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Experimental Investigation & Evaluation of Incorporated Material to Set their Optimum Re-Order Point in Kanban Control

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Abstract - In a manufacturing company inventory cost is a significant part of expense. So, the Re-order Point (R.O.P.) of the items must be optimum to reduce its carrying cost. We have study about the inventory and R.O.P. in Nevatia Steel & Alloys Pvt. Ltd. Mumbai and tried to find the optimum R.O.P. by applying VED and XYZ Analysis. Finally, for mathematical modeling we also take help of MatLab.

Keywords - *Re-order Point (R.O.P.), Inventory Carrying Cost (I.C.C.), VED analysis, XYZ analysis and MatLab R2008a.*

I. INTRODUCTION

A. Literature History & Problem Identification:

In a manufacturing industry some items are vital from production point of view but inventory cost of these parts is very high. So, we cannot keep more safety stock for these kinds of items but unavailability of these items will stop the manufacturing operation of that plant. But now-a-days, business environment is highly uncertain which affects the lead time of the procurement of the items and we have to keep the safety stock of such items. It means that the company should achieve the balance between the safety stock they have to keep on hand and cost of carrying inventory. In this paper we tried to find out the optimum value of R.O.P.

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II. DATA COLLECTION

TABLE I : DATA COLLECTED FROM NEVATIA STEEL & ALLOYS PVT. LTD. MUMBAI

SR. No.	Name of the Item	Annual Requirement (S)	Ordering Cost in Rs. (Cp)	Unit Cost in Rs. (Cu)	% of Average Inventory Investment (I)	Lead Time (In Weeks) (LT)	Consumption rate (CR)	Nature of the Item	Source of the supply	Way of the transportation	Re-order Point (Weeks) (ROP)
1.	a	80	980	570	1.8	1.6	1	Standard	Local	Truck	36
2.	b	1300	1.4	0.80	1.4	0.6	1130	Standard	Local	Truck	42
3.	c	940	1.3	0.70	1.6	1.1	645	Standard	Local	Truck	42
4.	d	2000	4	2.70	1.5	1.2	1730	Standard	Local	Truck	42
5.	e	4500	1.2	0.8	1.8	1.3	3678	Standard	Local	Truck	42
6.	f	1200	1.8	0.76	1.4	1.1	1015	Standard	Local	Truck	42
7.	g	1600	1.4	0.81	1.6	1.1	1340	Standard	Local	Truck	42
8.	h	800	360	257	2.3	1.3	560	Commercial	National	Train	42
9.	i	500	160	128	1.7	1.2	380	Commercial	National	Train	47
10.	j	1200	360	185	1.6	3.0	1035	Standard	Local	Truck	15
11.	k	460	450	295	1.4	2.0	317	Commercial	National		29

SR. No.	Name of the Item	Annual Requirement (S)	Ordering Cost in Rs. (Cp)	Unit Cost in Rs. (Cu)	% of Average Inventory Investment (I)	Lead Time (In Weeks) (LT)	Consumption rate (CR)	Nature of the Item	Source of the supply	Way of the transportation	Re-order Point (Weeks) (ROP)
12.	L	1800	1.2	0.7	1.5	1.5	1640	Commercial	Local	Truck	18
13.	M	5	7800	6340	1.7	3.0	2	Commercial	National	Train	48
14.	N	5	35000	32500	1.6	4.0	2	Buyers	National	Train	22
15.	o	4	18000	16500	1.5	5.0	2	buyers	national	train	22
16.	p	30	940	870	1.3	2.0	18	Standard	National	Train	18
17.	q	1000	10	6	2.5	5.0	750	Standard	National	Train	60
18.	r	3000	30	2	2	7.0	2830	Buyer's design	National	Truck	35
19.	s	60	4000	2875	1.6	3.0	27	Standard	National	Train	35
20.	t	5000	40	5	5.0	6.0	3840	Buyer's design	Foreign	Ship	5
21.	u	3000	48	8	2.3	3.0	2420	Buyer's design	National	Truck	4
22.	v	2400	280	180	1.4	4.0	2130	Buyer's design	National	Truck	4
23.	w	30	940	840	1.5	1.0	22	Standard	Local	Truck	28
24.	x	140	320	275	1.8	1.0	125	Commercial	Local	Truck	28
25.	y	1200	1.9	0.4	1.3	1.2	590	Standard	Local	Truck	32

III. METHODOLOGY

For this paper we have collected data from Nevatia Steel & Alloys Pvt. Ltd. Mumbai as shown in table I. On all the items we applied firstly VED Analysis and then XYZ Analysis. By applying both VED and XYZ Analysis we can find out such items which are very crucial and important from project point of view. So, methodology is applied on these five items. For finding out the optimum R.O.P. we use the Regression Modelling with the help of MatLab software.

A. VED Analysis[7]

Here we 'V' is consider for 'Vital', 'E' is for 'Essential' and 'D' is for 'Desirable'. The result of this analysis will be helpful in converging our focus on the 'Vital items', for which the level of inventory control required would be tighter than the parts.

For VED Analysis we consider following factors, which affects the R.O.P. of items in the industry:

1) Ordering cost(OC) (as per unit)
2) Lead Time (LT)(in Year)
3) Nature Of Item
4) Source Of Supply
5) Way Of Transportation

After finding out the factors which affects the R.O.P., we give them weightage according to their importance for R.O.P. For weightage of factors we draw a table as follows: []

TABLE II : FACTORS CONSIDERED FOR VED ANALYSIS WITH THE PLAN FOR WEIGHTAGE & POINT

Sr. No.	Factors	First Degree	Second Degree	Third Degree
1.	Ordering cost (5)	OC<100 (5)	100≤OC≤1000 (10)	OC>1000 (15)
2.	Lead Time (20)	LT <2 (20)	2≤ LT ≤4 (40)	LT >4 (60)
3.	Nature Of Item (20)	Buyer's Design (20)	Commercial (40)	Standard (60)
4.	Source Of Supply (25)	Local (25)	National (50)	Foreign (75)
5.	Way Of Transportation (30)	Truck (30)	Train (60)	Ship (90)

TABLE III : CATEGORIZATION OF V/E/D

On the basis of this table we categorized all the items into V or E or D as shown in Table IV.

Points	Classification
<150	Desirable (D)
150 to 175	Essential (E)
>175	Vital (V)

TABLE IV : CATEGORIZATION OF ITEMS INTO V/E/D

Sr. No.	Name Of Item	Ordering cost (A)	Lead Time (B)	Nature Of Item (C)	Source Of Supply (D)	Way Of Transportation (G)	Total (A+B+C+D+G)	Category (V/E/D)
1.	a	10	20	60	25	30	145	D
2.	b	5	20	60	25	30	140	D
3.	c	5	20	60	25	30	140	D
4.	d	5	20	60	25	30	140	D
5.	e	5	20	60	25	30	140	D
6.	f	5	20	60	25	30	140	D
7.	g	5	20	60	25	30	140	D
8.	h	10	20	40	50	60	180	V
9.	i	10	20	40	50	60	180	V
10.	j	10	40	60	25	30	165	E
11.	k	10	40	40	25	30	145	D
12.	l	5	20	40	25	30	120	D
13.	m	15	40	40	50	30	175	E
14.	n	15	40	20	50	60	185	V
15.	o	15	60	20	50	60	205	V
16.	p	10	40	60	50	60	220	V
17.	q	5	60	60	50	60	235	V
18.	r	5	60	20	50	30	165	E
19.	s	15	40	60	50	60	225	V
20.	t	5	60	20	75	90	250	V
21.	u	5	40	20	50	30	145	D
22.	v	10	40	20	50	30	150	E
23.	w	10	20	60	25	30	145	D
24.	x	10	20	40	25	30	125	D
25.	y	5	20	60	25	30	135	D

B. XYZ Analysis[7]

After VED Analysis we will switch over to XYZ Analysis. For this analysis we consider I.C.C. for categorization of items into X or Y or Z. Here we consider X for higher I.C.C., Y for medium I.C.C. and Z for lower I.C.C. as shown in Table V.

The following formula of Economic Order Quantity (EOQ) and Inventory carrying Cost (I.C.C.) is used for all five items selected for XYZ Analysis.

$EOQ = \sqrt{(2S * C_P / C_U * I)}$

$I.C.C. = (EOQ/2) * C_U * I$

Here S = Annual requirements of items (nos.)

C_P = Ordering cost (as per unit)

C_U = Manufacturing Cost or Unit Cost (Rs. Per Unit)

I = Inventory Investment

Factors considered for XYZ Analysis and Categorization

CATEGORIZATION OF ITEMS INTO X/Y/Z

Parameters	Category		
	X	Y	Z
Inventory carrying Cost (I.C.C.)	I.C.C.>200	200≥I.C.C.≥100	I.C.C.<100

COMBINED RESULTs OF VED & XYZ ANALYSIS

Sr. No.	Name of Item	V/E/D	Category (X/Y/Z)
1	a	D	X
2	b	D	Z
3	c	D	Z
4	d	D	Z
5	e	D	Z
6	f	D	Z
7	g	D	Z
8	h	V	X
9	i	V	X
10	j	E	X
11	k	D	X
12	l	D	Z
13	m	E	X
14	n	V	X
15	o	V	X
16	p	V	X
17	q	V	Z
18	r	E	Z
19	s	V	Z
20	t	V	Y
21	u	D	Y
22	v	E	X
23	w	D	X
24	x	D	X
25	y	D	Z

using this table we made a nine point matrix. In this matrix we distribute the entire items category into the combination of V/E/D and X/Y/Z.

Nine point matrix

X	Y	Z	
h, i, n, o, p	t	q, s	V
j, m, v		r,	E
a, k, w, x	u	b, c, d, e, f, g, l, y	D

By this table we find out five items h, i, n, o & p that comes into category of X and V. So, these five items are very crucial from project point of view. So, we applied methodology on these five items only.

C. Calculation for Re-Order Point (R.O.P.):

For calculation of R.O.P. we consider the following steps for all five items.

For item h:

Annual consumption = 560 Items

EOQ = 312.16

Lead Time = 1.3 weeks =1.3/52= 0.025 Year

As 560 items consumed in 1 Year, so the 312.16 items will consume in 0.5581 Year but lead time of the item is 0.025 Year so the Re-Order of Item 'h' should be at least 0.025 Year before. So, appropriate Re-Order Point of Item 'h' is 0.5581-0.025=0.5331 Year.

Same calculation is applied for items i, n, o & p then

For item i: ROP=0.6904 Year

For item n: ROP= 12.8931 Year

For item o: ROP= 11.9638 Year

For item p: ROP= 3.885 Year

D. Modelling Of Parameters

To generalize the results, the Modelling of input parameters (Consumption Rate, Lead Time, ordering Cost, Inventory Investment & unit cost) and Re-Order Point (R.O.P.) is done using Regression Modelling and MatLab software R2008a.

The parameters under consideration are

1) Consumption Rate (C.R.)
2) Ordering Cost (O.C.)
3) Lead Time (L.T.)
4) Inventory Investment (I.I.)
5) Unit Cost (U.C.)

The Re-Order Point is a function of C.R., L.T., O.C., I.I. & U.C. So, we can take R.O.P. as:

$\ln (R.P.) = C_1 \ln (C.R.) + C_2 \ln (O.C.) + C_3 \ln (L.T.) + C_4 \ln (I.I.) + C_5 \ln (U.C.)$

Where, C_1, C_2, C_3, C_4, C_5 are constants which are to be determined by Regression Modelling and using MATLAB software.

The output parameter Re-Order Point and input parameters are converted from actual absolute values to natural logarithms. For regression analysis, the natural logarithms of Re-Order Point is taken as single output parameter [Y] whereas natural logarithms of C.R. =[X_1], L.T. =[X_2], O.C. =[X_3], I.I. =[X_4] & U.C. =[X_5] has been taken as input parameters X=[X_1 X_2 X_3 X_4 X_5].

The following steps were followed and MATLAB is used.

1) Consider the output parameter natural logarithms of Re-Order Point (R.P.) [Y] and input parameters [X].
2) X' = Transpose of [X] was determined.
3) X' Transpose of [X] was multiplied with [X] to get the product [X'*X].
4) The inverse of product [X'*X] = $[X'*X]^{-1}$ was obtained.
5) X' Transpose of [X] was multiplied with Re-Order Point (R.P.) [Y] to get the product = [X'*Y].
6) Step 4 $[X'*X]^{-1}$ was multiplied with step 5 [X'*Y] to obtain the product of $[X'*X]^{-1}$ and [X'*Y].
7) The final matrices found in the form of;

$$\beta = \begin{vmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ B_4 \\ B_5 \end{vmatrix}$$

Finally, after the completion of program and the values of constants found as follows:

- $C_1 = \beta_1$
- $C_2 = \beta_2$
- $C_3 = \beta_3$
- $C_4 = \beta_4$
- $C_5 = \beta_5$

Stepwise MATLAB calculation is as follows:

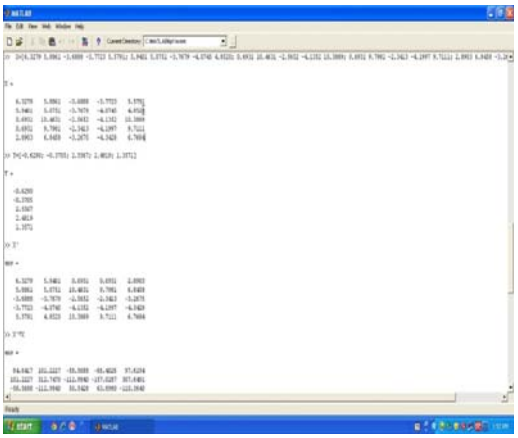

Fig.1: Regression Modelling by using MATLAB R2008a

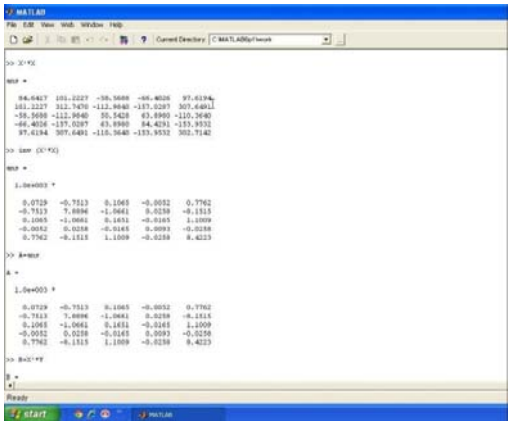

Fig. 2: Regression Modelling by using MATLAB R2008a

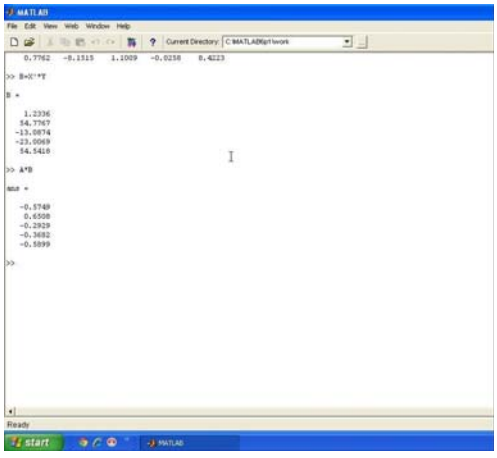

Fig. 3: Regression Modelling by using MATLAB R2008a

From Regression Modelling we find out the values of 'β' shown as follows:

$$B = \begin{matrix} -0.5749 \\ 0.6508 \\ -0.2929 \\ -0.3682 \\ -0.5899 \end{matrix}$$

From this result we get

$\beta_1 = -0.5749$

$\beta_1 = 0.6508$

$\beta_1 = -0.2929$

$\beta_1 = -0.3682$

$\beta_1 = -0.5899$

The values of constants obtained are:

$C_1 = \beta_1 = -0.5749$

$C_2 = \beta_1 = 0.6508$

$C_3 = \beta_1 = -0.2929$

$C_4 = \beta_1 = -0.3682$

$C_5 = \beta_1 = -0.5899$

Substituting these values the equation of R.O.P. becomes,

$$\textbf{R.O.P.} = \textbf{(C.R.)}^{-0.5749} * \textbf{(O.C.)}^{0.6508} * \textbf{((L.T.)}^{-0.2929} * \textbf{(I.I.)}^{-0.3682} * \textbf{(U.C.)}^{-0.5899}$$

IV. CONCLUSION

Inventory carrying cost is a vital part of economic analysis. It varies with no. of items and it's Re-order Point (R.O.P.). By mathematical modelling we find out that R.O.P. of every item is directly proportional to its Ordering Cost and inversely proportional to its Consumption Rate, Lead Time, Inventory Investment and Unit Cost. The formula obtained for R.O.P. is

$$\textbf{R.O.P.} = \textbf{(C.R.)}^{-0.5749} * \textbf{(O.C.)}^{0.6508} * \textbf{((L.T.)}^{-0.2929} * \textbf{(I.I.)}^{-0.3682} * \textbf{(U.C.)}^{-0.5899}$$

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