3.10. Economic Order Quantity :

A. Meaning and Concept :

Economic Ordering Quantity (EOQ) of a material is the optimum or the most favourable quantity ascertained on the principle of inventory cost minimisation which should ideally be purchased each time for replenishment of fresh stock in the storehouse whenever the reordering level has been reached. In other words, economic ordering quantity is that size of purchase order which gives the maximum economy in purchasing the materials and which ultimately contributes towards maintaining the material at the optimum level at different times with minimum cost. It is also known as Economic Order Quantity, Optimum Ordering Quantity, Standard Order Quantity, Economic Lot Size, Best Ordering Lot etc.

Besides the purchase/acquistion cost, other related cost of inventory or materials consists of the following two elements :

(i) Ordering Cost or Non-Carrying Cost or Procurement Cost or Buying Cost; and

(ii) Carrying Cost or Stock Holding Cost or Possession Cost.

Ordering Cost : This cost is related to the expenses in placing a purchase order for procurement of materials. The ordering cost includes the cost relating to (a) preparation of purchase order, (b) invitation of tenders/quotation, (c) tender processing, (d) placing purchase order and following up delivery, (e) inspection of materials and taking up delivery, (f) stationery and printing relating to purchases, (g) postage, telegram and telephone charges for purchasing, (h) discount forgone by suppliers, etc.

Carrying Cost : This cost is related to the expenses for holding and carrying the inventory or materials in the storehouse. The carrying cost includes the cost relating to (a) receiving and placing into the bins, (b) handling and internal transportation, (c) interest on capital or loan for materials held, (d) rent, rates &

taxes on store, (e) insurance on stock and godown, (f) depreciation on furniture and fixture, equipment and building, (g) salary of store-keeper and store clerks, (h) loss of materials due to wastage, breakage, deterioration, pilferage etc., (i) stationery and printing for store etc.

In general, material acquisition cost remains the same. Normally ordering cost per order is fixed, whatever may be the quantity purchased at a time. Total ordering cost of a year is the product of the number of orders and the ordering cost per order. On the other hand carrying cost per unit of material held per period is more or less fixed in amount and so total carrying cost for year is computed by multiplying the average quantity held by the carrying cost per unit per year. So, economic ordering quantity (EOQ) is fixed at that point where total ordering cost and total carrying cost of inventoty is minimum.

B. Assumptions in Economic Ordering Quantity Method of Stock Control :

The economic ordering quantity is computed by considering certain assumptions. The following are the important assumptions to be made for economic ordering quantity model:

(i) Minimum level is taken as zero (i.e., quantity of material at the time of fresh receipt is nil and rate of consumption is uniform.
(ii) The price of the material remains fixed during the year and no discount is available for bulk purchases.
(iii) Ordering cost per order remains constant whatever may be the quantity purchased.
(iv) Carrying cost per unit of material per year is constant.
(v) The annual requirement, lead time, carrying cost, ordering cost, etc. are certain and known.
(vi) Purchasing, material-issuing and production are done evenly throughout the year.
(vii) Equal quantity is purchased in each lot.
(viii) Fresh materials are purchased very quickly after making purchase order.
(ix) Purchase reqisition is issued only when reorder level of the stock of material reaches.

C. Different Methods for Computation of Economic Ordering Quantity :

Economic ordering quanitity for a material can be computed in several ways. The following are the different methods generally followed for computation of economic ordering quantity of material :

(i) Tabular Method or Statement Method or Purchase Order Table Method;
(ii) Graphical Method or Line Diagram Method;
(iii) Mathematical method or Algebraic Method or Wilson Model.

1. Tabular Method or Statement Method :

Under this method, a table or statement is prepared with a number of columns based on the number of orders for computation of economic ordering quantity of a material. The order size for which the total cost is minimum is the economic ordering quantity. The corresponding number of orders at this level is known ***as Optimum Number of Orders.*** This method is also known as Purchase Order Table Method.

Under this method the acquisition cost of material is indifferent to the volume of order size.

Illustration 8 (M) : From the following data Calculate the Economic Ordering Quantity of the material "SP" under Tabular Method :

Annual consumption : 24,000 units
Ordering cost per order : ₹ 120
Carrying cost per year : 20% of inventory value;
Cost of material per unit : ₹ 5

$EOQ = \sqrt{\frac{2AO}{C}}$

$= \sqrt{\frac{2 \times 2{,}40{,}000 \times 120}{1}}$

$= 2400$ units.

where A = 2400 units
O = 120
C = 20% of Rs 5
= 1

C = Carrying Cost per unit per year (in ₹) = 15

So, EOQ in Units = $\sqrt{\frac{2 \times 12{,}000 \times 100}{15}} = \sqrt{\frac{24{,}00{,}000}{15}} = \sqrt{1{,}60{,}000} = 400$ units.

Illustration 12 (M) : The following data is available in respect of the use of a material for the year 2013 :

Weekly consumption – 300 units
Ordering cost per order – ₹ 104
Stock holding cost @ 2% per month on cost of material
Cost of material per unit – ₹ 50.

Compute (a) Economic Ordering Quantity, (b) Number of Orders during the year and (c) Time between two consecutive orders.

Solution : (a) We know, Economic Ordering Quantity (EOQ) = $\sqrt{\frac{2UO}{C}}$ units

Here, U = Annual Consumption (in units) = 300 × 52 = 15,600
O = Ordering Cost per order (in ₹) = 104
C = Stock Holding/Carrying Cost per unit per year (in ₹)
= 2% p.m. × 12 × ₹ 50 = 24% × ₹ 50 = ₹ 12

So, EOQ (in units) = $\sqrt{\frac{2 \times 15{,}600 \times 104}{12}} = \sqrt{\frac{32{,}44{,}800}{12}} = \sqrt{2{,}70{,}400} = 520$ *units*

(b) Number of Orders to be placed during the year

$$= \frac{\text{Annual Consumption (units)}}{\text{EOQ (units)}} = \frac{15{,}600}{520} = 30 \text{ times}$$

(c) Time between two consecutive orders

$$= \frac{365 \text{ days}}{\text{Number of Orders}} = \frac{365 \text{ days}}{30} = 12 \text{ days (approx.)}$$

Working Note :

As the Usage (U) and Carrying Cost (C) are given in different units of time, they are converted into same unit, i.e., year, for convenience.

Illustration 13 (M) : From the following particulars in respect of the use of material compute (i) Economic Order Quantity, (ii) Frequency of Orders during the year and (iii) Time interval between orders :

Annual Usage : ₹ 3,60,000
Ordering Cost per order : ₹ 100
Carrying Cost per annum : 8%

Solution : (a) We know, Economic Order Quantity/EOQ (in ₹) = $\sqrt{\frac{2UO}{C}}$

Here, U = Annual Usage (in ₹) = 3,60,000
O = Ordering Cost per order (in ₹) = 100

C = Rate of Carrying Cost per annum = 8% = $\frac{8}{100}$

So, EOQ (in ₹) = $\sqrt{\frac{2 \times 3,60,000 \times 100}{\frac{8}{100}}} = \sqrt{\frac{2 \times 3,60,000 \times 100 \times 100}{8}} = \sqrt{10^8 \times \frac{72}{8}}$

$= \sqrt{9 \times 10^8} = 3 \times 10^4 = ₹\ 30,000.$

(b) Frequency of Orders during the year = $\frac{\text{Annual Usage (₹)}}{\text{EOQ (₹)}} = \frac{₹\ 3,60,000}{₹\ 30,000} = 12$ times.

(c) Time interval between orders = $\frac{12 \text{ months (in a year)}}{\text{No. of Orders}} = \frac{12 \text{ months}}{12} = 1$ month

Illustration 14 (M) : Find out the Economic Order Quantity and Order Schedule for raw materials and packaging materials with the following data given to you:

1. Cost of ordering :	Raw Materials	: ₹ 1,000 per order
	Packaging Materials	: ₹ 5,000 per order
2. Cost of holding inventory :	Raw Materials	: 1 p. per unit p.m.
	Packaging Materials	: 5 p. per unit p.m.
3. Production rate :	2,00,000 units per month	

[C.S. Final]

Solution : We know, Economic Order Quantity/EOQ (in unit) = $\sqrt{\frac{2UO}{C}}$

Where, U = *Monthly* Consumption (in units)
O = Ordering Cost per order (in ₹)
C = Carrying Cost *per month* per unit (in ₹)

(i) In case of Raw Materials, U = 2,00,000 units, O = ₹ 1,000 and C = 1 P. = ₹ 0.01

So, EOQ for Raw Materials = $\sqrt{\frac{2 \times 2,00,000 \times 1,000}{0.01}}$ = 2,00,000 units

No. of Orders to be placed in a month = $\frac{\text{Monthly Consumption}}{\text{EOQ}} = \frac{2,00,000}{2,00,000} = 1$

and Time for Ordering Schedule = $\frac{1 \text{ month}}{\text{No. of orders}} = \frac{1 \text{ month}}{1} = 1$ month.

(ii) In case of Packaging Material, U = 2,00,000 units, O = ₹ 5,000 and C = 5P. = Re. 0.05.

So, EOQ for Packaging Materials = $\sqrt{\frac{2 \times 2,00,000 \times 5,000}{0.05}}$ = 2,00,000 units

No. of Orders to be placed in a month = $\frac{2,00,000}{2,00,000} = 1$ and Time for Ordering Schedule

$= \frac{1 \text{ month}}{1} = 1$ month

Working Notes : ***(i) As the consumption (U) and Rate of carrying cost (C) are both given on monthly basis, yearly data are not required for EOQ.***

(ii) Assume one unit of raw material and one unit of packaging material are required for a single unit of output.

Illustration 15 (M) : About 50 items are required every day for a machine. A fixed cost of ₹ 50 per order is incurred for placing an order. The inventory Carrying Cost per item amounts to ₹ 0.02 per day. The lead period is 32 days.

Compute (i) Economic Order Quantity and (ii) Re-order Level. ***[C.A., Inter.]***

Solution : (i) We know, Economic Order Quantity (EOQ) = $\sqrt{\frac{2UO}{C}}$ units

Here, U = *Daily* Requirement (in units) = 50
O = Ordering Cost per Order (in ₹) = 50
C = Carrying Cost per unit per day (in ₹) = 0.02

So, EOQ = $\sqrt{\frac{2 \times 50 \times 50}{0.02}} = \sqrt{2,50,000} = 500$ items.

(ii) Re-order Level of a Material = Maximum Rate of Requirement × Maximum Delivery / Lead Period = 50 × 32 = 16,000 items.

Working Note :

(a) Here daily requirement of material is 50 items and delivery period is 32 days. It is assumed that both are more or less fixed in nature. So maximum, minimum and normal lead period are all 32 days.

(b) It is not necessary to convert the "Quantity Requirement/Usage/Demand (U) 'on Yearly basis", because both "U" and "C" are given on daily basis ? It is to be remembered that both "U" and "C" must be always either yearly, monthly, quarterly or weekly or daily basis.

Illustration 16 (L) : The following data are available in respect of the material used in Modern Engineering Co. for the year 2014 :

Purchase Price per unit ₹ 12
Interest per unit per month Re. 0.10
Clerical & Administration Cost per order ₹ 200
Insurance charge per annum 12%
Wastage of Material per unit per quarter 2%
Cost of Buying Office, Inspection and Accounting per order ₹ 400.
Monthly consumption 1,000 units.

You are required to compute (i) Best Ordering Quantity of the material buying; (ii) Frequency of Orders; (iii) Time gap between two consecutive orders, and (iv) Total Inventory Cost at optimal policy of buying.

Solution : (i) The Best Ordering Quantity or Economic Order Quantity (EOQ) = $\sqrt{\frac{2UO}{C}}$ units.

Here, U = Annual Usage / Consumption (Units) = 1,000 × 12 = 12,000.
O = Ordering Cost per Order = Clerical & Administration Cost + Cost of Buying Office etc. = ₹ 200 + ₹ 400 = ₹ 600.
C = Carrying Cost per unit of Material per year
= Interest p.a. + Insurance p.a. + Wastage p.a.

= (12 × Re. 0.10) + (12% of ₹ 12) + (4 × 2% of ₹ 12)
= ₹ 1.20 + ₹ 1.44 + Re. 0.96 = ₹ 3.60.

So, EOQ = $\sqrt{\frac{2 \times 12,000 \times 600}{3.60}} = \sqrt{\frac{1,44,00,000}{3.60}} = \sqrt{40,00,000}$ = 2,000 units.

(ii) Optimal Frequency or No. of Orders during the year = $\frac{U}{EOQ} = \frac{12,000 \text{ units}}{2,000 \text{ units}}$ = 6 times.

(iii) Time gap between two consecutive orders = $\frac{12 \text{ months}}{\text{No. of Orders}} = \frac{12 \text{ months}}{6}$ = 2 months

(iv) Total Material/Inventory Cost
= Total Purchase Cost + Total Ordering Cost + Total Carrying Cost
= (Annual Usage Units × Cost per Unit) + (No. of Orders × Ordering Cost per Order)
+ (Average Inventory × Carrying Cost per unit per year)

= 12,000 × ₹ 12 + 6 × ₹ 600 + $\frac{2,000}{2}$ × ₹ 3.60.
= ₹ 1,44,000 + ₹ 3,600 + ₹ 3,600 = ₹ 1,51,200

Illustration 17 (L) : A purchase manager places order, each time for a lot of 500 numbers of a particular item. From the available data the following results are obtained:

Inventory Carrying Cost	40%	Cost per unit	₹ 50
Ordering Cost per order	₹ 600	Annual Demand	1,000

Find out the Loss to the Organisation due to his ordering policy. ***[I.C.W.A., Final]***

Solution : We know, Economic Order Quantity/EOQ (in units) = $\sqrt{\frac{2UO}{C}}$

Here, U = Annual Demand (in units) = 1,000
O = Ordering Cost per order (in ₹) = 600
C = Carrying Cost per unit per year (in ₹)
= 40% of ₹ 50 = ₹ 20

So, EOQ (in units) = $\sqrt{\frac{2 \times 1,000 \times 600}{20}} = \sqrt{60,000}$ = 245 units (approx.)

Therefore, Number of Orders during a year = $\frac{1,000}{245}$ = 4.08, but as number of orders cannot be a fraction, it is more convenient to purchase 1,000 units in 4 lots (ordery) of 250 units.

But the Purchase Manager actually purchased 1,000 units in 2 lots of 500 units. As he does not follow EOQ, the organisation incurs a loss due to extra cost.

Comparative Statement showing the Present Cost and Loss sustained at Present inventory ordering policy than EOQ Level :

Particulars	*EOQ Level*	*Present Policy*	*Increase in Cost*
	₹	₹	₹
(i) Purchase Cost of Materials (1,000 × ₹ 50)	50,000	50,000	Nil
(ii) Ordering Cost for the year :			

4 orders @ ₹ 600 per order	2,400		
2 orders @ ₹ 600 per order		1,200	(–)1,200
(iii) Carrying Cost for the year :			
@ ₹ 20 per unit for $\frac{250}{2}$ units of average stock (20 × 125)	2,500		
@ ₹ 20 per unit for $\frac{500}{2}$ units of average stock (20 × 250)		5,000	2,500
Total Inventory Cost	**54,900**	**56,200**	**1,300**

So, at present, the Amount of Loss to the Organisation due to unscientific ordering policy is ₹ 1,300.

Illustration 18 (L) : Sriram Enterprises manufacture a special product "Zed". The following particulars were collected for the year 2013 :

(a) Monthly demand of Zed – 1,000 units.
(b) Cost of placing an order ₹ 100.
(c) Annual Carrying cost per unit ₹ 15.
(d) Normal usage 50 units per week.
(e) Minimum usage 25 units per week.
(f) Maximum usage 75 units per week.
(g) Reorder period 4 to 6 weeks.

Compute from the above (i) Reorder Quantity, (ii) Reorder Level, (iii) Minimum Level, (iv) Maximum Level, (v) Average Stock Level. ***[C.A., Inter.]***

Solution : (i) We know that the economic order quantity is the reorder quantity computed scientifically on the principle of cost minimisation and fixed ordering system. So here economic order quantity is to be considered for reorder quantity.

$$\text{Reorder Quantity / EOQ (in units)} = \sqrt{\frac{2UO}{C}}$$

Here, U = Annual Demand of Raw materials (in units) = Normal Usage @ 50 units per week for 52 weeks = 2,600 units. [Assume these 2,600 units of raw materials are required for 12,000 units of output)

O = Ordering cost per order (in ₹) = 100

C = Carrying cost per unit per year (in ₹) = 15

$$\therefore \text{Recorder Quantity (EOQ)} = \sqrt{\frac{2 \times 2{,}600 \times 100}{15}} = \sqrt{\frac{5{,}20{,}000}{15}} = \sqrt{34{,}667} = 186 \text{ units}$$

(ii) Reorder Level = Maximum Usage × Minimum Reorder Period = 75 × 6 = 450 units.

(iii) Minimum Level = Reorder Level – Normal Usage × Average Reorder Period

$$= 450 - 50 \times \frac{4+6}{2} = 450 - 250 = 200 \text{ units.}$$

(iv) Maximum Level = Reorder Level + Reorder Quantity – Minimum Usage × Minimum Reorder period = 450 + 186 – 25 × 4 = 636 – 100 = 536 units.

(v) Average Stock Level = Minimum Level + 1/2 × Reorder Quantity
= 200 + 1/2 × 186 = 200 + 93 = 293 units.