CHAPTER - IV

REPRESENTATION OF THE DATA AND DEVELOPMENT OF THE PRODUCTION AUGMENTED MODEL FOR EACH SELECTED INDUSTRIES

4.1 M/S KISAN AGRO INDUSTRIES

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CHAPTER - IV

REPRESENTATIONS OF THE DATA AND DEVELOPMENT OF THE PRODUCTION AUGMENTED MODELS FOR EACH SELECTED INDUSTRY

In this chapter the data has been collected from the selected small scale agro based industries for each product regarding production details such as Assembly, painting, Testing, Machine and Labour for developing the Linear Programming Model by using simplex method.

However, the data has been collected from the industries regarding sales for the last five years for forecasting of sales for the comming five years.

The data also has been collected from the industries regarding inventories for developing the inventory model.

4.1 M/s KISAN AGRO INDUSTRIES

The company manufactures different products such as Two Furrow Plough, Two Furrow Surry ridger, Three Furrow plough, Spring Cultivator, Terassor blade, Four wheel Trailer, Two wheel Trailer, Two wheel semi-Trailer, and Two wheel non-semi Trailer.

The production planning department is provided the production details. The following Table shows the times required for manufacturing one unit of each product.

	PRODUCTS	A Hrs.	P Hrs.	T Hrs.	M Hrs.	L Hrs.
1.	Two Furrow Plough	20	5	2	2	25
2.	Two Furrow Surry Ridger	14	4	1	3	16
3.	Three Furrow Plough	18	3	2	3	22
4.	Spring cultivator	15	5	1	4	15
5.	Terassor Blade	19	4	2	2	23
6.	Four wheel Trailer	26	8	3	4	33
7.	Two wheel Trailer	23	7	2	3	29
8.	Two Wheel Semi Trailer	21	6	2	2	27
9.	Two Wheel Tipping Trailer	17	5	1	2	21

The profit per unit for each products are Rs. 550, 430, 710, 550, 700, 5100, 3400, 2450 and 1800.

Total 756 hours are available for assembly, per week, 210 hours for painting, 84 hours for testing, Maches are available for 42 hours and 850 hours for Labours.

The company at the most can produce

Four Quantities of two Furrow plough

Three " of two furrow surry ridger

Three " of three furrow plough

Four Quantities of Spring Cultivator

Four " of Terassor Blade

Three " of Four Wheel Trailer

Two " of Two Wheel Trailer

Two " of Two Wheel semi Trailer

Three " of Two wheel non Semi Trailer

Per week depending upon available capacities of machine and labours.

Development and Formulation of the Linear Programming Model

Let X_1 be the no. of two furrow plough

X_2 be the no. of two furrow surry ridger

X_3 be the no. of three furrow plough

X_4 be the no. of spring cultivator

X_5 be the no. of Terassor Blade

X_6 be the no. of Four wheel trailer

X_7 be the no. of two wheel trailer

X_8 be the no. of two wheel semi trailer

X_9 be the no. of two wheel non semi trailer

Max. Z =

$$550 X_1 + 430 X_2 + 710 X_3 + 350 X_4 + 700 X_5 +$$
$$5100 X_6 + 3400 X_7 + 2450 X_8 + 1800 X_9$$

Assembly

$$20 X_1 + 14 X_2 + 18 X_3 + 15 X_4 + 19 X_5 + 26 X_6 + 23 X_7 + 21 X_8 + 17 X_9 \leq 756$$

Painting

$$5 X_1 + 4 X_2 + 3 X_3 + 5 X_4 + 4 X_5 + 8 X_6 + 7 X_7 + 6 X_8 + 5 X_9 \leq 210$$

Testing

$$2 X_1 + X_2 + 2 X_3 + X_4 + 2 X_5 + 3 X_6 + 2 X_7 + 2 X_8 + X_9 \leq 84$$

Machine

$$2 X_1 + 3 X_2 + 3 X_3 + 4 X_4 + 2 X_5 + 4 X_6 + 3 X_7 + 2 X_8 + 2 X_9 \leq 42$$

Labour

$$25 X_1 + 16 X_2 + 22 X_3 + 15 X_4 + 23 X_5 + 33 X_6 + 29 X_7 + 27 X_8 + 21 X_9 \leq 850$$

Quantity

$$X_1 \leq 4 \qquad X_2 \leq 3 \qquad X_3 \leq 3$$

$$X_4 \leq 4 \qquad X_5 \leq 4 \qquad X_6 \leq 3$$

$$X_7 \leq 2 \qquad X_8 \leq 2 \qquad X_9 \leq 3$$

SOLUTION

The above Linear Programming problem is solved by using computer programme developed in BASIC for solving L.P.P. by simplex method. The programme gave the following optimal solution

$X_1 = 4$

The company has to produce Four units of two Furrow plough

$X_3 = 2$

Two units of three furrow plough

$X_6 = 3$

Three units of Four wheel trailer

$X_7 = 2$

Two units of two wheel trailer

$X_8 = 2$

Two units of two wheel semi trailer

$X_9 = 3$

Three units of two wheel non semi trailer

To get the Maximum profit of Rs. 36,020

Present profit Rs. 24,000

SALES FORECASTING :

The company is provided following information regarding sales for the last five years.from 1985 to 1989.

Years	Sales (in Rupees)
1985	7,25,000
1986	9,72,000
1987	20,00,000
1988	24,00,000
1989	31,00,000

Forecasting of sales by using fitting of straight line by least square method.

Here n = 5 i.e. odd and therefore we shift the origin to the middle time period viz. the year 1987.

Let t = X - 1987

Computation of Trend Value and Line

Years	Sales	t	t.ut	t^2	Trend value ue
1985	7,25,000	-2	-14,50,000	4	-7,11,800
1986	9,72,000	-1	- 9,72,000	1	5,63,800
1987	20,00,000	0	0	0	18,39,400
1988	24,00,000	1	24,00,000	1	31,15,000
1989	31,00,000	2	62,00,000	4	43,90,600

Let the least square line of Ut on t be

$ut = at\ b^t$

The normal equation for estimating a and b are

$\Sigma Ut = na+b+b\Sigma t$ and $\Sigma tut = a\Sigma t + b\Sigma t^2$

$91,97,000 = 5\ a$ $\qquad$ $63,78,000 = 5\ b$

$a = \frac{91,97,000}{5}$ $\qquad$ $b = \frac{63,78,000}{5}$

$a = 18,39,400$ $\qquad$ $b = 12,75,600$

Hence the least square line bitting the data is

$ut = 18,39,400 + 12,75,600\ t$

where origin is 1987 and unit t = 1 year

Trend value for the years 1985 to 1989 are obtained on putting t = -2, -1 respectively in (xxxx) and have been tabulated in the last column of the above table.

1985

$= 18,39,400 + 12,75,600\ (-2)$

$= 18,39,400 + -25,51,200$

$= -7,11,800$

1986

$= 18,39,400 + 12,75,600\ (-1)$

$= 18,39,400 + -12,75,000$

$= + 5,63,800$

1987

$= 18,39,400 + 12,75,600\ (0)$

$= 18,39,400 + 0000000$

$= + 18,39,400$

1988

= 18,39,400 + 12,75,600 (1)

= 18,39,400 + 12,75,600

= + 31,15,000

1989

= 18,39,400 + 12,75,600 (2)

= 18,39,400 + 25,51,200

= + 43,90,600

Estimated for 1990

t = 1990 - 1987 = 3

Hence the estimated sales of the firm for 1990 is obtained on putting t = 3 in (xxx) and is given by Ue 1990.

Ue 1990 = 18,39,400 + 12,75,600 - 20,00,000 (3)

= 31,15,000 - 20,00,000 x 3

= 11,15,000 x 3

= 33,45,000

Estimated for 1991

Ue 1991 = 18,39,400 + 12,75,600 - 20,00,000 (4)

= 31,15,000 - 20,00,000 x 4

= 11,15,000 x 4

= 44,60,000

Estimated for 1992

Ue 1992 = 18,39,400 + 12,75,600 - 20,00,000 (5)

= 31,15,000 - 20,00,000 x 5

= 11,15,000 x 5

= 55,75,000

Estimated for 1993

Ue 1993 = 18,39,400 + 12,75,600 - 20,00,000 (6)

= 31,15,000 - 20,00,000 x 6

= 11,15,000 x 6

= 66,90,000

Estimated for 1994

Ue 1994 = 18,39,400 + 12,75,600 - 20,00,000 (7)

= 31,15,000 - 20,00,000 x 7

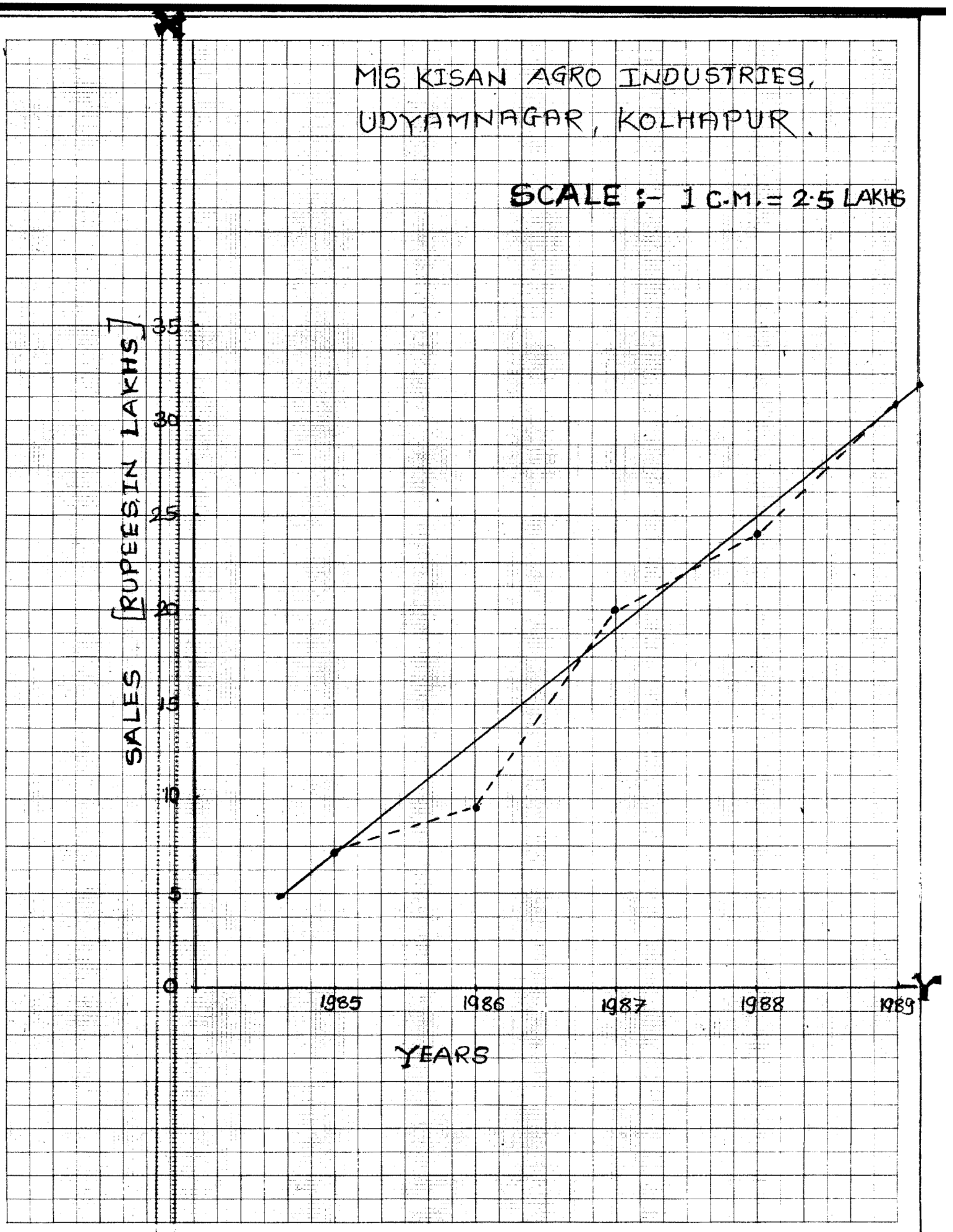
= 11,15,000 x 7

= 78,05,000

Similarly, the graph of the original data and trend line is plotted on graph paper.

M/S KISAN AGRO INDUSTRIES,
UDYAMNAGAR, KOLHAPUR.

SCALE :- 1 C.M. = 2.5 LAKHS



INVENTORY MODEL

The following information is provided by the company regarding inventory.

Annual demand for product (D) = 200 Units

Inventory carrying cost (h) = 10%

Ordering or set up costs = Rs. 20 Per Unit

Cost of production = Rs. 5,000/-

Past lead times; 20 days, 15, 25, 18, 30, 27

1. Economic order quantity

$$E.O.Q. = \sqrt{\frac{2DCS}{h}}$$

Where

D = Annual demand for product

S = Set up or ordering costs

h = Inventory carrying or holding cost

c = Cost of production per unit

v = Value of total demand.

$$E.O.Q. = \sqrt{\frac{2 \times 200 \times 5000 \times 20}{10/100}}$$

$$= \sqrt{\frac{40000000 \times 100}{10}}$$

$$= \sqrt{400000000}$$

E. O. Q. = 20,000

2. Optimum buffer stock

OBS = (Maximum Lead Time - Normal Lead Time) X Monthly Demand.

$$= \frac{30 - 15}{30} \times \frac{200}{12}$$

$$= 1/2 \times 16.67$$

$$= \underline{8.34 \text{ Units}}$$

3. Reorder Level

ROL = Safety stock + Normal Lead Time Demand

= 8.34 + 8.33

= 16.67 Units.

4. Maximum Inventory Level

MIL = Annual demand + Safety Stock

= 200 + 8.34

= 208.34 Units

5. Minimum Inventory Level.

= Reorder Level - Normal Lead Time

= 16.67 - 8.33

= 8.34 Units

6. Average Inventory Level

$$= \frac{\text{Maximum Level + Minimum Level}}{2}$$

$$= \frac{208.34 + 8.34}{2}$$

$$= \frac{216.68}{2}$$

= 108.34 Units.

7. Normal Lead Time Demand

= Normal lead time X monthly demand

$$= \frac{15}{30} \times \frac{200}{12}$$

$$= 1/2 \times 16.67$$

= 8.34 Units.

4.2 M/s POPULAR INDUSTRIES

The company manufactures different products such as, Two furrow plough, Reversible plough, Three furrow plough, DISC Harrow, Spring cultivator, Two wheel Trailer, Four wheel trailer (with body), Four wheel Trailer(without body) and Two wheel semi Trailer.

The production planning department provided the following information regarding manufacturing of one unit of each product in hours.

PRODUCTS	A Hrs.	P Hrs.	T Hrs.	M Hrs.	L Hrs.
1. Reversible plough	17	4	1	3	19
2. Two furrow plough	24	5	2	2	29
3. Three furrow plough	18	4	2	2	22
4. DISC Harrow	22	3	1	3	23
5. Spring cultivator	16	5	3	3	18
6. Two wheel Trailer	30	8	2	4	36
7. Four wheel Trailer (with body)	32	6	2	3	35
8. Four wheel Trailer (without body)	26	7	3	3	32
9. Two wheel semi Trailer	23	8	2	2	31

The profit per unit for each product are Rs. 870, 2160, 1080, 1800, 900, 5400, 5350, 6750 and 4050.

Total 420 hours are available for assembly per week, 126 hours for painting, 84 hours for Testing, machines are available for 42 hours and 630 hours for Labours.

The company at the most can produce

Three	Quantities	of Reversible plough
Two	"	of Two furrow plough
Three	"	of Three furrow plough
Two	"	of DISCHarrow
Three	"	of Spring Cultivator
One	"	of two wheel trailer,
One	"	of Four wheel trailer
One	"	of Four wheel trailer (without body)
Two	"	Two wheel semi trailer

DEVELOPMENT AND FORMULATION OF L.P.P. MODEL

Let X_1 be the no. of Reversible plough

X_2 be the no. of two furrow plough

X_3 be the no. of three furrow plough

X_4 be the no. of DISC Harrow

X_5 be the no. of Spring Cultivator

X_6 be the no. of Two wheel trailer

X_7 be the no. of Four wheel trailer (with body)

X_8 be the no. of Four wheel trailer (without body)

X_9 be the no. of Two wheel semi trailer

Max. Z =

$$870 X_1 + 2160 X_2 + 1080 X_3 + 1800 X_4 + 900 X_5 + 5400 X_6 + 6750 X_7 + 5350 X_8 + 4050 X_9$$

Assembly

$$17 X_1 + 24 X_2 + 18 X_3 + 22 X_4 + 16 X_5 + 30 X_6 + 32 X_7 + 26 X_8 + 23 X_9 \leq 420$$

Painting

$$4 X_1 + 5 X_2 + 4 X_3 + 3 X_4 + 4 X_5 + 8 X_6 + 6 X_7 + 7 X_8 + 8 X_9 \leq 126$$

Testing

$$X_1 + 2 X_2 + 2 X_3 + X_4 + 3 X_5 + 2 X_6 + 2 X_7 + 3 X_8 + 2 X_9 \leq 84$$

Machine

$$3 X_1 + 2 X_2 + 2 X_3 + 3 X_4 + 3 X_5 + 4 X_6 + 3 X_7 + 3 X_8 + 2 X_9 \leq 42$$

Labour

$$19 X_1 + 29 X_2 + 22 X_3 + 23 X_4 + 18 X_5 + 36 X_6 + 35 X_7 + 32 X_8 + 31 X_9 \leq 630$$

Quantity

$X_1 \leq 3$ $X_2 \leq 2$ $X_3 \leq 3$

$X_4 \leq 2$ $X_5 \leq 3$ $X_6 \leq 1$

$X_7 \leq 1$ $X_8 \leq 1$ $X_9 \leq 2$

SOLUTION

The above Linear Programming problem is solved by using computer programme developed in BASIC for solving L.P.P. by simplex method.

The programme gave the following optimal solution

$X_1 = 1$

The company has to produce one unit of Reversible plough

$X_2 = 2$

Two units of two furrow plough

$X_3 = 3$

Three units of three furrow plough

$X_4 = 2$

Two units of DISC Harrow

$X_5 = 3$

Three units of Spring cultivator

$X_6 = 1$

One unit of Two wheel trailer

$X_7 = 1$

One unit of four wheel trailer (with body)

$X_8 = 1$

One unit of four wheel trailer (without body)

$X_9 = 2$

Two units of Two wheel semi Trailer

To get the maximum profit of Rs. 40,330

Present profit Rs. 32,000

z

SALES FORECASTING

The company has provided the following information regarding the Sales for the last five years from 1985 to 1989.

YEARS	SALES (in Rupees)
1985	3,31,000
1986	3,81,000
1987	4,66,000
1988	11,94,000
1989	15,14,000

Forecasting of Sales by using fitting of straight line by least square method.

Here n = 5 i.e. odd and therefore we shift the origin to the middle time period viz. the year 1987.

Let t = x 1987

computation of Trend Value and Line

Year	Sales	t	t.ut	t^2	Trend value
1985	3,31,000	-2	-6,62,000	4	-4,94,000
1986	3,81,000	-1	-3,81,000	1	1,41,400
1987	4,66,000	0	0	0	7,77,200
1988	11,94,000	1	11,94,000	1	14,13,000
1989	15,14,000	2	30,28,000	4	20,48,800

Let the least square line of Ut on t be

Ut = a + bt

The normal equation for estimating a and b are

$\Sigma Ut = na + b\Sigma t$ and $\Sigma t\ Ut = a\Sigma t + b\Sigma t^2$

$38,86,000 = 5\ a$ $\qquad$ $31,79,000 = 5\ b$

$a = \frac{38,86,000}{5}$ $\qquad$ $b = \frac{31,79,000}{5}$

$a = 7,77,200$ $\qquad$ $b = 6,35,800$

Hence the least square method the data is

Ut = 7,77,200 + 6,35,800 t

where origin is 1987 and unit t = 1 year

Trend value for the years 1985 to 1989 are obtained on putting t = -2, -1 respectively in (xxxx) and have been tabulated in the last column of the above table.

1985

= 7,77,200 + 6,35,800 (-2)

= 7,77,200 + -12,71,600

= - 4,94,400

1986

= 7,77,200 + 6,35,800 (-1)

= 7,77,200 + -6,35,800

= + 1,41,400

1987

= 7,77,200 + 6,35,800 (0)

= 7,77,200 + 00000

= + 7,77,200

1988

= 7,72,200 + 6,35,800 (1)

= 7,77,200 + 6,35,800

= + 14,13,000

1989

= 7,77,200 + 6,35,800 (2)

= 7,77,200 +12,71,600

= 7,77,200 +12,71,600

= 20,48,800

Estimated for 1990

t = 1990 - 1987 = 3

Ue 1990 = 7,77,200 + 6,35,800 - 4,66,000 (3)

= 14,13,000 - 4,66,000 X 3

= 9,47,000 X 3

= 28,41,000

Estimated for 1991

Ue 1991 = 7,77,200 + 6,35,800 - 4,66,000 (4)

= 14,13,000 - 4,66,000

= 9,47,000 X 4

= 37,88,000

Estimated for 1992

Ue 1992 = 7,77,200 + 6,35,800 - 4,66,000 (5)

= 14,13,000 - 4,66,000

= 9,47,000 X 5

= 47,35,000

Estimated for 1993

$$Ue\ 1993 = 7,77,200 + 6,35,800 - 4,66,000 \quad (6)$$

$$= 14,13,000 - 4,66,000$$

$$= 9,47,000 \times 6$$

$$= 58,82,000$$

Estimated for 1994

$$Ue\ 1994 = 7,77,200 + 6,35,800 - 4,66,000 \quad (7)$$

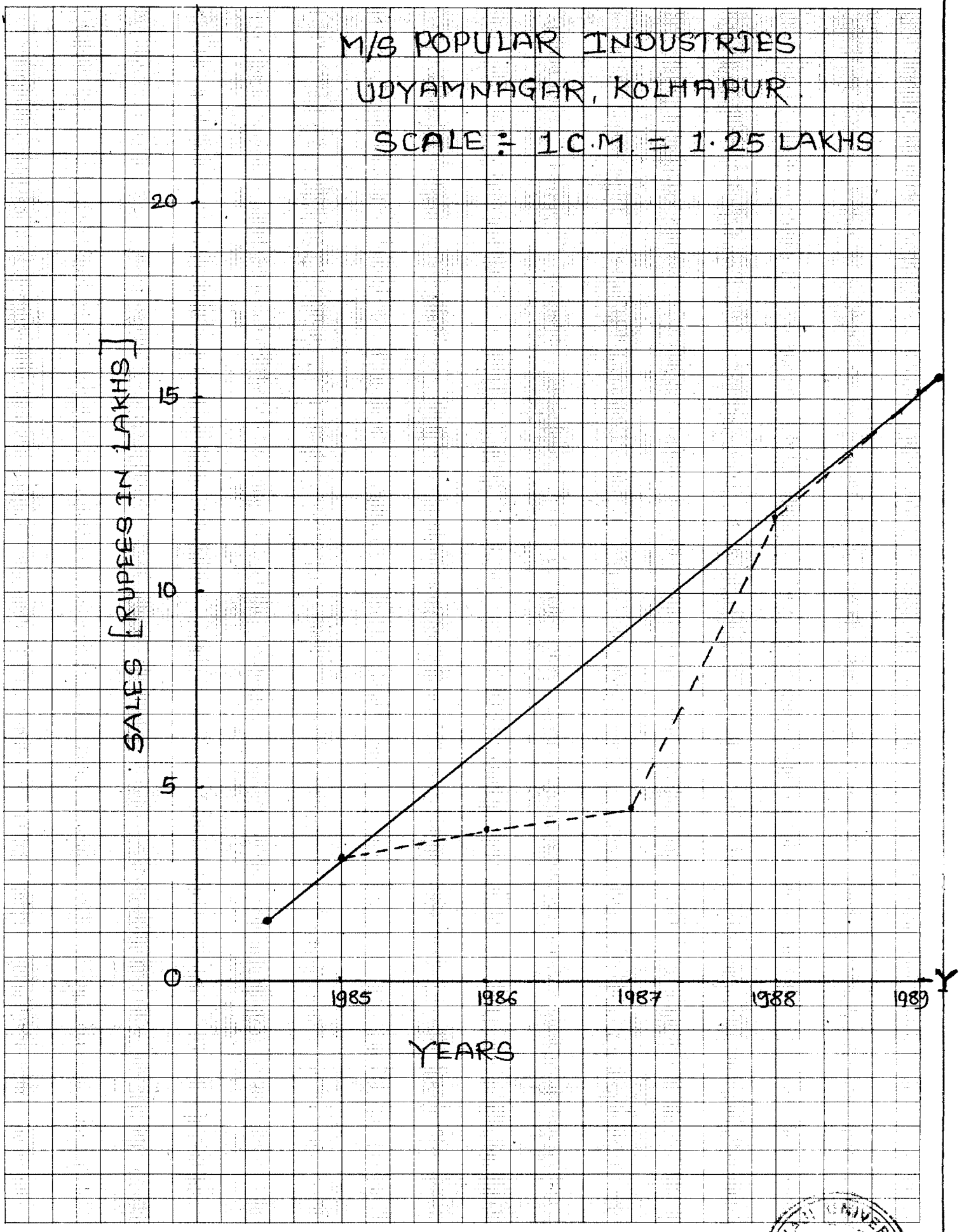
$$= 14,13,000 - 4,66,000$$

$$= 9,47,000 \times 7$$

$$= 66,29,000$$

Similarly, the graph of the original data has been plotted on the graph paper.

M/S POPULAR INDUSTRIES
UDYAMNAGAR, KOLHAPUR.
SCALE :- 1 C.M = 1·25 LAKHS



Major

INVENTORY MODEL

The following information is provided by the company regarding the inventory.

Annual demand for the product (d) = 150 Units

Inventory carrying costs (h) = 15%

Ordering or set up cost = Rs. 25 P.U.

Cost of production per unit = Rs. 5,200/-

Past Lead Times 10 days, 18, 15, 25, 30, 22

1. E. O. Q. $= \sqrt{\frac{2\,D\,C\,S}{h}}$

$= \sqrt{\frac{2 \times 150 \times 5200 \times 25}{15/100}}$

$= \sqrt{\frac{38900000 \times 100}{15}}$

$= \sqrt{\frac{3890000000}{15}}$

$= \sqrt{259333333.33}$

= 16,103.83

2. Optimum Buffer Stock

OBS = (Maximum Lead Time - Normal Lead Time) X Monthly Demand

$= (\frac{30 - 10}{30}) \times \frac{150}{12}$

= 1/3 X 12.50

= 4.17 Units.

3. Normal Lead Time Demand

= Normal Lead time X Monthly demand

$= \frac{10}{30} \times \frac{150}{12}$

= 1/3 X 12.50

= 4.17 Units.

4. Reorder Level

ROL = Safety stock + Normal Lead Time Demand

= 4.17 + 4.17

= 8.34 Units.

5. Maximum Inventory Level

= Annual demand + Safety stock

= 150 + 4.17

= 154.17 Units.

6. Minimum Inventory Level

= Reorder Level - Normal Lead Time Demand

= 8.34 - 4.17

= 4.17 Units.

7. Average Inventory Level

$= \frac{\text{Maximum Level + Minimum Level}}{2}$

$= \frac{154.17 + 4.17}{2}$

$= \frac{158.34}{2}$ Units.

= 79.17 Units.

4.3 M/s POWER STEEL WORKS

The company manufactures the different products such as two furrow plough, reversible plough, three furrow plough, DISC harrow, spring cultivator, two furrow surry ridger, three furrow surry ridger, tiller spring loaded and surry side cutting ridger.

The production planning department is provided the following information regarding the production details for developing the linear programming problem model. The following table shows the time's required for manufacturing one unit of each product in hours.

PRODUCTS	A Hrs.	P Hrs.	T Hrs.	M Hrs.	L Hrs.
1. Two furrow plough	16	3	1	3	17
2. Reversible plough	24	5	2	4	27
3. Three furrow plough	17	4	2	4	18
4. DISC harrow	18	5	2	3	22
5. Spring cultivator	23	6	2	3	26
6. Two furrow surry ridger	21	5	1	2	25
7. Three furrow surry ridger	25	7	2	3	31
8. Tiller spring loaded	22	6	2	2	28
9. Surry side cutting ridger	10	3	1	2	12

The profit per unit for each product are Rs. 1000,1800, 1400,1900,1000,780,1140,1100,600.

Total 294 hours are available for assembly per week, 84 hours for painting, 42 hours for testing, machines are available for 42 hours and labourers for 420 hours.

The company at the most can produce two quantities of two furrow plough
One Quantity of Reversible plough
Two Quantities of Three furrow plough
Two quantities of DISC harrow
One quantity of spring cultivator
one quantity of Two furrow surry ridger
One quantity of Three furrow surry ridger
One quantity of Tiller spring loaded
Two quantities of surry side cutting ridger
per week depending upon available capacities of machines and labourers.

FORMULATION AND DEVELOPMENT OF L.P.P. MODEL

Let X_1 be the No. of two furrow plough
X_2 be the No. of Reversible plough
X_3 be the No. of three furrow plough
X_4 be the No. of DISC harrow
X_5 be the No. of spring cultivator
X_6 be the No. of two furrow surry ridger
X_7 be the No. of three furrow surry ridger
X_8 be the No. of Tiller spring loaded.
X_9 be the No. of surry side cutting ridger.

Max Z =

$$1000 X_1 + 1800 X_2 + 1400 X_3 + 1900 X_4 + 1000 X_5 +$$
$$780 X_6 + 1140 X_7 + 1100 X_8 + 600 X_9$$

Assembly

$$16 X_1 + 24 X_2 + 17 X_3 + 18 X_4 + 23 X_5 +$$
$$21 X_6 + 25 X_7 + 22 X_8 + 10 X_9 \leq 294$$

Painting

$$3 X_1 + 5 X_2 + 4 X_3 + 5 X_4 + 6 X_5 +$$
$$5 X_6 + 7 X_7 + 6 X_8 + 3 X_9 \leq 84$$

Testing

$$X_1 + 2 X_2 + 2 X_3 + 2 X_4 + 2 X_5 +$$
$$X_6 + 2 X_7 + 2 X_8 + X_9 \leq 42$$

Machine

$$3 X_1 + 4 X_2 + 4 X_3 + 3 X_4 + 3 X_5 +$$
$$2 X_6 + 3 X_7 + 2 X_8 + 2 X_9 \leq 42$$

Labour

$$17 X_1 + 27 X_2 + 18 X_3 + 22 X_4 + 26 X_5 +$$
$$25 X_6 + 31 X_7 + 28 X_8 + 12 X_9 \leq 420$$

Quantity

$X_1 \leq 2$ $\quad X_2 \leq 1$ $\quad X_3 \leq 2$

$X_4 \leq 2$ $\quad X_5 \leq 1$ $\quad X_6 \leq 1$

$X_7 \leq 1$ $\quad X_8 \leq 1$ $\quad X_9 \leq 2$

SOLUTION

The above Linear Pregramming problem is solved by using computer progrwmme. Linear programming model developed in BASIC. For solving L.P.P. by simplex method.
The programme gave the following optimal solution.

$X_1 = 2$

The company has to produce two units of two furrow plough

$X_2 = 1$

One unit of Reversible plough

$X_3 = 2$

Two units of three furrow plough

$X_4 = 2$

Two units of DISC Harrow

$X_8 = 1$

One unit of Tiller spring loaded

$X_9 = 2$

Two units of surry side cutting ridger

To get the maximum profit of Rs. 18,446

Present Profit Rs. 9,000

SALES FORECASTING

The company has provided the following information regarding sales for the last five years from 1985 to 1989.

YEARS	SALES (in Ruppes)
1985	2,50,000
1986	4,75,000
1987	7,50,000
1988	9,80,000
1989	12,00,000

Forecasting of sales by using fitting of straight line by least square method.

Here n = 5 i.e. odd and therefore we shift the origin to the middle time period viz. the year 1987

Let t = x - 1987.

Computation of Trend Value and Line

Years	Sales	t	t.ut	t^2	Trend value
1985	2,50,000	-2	- 50,000	4	- 2,31,000
1986	4,75,000	-1	-4,75,000	1	2,50,000
1987	7,50,000	0	0	0	7,31,000
1988	9,80,000	1	9,80,000	1	12,12,000
1989	12,00,000	2	24,00,000	4	16,93,000

Let the last square line of Ut on t be Ut = a + b t

The normal equation for estimating a and b are

$\Sigma U t = na + b \Sigma t$ and $\Sigma t\ ut = a\Sigma + b\Sigma t^2$

$36,55,000 = 5\ a$ $\qquad$ $24,05,000 = 5\ b$

$a = \frac{36,55,000}{5}$ $\qquad$ $b = \frac{24,05,000}{5}$

$a = 7,31,000$ $\qquad$ $b = 4,81,000$

Hence the least square line fitting the data is

Ut = 7,31,000 + 4,81,000 t

Where origin is 1987 and unit t = 1 year

Trend value for the year 1985 - 1989 are obtained on putting t = -2, -1 respectively in (xxx) and have been tabulated in the last column of the above table.

1985

= 7,31,000 + 4,81,000 (-2)

= 7,31,000 + -9,62,000

= - 2,31,000

1986

= 7,31,000 + 4,81,000 (-1)

= 7,31,000 + - 4,81,000

= 2,50,000

1987

= 7,31,000 + 4,81,000 (0)

= 7,31,000 + 000000

= 7,31,000

1988

= 7,31,000 + 4,81,000 (1)

= 7,31,000 + 4,81,000

= 12,12,000

1989

= 7,31,000 + 4,81,000 (2)

= 7,31,000 + 9,62,000

= 16,93,000

Estimated for 1990

Ue = 7,31,000 + 4,81,000 - 7,50,000 (3)

= 12,12,000 - 7,50,000

= 4,62,000 x 3

= 13,86,000

Estimated for 1991

Ue 1991 = 7,31,000 + 4,81,000 - 7,50,000 (4)

= 12,12,000 - 7,50,000

= 4,62,000 x (4)

= 18,48,000

Estimated for 1992

Ue 1992 = 7,31,000 + 4,81,000 - 7,50,000 (5)

= 12,12,000 - 7,50,000

= 4,62,000 x 5

= 23,10,000

Estimated for 1993

Ue 1993 = 7,31,000 + 4,81,000 - 7,50,000 (6)

= 12,12,000 - 7,50,000

= 4,62,000 x 6

= 27,72,000

Estimated for 1994

Ue 1994 = 7,31,000 + 4,81,000 - 7,50,000 (7)

= 12,12,000 - 7,50,000

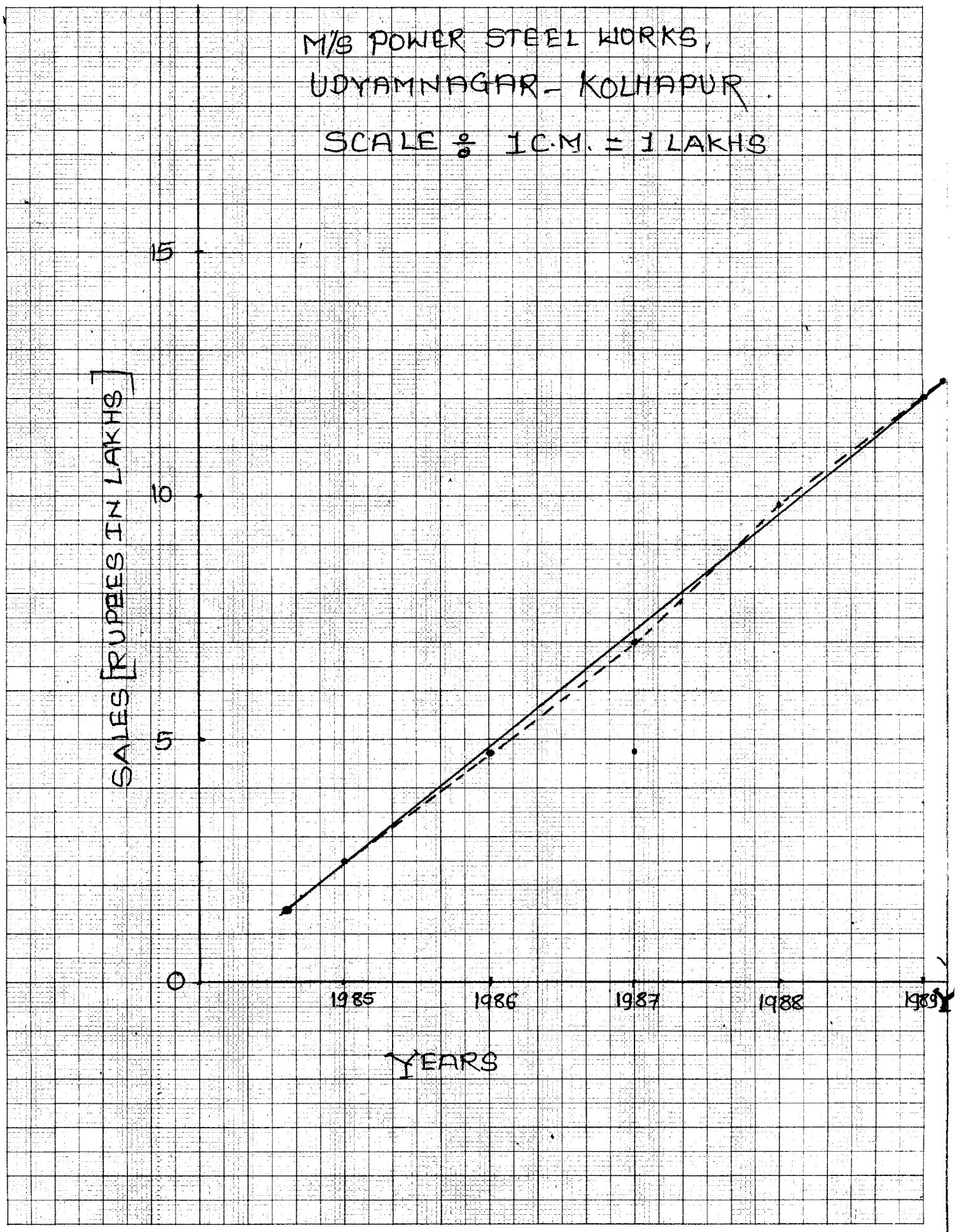
= 4,62,000 x 7

= 32,34,000

Similarly the graph of the original data has been plotted on graph paper.

M/S POWER STEEL WORKS,
UDYAMNAGAR - KOLHAPUR.

SCALE :- 1 C.M. = 1 LAKHS



INVENTORY MODEL

The following information is provided by the company regarding inventory.

Annual demand for the product (D) = 100 units

Inventory carrying cost = 12%

Ordering cost = Rs. 15 per unit

Cost of rpdocution per unit = Rs. 4,500

past lead time 17 days, 15, 18, 20, 30, 25, 29

1. Economic Order Quantity

$$E.O.Q. = \sqrt{\frac{2\,D\,C\,S}{h}}$$

$$= \sqrt{\frac{2 \times 100 \times 4500 \times 15}{12/100}}$$

$$= \sqrt{\frac{13500000 \times 100}{12}}$$

$$= \sqrt{\frac{135\,0000000}{12}}$$

$$= \sqrt{112500000}$$

$$= 10,606.601$$

2. Optimum buffer stock

O.B.S. = (Maximum lead time - Normal lead time) x monthly demand

$$= \left(\frac{30-15}{30}\right) * \frac{100}{12}$$

= ½ x 8.34

= 4.17 units

3. Normal lead time demand

= Normal lead time x monthly demand

= 15/30 x 100/12

= ½ x 8.34

= 4.17 units

4. Reorder Level

ROL = Safety stock + Normal Lead time deamnd

= 4.17 + 4.17

= 8.34 units

5. Maximum Inventory Level

= Annual demand + safety stock

= 100 + 4.17

= 104.17 units

6. Minium Inventory Level

= Reorder Level - Normal lead time

= 8.34 - 4.17

= 4.17 units

7. Average Inventory Level

$$= \frac{\text{Max. level + Min. Level}}{2}$$

$$= \frac{104.17 + 4.17}{2}$$

$$= \frac{108.34}{2}$$

= 54.17 units

4.4 M/s SHVAN AND FARMER AGRO INDUSTRIES

The company manufactures the different products such as Two furrow plough, Two furrow surry Ridger, Three furrow plough, Terassor Blade, Spring cultivator, Reversible plough, Three furrow surry ridger, Two wheel Trailer and Four wheel Trailer.

The production planning department is provided the following production details for developing L.P. P. Model. The following table shows the times required for manufacturing one unit of each product (in hours)

PRODUCTS	A Hrs.	P Hrs.	T Hrs.	M Hrs.	L Hrs.
1. Two furrow plough	14	4	2	3	16
2. Two furrow surry ridger	18	6	2	4	22
3. Three furrow plough	16	5	1	2	22
4. Terassor Blade	17	7	3	3	24
5. Spring cultivator	24	5	2	2	29
6. Reversible plough	15	3	1	4	15
7. Three furrow surry ridger	17	4	1	3	21
8. Two wheel Trailer	30	8	2	4	36
9. Four wheel Trailer	36	7	2	5	40

The profit per unit for each product are Rs. 825, 1275, 625, 825, 2280, 825, 1425, 5400 and 8,100.

Total 336 hours are avialable for assembly per week, 126 hours are for painting, 42 hours for Testing, Machines are available for 42 hours, and labour for 504 hours.

The company at the most can product

Three Quantities of Two furrow plough
One " of Two furrow surry ridger
Two " of Three furrow plough
Four " of Terassor blade
One " of Spring cultivator
One " of Reversible plough
Two " of Three furrow surry ridger
One " of Two wheel trailer
Two " of Four wheel trailer
Per week depending upon available capacities of machines and labours.

DEVELOPMENT AND FORMULATION OF MODEL

Let X_1 be the no. of Two furrow plough

X_2 be the no. of Two furrow surry ridger

X_3 be the no, of Three furrow plough

X_4 be the no. of Terassor Blade

X_5 be the no. of Spring cultivator

X_6 be the no. of Reversible plough

X_7 be the no. of Three furrow surry ridger

X_8 be the no. of Two wheel Trailer

X_9 be the no. of Four wheel trailer

Max. z =

$$825 X_1 + 1275 X_2 + 625 X_3 + 825 X_4 + 2280 X_5 +$$
$$825 X_6 + 1425 X_7 + 5400 X_8 + 8100 X_9$$

Assembly

$$= 14 X_1 + 18 X_2 + 16 X_3 + 17 X_4 + 24 X_5 +$$
$$15 X_6 + 17 X_7 + 30 X_8 + 36 X_9 \leq 336$$

Painting

$$= 4 X_1 + 6 X_2 + 5 X_3 + 7 X_4 + 5 X_5 +$$
$$3 X_6 + 4 X_7 + 8 X_8 + 7 X_9 \leq 126$$

Testing

$$= 2 X_1 + 2 X_2 + X_3 + 3 X_4 + 2 X_5 +$$
$$X_6 + X_7 + 2 X_8 + 2 X_9 \leq 42$$

Machine

$$= 3 X_1 + 4 X_2 + 2 X_3 + 3 X_4 + 2 X_5 +$$
$$4 X_6 + 3 X_7 + 4 X_8 + 5 X_9 \leq 42$$

Labour

$$= 16 X_1 + 22 X_2 + 22 X_3 + 24 X_4 + 29 X_5 +$$
$$15 X_6 + 21 X_7 + 36 X_8 + 40 X_9 \leq 504$$

Quantity

$X_1 \leq 3$ $\quad X_2 \leq 1$ $\quad X_3 \leq 2$

$X_4 \leq 4$ $\quad X_5 \leq 1$ $\quad X_6 \leq 1$

$X_7 \leq 2$ $\quad X_8 \leq 1$ $\quad X_9 \leq 2$

SOLUTION

The above linear programming problem is solved by using computer programme developed in BASIC for solving L.P.P. by simplex method.

The programme gave the following optimal solution.

$X_1 = 3$

The company has to produce three units of two furrow plough

$X_2 = 1$

One unit of Two furrow surry ridger

$X_3 = 2$

Two units of three furrow plough

$X_4 = 1$

One unit of Terassor Blade

$X_5 = 1$

One unit of spring cultivator

$X_7 = 2$

Two units of three furrow surry ridger

$X_8 = 1$

One unit of Two wheel trailer

$X_9 = 2$

Two units of four wheel trailer

To get the maximum profit of Rs. 32,555

Present profit Rs. 17,000

SALES FORECASTING

The company has provided the following information regarding the sales for the last five year from 1985 to 1989.

YEARS	SALES (in Rupees)
1985	3,25,000
1986	4,75,000
1987	7,40,000
1988	11,00,000
1989	13,00,000

Forecasting of sales by least square method

Here n = 5 i.e. odd and therefore we shift the origin to the middle time period viz. the year 1987

Let t = x - 1987

Computation of Trend Value and Line

Years	Sales	t	t.ut	t^2	Trend Value
1985	3,25,000	-2	- 6,50,000	4	- 2,42,000
1986	4,75,000	-1	- 4,75,000	1	2,73,000
1987	7,40,000	0	0	0	7,88,000
1988	11,00,000	1	11,00,000	1	13,03,000
1989	13,00,000	2	26,00,000	4	18,18,000

Let the least square line of ut on t be

$Ut = a + b^t$

The normal equation for estimating a and b are

$\sum Ut = na + b\Sigma t$ and $\Sigma t\, Ut = a\Sigma t + b\Sigma t^2$

$39,40,000 = 5a$ $\qquad$ $25,75,000 = 5\,b$

$a = \frac{39,40,000}{5}$ $\qquad$ $b = \frac{25,75,000}{5}$

$= 7,88,000$ $\qquad$ $= 5,15,000$

Hence the least square line fitting the data is

$Ut = 7,88,000 + 5,15,000\ t$

where origin is 87 and unit t = 1 year

Trend value for the year 1985 to 1989 are obtained on putting t = -2, -1 respectively in (xxx) and have been tabulated in the last column of the above table.

1985

$= 7,88,000 + 5,15,000\ (-2)$

$= 7,88,000 + -10,30,000$

$= -2,42,000$

1986

$= 7,88,000 + 5,15,000\ (-1)$

$= 7,88,000 + -5,15,000$

$= 2,73,000$

1987

$= 7,88,000 + 5,15,000\ (0)$

$= 7,88,000 + 5,15,000$

$= 7,88,000 + 0000000$

$= 7,88,000$

1988

= 7,88,000 + 5,15,000 (1)

= 7,88,000 + 5,15,000

= 13,03,000

1989

= 7,88,000 + 5,15,000 (2)

= 7,88,000 + 10,30,000

= 18,18,000

Estimated for 1990

Ue 1990 = 7,88,000 + 5,15,000 - 7,40,000 (3)

= 13,03,000 - 7,40,000

= 5,63,000 x 3

= 16,89,000

Estimated for 1991

Ue 1991 = 7,88,000 + 5,15,000 - 7,40,000 (4)

= 13,03,000 - 7,40,000

= 5,63,000 x 4

= 22,52,000

Estimated for 1992

Ue 1992 = 7,88,000 + 5,15,000 - 7,40,000 (5)

= 13,03,000 - 7,40,000

= 5,63,000 x 5

= 28,15,000

Estimated for 1993

Ue 1993 = 7,88,000 + 5,15,000 - 7,40,000 (6)

= 13,03,000 - 7,40,000

= 5,63,000 x 6

= 33,78,000

Estimated for 1994

Ue 1994 = 7,88,000 + 5,13,000 - 7,40,000 (7)

= 13,03,000 - 7,40,000

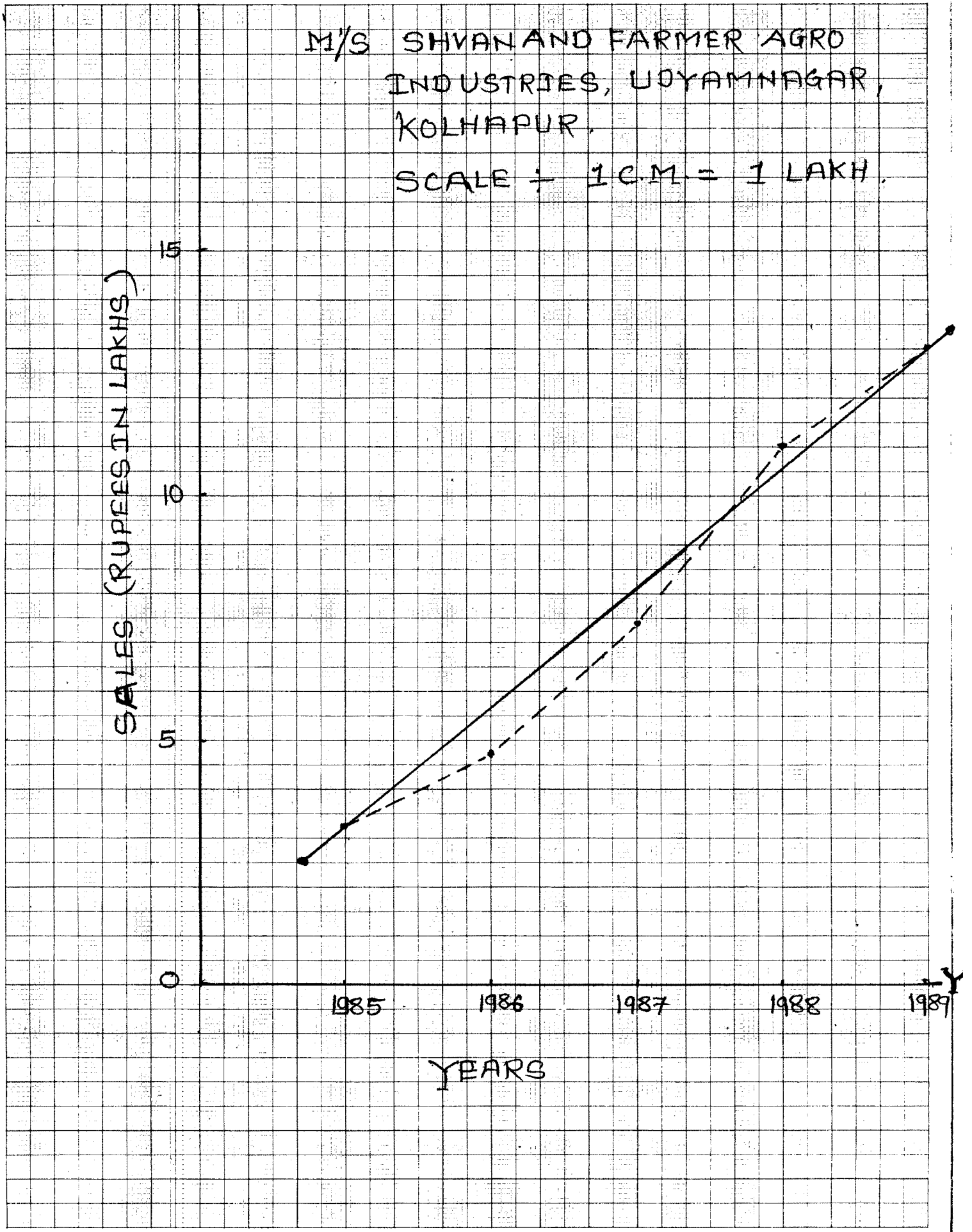
= 5,63,000 x 7

= 39,41,000

Similarly the graph of the original data has been plotted on the graph paper.

M/S SHIVANAND FARMER AGRO INDUSTRIES, UDYAMNAGAR, KOLHAPUR.

SCALE :- 1 C.M. = 1 LAKH.



INVENTORY MODEL

The following information is provided by the company regarding inventory.

Annual demand for product (D) = 160 units

Inventory carrying costs (h) = 10%

Ordering or set up cost = Rs. 30 per unit

cost of production per unit = Rs. 4,000

Past lead times 10 days, 28, 25, 20, 30, 27.

1. Economic Order Quantity

$$E.O.Q. = \sqrt{\frac{2\,D\,C\,S}{h}}$$

$$= \sqrt{\frac{2 \times 160 \times 4000 \times 30}{10/100}}$$

$$= \sqrt{\frac{38400000 \times 100}{10}}$$

$$= \sqrt{384000000}$$

$$= 19,595.917$$

2. Optimum buffer stock

O.B.S. = (maximum lead time - Normal lead time) x monthly demand

$$= \left(\frac{30 - 10}{30}\right) \times \frac{160}{12}$$

$$= 2/3 \times 13.34$$

$$= 8.89 \text{ units}$$

3. Normal lead time demand

= Normal lead time x monthly demand

= 20/30 x 160/12

= 2/3 x 13.34

= 8.89 units

4. Reorder Level

R.O.L. = Safety stock + Normal lead time demand

= 8.89 + 8.89

= 17.78 units

5. Maximum Inventory Level

= Annual demand + safety stock

= 160 + 8.89

= 168.89 units

6. Minium Inventory Level

= Reorder level - Normal lead time

= 17.78 - 8.89

= 8.89 units

7. Average Inventory Level

$$= \frac{\text{Maximum inventory + Minimum inventory}}{2}$$

$$= \frac{168.89 + 8.89}{2}$$

$$= \frac{177.78}{2}$$

= 88.89 units

COMPARATIVE TABLES

Table 1

The following table shows the comparative profits of selected small scale agro based industries.

Sr. No.	NAME OF THE UNITS	PRESENT PROFIT	PROFIT BY L.P.P.
1.	M/s KISAN AGRO INDUSTRIES	24,000	36,020
2.	M/s POPULAR INDUSTRIES	32,000	40,330
3.	M/s POWER STEEL WORKS	9,000	18,446
4.	M/s SHVAN AND FARMER AGRO INDUSTRIES	17,000	32,555

The above table indicates that presently the companies are not utilising the available resources for optimal combination of product which gives maximum profit.

Table 2

The following table shows comparision between original sales and forecast of the sales.for each industry.

M/s KISAN AGRO INDUSTRIES

Years	Original sales	Years	Forecasting sales
1985	7,25,000	1990	33,45,000
1986	9,72,000	1991	44,60,000
1987	20,00,000	1992	55,75,000
1988	24,00,000	1993	66,90,000
1989	31,00,000	1994	78,05,000

Table 3 M/S POPULAR INDUSTRIES

Years	Original Sales	Years	Forecasting Sales.
1985	3,31,000	1990	28,41,000
1986	3,81,000	1991	37,88,000
1987	4,66,000	1992	47,35,000
1988	11,94,000	1993	58,82,000
1989	15,14,000	1994	66,29,000

Table 4 M/S POWER STEEL WORKS

Years	Original Sales	Years	Forecasting Sales.
1985	2,50,000	1990	13,86,000
1986	4,75,000	1991	18,48,000
1987	7,50,000	1992	23,10,000
1988	9,80,000	1993	27,72,000
1989	12,00,000	1994	32,34,000

Table 5 M/S SHVAN AND FARMAR AGRO INDUSTRIES

Years	Original Sales	Years	Forecasting Sales.
1985	3,25,000	1990	16,89,000
1986	4,75,000	1991	22,52,000
1987	7,40,000	1992	28,15,000
1988	11,00,000	1993	33,78,000
1989	13,00,000	1994	39,41,000

The above tables regarding original sales and forecasting sales indicates that the sales has been increased treamondouslly, for the coming five years from 1990 to 1994.

Table 6

The following table indicates the Economic Order Quantity for each selected industries

Name of the industry	E.O.Q.
1. M/S Kisan Agro Industries	20,000
2. M/s Popular Industries.	16103.83
3. M/s Power Steel Works	10606.601
4. M/s Shvan & Farmar Agro Industries	19595.917

The above table shows the M/s Kisan Agro Industries should give order for more quantities than other industries.