Fuzzy Inventory Control Problem With Quadratic Time Dependent Demand, Deterioration Rate & Holding Cost With Shortage

1.Sachin Kumar Rana* 2. Dr. Amit Kumar**

* Research Scholar, S.M.P.G. Degree College Meerut.
** Assistant Professor, S.M.P.G. Degree College Meerut.

Abstract: In this model, we consider fuzzy inventory model for deteriorating items with time dependent demand rate and backlogging of items depend on demand of the items with no lead time. This model is quite helpful for such business conditions where demand increase rapidly because we take demand rate as quadratic function of time. Inventory holding cost, ordering cost, and deterioration rate are all of function of time. The version is solved analytically via way of means of minimizing the whole stock fee. The end result is illustrated with numerical instance for the version. Graded mean representation method is used to defuzzify the fuzzified values.

Key Words: **Fuzzy numbers, Defuzzification, deterioration, holding cost etc.**

Introduction: The stock version count on sure or unsure call for and deliver. Demand and deliver each are unsure because of unpredictable events. Since a number of the uncertainty inside stock gadget can not be taken into consideration as it should be the usage of idea of possibility idea, fuzzy set idea has been utilized in version of stock gadget. In the stock the impact of degradation could be very important. As the stock degree is going up the fee of storing, preserving stock and inventory out additionally increases. Fuzzy set idea has been utilized in modeling of stock systems. Fuzzy set idea, first added via way of means of Zadeh, offer a framework thinking about parameters which are unclearly described or decided primarily based totally on subjective ideals of individuals.

Fuzzy Inventory Control Models: The stock manage the usage of the bushy set idea has awesome benefits in decreasing the wide variety of set-ups and inventory-outs. In the bushy surroundings, the stock version became initiated via way of means of Lee and Yao [8]. Following Lee and Yao [8], many researchers had studied numerous training of fuzzy stock models. Ching-Wu Chu et al. [3] analysed a brand new stock manage method known as ABC fuzzy classification. Faritha Asma and Henry Amirtharaj [5] proposed a technique for fixing a fuzzy multi object stock version collectively with the constraints. Rong and Maiti [12] advanced a brand new method to clear up an EOQ version with provider degree constraint and controllable lead time. Majumder et al. [9] and Mishra et al. [10] analysed a fuzzy monetary manufacturing fine version for deteriorating objects. Datta and Kumar (4) advanced fuzzy stock version with out scarcity the usage of fuzzy trapezoidal numbers. They used signed distance technique for defuzzification. They concluded that fuzzy trapezoidal numbers had been higher and monetary than fuzzy triangular numbers. Ranganathan and Thirunavukarasu (11) advanced fuzzy stock version with scarcity the usage of trapezoidal fuzzy wide variety. They taken into consideration constant deterioration and call for with scarcity and completely backlogged. They defuzzified the bushy version the usage of graded suggest integration illustration technique. Karthiegeyan et al. (7) had advanced fuzzy optimize manufacturing EOQ version with consistent price and permitting the shortages. They analyzed a non-stop manufacturing stock version for deteriorating objects with shortages below fuzzy surroundings to estimate numerous fuzzy ultimate portions along side the respective defuzzified end result via way of means of assuming the call for and manufacturing charges along side the preserving fee, scarcity fee and deteriorating fee as trapezoidal fuzzy numbers and the time of degradation is exponential. Murthy etal.(2) advanced fuzzy stock manage trouble with Weibull deterioration and logarithmic call for price the usage of trapezoidal fuzzy wide variety. GMRI technique is used to defuzzify the fuzzyified values. Javad et al. (6) advanced a restricted supplier-controlled stock version with fuzzy call for for a single-supplier multi-store SC, wherein the centroid defuzzification technique defuzzifies trapezoidal fuzzy numbers of the call for. Asif et al. (1) investigated a multi-restricted SC version with ultimate manufacturing price with regards to fine of merchandise below stochastic fuzzy call for. Seyed (14) took a greater whole method via way of means of the usage of fuzzy mathematical programming to assemble a multi-goal version for a opposite logistics network. S. Priyan et.al.(13) advanced a sustainable dual-channel supplier-purchaser deliver chain version has taken into consideration for a controllable emission below fuzzy call for and strength consumption.

Notations & Assumptions:

The mathematical model is developed on the following assumptions and notations:

- The demand rate D(t) at time t is assumed to be D(t) = $a + bt + ct^2, a \geq 0, b \neq 0, c \neq 0$. Here a is the initial rate of demand, b is the initial rate of change of the demand and c is the acceleration of demand rate.
- Deterioration rate is time proportional.
- $\alpha(t) = \alpha t$, where α is the rate of deterioration; 0< α <1.
- Replenishment rate is infinite and lead time is zero.
- S, the selling price per unit.
- Other inventory related cost are subject to same rate of inflation, say k. Ordering quantity can be determined by minimizing the total system cost over the planning period.

- A(t) is the ordering cost at time t.
- C(t) denotes unit cost at time I.
- I(t) is the inventory level at time t.

Fuzzy Concepts:

Fuzzy number- If a fuzzy set is convex and normalized and its membership function is defined in R and piecewise continuous is called as fuzzy number.

Fuzzy arithmetical operations:

If $\tilde{A} = (a_1, a_2, a_3, a_4)$ and $\tilde{B} = (b_1, b_2, b_3, b_4)$ are two trapezoidal fuzzy number, then

$\tilde{A} + \tilde{B} = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4)$

$\tilde{A}\tilde{B} = (c_1, c_2, c_3, c_4)$ where $T = (a_1b_1, a_1b_4, a_4b_1, a_4b_4), T_1 = (a_2b_2, a_2b_3, a_3b_2, a_3b_3),$

$c_1 = minT, c_2 = minT_1, c_3 = maxT_1, and\ c_4 = maxT$

If $a_1, a_2, a_3, a_4, b_1, b_2, b_3, b_4$ are all non-zero positive real numbers, then $\tilde{A}\tilde{B} = (a_1b_1, a_2b_2, a_3b_3, a_4b_4)$, $\sqrt{\tilde{A}} = \sqrt{(a_1, a_2, a_3, a_4)} = (\sqrt{a_1}, \sqrt{a_2}, \sqrt{a_3}, \sqrt{a_4})$

$\tilde{A} - \tilde{B} = (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1)$, $-\tilde{B} = (-b_4, -b_3, -b_2, -b_1)$

$\frac{1}{\tilde{B}} = \tilde{B}(-1) = \left(\frac{1}{b_4}, \frac{1}{b_3}, \frac{1}{b_2}, \frac{1}{b_1}\right)$ and $\tilde{A}/\tilde{B} = (\frac{a_1}{b_4}, \frac{a_2}{b_3}, \frac{a_3}{b_2}, \frac{a_4}{b_1})$

Graded mean representation integration : method of defuzzification of a generalized trapezoidal fuzzy number by its graded mean integration representation was proposed by Hsieh and defined by $GMRI(\tilde{A}) = (a_1 + 2a_2 + 2a_3 + a_4)/6$

Mathematical Model & Its Analysis:

In this deterministic model demand is quadratic time dependent with no lead time. The objective of the inventory problem is to determine the optimal order quantity, where deterioration rate, holding cost both are function of time and shortages are not allowed. If $I(t)$ be the inventory level at time t, the differential equation which describes the inventory level at time t are given by

$$\frac{dI_1}{dt} = -\alpha(t)I_1(t) - D(t), \qquad 0 \le t \le t_1 \qquad (1)$$

$$\frac{dI_2}{dt} = -D(t), \qquad t_1 \le t \le T \qquad (2)$$

Where $D(t) = a + bt + ct^2$.

Boundary conditions are $I_1(0) = I_0$ at time t = 0 and $I(T) = 0$. (3)

Solution of equation (1) and (2) are given by

$$I_1(t) = -e^{-\frac{\alpha t^2}{2}} \int_t^{t_1} (1 + \frac{\alpha t^2}{2})(a + bt + ct^2)\ dt \qquad (4)$$

$$I_2(t) = -\int_{t_1}^{T} (a + bt + ct^2)\ dt \qquad (5)$$

Solution of (4) and (5) are

$$I_1(t) = a(t_1 - t) + b(\frac{t_1^2}{2} - \frac{t^2}{2}) + (c + \frac{a\alpha}{2})(\frac{t_1^3}{3} - \frac{t^3}{3}) + \frac{b\alpha}{2}(\frac{t_1^4}{4} - \frac{t^4}{4}) + \frac{c\alpha}{2}(\frac{t_1^5}{5} - \frac{t^5}{5})$$
$$-\frac{\alpha t^2}{2}\{a(t_1 - t) + b(\frac{t_1^2}{2} - \frac{t^2}{2}) + \frac{c}{2}(\frac{t_1^3}{3} - \frac{t^3}{3})\}, \qquad 0 \le t \le t_1 \qquad (6)$$

$$I_2(t) = a(t_1 - t) + b(\frac{t_1^2}{2} - \frac{t^2}{2}) + c(\frac{t_1^3}{3} - \frac{t^3}{3}), \qquad t_1 \le t \le T \qquad (7)$$

As the replenishment is instantenous, lead time zero.

$$S = I_1(0) = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha}{2}(\frac{T^5}{5}) \qquad (8)$$

Deteriorating cost during $(0, \tau)$ is

$$= \frac{C_d}{T}(S - \int_0^{t_1}(at^2 + bt + c)dt)$$

$$= \frac{C_d}{T}\{aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha}{2}(\frac{T^5}{5}) - (\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1)\}$$

Shortage cost $= \frac{C_s}{T}\int_{t_1}^{T} I_2(t)\,dt$

$$= \frac{C_s}{T}\{-(T - t_1)^2\left(\frac{3a + 3bT + 6bt_1 + 2cT^2 + 4cTt_1 + 6ct_1^2}{12}\right)\}$$

Holding cost during $(0, \tau)$ is

$$\frac{C_h}{T}\int_0^{t_1} I(t)\,dt)$$

$$= \frac{C_h}{T}\int_0^{t_1} I_1(t)\,dt \qquad (9)$$

Here $\int_0^{t_1} I_1(t)\,dt = \frac{at_1^2}{2} + \frac{bt_1^3}{3} + \frac{ct_1^4}{4} + \frac{a\alpha t_1^4}{12} + \frac{b\alpha t_1^5}{15} + \frac{5c\alpha t_1^6}{72}$

Total cost of inventory system during $(0, \tau)$ is given by

$K(T, \tau) = deteriorating\ cost + shortage\ cost + holding\ cost$

$$TC = K(T, \tau) = \frac{C_d}{T}\{aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha}{2}(\frac{T^5}{5}) - \left(\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1\right)\} + \frac{C_s}{T}\left\{-(T - t_1)^2\left(\frac{3a + 3bT + 6bt_1 + 2cT^2 + 4cTt_1 + 6ct_1^2}{12}\right)\right\} + \frac{C_h}{T}(\frac{at_1^2}{2} + \frac{bt_1^3}{3} + \frac{ct_1^4}{4} + \frac{a\alpha t_1^4}{12} + \frac{b\alpha t_1^5}{15} + \frac{5c\alpha t_1^6}{72}) \qquad (10)$$

To minimize the total cost

$$\frac{\partial TC}{\partial T} = 0\ And\ \frac{\partial TC}{\partial \tau} = 0 \qquad (11)$$

Condition for TC to be minimum is

$\left(\frac{\partial^2 TC}{\partial \tau^2}\right)\left(\frac{\partial^2 TC}{\partial T^2}\right) - \left(\frac{\partial^2 TC}{\partial \tau \partial T}\right) > 0 \;\; and \;\; \left(\frac{\partial^2 TC}{\partial \tau^2}\right) > 0$

Equation (10) and (11) provide minimum total inventory cost per unit time of the inventory system, nature of the cost function is highly non- linear.

FUZZY MODEL

We consider this model in fuzzy environment. We use the following variables :

$\tilde{\alpha}$: *fuzzy scale parameter in time dependent deterioration*, C_d: *fuzzy deterioration cost*, C_h: *fuzzy holding cost*, C_s: *fuzzy shortage cost.*

Suppose $\tilde{C}_d = (\tilde{C}_{d1}, \tilde{C}_{d2}, \tilde{C}_{d3}, \tilde{C}_{d4}), \tilde{C}_h = (\tilde{C}_{h1}, \tilde{C}_{h2}, \tilde{C}_{h3}, \tilde{C}_{h4}), \tilde{C}_s = (\tilde{C}_{s1}, \tilde{C}_{s2}, \tilde{C}_{s3}, \tilde{C}_{s4})$, $\tilde{\alpha} = (\tilde{\alpha}_1, \tilde{\alpha}_2, \tilde{\alpha}_3, \tilde{\alpha}_4)$ are non-negative trapezoidal fuzzy numbers.

The total average cost per unit time is given by

$\tilde{T}(avg) = \tilde{C}_d \otimes \{(\tilde{\alpha} \otimes P) \oplus L\} \oplus (\tilde{C}_s \otimes M) \oplus \tilde{C}_h \otimes \{(\tilde{\alpha} \otimes Q) \oplus N\}$

Where, $L = \frac{1}{T}\left(a\left(T - \frac{\alpha T^3}{6} - \frac{t_1^3}{3}\right)\right)$

$P = \frac{1}{T}\left(b\left(\frac{T^2}{2} + \frac{\alpha T^4}{8} - \frac{t_1^2}{2}\right) + c\left(\frac{T^3}{3} + \frac{\alpha T^5}{10} - t_1\right)\right)$

$M = T_1 + T_2 + T_3$, $where\ T_1 = \frac{1}{T}\left(\frac{a}{4}(T - t_1)^2\right)$, $T_2 = \frac{1}{T}\left(\frac{b}{4}(T - t_1)^2(T + 2t_1)\right)$

$T_3 = \frac{1}{T}\left(\frac{c}{6}(T - t_1)^2(T^2 + 2Tt_1 + 3t_1^2)\right)$

$Q = \frac{1}{T}\left(\frac{a\alpha t_1^4}{12} + \frac{b\alpha t_1^5}{15} + \frac{5c\alpha t_1^6}{72}\right)$

$N = \frac{1}{T}\left(\frac{at_1^2}{2} + \frac{bt_1^3}{3} + \frac{ct_1^4}{4}\right)$

$\tilde{T}(avg) = (P \otimes (\tilde{\alpha} \otimes \tilde{C}_d)) \oplus (L \otimes \tilde{C}_d) \oplus (\tilde{C}_s \otimes M) \oplus (Q \otimes (\tilde{\alpha} \otimes \tilde{C}_h)) \oplus (n \otimes \tilde{C}_h)$

$T(avg(t_1) = [(T(avg_1(t_1)), (T(avg_2(t_1), (T(avg_3(t_1), (T(avg_4(t_1))]$

$(T(avg_1(t_1) = P\tilde{\alpha}_1\tilde{C}_{d1} + L\tilde{C}_{d1} + M\tilde{C}_{s1} + Q\tilde{\alpha}_1\tilde{C}_{h1} + N\tilde{C}_{h1}$

$(T(avg_2(t_1) = P\tilde{\alpha}_2\tilde{C}_{d2} + L\tilde{C}_{d2} + M\tilde{C}_{s2} + Q\tilde{\alpha}_2\tilde{C}_{h2} + N\tilde{C}_{h2}$

$(T(avg_3(t_1) = P\tilde{\alpha}_3\tilde{C}_{d3} + L\tilde{C}_{d3} + M\tilde{C}_{s3} + Q\tilde{\alpha}_3\tilde{C}_{h3} + N\tilde{C}_{h3}$

$(T(avg_4(t_1) = P\tilde{\alpha}_4\tilde{C}_{d4} + L\tilde{C}_{d4} + M\tilde{C}_{s4} + Q\tilde{\alpha}_4\tilde{C}_{h4} + N\tilde{C}_{h4}$

Defuzzifying the total average cost $T(avg(t_1)$ by GMIR method.

$$T(avg(t_1) = \frac{P}{6}(\tilde{\alpha}_1\tilde{C}_{d1} + 2\tilde{\alpha}_2\tilde{C}_{d2} + 2\tilde{\alpha}_3\tilde{C}_{d3} + \tilde{\alpha}_4\tilde{C}_{d4}) + \frac{L}{6}(\tilde{C}_{d1} + 2\tilde{C}_{d2} + 2\tilde{C}_{d3} + \tilde{C}_{d4}) + \frac{M}{6}(\tilde{C}_{s1} + 2\tilde{C}_{s2} + 2\tilde{C}_{s3} + \tilde{C}_{s4}) + \frac{Q}{6}(\tilde{\alpha}_1\tilde{C}_{h1} + 2\tilde{\alpha}_2\tilde{C}_{h2} + 2\tilde{\alpha}_3\tilde{C}_{h3} + \tilde{\alpha}_4\tilde{C}_{h4}) + \frac{N}{6}(\tilde{C}_{h1} + 2\tilde{C}_{h2} + 2\tilde{C}_{h3} + \tilde{C}_{h4})$$

To minimize the total average cost per unit time

$$\frac{d}{dt_1}T(avg(t_1) = \frac{P'}{6}(\tilde{\alpha}_1\tilde{C}_{d1} + 2\tilde{\alpha}_2\tilde{C}_{d2} + 2\tilde{\alpha}_3\tilde{C}_{d3} + \tilde{\alpha}_4\tilde{C}_{d4}) + \frac{L'}{6}(\tilde{C}_{d1} + 2\tilde{C}_{d2} + 2\tilde{C}_{d3} + \tilde{C}_{d4}) + \frac{M'}{6}(\tilde{C}_{s1} + 2\tilde{C}_{s2} + 2\tilde{C}_{s3} + \tilde{C}_{s4}) + \frac{Q'}{6}(\tilde{\alpha}_1\tilde{C}_{h1} + 2\tilde{\alpha}_2\tilde{C}_{h2} + 2\tilde{\alpha}_3\tilde{C}_{h3} + \tilde{\alpha}_4\tilde{C}_{h4}) + \frac{N'}{6}(\tilde{C}_{h1} + 2\tilde{C}_{h2} + 2\tilde{C}_{h3} + \tilde{C}_{h4})$$

Where, $P' = \frac{at_1^2}{T}$

$L' = \frac{-bt_1 - c}{T}$

$M' = \frac{1}{T}\left(\frac{a(t_1 - T)}{2} + \frac{3bt_1(t_1 - T)}{2} + 2ct_1^2(t_1 - T)\right)$

$Q' = \frac{1}{T}\left(\frac{a\alpha t_1^3}{3} + \frac{b\alpha t_1^4}{3} + \frac{5c\alpha t_1^5}{12}\right)$

$N' = \frac{1}{T}(at_1 + bt_1^2 + ct_1^3)$

Optimal amount of the initial inventory after fulfilling backorder S̃ denoted by S̃* by GMIR method is

S̃*=$(S*_1 + S*_2 + S*_3 + S*_4)/6$, where

$S*_1 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_1}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_1}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_1}{2}\left(\frac{T^5}{5}\right)$

$S*_2 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_2}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_2}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_2}{2}\left(\frac{T^5}{5}\right)$

$S*_3 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_3}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_3}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_3}{2}\left(\frac{T^5}{5}\right)$

$S*_4 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_4}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_4}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_4}{2}\left(\frac{T^5}{5}\right)$

Optimal amount of unit deteriorating D̃ denoted by D̃* by GMIR method is

D̃*=$(D*_1 + D*_2 + D*_3 + D*_4)/6$, where

$D*_1 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_1}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_1}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_1}{2}\left(\frac{T^5}{5}\right) - \left(\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1\right)$

$D*_2 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_2}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_2}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_2}{2}\left(\frac{T^5}{5}\right) - \left(\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1\right)$

$D*_3 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_3}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_3}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_3}{2}\left(\frac{T^5}{5}\right) - \left(\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1\right)$

$\tilde{D}*_4 = aT + b\left(\frac{T^2}{2}\right) + \left(c + \frac{a\alpha_4}{2}\right)\left(\frac{T^3}{3}\right) + \frac{b\alpha_4}{2}\left(\frac{T^4}{4}\right) + \frac{c\alpha_4}{2}\left(\frac{T^5}{5}\right) - \left(\frac{at_1^3}{3} + \frac{bt_1^2}{2} + ct_1\right)$

Thus minimum value of the total cost $T(avg(t_1)$ denoted by $T(avg(t_1) *$ by GMIR method is

$$T(avg(t_1) *= \frac{1}{6}\left(P\tilde{\alpha}_1\tilde{C}_{d1} + L\tilde{C}_{d1} + M\tilde{C}_{s1} + Q\tilde{\alpha}_1\tilde{C}_{h1} + N\tilde{C}_{h1}\right) + \frac{1}{3}\left(P\tilde{\alpha}_2\tilde{C}_{d2} + L\tilde{C}_{d2} + M\tilde{C}_{s2} + Q\tilde{\alpha}_2\tilde{C}_{h2} + N\tilde{C}_{h2}\right) + \frac{1}{3}\left(P\tilde{\alpha}_3\tilde{C}_{d3} + L\tilde{C}_{d3} + M\tilde{C}_{s3} + Q\tilde{\alpha}_3\tilde{C}_{h3} + N\tilde{C}_{h3}\right) + \frac{1}{6}\left(P\tilde{\alpha}_4\tilde{C}_{d4} + L\tilde{C}_{d4} + M\tilde{C}_{s4} + Q\tilde{\alpha}_4\tilde{C}_{h4} + N\tilde{C}_{h4}\right)$$

Numerical Examples

In this paper, holding, shortage, deterioration costs and other parameter assumed in crisp model and in Fuzzy model as a trapezoidal fuzzy numbers using graded mean integration representation (GMIR) method. Result is shown by an example:-

ILLUSTRATION

The given values are $C_d = 15, C_s = 41, C_h = 75, and\ we\ assume\ t_1 = 0.5, T = 1,$

$a = 100, b = 15, c = 0.05, \alpha = 0.1$

SOLUTION

For crisp model:-

D*=D=1499.617 and K(T, τ) $= T(avg) = 2821.55$

For fuzzy model:-

$\tilde{\alpha} = (\tilde{\alpha}_1, \tilde{\alpha}_2, \tilde{\alpha}_3, \tilde{\alpha}_4) = (0.05, 0.1, 0.1, 0.15),$

$\tilde{C}_d = (14,15,15,16), \tilde{C}_h = (70,75,75,80), \tilde{C}_s = (40,41,41,42),$

P=94.17, L=5.8045, M=8.13, Q=0.55, N=13.126

$T(avg(t_1) *= 1551.841$

Conclusion

In this paper, scale parameter in deterioration cost, holding cost, shortage cost are considered as trapezoidal fuzzy number by GMIR method for a given cycle. To defuzzify the fuzzy model we use GMIR method. From the numerical illustration we see that total average cost in crisp model is more than the fuzzy model. For cost minimization fuzzy model is suitable.

REFERENCES

1. Asif, I.M., Byung, S.K., *A multi-constrained SC model with optimal production rate in relation to quality of products under stochastic fuzzy demand*. Comput. Ind. Eng. 149(2020), 106814.
2. Balarama Murthy S., Karthigeyan S., and Pragathi J., *Fuzzy inventory control problem with Weibull deterioration rate and logarithmic demand rate*, International Journal of Pure and Applied Mathematics, (2017),117(11), 335-344.
3. Ching-Wu Chu, Gin-Shuh Liang and Chien-Tseng Liao, *Controlling inventory by combining ABC analysis and fuzzy classification*, Computers & Industrial Engineering, 55 (2008), 841- 851.
4. Dutta D., and Kumar P., *Fuzzy inventory model without shortage using trapezoidal fuzzy numbers with sensitive analysis,* ISOR Journal of Mathematics, (2012),4(3), 32-37.
5. Faritha Asma, A., and Henry Amirtharaj, E.C., *A new method for solving deterministic multi-item fuzzy inventory model with three constraints*, International Journal for Scientific Research & Development, 3 (2015), 540-543.
6. Javad, S., Seyed, M.M., Seyed, T.A.N., *Optimizing an inventory model with fuzzy demand, backordering, and discount using a hybrid imperialist competitive algorithm*. Appl. Math. Model. 40(2016), 7318–7335.
7. Karthigeyan S., Balarama Murthy S., and Saranya A., *Fuzzy optimized production EOQ model with constant rate and allowing the shortages*, International Journal of Applied Engineering Research, (2015), 10(80), 13-17.
8. Lee, H.M., and Yao, J.S., *Economic production quantity for fuzzy demand and fuzzy production quantity*, European Journal of Operational Research, 109 (1998), 203-211.
9. Majumder, P., Bera, U.K., and Maiti, M., *An EPQ model of deteriorating items under partial trade credit financing and demand declining market in crisp and fuzzy environment*, Procedia Computer Science, 45 (2015), 780-789.
10. Mishra, S.S., Gupta, S., Yadav, S.K., and Rawat, S., *Optimization of fuzzified economic order quantity model allowing shortage and deterioration with full backlogging*, American Journal of Operational Research, 5 (2015), 103-110.
11. Ranganathan, V., and Thirunavukarasu, P., *An inventory control model for constant deterioration in fuzzy environment*, International Journal of Fuzzy Mathematics and Systems, 4 (2014), 17-26.
12. Rong, M., and Maiti, M., *On an EOQ model with service level constraint under fuzzy-stochastic demand and variable leadtime*, Applied Mathematical Modelling, 39 (2015),5230-5240.
13. Seyed, E., *A fuzzy multi-objective optimization model for a sustainable reverse logistics network design of municipal waste-collecting considering the reduction of emissions.* J. Clean. Prod. 318(2021), 128577.
14. S. Priyan , R. Udayakumar , P. Mala , M. Prabha , Ananya Ghosh, *A sustainable dual-channel inventory model with trapezoidal fuzzy demand and energy consumption*. Cleaner Engineering and Technology 6 (2022), 100400.