysis of genetic algorithm and particle swarm optimization for warehouse with supply chain management in inventory control. Swami, et., al. (2015) analyzed an inventory policies for deteriorating item with stock dependent demand and variable holding costs under permissible delay in payment. Swami, et., al. (2015) presented an inventory model for decaying items with multivariate demand and variable holding cost under the facility of trade-credit. Swami, et., al. (2015) discuses an inventory model with price sensitive demand, variable holding cost and trade-credit under inflation. Gupta, et., al. (2015) proposed a binary multi-objective genetic algorithm &PSO involving supply chain inventory optimization with shortages, inflation. Yadav, et., al. (2015) analyzed a soft computing optimization based two ware-house inventory model for deteriorating items with shortages using genetic algorithm. Gupta, et., al. (2015) discuses a fuzzy-genetic algorithm based inventory model for shortages and inflation under hybrid & PSO. Yadav, et., al. (2015) presented a two warehouse inventory model for deteriorating items with shortages under genetic algorithm and PSO. taygi, et., al. (2015) analyzed an inventory model with partial backordering, weibull distribution deterioration under two level of storage. Yadav and Swami (2014) presented a two-warehouse inventory model for deteriorating items with ramp-type demand rate and inflation. Yadav and Swami (2013) discuses a effect of permissible delay on two-warehouse inventory model for deteriorating items with shortages. Yadav and Swami (2013) analyzed a two-warehouse inventory model for decaying items with exponential demand and variable holding cost. Yadav and Swami (2013) presented a partial backlogging two-warehouse inventory models for decaying items with inflation.

III. ASSUMPTION AND NOTATIONS

Assumption

1. Replenishment rate is infinite and lead time is insignificant i.e. zero.
2. The time horizon of the Inventory of Chemical Industry Inventory Model is infinite.

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3. Goods of Distribution centres of Chemical Industry are consumed only after the consumption of goods kept in Ware-house of Chemical Industry due to the more holding cost in Ware-house of Chemical Industry than in Distribution centres of Chemical Industry.
4. The Distribution centres of Chemical Industry has the limited capacity of storage and ware-house has unlimited capacity.
5. Demand vary with time and is linear function of time and given by $D(t)=\{\delta + (\eta - 1)t \text{ if } t > 0\}$; where $\delta>0$ and $(\eta-1)>0$
6. The unit Inventory of Chemical Industry cost (Holding cost) in Ware-house of Chemical Industry > Distribution centres of Chemical Industry.

Here assume that the holding cost will be fixed till a definite time in Ware-house of Chemical Industry and the will increased according to a fraction of ordering cycle length. So for holding cost (h_r), Here have k a time moment before which holding cost is constant. $h_r=\{h_r t \text{ if } t > \lambda\}$

Notations

A: Chemical Industry Ordering cost per Order

C_O: Capacity of Distribution centres of Chemical Industry.

C_R: Capacity of Ware-house of Chemical Industry.

T : The length of replenishment cycle.

I_{max}: Maximum Inventory of Chemical Industry level per cycle to be ordered.

t_1: The time up to which Inventory of Chemical Industry vanishes in Ware-house of Chemical Industry.

t_2: The time at which Inventory of Chemical Industry level reaches to zero in Distribution centres of Chemical Industry and shortages begins.

λ: Definite time up to which Chemical Industry holding cost is constant.

h_m: The Chemical Industry holding cost per unit time in Distribution centres of Chemical Industry .

h_r: The Chemical Industry holding cost per unit time in Ware-house of Chemical Industry.

s_c: The Chemical Industry shortages cost per unit per unit time.

L_c: The opportunity cost per unit per time

$\prod^r(t)$: The level of inventory in Ware-house of Chemical Industry.

$\prod^i(t)$: The level of inventory in Distribution centres of Chemical Industry where i=1,2.

$\prod^s(t)$: Determine the inventory level at time t in which the product has shortages.

u : Deterioration rate in Ware-house of Chemical Industry Such that 0<u<1

v: Deterioration rate in Distribution centres of Chemical Industry such that 0<v<1

C_p: Purchase cost per unit of items.

A_B: Maximum amount of inventory backlogged.

A_L: Amount of inventory lost.

C_P: Cost of Chemical Industry purchase.

C_S: Cost of Chemical Industry shortages.

CL: Cost of Chemical Industry lost sale

H_C: Cost of Chemical Industry holding inventory

A_c: Chemical Industry Advertisement cost

$T^C(t_1, T)$: The total relevant inventory cost per unit time of inventory system.

IV. WAREHOUSE OF CHEMICAL INDUSTRY AND DISTRIBUTION CENTRES MATHEMATICAL FORMULATION OF MODEL AND ANALYSIS

$$\frac{d\prod^r(t)}{dt} = -(\delta + (\eta - 1)t) - (u\prod^r(t));\quad 0\le t\le t_1 \tag{1}$$

$$\frac{d\prod^{1w}(t)}{dt} = -v\prod^{1w}(t) \quad ; \quad 0\le t\le t_1 \tag{2}$$

$$\frac{d\prod^{2w}(t)}{dt} = -(\delta + (\eta - 1)t) - (\beta\prod^r(t)) \quad ;t_1\le t\le t_2 \tag{3}$$

$$\frac{d\prod^{s}(t)}{dt} = -f(\delta + (\eta - 1)t); \quad t_3\le t\le T \tag{4}$$

$\prod^r(t_1)=0$; $\prod^{1w}(0)=C_O$; $\prod^{2w}(t_2)=0$; $\prod^S(t_2)=0$;

Therefore Differential eq. (1)

$$\prod^r(t)=\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}\{(ut_1-1)\}e^{u(t_1-t)}-\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}(ut-1)\}; \tag{5}$$

$$\prod^{1w}(t)=C_O e^{-vt_1} \quad ; \tag{6}$$

$$\prod^{2w}(t)=\{\frac{\delta}{v}+\frac{(\eta-1)}{v^2}\{(vt_2-1)\}e^{v(t_2-t)}-\{\frac{\delta}{v}+\frac{(\eta-1)}{v^2}(vt-1)\}; \tag{7}$$

$$\prod^S(t)= f\{\delta(t_2-t)+\frac{(\eta-1)}{2}(t_2^2-t^2\}; \tag{8}$$

Now at $t=0$ $\prod^r(0)=C_R$ therefore equation (5) yield

$$C_R=\{(\frac{(\eta-1)}{u^2}-\frac{\delta}{u})+\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}(ut_1-1)e^{-ut_1}\}; \tag{9}$$

Maximum amount of inventory backlogged during shortages period (at t=T) is given by

$$A_B = -\prod^S(T) = f\{\delta(T-t)+\frac{(\eta-1)}{2}(T^2-t^2)\}; \tag{10}$$

Amount of Inventory of Chemical Industry lost during shortages period

$$A_L = (1-A_B)= (1-f\{\delta(T-t)+\frac{(\eta-1)}{2}(T^2-t^2)\}) \tag{11}$$

The maximum Inventory of Chemical Industry to be ordered is given as

$$I_{max}= C_O+\prod^r(0)+A_B= C_O+\{(\frac{(\eta-1)}{u^2}-\frac{\delta}{u})+\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}(ut_1-1)e^{ut_1}\}+f\{\delta(T-t_2)+\frac{(\eta-1)}{2}(T-t_2^2)\}; \tag{12}$$

Now continuity at $t=t_1$ shows that $I^{1w}(t_1)=I^{2w}(t_1)$ therefore from eq. (6) & (7) Here have

$$(\eta-1)v^2t_2^2-uv^2t_2-(u^2(C_O+Z)+(\eta-1)-uv)=0 \tag{13}$$

Where $Z=\{\frac{\delta}{v}+\frac{(\eta-1)}{v^2}(vt_1-1)\}e^{-vt_1}$

which is quadratic in t_2 and further can (η-1)e solved for t_2 in terms of t_1 i.e.

$$t_2=\varphi(t_1) \tag{14}$$

where $\varphi(t_1)=\frac{-\delta^2v^4\pm\sqrt{D}}{2(\eta-1)v^2}$ and $D=\delta^2v^4+4(\eta-1)v^2((\eta-1)-\delta v+v^2(C_O+\{\frac{\delta}{v}+\frac{(\eta-1)}{v^2}(vt_1-1)\}e^{-vt_1})$

Next the total relevant Inventory of Chemical Industry cost per cycle includes following parameters:

1. **Ordering cost of Chemical Industry per cycle** = A
2. **Purchase cost of Chemical Industry per cycle = P×Imax**
3. **The present worth holding cost of Chemical Industry** = H_C

$$Hc = \int_0^{\lambda} h_r\prod^r(t)dt$$

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$+\int_{\lambda}^{t_1} h_r\, t \prod^{r}(t)dt+\int_{0}^{t_1} h_w \prod^{1w}(t)dt+\int_{t_1}^{t_2} h_w \prod^{2w}(t)dt$

$H_C=h_r(\delta t_1\lambda+(\eta-1)t_1^2 k-\frac{(\eta-1)\lambda^2}{2u}-\frac{(\eta-1)t_1^2}{3u}+\delta t_1^3+(\eta-1)t_1^4-\frac{\delta\lambda}{u}-(\eta-1)t_1\lambda^2-\delta t_1\lambda^2-(\eta-1)t_1^2\lambda^2+\frac{(\eta-1)\,t_1\lambda^2}{u}+\frac{\delta\lambda^2}{u}+\frac{(\eta-1)\,\lambda^3}{3u})+h_w(C_O t_1+\frac{(\eta-1)t_2^2}{v}-\frac{(\eta-1)t_1 t_2}{v}+\frac{(\eta-1)t_1^2}{2v}-\frac{(\eta-1)t_2^2}{2v})$ (15)

4. **Shortages cost of Chemical Industry**

$C_S = S_c f\ (\frac{\delta T^2}{2}-\frac{\delta t_2^2}{2}+\frac{(\eta-1)T^3}{6}-\frac{(\eta-1)t_2^3}{6}-\delta t_1 T+\delta t_2^2-\frac{(\eta-1)t_2^2\,T}{2}+\frac{(\eta-1)t_2^3}{2})$ (16)

5. **Opportunity cost/Lost sale cost of Chemical Industry**

$CL= L_c\ \left(1-(\frac{\delta T^2}{2}-\frac{\delta t_2^2}{2}+\frac{(\eta-1)T^3}{6}-\frac{(\eta-1)t_2^3}{6}-\delta t_1 T+\delta t_2^2-\frac{(\eta-1)t_2^2\,T}{2}+\frac{(\eta-1)t_2^3}{2})\right)$ (17)

6. **Purchase cost of Chemical Industry**

$C_P=P_c\ \left(C_O+\{(\frac{(\eta-1)}{u^2}-\frac{\delta}{u})+\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}(\delta t_1-1)e^{-ut_1}\}+f\{\delta(T-t_2)+\frac{(\eta-1)}{2}(T^2-t_2^2)\}\right)$ (18)

7. **Advertisement cost of Chemical Industry**

$AC= A_c$ (19)

Therefore Total relevant Inventory of Chemical Industry cost

$\mathbf{T^C}$ **(t_1, T)** $=\frac{1}{T}[A+C_P+C_S+CL+H_C]+AC$

$=\frac{1}{T}\ [A+P_c\ \left(C_O+\{(\frac{(\eta-1)}{u^2}-\frac{\delta}{u})+\{\frac{\delta}{u}+\frac{(\eta-1)}{u^2}(\delta t_1-1)e^{-ut_1}\}+f\{\delta(T-t_2)+\frac{(\eta-1)}{2}(T^2-t_2^2)\}\right)+S_c f(\frac{\delta T^2}{2}-\frac{\delta t_2^2}{2}+\frac{(\eta-1)T^3}{6}-\frac{(\eta-1)t_2^3}{6}-\delta t_1 T+\delta t_2^2-\frac{(\eta-1)t_2^2\,T}{2}+\frac{(\eta-1)t_2^3}{2})\ +L_C\ \left(1-(\frac{\delta T^2}{2}-\frac{\delta t_2^2}{2}+\frac{(\eta-1)T^3}{6}-\frac{(\eta-1)t_2^3}{6}-\delta t_1 T+\delta t_2^2-\frac{(\eta-1)t_2^2\,T}{2}+\frac{(\eta-1)t_2^3}{2})\right)+h_r(\delta t_1\lambda+(\eta-1)t_1^2\lambda-\frac{(\eta-1)\lambda^2}{2u}-\frac{(\eta-1)t_1^2}{3u}+\delta t_1^3+(\eta-1)t_1^4-\frac{\delta\lambda}{u}-(\eta-1)t_1\lambda^2-\delta t_1\lambda^2-(\eta-1)t_1^2\lambda^2+\frac{(\eta-1)\,t_1\lambda^2}{u}+\frac{\delta\lambda^2}{u}+\frac{(\eta-1)\,\lambda^3}{3u})+h_w(C_O t_1+\frac{(\eta-1)t_2^2}{v}-\frac{(\eta-1)t_1 t_2}{v}+\frac{(\eta-1)t_1^2}{2v}-\frac{(\eta-1)t_2^2}{2v})]+A_C$

(20)

The total relevant inventory cost is minimum if

$\frac{\partial T^C}{\partial t_1}=0$ and $\frac{\partial T^C}{\partial T}=0$

$\left(\frac{\partial^2 T^C}{\partial t_1^2}\right)\left(\frac{\partial^2 T^C}{\partial T^2}\right)-\frac{\partial^2 T^C}{\partial t_1\,\partial T}>0$

V. PROPOSED PARTICLE SWARM OPTIMIZATION ALGORITHM

Particle Swarm Optimization (PSO) introduced by Kennedy and Eberhart in 1995 is a population based evolutionary computation technique. It has been developed by simulating bird flocking fish schooling or sociological behaviour of a group of people artificially. Here the population of solution is called swarm which is composed of a number of agents known as particles. Each particle is treated as point in d-dimensional search space which modifies its position according to its own flying experience and that of other particles present in the swarm. The algorithm starts with a population (swarm) of random solutions (particles). Each particle is assigned a random velocity and alloHered to move in the problem space. The particles have memory and each of them keeps track of its previous (local) best position.

K: =0
$\{L_s, E_s, H_s, J_s\}_{s=1}^{S}$:= initialize()
For x: = 1: U
For b: = 1: S
For r: = 1: R
$e_{sc}^{(x+1)} = ye_{sc}^{x} + c_1 l_1[J_{sc} - l_{sc}^{x}] + c_2 d_2\,[H_{sc} - l_{sc}^{x}]$
$D_s^{x+1} = D_s^{x} + dE_s^{x} + \epsilon^{x}$
end
D_s: = enforce Constraints(S)
Y_s= f(L_s)
If $D_s \npreceq$e ∀ e ∈ K
K:= {e ∈K/ e$\nprec L_s$ }
K:= K∪L_s
End
End
If $L_s \preceq J_s$ ∨ (S$L_s \nprec J_s \wedge J_s \nprec D_s$)
J_s := L_s
End
H_s := selectGuide(S , A)
End

VI. PROPOSED SIMULATED ANNEALING

Simulated Annealing (SA) is a technique for finding good solution to minimization problems. It simulates the physical annealing process of solidifying a metal to a uniform crystalline structure. In order to achieve this uniform crystalline structure the metal is first heated to a molten state and the gradually cooled down. The critical parameter of this process is the rate of cooling. If the cooling takes place too quickly energy gaps will be formed resulting in non-uniformity in the crystalline structure. On the other hand if the cooling takes place too slowly then time is wasted. The optimal cooling rate varies from metal to metal.

Let us assume that a minimization problem involving m design variables: $x_1, x_2, \ldots\ldots\ldots, x_m$ is to be solved the SA

The problem may be stated as follows:

Minimize P = J (X)

Subject to

$X^{min} \leq X \leq X^{max}$

Step 1: Here assign a high intitial temperature to molten metal say Y_0 select an initial solution X_0 at random and set a termination criterion ε to a small value and iteration number y = 0

Step 2: Here calculate the temperature of (y+1)-th iteration that is Y_{y+1} as 60% of that of y-th iteration that is Y_y therefore $Y_{y+1}=0.6\times Y_y$ Here generate a candidate solution for (y+1)-th iteration that is X_{y+1} at random in the neighborhood of X_y .

Step 3: if the change in energy $\delta J = J(X_{t+1}) - J(X_t) < 0$ then Here accept X_{y+1} as the next solution and set y = y+1

Else Here generate a random number r lying in the range of (1.0, 4.0) and if $r \leq \exp\,(\frac{-\delta J}{Y_{y+1}})$ Here accept X_{y+1} as the next solution and set y = y+1

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Else Here reject X_{y+1} and set y = y and go to step 2.

Step 4: if | $J(X_{y+1}) - J(X_y)$ |< ε and Y reaches a small value Here terminate the program.

VII. IMPLEMENTATION OF SYSTEM & RESULTS

In the proposed algorithm steps is applied on mathematical results obtained from the mathematical inventory model. It provides best cost solution and optimizes the results. MATLAB is used to implement the proposed work. MATLAB stands for matrix programming language which was developed by Math Works. It is a programming language that makes algebra programming simple. MATLAB is a fourth-generation high level programming language that provides an interactive environment for computation, visualization and programming. Functions of MATLAB that are used in proposed work are:

- Zeros: it will create an array of all zeros.
- Rand: It will generate array of random numbers.
- Sum: Sum of array elements.
- Ones: Create an array of all ones.
- Consume: It returns cumulative sum of all elements.
- Cost function: This function is used to optimize the results.
- Floor: Rounds the elements to the nearest integers less than or equal to value.
- Plot: To plot graphs.

VIII. NUMERICAL ANALYSIS

The following randomly chosen data in appropriate units has been used to find the optimal solution and validate the model of the three players the producer, the distributor and the retailer. The data are given as δ=50, A=450, C=400, (η-1)=2.50, h_w=80, h_r=57, P_C=450, u=3.01, v=4.01, S_C=750, λ =3.16, f=4.07 and Lc=200.

Particle Swarm optimization algorithm for lot Sizing Problem

The total 10 problem instances are run for the binary PSO with holding cost of δ+(η-1)t = € 1.52, ordering cost of A=€ 70, shortages cost of SC = € 1.50 and advertisement Cost of AC = € 1.57 in order to compare the results with those optimal by the Wagner-Whit in algorithm. For each problem instance, 10 replications are conducted. Minimum, maximum, average, and standard deviation are given together with the CPU times.

Simulate Annealing to solve this minimization Problem

The initial temperature of modal Y_0 = 6000^0 K, Initial solution selected at random $X_0 = \binom{4.7}{4.7}$

Termination criterion = 1.001, Let random number varying in the range of (1.0, 2.0) are as follows: 1.3, 1.8, 1.9, 1.8, 1.4, 1.7, 1.4, 1.6, 1.9, 1.7, and so on

The computational optimal solutions of the models are shown in Table-1.

Table-1: Total relevant cost

Cost function	t_1^*	t_2^*	T^*	Total relevant cost	Particle Swarm optimization	Simulate Annealing
$T^c(t_1^*, T)$	4.47	36.70	97.24	71351	61351	61300

IX. SENSITIVITY ANALYSIS

Table-2: Sensitivity analysis

Parameter		t_1^*	t_2^*	T	% change in $T^c(t_1^*, T^*)$
Δ	50	1.49	4.19	4.61	5.10
	60	4.51	5.57	5.05	3.37
	45	3.44	1.09	3.45	-0.38
	40	1.41	9.33	3.76	-2.94
(η-1)	0.45	3.46	9.47	1.68	5.06
	0.65	1.45	6.64	9.47	13.10
	0.57	5.48	6.44	7.26	-2.78
	0.30	4.49	7.83	8.88	-6.58
A	650	1.47	2.70	7.24	7.16
	800	2.74	6.70	7.27	1.56
	350	2.15	3.70	4.24	1.26
	200	3.12	4.70	5.24	1.56
C_s	75	3.14	3.03	3.60	2.34
	30	1.54	3.31	3.06	2.76
	25	3.65	2.31	5.02	3.50
	20	2.13	1.84	5.98	0.74
L_c	210	3.47	6.68	4.26	3.72
	220	4.74	6.66	4.27	1.86
	80	2.47	6.72	4.23	4.97
	50	1.52	6.75	4.22	2.83
Λ	2.77	4.52	8.61	8.70	19.12
	2.93	4.65	4.48	8.34	21.94
	2.44	4.34	7.10	6.07	-7.20
	2.28	4.93	5.82	6.29	-14.15
P_C	650	3.59	3.95	5.20	4.75
	800	4.70	5.14	6.07	6.84
	350	3.35	1.37	3.19	-2.28
	200	4.21	9.97	2.05	-2.41
h_w	62	5.46	59.64	7.96	7.79
	74	5.45	6.95	6.90	8.58
	51	5.48	6.21	7.98	-3.57
	47	5.49	7.30	80.24	-5.19
h_r	28.5	2.73	6.30	7.39	4.21
	30.0	2.82	6.81	7.43	7.54
	76.5	2.95	6.01	7.97	-2.87
	61.0	2.37	5.19	6.54	-4.70
U	0.14	3.48	6.02	7.11	-4.11
	0.15	3.49	5.58	7.28	-5.57
	0.11	3.46	6.69	7.76	4.15
	0.10	3.44	6.08	7.80	8.24
v	0.15	1.46	6.02	7.90	-2.90
	0.16	1.45	9.15	7.45	-4.15
	0.12	2.24	9.17	7.46	7.88
	0.11	2.94	5.39	6.53	12.60

Table 3:- PSO Results

P	WW	PSO			
	OPT	BEST	MAX	AVG	STD
1	21.10	21.50	21.25	28.10	2.27
2	21.20	21.55	21.35	28.15	1.66
3	20.30	20.60	25.40	21.20	3.01

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4	20.40	20.65	23.45	29.25	6.04
5	20.55	20.75	20.55	22.30	3.59
6	21.60	21.80	21.60	24.35	5.15
7	20.65	20.85	21.65	28.40	1.81
8	21.70	21.90	21.70	20.45	5.47
9	22.75	22.95	22.75	26.47	2.32
10	20.80	20.00	20.80	24.50	4.58

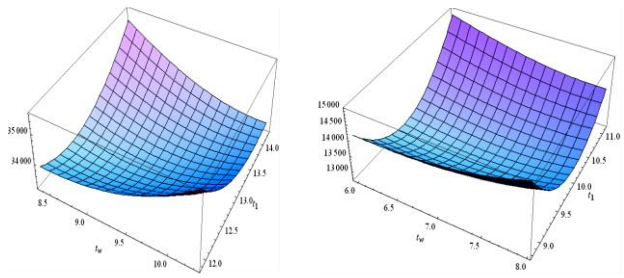

Figure-1: Graph representing inventory cost function

X. CONCLUSION

In this research paper, a new Particle swarm optimization Algorithm and Simulated Annealing has been proposed for the optimization of two warehouse inventory model with the objective of minimizing the total relevant cost. Two different cases have been considered to optimize the relevant cost. Furthermore the proposed Particle swarm optimization Algorithm and Simulated Annealing is very useful to optimize the cost. The Particle swarm optimization Algorithm and Simulated Annealing is implemented in MATLAB. The Particle swarm optimization Algorithm and Simulated Annealing is applied on mathematical model to optimize the cost. Consequently, it can be concluded that this Particle swarm optimization Algorithm and Simulated Annealing is a Herell-designed and promising method for optimization.

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