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# DETERIORATING INVENTORY MODEL FOR SHORTAGES AND TRAPEZOIDAL TYPE DEMAND RATE

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**ABSTARCT**

It is important to control and maintain the inventories of deteriorating items for the modern corporation. We will discuss two models: one is without shortage, and the other is with shortage. We obtain the optimal solutions in this paper; we assume that the inventory objective is to minimize the total cost per unit time of the system.

**KEYWORDS:** Deteriorating, shortage

## INTRODUCTION

The effect of deterioration is very important in many inventory systems. Most of the literature assumes that a constant proportion of items will deteriorate per time-unit while they are in storage. Ghare and Schrader were the first proponents for developing a model for an exponentially decaying inventory, to consider continuously decaying inventory for a constant demand [1]. Covert and Philip used a variable deterioration rate of two-parameter Weibull distribution to formulate the model with assumptions of a constant demand rate and no shortages [2]. Shah and Jaiswal presented an order-level inventory model for deteriorating items with a constant rate of deterioration [3]. Dave and Patel first considered the inventory model for deteriorating items with time-varying demand [4]. They considered a linear increasing demand rate over a finite horizon and a constant deterioration rate. Chang and Dye developed an EOQ model for deteriorating items with time-varying demand and partial backlogging [5]. Skouri and Papachristos presented a continuous review inventory model, with deteriorating items, time-varying demand, linear replenishment cost, partially time-varying backlogging [6]. Other researchers, there are many literatures that propose and evaluate the algorithms [7], [8], [9], [10], [11].

In the classical inventory model, the demand rate is assumed to be a constant. In reality, the demand for physical goods may be time-dependent, stock-dependent and price dependent. Hill first considered the inventory models for increasing demand followed by a constant demand [12]. M and al and Pal extended the inventory model with ramp type demand for deterioration items and allowing shortage [13]. Chen, Ouyang and Teng considered an EOQ model with ramp type demand rate and time dependent deterioration rate [14]. P and a, Senapati and Basu developed optimal replenishment policy for perishable seasonal products in a season with ramp-type time dependent demand [15]. Other researchers, there are many literatures that propose and evaluate the algorithms [16].

## REVIEW OF LITERATURE

Inventory models create a lot of interest due to their ready applicability at various places like market yards, warehouses, production process, transportation systems cargo handling, etc., several inventory models have been developed and analyzed to study various inventory systems. Much work has been reported in literature regarding Economic Production Quantity (EPQ) models during the last two decades. The EPQ models are also a particular case of inventory models. The major constituent components of the EPQ models are 1) Demand 2) production (Production) (Replenishment) and 3) Life time of the commodity. Several EPQ models have been developed and analyzed with various assumptions on demand pattern and life time of the commodity. In general, it is customary to consider that the replenishment is random in production inventory models. Several researchers have developed various inventory models with stock dependent demand. Silver and Peterson (1985) mentioned that the demand for many consumer items is directly proportional to the stock on hand. Gupta and Vrat (1986) have pointed the inventory models with stock dependent demand. Later, Baker and Urban (1988), Mandal and Phaujdhar (1989), Datta and Pal (1990), Venkat Subbaiah, et al. (2004), Teng and Chang (2005), Arya, et al. (2009), Mahata and Goswami (2009a), Panda, et al. (2009c), Roy, et al. (2009), Uma Maheswara Rao, et al. (2010), Yang, et al. (2010), Yang, et al. (2011), Srinivasa Rao and Essay (2012), Jasvinder Kaur, et al. (2013), Santanu Kumar Ghosh, et al. (2015) and others have developed inventory models for deteriorating items with stock dependent demand. In all these models they assumed that the replenishment is instantaneous or having fixed finite rate, except Sridevi, et al. (2010) that developed and analyzed an inventory model with the assumption that the rate of production is random and follows a Weibull distribution. However, in many practical situations arising at production processes, the production (replenishment) rate is dependent on the stock on hand. But in some other situations such as textile markets, seafood's industries, etc., the demand is a function of stock on hand. Levin et al. (1972) has have observed that at times the presence of inventory has a motivational effect on demand. It is also generally known that large pails of goods displayed in the markets encourage customers to buy more. Thus, in certain items, the demand increases if large amount of stock is on hand. Another important consideration for developing the EPQ models for deteriorating items is the life time of the commodity. For items like food, processing the life time of the commodity is random and follows a generalized Pareto distribution. (Srinivasa Rao, et al. (2005), Srinivasa Rao and Begum (2007), Srinivasa Rao and Eswara Rao (2015)).

**ASSUMPTIONS:**

1.The replenishment rate is infinite, thus replenishment rate is instantaneous.

2.The demand rate, D(t) which is positive and consecutive, is assumed to be a trapezoidal type function of time that is:

$$D(t)=\begin{cases} a_1+b_1 t, t\le \mu_1 \\ D_0, \mu_1 \le t \le \mu_2 \\ a_2-b_2 t, \mu_2 \le t \le T \le \dfrac{a_2}{b_2} \end{cases}$$

Where $\mu_1$ is time point changing from the increasing linearly demand to constant demand, and $\mu_2$ is time point changing from the constant demand to the decreasing linearly demand.

3. The length of each ordering cycle is fixed.
4. Deterioration rate is taken as time dependant.
5. Shortages occur and partially backlogged.
6. Backlogging rate is exponential decreasing function of time.

**NOTATIONS:**

| | |
|---|---|
| I(t) | inventory level at any time t |
| T | the fixed length of each ordering cycle |
| Kt | Time dependent deterioration rate and K is a constant |
| $t_1$ | the time when the inventory level reaches zero |
| $A_0$ | fixed ordering cost per order |
| $c_1$ | the cost of each deteriorated item |
| $c_2$ | inventory holding cost per unit per unit of time |
| $c_3$ | shortage cost per unit per unit of time |
| S | maximum inventory level |
| Q | ordering quantity per cycle |
| $\mu_1$ | time point changing from the increasing linearly demand to constant demand |

$\mu_2$ time point changing from the constant demand to the decreasing linearly demand

$e^{-\delta t}$ waiting time during shortages up-to next replenishment

**MATHEMATICAL FORMULATION:**

We considered an order level inventory model with trapezoidal type demand rate. Replenishment occurs at time t = 0 when the inventory level attains its maximum. From t = 0 to $t_1$, the inventory level reduces due to demand and deterioration. At $t_1$, the inventory level achieves zero, then shortage is allowed to occur during the time interval $(t_1, T)$ and all of the demand during the shortage period is partially backlogged due to impatience of customer.

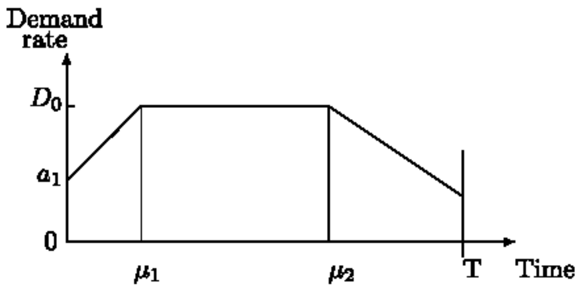



**Fig. 1.** A trapezoidal type function of the demand rate.

The differential equations governing the transition of the system are given by:

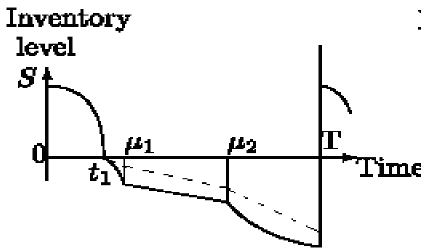
$$\frac{dI(t)}{dt} = -KtI(t) - D(t) \quad 0 \le t \le t_1 \qquad \dots (1)$$

$$\frac{dI(t)}{dt} = -e^{-\delta t} D(t) \quad t_1 \le t \le T \qquad \dots (2)$$

With boundary condition $I(t_1)=0$

Now we consider three possible cases based on the values of $t_1, \mu_1$ and $\mu_2$.These three cases are shown as follows:

**Case-1:** When $0 \le t_1 \le \mu_1$




Case 1. $0 < t_1 \le \mu_1$

Due to combined effect of demand and deterioration the inventory level gradually diminishes during the period $[0, t_1]$ and ultimately falls to zero at time $t_1$. The differential equations are given by:

$$\frac{dI(t)}{dt} = -KtI(t) - (a_1 + b_1 t) \quad 0 \le t \le t_1 \qquad \dots (3)$$

$$\frac{dI(t)}{dt} = -(a_1 + b_1 t)e^{-\delta t} \quad t_1 \le t \le \mu_1 \qquad \dots (4)$$

$$\frac{dI(t)}{dt} = -D_0 e^{-\delta t} \quad \mu_1 \le t \le \mu_2 \qquad .. (5)$$

$$\frac{dI(t)}{dt} = -(a_2 - b_2 t)e^{-\delta t} \quad \mu_2 \le t \le T \qquad .. (6)$$

With boundary condition I($t_1$) = 0

The solutions of these equations are given by:-

$$I(t) = [a_1(t_1 - t) + \frac{b_1}{2}(t_1^2 - t^2) + \frac{a_1 k}{6}(t_1^3 - t^3) + \frac{b_1 k}{8}(t_1^4 - t^4)]e^{-\frac{kt^2}{2}} \quad 0 \le t \le t_1 \qquad \text{....(7)}$$

$$I(t) = (a_1 + b_1 t)\frac{e^{-\delta t}}{\delta} - (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta} + \frac{b_1}{\delta^2}(e^{-\delta t} - e^{-\delta t_1}) \quad t_1 \le t \le \mu_1 \qquad \text{.... (8)}$$

$$I(t) = \frac{D_0}{\delta}(e^{-\delta t} - e^{-\delta \mu_1}) + (a_1 + b_1 \mu_1)\frac{e^{-\delta \mu_1}}{\delta} - (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta} + \frac{b_1}{\delta^2}(e^{-\delta \mu_1} - e^{-\delta t_1}) \quad \mu_1 \le t \le \mu_2 \qquad \text{... (9)}$$

$$I(t) = (a_2 - b_2 t)\frac{e^{-\delta t}}{\delta} - (a_2 - b_2 T)\frac{e^{-\delta t}}{\delta} + \frac{b_2}{\delta^2}(e^{-\delta T} - e^{-\delta t}) \quad \mu_2 \le t \le T \qquad \text{... (10)}$$

The inventory level at the beginning is given by:-

$$I(0) = [a_1 t_1 + \frac{b_1}{2}t_1^2 + \frac{a_1 k}{6}t_1^3 + \frac{b_1 k}{8}t_1^4] = S \qquad \text{... (11)}$$

The total no. of items which perish in the inventory [ $0, t_1$ ], say $D_T$, is:-

$$D_T = S - \int_0^{t_1} D(t).dt$$

So the cost of deterioration is given by:-

$$\text{Det. Cost} = (\frac{a_1 k}{6}t_1^3 + \frac{b_1 k}{8}t_1^4)c_1 \qquad \text{... (12)}$$

The total number of inventory carried during the interval [ $0, t_1$ ]:

$$H_T = c_2 \int_0^{t_1} I(t)dt$$

$$= c_2(a_1 \frac{t_1^2}{2} + b_1 \frac{t_1^3}{3} + \frac{a_1 k}{12}t_1^4 + \frac{b_1 k}{15}t_1^5) \qquad \text{.... (13)}$$

The total shortage quantity during the interval [$t_1, T$], say $B_T$, is:-

$$B_T = -\int_{t_1}^{\mu_1} I(t).dt - \int_{\mu_1}^{\mu_2} I(t).dt - \int_{\mu_2}^{T} I(t).dt$$

$$\begin{aligned} B_T = & -\{(a_1 + b_1\mu_1)\frac{e^{-\delta\mu_1}}{-\delta^2} - \frac{b_1 e^{-\delta\mu_1}}{\delta^3} - (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta}\mu_1 - \frac{b_1}{\delta^2}(\frac{e^{-\delta\mu_1}}{\delta} + \mu_1 e^{-\delta t_1}) + \\ & (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta^2} + \frac{b_1 e^{-\delta t_1}}{\delta^3} + (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta}t_1 + \frac{b_1}{\delta^2}(\frac{e^{-\delta t_1}}{\delta} + t_1 e^{-\delta t_1})\} - \\ & \{\frac{D_0}{\delta}(\frac{e^{-\delta\mu_2}}{-\delta} - \mu_2 e^{-\delta\mu_1}) + (a_1 + b_1\mu_1)\frac{e^{-\delta\mu_1}}{\delta}\mu_2 - (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta}\mu_2 + \frac{b_1}{\delta^2}(e^{-\delta\mu_1} - e^{-\delta t_1})\mu_2 + \\ & \frac{D_0}{\delta}(\frac{e^{-\delta\mu_1}}{\delta} + \mu_1 e^{-\delta\mu_1}) - (a_1 + b_1\mu_1)\frac{e^{-\delta\mu_1}}{\delta}\mu_1 + (a_1 + b_1 t_1)\frac{e^{-\delta t_1}}{\delta}\mu_1 - \frac{b_1}{\delta^2}(e^{-\delta\mu_1} - e^{-\delta t_1})\mu_1\} \\ & -\{(a_2 - b_2 T)\frac{e^{-\delta T}}{-\delta^2} + \frac{b_2 e^{-\delta T}}{\delta^3} - (a_2 - b_2 T)\frac{e^{-\delta T}}{\delta}T + \frac{b_2}{\delta^2}(e^{-\delta T}T + \frac{e^{-\delta T}}{\delta}) + \\ & (a_2 - b_2\mu_2)\frac{e^{-\delta\mu_2}}{\delta^2} - \frac{b_2 e^{-\delta\mu_2}}{\delta^3} + (a_2 - b_2 T)\frac{e^{-\delta T}}{\delta}\mu_2 - \frac{b_2}{\delta^2}(e^{-\delta T}\mu_2 + \frac{e^{-\delta\mu_2}}{\delta})\} \end{aligned} \qquad \text{... (14)}$$

$$\text{Shortage Cost} = C_3 B_T \qquad \text{... (15)}$$

Then, the average total cost per unit time under the condition $t_1 \le \mu_1$ can be given by:

$$C_1(t_1, T) = \frac{1}{T}[A_0 + c_1 D_T + c_2 H_T + c_3 B_T] \qquad \text{... (16)}$$

The necessary conditions for the total relevant cost per unit time of the equation (16) is to be minimized is

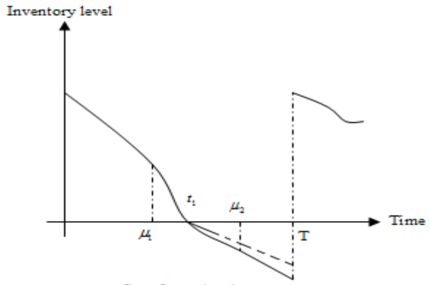
$$\frac{\partial C_1(t_1, T)}{dt_1} = 0 \text{ and } \frac{\partial C_1(t_1, T)}{dT} = 0$$

$$\left.\frac{\partial^2 C_1(t_1, T)}{\partial t_1^2}\right| > 0, \left.\frac{\partial^2 C_1(t_1, T)}{\partial T^2}\right| > 0$$

$$\left(\frac{\partial^2 C_1(t_1,T)}{\partial t_1^{\,2}}\right)\left(\frac{\partial^2 C_1(t_1,T)}{\partial T^2}\right)-\left(\frac{\partial^2 C_1(t_1,T)}{\partial t_1 \partial T}\right)\Bigg| > 0 \qquad \text{… (17)}$$

**Case 2:** $\mu_1 \le t_1 \le \mu_2$

The differential equations governing the transition of the system are given by:-




Case 2. $\mu_1 \le t_1 \le \mu_2$

$$\frac{dI(t)}{dt} = -KtI(t) - (a_1 + b_1 t) \quad 0 \le t \le \mu_1 \qquad \text{… (18)}$$

$$\frac{dI(t)}{dt} = -KtI(t) - D_0 \quad \mu_1 \le t \le t_1 \qquad \text{... (19)}$$

$$\frac{dI(t)}{dt} = -D_0 e^{-\delta t} \quad t_1 \le t \le \mu_2 \qquad \text{… (20)}$$

$$\frac{dI(t)}{dt} = -(a_2 - b_2 t)e^{-\delta t} \quad \mu_2 \le t \le T \qquad \text{…. (21)}$$

With boundary condition I( $t_1$ ) = 0

The solutions of these equations are given by:-

$$I(t) = [a_1(\mu_1 - t) + \frac{a_1 k}{6}(\mu_1^{\,3} - t^3) + \frac{b_1}{2}(\mu_1^{\,2} - t^2) + \frac{b_1 k}{8}(\mu_1^{\,4} - t^4) + D_0\{(t_1 - \mu_1) + \frac{k}{6}(t_1^{\,3} - \mu_1^{\,3})\}]e^{-\frac{kt^2}{2}} \quad 0 \le t \le \mu_1 \qquad \text{…. (22)}$$

$$I(t) = D_0\{(t_1 - t) + \frac{K}{6}(t_1^{\,3} - t^3)\}e^{-\frac{Kt^2}{2}} \quad \mu_1 \le t \le t_1 \qquad \text{…. (23)}$$

$$I(t) = \frac{D_0}{\delta}(e^{-\delta t} - e^{-\delta t_1}) \quad t_1 \le t \le \mu_2 \qquad \text{… (24)}$$

$$I(t) = (a_2 - b_2 t)\frac{e^{-\delta t}}{\delta} - (a_2 - b_2 T)\frac{e^{-\delta T}}{\delta} - \frac{b_2}{\delta^2}(e^{-\delta t} - e^{-\delta T}) \quad \mu_2 \le t \le T \qquad \text{…. (25)}$$

The beginning inventory level is:-

$$I(0) = S = \{a_1\mu_1 + \frac{a_1 K}{6}\mu_1^{\,3} + \frac{b_1\mu_1^{\,2}}{2} + \frac{b_1 K\mu_1^{\,4}}{8} + D_0(t_1 + \frac{K}{6}t_1^{\,3})\} \qquad \text{... (26)}$$

The total no. of items which perish in the inventory [ 0, $t_1$ ], say D $_T$ , is:-

$$D_T = S - \int_0^{t_1} D(t).dt$$

So the cost of deterioration is given by:

$$\text{D.C.} = \{a_1\mu_1 + \frac{a_1 K}{6}\mu_1^{\,3} + \frac{b_1\mu_1^{\,2}}{2} + \frac{b_1 K\mu_1^{\,4}}{8} + D_0(t_1 + \frac{K}{6}t_1^{\,3}) - (a_1\mu_1 + \frac{b_1\mu_1^{\,2}}{2}) - D_0(t_1 - \mu_1)\}c_1 \qquad \text{… (27)}$$

The total number of inventory carried during the interval [ 0, $t_1$ ]: -

$$H_T = \int_0^{t_1} I(t)dt$$

$$=[a_1\frac{\mu_1^{2}}{2}+a_1\frac{K\mu_1^{4}}{8}+\frac{b_1}{3}\mu_1^{3}+b_1\frac{K\mu_1^{5}}{10}+D_0\{\mu_1(t_1-\mu_1)+\frac{K}{6}\{\mu_1(t_1^{3}-\mu_1^{3})\}$$
$$-\frac{a_1K}{24}\mu_1^{4}-\frac{b_1K}{30}\mu_1^{5}-D_0\frac{K}{2}\{\frac{\mu_1^{3}}{3}(t_1-\mu_1)\}+D_0(\frac{t_1^{2}}{2}+\frac{K}{8}t_1^{4})-\frac{D_0K}{24}t_1^{4} \quad \dots (28)$$
$$-D_0\{(t_1\mu_1-\frac{\mu_1^{2}}{2})+\frac{K}{6}(t_1^{3}\mu_1-\frac{\mu_1^{4}}{4})\}+\frac{D_0K}{2}(t_1\frac{\mu_1^{3}}{3}-\frac{\mu_1^{4}}{4})]$$

The total shortage quantity during the interval $[t_1, T]$, say $B_T$, is:-

$$B_T = -\int_{t_1}^{\mu_2} I(t).dt - \int_{\mu_2}^{T} I(t).dt$$

$$B_T =$$
$$[\frac{D_0}{\delta}(\frac{e^{-\delta\mu_2}-e^{-\delta t_1}}{\delta}+e^{-\delta t_1}(\mu_2-t_1))+(a_2-b_2T)\frac{e^{-\delta T}}{\delta^2}-(a_2-b_2\mu_2)\frac{e^{-\delta\mu_2}}{\delta^2}$$
$$-2\frac{b_2}{\delta^3}(e^{-\delta T}-e^{-\delta\mu_2})+(a_2-b_2T)(T-\mu_2)\frac{e^{-\delta T}}{\delta}-\frac{b_2}{\delta^2}e^{-\delta T}(T-\mu_2)] \quad \dots (29)$$

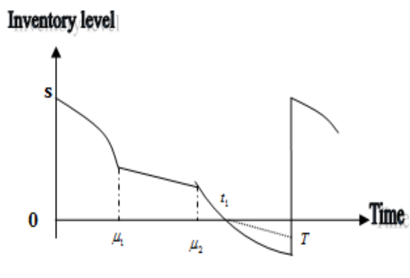
Then the average total cost per unit time for this case is given by:-

$$C_2(t_1)=\frac{1}{T}[A_0+c_1D_T+c_2H_T+c_3B_T] \quad \dots (30)$$

The necessary conditions for the total relevant cost per unit time of the equation (30) is to be minimized is

$$\frac{\partial C_2(t_1,T)}{dt_1}=0 \text{ and } \frac{\partial C_2(t_1,T)}{dT}=0$$
$$\left.\frac{\partial^2 C_2(t_1,T)}{\partial t_1^{2}}\right| >0, \left.\frac{\partial^2 C_2(t_1,T)}{\partial T^2}\right| >0$$
$$\left.\left(\frac{\partial^2 C_2(t_1,T)}{\partial t_1^{2}}\right)\left(\frac{\partial^2 C_2(t_1,T)}{\partial T^2}\right)-\left(\frac{\partial^2 C_2(t_1,T)}{\partial t_1\partial T}\right)\right| >0 \quad \dots (17)$$

**Case-3:** $\mu_2 \le t_1 \le T$




$\mu_2 \le t_1 \le T$

The differential equations governing the transition of the system are given by:-

$$\frac{dI(t)}{dt}=-KtI(t)-(a_1+b_1t) \quad 0\le t\le \mu_1 \quad \dots (31)$$
$$\frac{dI(t)}{dt}=-KtI(t)-D_0 \quad \mu_1\le t\le \mu_2 \quad \dots (32)$$
$$\frac{dI(t)}{dt}=-KtI(t)-(a_2-b_2t) \quad \mu_2\le t\le t_1 \quad \dots (33)$$
$$\frac{dI(t)}{dt}=-(a_2-b_2t)e^{-\delta t} \quad t_1\le t\le T \quad \dots (34)$$

Using boundary condition $I(t_1)=0$

Solution of these equation are given by-

$$I(t)=\{S-(a_1t+\frac{b_1}{2}t^2+\frac{a_1K}{6}t^3+\frac{b_1K}{8}t^4)\}e^{-\frac{Kt^2}{2}} \quad 0\le t\le \mu_1 \quad \dots (35)$$

$$I(t) = \{D_0((\mu_2 - t) + \frac{K}{6}(\mu_2^3 - t^3)) + a_2(t_1 - \mu_2) + \frac{a_2K}{6}(t_1^3 - \mu_2^3) - \frac{b_2}{2}(t_1^2 - \mu_2^2) - \frac{b_2K}{8}(t_1^4 - \mu_2^4)\}e^{-\frac{Kt^2}{2}}$$

$$\mu_1 \le t \le \mu_2 \qquad \text{... (36)}$$

$$I(t) = \{a_2(t_1 - t) + \frac{a_2K}{6}(t_1^3 - t^3) - \frac{b_2}{2}(t_1^2 - t^2) - \frac{b_2K}{8}(t_1^4 - t^4))\}e^{-\frac{Kt^2}{2}}\} \quad \mu_2 \le t \le t_1 \qquad \text{... (37)}$$

$$I(t) = (a_2 - b_2t)e^{-\frac{\delta t}{\delta}} - (a_2 - b_2t_1)e^{-\frac{\delta t_1}{\delta}} - \frac{b_2}{\delta^2}(e^{-\delta t} - e^{-\delta t_1}) \quad t_1 \le t \le T \qquad \text{... (38)}$$

$$S = D_0\{(\mu_2 - \mu_1) + \frac{K}{6}(\mu_2^3 - \mu_1^3)\} + a_2(t_1 - \mu_2) + \frac{a_2K}{6}(t_1^3 - \mu_2^3)$$
$$- \frac{b_2}{2}(t_1^2 - \mu_2^2) - \frac{b_2K}{8}(t_1^4 - \mu_2^4)\} + (a_1\mu_1 + \frac{a_1K}{6}\mu_1^3 + b_1\frac{\mu_1^2}{2} + \frac{b_1K}{8}\mu_1^4) \qquad \text{... (39)}$$

**Table 1: Variation in total cost with the variation in K**

| K | $t_1$ | T.C |
|---|---|---|
| 0.0004 | 1.38958 | 14557.7 |
| 0.0006 | 1.38963 | 14557.8 |
| 0.0008 | 1.38967 | 14557.8 |
| 0.001 | 1.38972 | 14557.9 |
| 0.0012 | 1.38977 | 14557.9 |
| 0.0014 | 1.38981 | 14558 |
| 0.0016 | 1.38986 | 14558 |
| 0.0018 | 1.3899 | 14558.1 |
| 0.002 | 1.38995 | 14558.1 |

**Table 2: Variation in total cost with the variation in $a_1$**

| $a_1$ | $t_1$ | T.C. |
|---|---|---|
| 100 | 1.19764 | 12409.3 |
| 110 | 1.24414 | 12832.8 |
| 120 | 1.28598 | 13259.8 |
| 130 | 1.32383 | 13689.9 |
| 140 | 1.35826 | 14122.7 |
| 150 | 1.38972 | 14557.9 |
| 160 | 1.41858 | 14995.1 |
| 170 | 1.44517 | 15434.1 |
| 180 | 1.46974 | 15874.7 |
| 190 | 1.49252 | 16316.8 |
| 200 | 1.5137 | 16760.1 |

## CONCLUSION:

It is assumed that the deterioration rate is time dependent. The nature of demand of seasonal and fashionable products is increasing-steady-decreasing and becomes asymptotic. For seasonal products like clothes, air conditions etc, demand of these items is very high at the starting of the season and become steady mid of the season and thereafter decreasing at the end of the season. The demand pattern assumed here is found to occur not only for all types of seasonal products but also for fashion apparel, computer chips of advanced computers, spare parts, etc.

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