International Journal of Scientific and Innovative Mathematical Research (IJSIMR)
Volume 3, Issue 7, July 2015, PP 36-42
ISSN 2347-307X (Print) & ISSN 2347-3142 (Online)
www.arcjournals.org

A study of EOQ Model with Ramp Type of Demand

Ashutosh Pandey

Department of Applied Sciences
ITM University Gurgaon(Haryana),India
ashutosh.srmcem@gmail.com

Himanshu Pandey

Department of Mathematics and Statistics
DDU Gorakhpur University
Gorakhpur U.P.
himanshu_62@yahoo.com

Dileep Kumar

Department of Mathematics and Statistics
DDU Gorakhpur University
Gorakhpur U.P.
ashutosh.srmcem@gmail.com

Abstract: *In this paper, an inventory model with ramp-type demand rate, nobacklogging and time-varying holding cost is considered. In the present model shortages are not allowed. The associated total cost minimized is illustrated by numerical example. Sensitivity analysis is carried out.*

Keywords:*Inventory, Ramp-type demand, Deterioration, Time-varying holding cost.*

MSC: *90B05.*

1. Introduction

Inventory handling is an important part of our manufacturing, retail and distribution infrastructure. Researchers were engaged to develop the inventory models considering the demand of the items to be constant, linearly increasing or decreasing, increasing or decreasing with time, stock-dependent etc. Later, it was realized that the said demand patterns do not precisely depict the demand of items such as newly introduced fashion items, garments, cosmetics, automobiles etc, for which the demand increases with time as they are introduced into the market and after few time, it becomes constant. In order to consider demand of such types, the concept of ramp-type demand is introduced.

Buzacott (1975) have been developed the first EOQ model taking inflationary effects into account. Ray and Chaudhari (1997) developed a finite time horizon deterministic economic order quantity inventory model with shortages. A dynamic programming model was proposed for inventory items with Weibull distributed deterioration by Chen (1998). A model have been discussed by moon and Lee(2000) on the effects of inflation and time value of money on an economic order quantity. Wee and Law (2001) developed a deteriorating inventory model assuming the time value of money for a deterministic inventory model in which demand is considered as price dependent. A model developed by Yang (2004) an inventory models for deteriorating items in which demand is assumed to be constant rate under inflation. Amodels for ameliorating items with time-varying demand pattern over a finite planning horizon were proposed by Moon et al.(2005). Jaggi et al. (2006) worked on the inventory replenishment policy of deteriorating items with under inflationary conditions using a discount cash flow approach over finite planning horizon. Jaggi et al. (2007) presented the optimal inventory replenishment policy for deteriorating items under inflationary conditions using a discounted cash flow approach over a finite time horizon. Singh and Diksha (2009) formulated an inventory model for deteriorating items during a finite planning horizon. Yang et al. (2010) considered a partial backlogging inventory lot size model for deteriorating items with stock-dependent demand. Pandey, H. and Pandey, A.have been developed An Inventory Model for Deteriorating Items with two level storage with uniform demand and shortage under Inflation and completely backlogged. Again Pandey, H. and Pandey, A. have been developed an optimum inventory policy for exponentially deteriorating items, considering multi variate Consumption Rate with Partial Backlogging.

2. Assumptions and Notations

This inventory model is developed on the basis of the following assumption and notations:

(i) A Single item inventory is considered over an infinite time horizone.

(ii) Deterioration rate is assumed to be θ, constant.

(iii) Demand rate D is assumed to be a ramp type function of time

(iv) $D = D_0[t-(t-\mu)F(t-\mu)]$, where $D_0 > 0$ and $F(t-\mu)$ is Heaviside's function and is given by

$$F(t-\mu) = \begin{cases} 1 \; if \; t \geq \mu \\ 0 \; if \; t < \mu \end{cases}$$

(v) Time varying holding cost is considered.

(vi) No shortage and backlogged.

We use the following notation:

(a) O_c is the ordering cost per order.

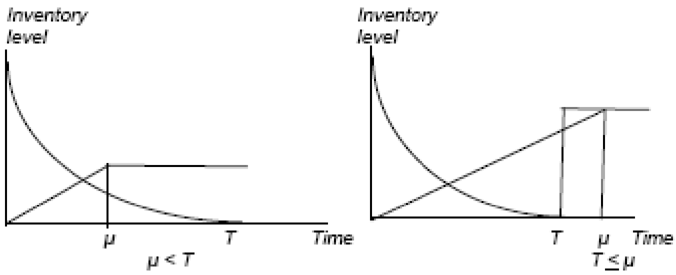
(b) D_c is the deterioration cost per unit per unit of time.

(c) H_c is the holding cost per unit per unit of time.

(d) T_c is the total cost.

2.1 Mathematical Formulation and Solution of the Model

For developing the current model we use the following two case:



Case I: $\mu < T$

Let $I(t)$ denote the inventory in hand in the interval at any time t in the interval $(0 \leq t \leq T)$, the following differential equation is used to describe the state of $I(t)$:

$$\frac{dI(t)}{dt} + \theta.I(t) = -D_0 t \;\; (0 \leq t \leq \mu) \quad (1)$$

$$\frac{dI(t)}{dt} + \theta.I(t) = -D_0 \mu \;\; (0 \leq t \leq \mu) \quad (2)$$

With the boundary condition $I(0) = I_0$ and $I(T) = 0$

By using boundary condition the solution of (1) and (2) is given, respectively by

$$I(t) = e^{-t\theta}Q + \frac{D}{\theta^2} - \frac{De^{-t\theta}}{\theta^2} - \frac{Dt}{\theta} \;(0 \leq t \leq \mu) \quad (3)$$

$$\text{I(t)} = -\frac{D\mu}{\theta} + \frac{De^{(-t+T)\theta}\mu}{\theta} \qquad (\mu \leq t \leq T) \quad (4)$$

Thus, the initial order quantity is obtained by putting the boundary condition,

$$I_0 = \frac{D}{\theta^2} - \frac{De^{\theta\mu}}{\theta^2} + \frac{De^{T\theta}\mu}{\theta} \quad (5)$$

The expression for various cost involving the model is obtained as follows:

(i) Ordering Cost (OC)

$OC = O_c$

(ii) Deterioration Cost:

$$Demand\ during\ [0,T]\ = \int_0^{\mu} Dt\, dt + \int_{\mu}^{T} D\mu\, dt$$

$$= D(T-\mu)\mu + \frac{D\mu^2}{2}$$

$$\text{Number of deteriorates units} = I_0 - Demand\ during\ time\ interval$$

$$= \frac{D_0}{\theta^2} - \frac{D_0 e^{\theta\mu}}{\theta^2} + \frac{D_0 e^{T\theta}\mu}{\theta} - D_0(T-\mu)\mu - \frac{D_0\mu^2}{2}$$

Hence the deterioration cost (DC)

$$= c_d \times Number\ of\ units\ deteriorate$$

$$= c_d\left(\frac{D}{\theta^2} - \frac{De^{\theta\mu}}{\theta^2} + \frac{De^{T\theta}\mu}{\theta} - D(T-\mu)\mu - \frac{D\mu^2}{2}\right) \tag{6}$$

(iii) Inventory holding cost(IHC) is obtained as:

$$IHC = \int_0^{\mu} (h+\delta t)\mathrm{I(t)}\, dt + \int_{\mu}^{T} (h+\delta t)\mathrm{I(t)}\, dt$$

$= \Big(-\frac{D_0\delta}{\theta^4} + \frac{D_0 e^{-\theta\mu}\delta}{\theta^4} - \frac{D_0 h}{\theta^3} + \frac{D_0 e^{-\theta\mu}h}{\theta^3} + \frac{I_0\delta}{\theta^2} - \frac{e^{-\theta\mu}I_0\delta}{\theta^2} + \frac{hI_0}{\theta} - \frac{e^{-\theta\mu}hI_0}{\theta} - \frac{D_0\delta\mu}{\theta^3} + \frac{D_0 e^{-\theta\mu}\delta\mu}{\theta^3} +$

D0℮Tθ−θμδμθ3+D0℮Tθ−θμhμθ2−D0Tδμθ2−D0hTμθ−℮−θμI0δμθ−D0T2δμ2θ+D0δμ22θ2
+D0℮Tθ−θμδμ2θ2+D0hμ22θ+D0δμ36θ

(7)

$$Hence\ Total\ Cost\ involving\ in\ the\ model(TC) = OC + DC + IHC$$

Hence

$$\boldsymbol{TC} = O_c - \frac{D_0\delta}{\theta^4} + \frac{D_0 e^{-\theta\mu}\delta}{\theta^4} - \frac{D_0 h}{\theta^3} + \frac{D_0 e^{-\theta\mu}h}{\theta^3} + \frac{I_0\delta}{\theta^2} - \frac{e^{-\theta\mu}I_0\delta}{\theta^2} + \frac{hI_0}{\theta} - \frac{e^{-\theta\mu}hI_0}{\theta} - \frac{D_0\delta\mu}{\theta^3} + \frac{D_0 e^{-\theta\mu}\delta\mu}{\theta^3} + \frac{D_0 e^{T\theta-\theta\mu}\delta\mu}{\theta^3} + \frac{D_0 e^{T\theta-\theta\mu}h\mu}{\theta^2} - \frac{D_0 T\delta\mu}{\theta^2} - \frac{D_0 hT\mu}{\theta} - \frac{e^{-\theta\mu}I_0\delta\mu}{\theta} - \frac{D_0 T^2\delta\mu}{2\theta} + \frac{D_0\delta\mu^2}{2\theta^2} + \frac{D_0 e^{T\theta-\theta\mu}\delta\mu^2}{\theta^2} + \frac{D_0 h\mu^2}{2\theta} + \frac{D_0\delta\mu^3}{6\theta} + C\left(\frac{D_0}{\theta^2} - \frac{D_0 e^{\theta\mu}}{\theta^2} + \frac{D_0 e^{T\theta}\mu}{\theta} - D_0(T-\mu)\mu - \frac{D_0\mu^2}{2}\right) \tag{8}$$

$$So, Average\ Total\ Cost(\boldsymbol{ATC}) = \frac{TC}{T}$$

$$= \frac{1}{T}\Big(O_c - \frac{D_0\delta}{\theta^4} + \frac{D_0 e^{-\theta\mu}\delta}{\theta^4} - \frac{D_0 h}{\theta^3} + \frac{D_0 e^{-\theta\mu}h}{\theta^3} + \frac{I_0\delta}{\theta^2} - \frac{e^{-\theta\mu}I_0\delta}{\theta^2} + \frac{hI_0}{\theta} - \frac{e^{-\theta\mu}hI_0}{\theta} - \frac{D_0\delta\mu}{\theta^3} + \frac{D_0 e^{-\theta\mu}\delta\mu}{\theta^3} + \frac{D_0 e^{T\theta-\theta\mu}\delta\mu}{\theta^3} + \frac{D_0 e^{T\theta-\theta\mu}h\mu}{\theta^2} - \frac{D_0 T\delta\mu}{\theta^2} - \frac{D_0 hT\mu}{\theta} - \frac{e^{-\theta\mu}I_0\delta\mu}{\theta} - \frac{D_0 T^2\delta\mu}{2\theta} + \frac{D_0\delta\mu^2}{2\theta^2} + \frac{D_0 e^{T\theta-\theta\mu}\delta\mu^2}{\theta^2} + \frac{D_0 h\mu^2}{2\theta} + \frac{D_0\delta\mu^3}{6\theta} + c_d\left(\frac{D_0}{\theta^2} - \frac{D_0 e^{\theta\mu}}{\theta^2} + \frac{D_0 e^{T\theta}\mu}{\theta} - D_0(T-\mu)\mu - \frac{D_0\mu^2}{2}\right)\Big) \tag{9}$$

For maxima and minima the first derivative of Average total cost should be zero and second derivative should be negative i.e.

$$\frac{\partial(ATC)}{\partial T} = 0\ and\ \frac{\partial(ATC)}{\partial\mu} = 0$$

$$\frac{\partial^2(ATC)}{\partial T^2} > 0\ and\ \frac{\partial^2(ATC)}{\partial\mu^2} > 0$$

Now

$\frac{\partial(ATC)}{\partial T} = 0 \; and \; \frac{\partial(ATC)}{\partial \mu} = 0$ the value of $T^* \; and \; \mu^*$.

$\Big[-\frac{O_c}{T^2} + \frac{D_0\delta}{T^2\theta^4} - \frac{D_0e^{-\theta\mu}\delta}{T^2\theta^4} + \frac{D_0h}{T^2\theta^3} - \frac{D_0e^{-\theta\mu}h}{T^2\theta^3} - \frac{c_dD_0}{T^2\theta^2} + \frac{c_dD_0e^{\theta\mu}}{T^2\theta^2} - \frac{I_0\delta}{T^2\theta^2} + \frac{e^{-\theta\mu}I_0\delta}{T^2\theta^2} - \frac{hI_0}{T^2\theta} + \frac{e^{-\theta\mu}hI_0}{T^2\theta} +$ *c0D0eTθμT+D0δμT2θ3−D0e−θμδμT2θ3−D0eTθ−θμδμT2θ3−D0eTθ−θμhμT2θ2+D0eTθ−θμδμTθ2−cdD0eTθμT2θ+D0eTθ−θμhμTθ−D0δμ2θ+e−θμI0δμT2θ−cdD0μ22T2−D0δμ22T2θ2−D0eTθ−θμδμ2T2θ2−D0hμ22T2θ+D0eTθ−θμδμ2Tθ−D0δμ36T2θ=0*(10)

$\Big[-c_dD_0 + \frac{e^{-\theta\mu}hI_0}{T} - \frac{D_0\delta}{T\theta^3} + \frac{D_0e^{T\theta-\theta\mu}\delta}{T\theta^3} - \frac{D_0e^{-\theta\mu}h}{T\theta^2} + \frac{D_0e^{T\theta-\theta\mu}h}{T\theta^2} - \frac{D_0\delta}{\theta^2} - \frac{D_0h}{\theta} + \frac{c_dD_0e^{T\theta}}{T\theta} - \frac{c_dD_0e^{\theta\mu}}{T\theta} -$ *D0Tδ2θ+cdD0μT+e−θμI0δμT+D0δμTθ2−D0e−θμδμTθ2+D0eTθ−θμδμTθ2+D0hμTθ−D0eTθ−θμhμTθ+D0δμ22Tθ−D0eTθ−θμδμ2Tθ=0* (11)

And

$$\frac{\partial^2(ATC)}{\partial T^2} > 0 \; and \; \frac{\partial^2(ATC)}{\partial \mu^2} > 0$$

A numerical example is provided at the end to calculate then average inventory cost.

Case II: $\mu \geq T$

In this case following differential equation is used to governing the $I(t)$:

$$\frac{dI(t)}{dt} + \theta.I(t) = -D_0 t \qquad (0 \leq t \leq T) \qquad (12)$$

Using boundary condition $I(0) = I_0 \; and \; I(T) = 0$.

The solution of (12) is

$$I(t) = e^{-t\theta}Q + \frac{D_o}{\theta^2} - \frac{e^{-t\theta}D_o}{\theta^2} - \frac{tD_o}{\theta} \qquad (13)$$

Using the boundary condition we get

$$I(0) = I_0 = \frac{D_o}{\theta^2} - \frac{e^{T\theta}D_o}{\theta^2} + \frac{e^{T\theta}TD_o}{\theta} \qquad (14)$$

The expression for various costs involving the model is obtained as follows:

(i) Ordering Cost (OC)

$OC = O_c$

(ii) Deterioration Cost:

The demand during the interval $[0, T]$ is given by:

$$Demand \; during \; [0,T] \; = \int_0^T D_0 t \, dt$$

$$= \frac{T^2D_0}{2}$$

The Number of Units deteriorates in $[0,T] = I_0 - demand \; during \; [0,T]$

$$= -\frac{1}{2}T^2D_0 + \frac{D_0}{\theta^2} - \frac{e^{T\theta}D_0}{\theta^2} + \frac{e^{T\theta}TD_0}{\theta}$$

$Cost \; of \; deterioration \; (DC) = c_d(-\frac{1}{2}T^2D_o + \frac{D_o}{\theta^2} - \frac{e^{T\theta}D_o}{\theta^2} + \frac{e^{T\theta}TD_o}{\theta})$ [15]

(iii) Inventory holding cost (IHC)=$\int_0^T (h + \delta t) I(t) \, dt$

IHC

$= \frac{I_0\delta}{\theta^2} - \frac{e^{-T\theta}I_0\delta}{\theta^2} + \frac{hI_0}{\theta} - \frac{e^{-T\theta}hI_0}{\theta} - \frac{e^{-T\theta}I_0T\delta}{\theta} - \frac{\delta D_o}{\theta^4} + \frac{e^{-T\theta}\delta D_o}{\theta^4} - \frac{hD_o}{\theta^3} + \frac{e^{-T\theta}hD_o}{\theta^3} + \frac{e^{-T\theta}T\delta D_o}{\theta^3} + \frac{hTD_o}{\theta^2} + \frac{T^2\delta D_o}{2\theta^2} - \frac{hT^2D_o}{2\theta} - \frac{T^3\delta D_o}{3\theta}$

$$Hence\ Total\ Cost\ involving\ in\ the\ model(TC) = OC + DC + IHC$$

Hence

TC=$\Big[O_c + \frac{I_0\delta}{\theta^2} - \frac{e^{-T\theta}I_0\delta}{\theta^2} + \frac{hI_0}{\theta} - \frac{e^{-T\theta}hI_0}{\theta} - \frac{e^{-T\theta}I_0T\delta}{\theta} - \frac{\delta D_o}{\theta^4} + \frac{e^{-T\theta}\delta D_o}{\theta^4} - \frac{hD_o}{\theta^3} + \frac{e^{-T\theta}hD_o}{\theta^3} + \frac{e^{-T\theta}T\delta D_o}{\theta^3} +$ $hTDo\theta2+T2\delta Do2\theta2-hT2Do2\theta-T3\delta Do3\theta+cd(-12T2Do+Do\theta2-eT\theta Do\theta2+eT\theta TDo\theta)$

Now, Average Total Cost(ATC) is given by:

$$ATC = \frac{O}{T} + \frac{Q\delta}{T\theta^2} - \frac{e^{-T\theta}Q\delta}{T\theta^2} + \frac{hQ}{T\theta} - \frac{e^{-T\theta}hQ}{T\theta} - \frac{e^{-T\theta}Q\delta}{\theta} - \frac{\delta D_o}{T\theta^4} + \frac{e^{-T\theta}\delta D_o}{T\theta^4} - \frac{hD_o}{T\theta^3} + \frac{e^{-T\theta}hD_o}{T\theta^3} + \frac{e^{-T\theta}\delta D_o}{\theta^3} + \frac{hD_o}{\theta^2} + \frac{T\delta D_o}{2\theta^2} - \frac{hTD_o}{2\theta} - \frac{T^2\delta D_o}{3\theta} - \frac{1}{2}Tc_dD_o + \frac{c_dD_o}{T\theta^2} - \frac{e^{T\theta}c_dD_o}{T\theta^2} + \frac{e^{T\theta}c_dD_o}{\theta}$$

For maxima and minima the first derivative of Average total cost should be zero and second derivative should be negative i.e.

$$\frac{\partial(ATC)}{\partial T} = 0\ and\ \frac{\partial^2(ATC)}{\partial T^2} > 0$$

Now

$\frac{\partial(ATC)}{\partial T} = 0$ gives the value of T^*.

$$\Big[-\frac{O}{T^2} + \frac{e^{-T\theta}hQ}{T} + e^{-T\theta}Q\delta - \frac{Q\delta}{T^2\theta^2} + \frac{e^{-T\theta}Q\delta}{T^2\theta^2} - \frac{hQ}{T^2\theta} + \frac{e^{-T\theta}hQ}{T^2\theta} + \frac{e^{-T\theta}Q\delta}{T\theta} + \frac{\delta D_o}{T^2\theta^4} - \frac{e^{-T\theta}\delta D_o}{T^2\theta^4} + \frac{hD_o}{T^2\theta^3} - \frac{e^{-T\theta}hD_o}{T^2\theta^3} - \frac{e^{-T\theta}\delta D_o}{T\theta^3} - \frac{e^{-T\theta}hD_o}{T\theta^2} + \frac{\delta D_o}{2\theta^2} - \frac{e^{-T\theta}\delta D_o}{\theta^2} - \frac{hD_o}{2\theta} - \frac{2T\delta D_o}{3\theta} - \frac{c_dD_o}{2} + e^{T\theta}c_dD_o - \frac{c_dD_o}{T^2\theta^2} + \frac{e^{T\theta}c_dD_o}{T^2\theta^2} - \frac{e^{T\theta}c_dD_o}{T\theta}\Big] = 0$$

3. Numerical Example

Let us consider the following with parameters to illustrate the present developed model, following data:

O_c=250 , D_c= 0.532 ,θ= 0.076, δ= 0.02, $H_c = 0.2$, D_0= 567 , $Q = 400$

The computational result calculated by **Mathematica** shows the following optimal values:

$\mu = 0.625$,$T = 1.235TC = 4817.34$

3.1 Sensitivity Analysis

Sensitivity analysis of various values for different parameters discussed in the previous section has been done. The sensitivity analysis is analysed in the table given below.

Table3.1. *The effect of change in different parameters:*

10	D_0	Q	δ	θ
-20	4744.06	4766.59	4808.28	4813.34
-15	4761.82	4778.59	4810.31	4813.59
-10	4779.84	4791.54	4812.21	4815.34
-5	4798.34	4804.59	4815.31	4815.59
0	4817.34	4817.34	4817.34	4817.34
5	4836.34	4830.36	4819.56	4818.34
10	4817.84	4843.31	4821.52	4819.32
15	4835.86	4857.1	4823.64	4821.09
20	4853.62	4870.43	4825.99	4822.18

4. Conclusion

An inventory model for constant deteriorating items with Ramp Type demand has been developed. Backlogged shortages are not allowed. The purpose of this study is to determine an optimal ordering policy for minimizing the expected total relevant inventory cost. An analytical formulation of the problem on the framework described above has been worked out to present an optimal solution procedure to find the optimal replenishment policy. Numerical example was presented to demonstrate the developed model and to illustrate the procedure. Sensitivity analysis of the optimal solution with respect to various parameters of the system was carried out. The demand parameters have maximum effect on the total cost in positive sense whereas the effect of deterioration on the total cost is not significant.

In the future studies, it is hoped to further incorporate several assumptions such as Effect of inflation, discounting,partial backlogging and a finite rate of replenishment to enhance the utility of the proposed model to still greater extent.

References

[1] S. Bose, A. Goswami and K. S. Chaudhary, An EOQ model for deteriorating items with linear time- dependent demand rate andshortage under inflation and time discounting, Journal of operational research society, 46(7)(1995), 771-782.

[2] J. A. Buzacott, Economic order quantities with inflation, *Operations Research Quarterly*, **26**(1975), 553-558.

[3] J.M. Chen, , an inventory model for deteriorating items with time-proportional demand and shortages under inflation and time discounting, International Journal of Production Economics,55, (1), (1998), 21-30.

[4] C.K.Jaggi, K.K. Aggrawal and S.K. Goel, Optimal order policy for deteriorating items with inflation induced demand, International Journal of Production Economics, 103(2)(2006),707-714.

[5] C.K.Jaggi, K.K. Aggrawal and S.K. Goel, Optimal inventory replenishment policy for deteriorating items under inflationary conditions, International Journal of Production Economics, 13,(2007), 200-207.

[6] A. Mirzazadeh, M.M. Seyyed, Esfahani and Ghomi, S.M.T.F.(2009), An inventory model under uncertain inflationary conditions, finite production rate and inflation-dependent demand rate for deteriorating items with shortages, International Journal of Systems Science,40(1)(2009),21-31.

[7] I. Moon., and S. Lee , the effects of inflation and time value of money on an economic order quantity model with a random product life cycle, Europian Journal of Operational Research, 125(3)(2000) , 588-601.

[8] I. Moon, B.C. Giri, and B. Ko, Economic order quantity models for ameliorating/deteriorating items under inflation and time discounting, European Journal of Operational Research, 162(3)(2005)773-785.

[9] J. Ray and K.S. Chaudhari, An EOQ model with stock dependent demand, shortage, inflation and time discounting, International Journal of Production Economics, 53(1997),171-180.

[10] S.R. Singh and C. Diksha, Supply Chain Model in a multi Echelon System with inflation induced demand, International Transaction in Applied Science, 1(2009) , 73-86

[11] H.M. Wee and S.T. Law, “Replenishment and précising policy for deteriorating items taking into account the time value of money”, Int. J. Production Economics 71,(2001),213-220.

[12] H. L. Yang, Two-warehouse inventory models for deteriorating items with shortages under inflation, European Journal of Operations Research, 157(2004),2,344-356

[13] H.L. Yang, T.T. Teng , M.S. Chern “ An inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages’, Int. J. Production Economics. 123(2010),8-19.

[14] Pandey, H.andPandey,A.(2013).“An Inventory Model for Deteriorating Items with two level storage with uniform demand and shortage under Inflation and completely backlogged” International Journal, Investigations in Mathematical Sciences. ISSN: 2250-1436 Vol. 3(1), 2013, 47-57].

[15] Pandey, H.andPandey,A.(2014) "An optimum inventory policy for exponentially deteriorating items, considering multi variate Consumption Rate with Partial Backlogging" ,Mathematical Journal of Interdisciplinary Sciences (MJIS) Print Version: ISSN 2278-9561Online Version: ISSN 2278-957X Vol 2(2) 155-170.

AUTHORS' BIOGRAPHY

Dr. AshutoshPandey,is working as the Assistant Professor in the Department of Applied Sciences, ITM University Gurgaon. His research interest includes Operations Research and Demography. He has published several research papers in peer reviewed journals.

Dr. HimanshuPandey, is working as Associate Professor in the Department of Mathematics and Statisticsat D.D.U. Gorakhpur University Gorakhpur. He has more than 100 papers in the peer reviewed journals, several conference proceedings. He has been written three books. He has life memberships of the many academic societies. His research area of interest is Technical Demography and Operations Research.

Mr. DileepKumar, is currently research scholar at D.D.U. Gorakhpur University Gorakhpur in the Department of Mathematics and Statistics.