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Experimental Investigation & Evaluation of Incorporated Material to Set Their Optimum Re-Order Point

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Abstract –In a manufacturing company inventory cost is a significant part of expenses. Therefore reordering point (ROP) of the items must be optimum to reduce its carrying cost. In this present work, Investigations have made about the inventory control and R O P in a steel manufacturing plant in India to find the optimum ROP by applying ved and xyz analysis. Mathematical modeling is done with the help of Mat lab software.

Keywords- Re-Order Point (R.O.P.), inventory carrying cost (I.C.C.), VED analysis, XYZ analysis and Mat lab R2011b .

I. INTRODUCTION

In a manufacturing Plant some items are vital from production point of view but inventory cost of these parts is very high. It's not Feasible to keep more safety stock for these kinds of items but unavailability of these items can stop the manufacturing operation of that plant. 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 can include that the company should achieve the balance among the safety stock they have to keep on hand and cost of carrying inventory. In this work an effort has made to find out the optimum value of Re-Order Point (R.O.P).

II. Literature review

A kanban technique attracted many researchers since it was first brought to light by Monden (1983). Heoriginally summarized the Toyota approach for determining the appropriate number of kanbans at a workstation. It is applied recently in supply chain systems to efficiently manage the flow of materials. Rees et al. (1987) extended the Toyota approach to fluctuating product-mix problem by using the next periods forecast demand and the last periods observed lead times. Co and Sharafali (1997) considered the over-planning factor in Toyota_s formula for computing the number of kanbans for several production inventory control models.

Altiok and Ranjan (1995) studied a multi-stage pull system that dealt with production inventory system. Martand Telsang (2004) describes the concept of Selective control which means variations in method of control from item to item based on selective basis. The criterion used for the purpose may be cost of the item, criticality, lead-time, consumption, procurement difficulties, or something else. Various classifications are employed to render selective treatment to different types of material, each classification emphasizes on a particular aspect. The ved analysis represents classification of items based on critically. The analysis classifies the items into three groups called Vital, Essential and Desirable. The xyz analysis is based on value of the stock on hand (i.e. inventory investment) items whose inventory values are high are called X items while those whose inventory values are low are called Z items. And Y items are those, which have moderate inventory stocks.

III. DATA COLLECTION

We have visited steel company when the manufacture leaf plate for spring and TMT bar 8mm , 10mm ,12mm, 16mm, 20mm, 25mm diameter. In for inventory they store more than 1000 items in store which are long used for production leaf plate and TMT bar.

Table1; Data Collected from Steel manufacturing plant in India

Name of the Item	Annual Require meant (S)	Ordering Cost in Rs. (Cp)	Unit Cost in Rs. (Cu)	% of Average Inventory Investment nt (I)	Lead Time (In Days) (LT)	Cons ump ion rate (CR)	Nature of the Item	Source of the supply	Way of the transport rotation
1	200	90	120	1.1904	15	180	Buyer's	Local	Truck
2	1300	60	353	1.2563	15	1279	Buyer's	Local	Train
3	1500	30	400	1.6543	15	1432	commercial	Local	Truck
4	2000	500	543	0.5875	15	1800	commercial	Local	Truck
5	460	25	220	0.0345	15	350	commercial	Local	Train
6	500	10	400	1.8763	15	400	Buyer's	Local	Truck
7	120	20	543	0.0045	15	100	Buyer's	Local	Truck
8	7	90	360	2.7734	21	6	Standard	National	Train
9	1800	120	110	1.8473	15	1650	Buyer's	Local	Truck
10	5	10	190	1.0084	15	4	commercial	Local	Truck
11	4	50	280	0.0765	15	1	Buyer's	Local	Truck

12	13	160	2904	0.1721	18	12	Standard	National	Truck
13	6	16	210	4.7691	15	12	Standard	National	Truck
14	120	75	180	1.8769	15	100	commercial	Foreign	Ship
15	246	37	450	0.3347	15	200	Standard	Local	Truck
16	456	73	200	0.5834	15	400	commercial	Local	Train
17	320	120	620	1.3541	15	260	commercial	Local	Truck
18	650	652	125	0.2541	15	550	commercial	Local	Train
19	15	120	128	0.0806	15	12	commercial	Local	Ship
20	65	10	652	0.9854	15	60	commercial	Local	Truck
21	1200	320	40	0.3654	15	1000	commercial	Local	Train
22	15	40	620	0.0125	15	12	commercial	Local	Train
23	15	15	400	2.7777	15	12	commercial	Local	Train
24	15	35	180	4.1661	15	12	Standard	Local	Train
25	180	40	120	1.1904	18	15	commercial	Local	Truck
26	18	120	4200	1.5625	15	6	Standard	Local	Truck
27	325	25	225	1.1904	20	300	Standard	Local	Truck
28	20	10	250	1.2563	15	10	Standard	National	Truck
29	450	60	500	1.6543	18	420	commercial	National	Truck
30	240	30	625	1.1904	20	5	commercial	Local	truck
31	500	90	451	1.1457	18	420	commercial	Local	Truck
32	800	65	120	0.3547	15	650	commercial	Local	Train
33	1600	255	30	0.3698	20	1200	Buyer’s	Local	Truck
34	500	120	80	1.0147	15	150	Buyer’s	Local	Train
35	13	70	640	0.8064	20	12	commercial	Local	Truck
36	32	20	45	0.1721	18	12	commercial	Local	Truck
37	1200	110	258	4.7691	15	950	Buyer’s	Local	Train
38	300	10	125	1.8769	15	220	commercial	Local	Truck
39	1200	220	520	0.3347	15	960	Buyer’s	Local	Truck
40	140	40	120	0.5834	18	120	commercial	National	Train
41	30	10	140	0.2145	18	5	commercial	Local	Truck
42	3000	354	459	0.2541	20	2700	commercial	Local	Truck
43	500	621	1005	0.3698	15	450	commercial	Local	Truck
44	60	25	30	0.1458	20	40	Buyer’s	National	Truck
45	5295	140	62	0.3333	15	480	Standard	National	Truck
46	1262	320	1500	0.1851	18	965	commercial	Foreign	Ship
47	32	10	4500	0.1721	15	25	Buyer’s	Local	Truck
48	254	39	150	4.7691	15	180	Buyer’s	Local	Train
49	125	40	147	1.8769	18	90	Standard	Local	Truck
50	30	15	625	0.3347	20	10	commercial	Local	Train
51	985	90	320	0.5834	15	780	Buyer’s	Local	Truck
52	150	160	60	0.0641	15	120	Buyer’s	Local	Truck
53	254	60	75	1.8763	20	200	Standard	Local	Train
54	25	15	654	0.0045	18	10	commercial	Local	Truck
55	15	15	250	2.7734	15	10	Buyer’s	Local	Truck
56	854	125	500	1.8473	18	720	Buyer’s	National	Train
57	680	225	450	1.0084	20	560	commercial	Local	Truck
58	450	135	650	0.0765	15	420	commercial	Local	Truck
59	12	135	262	1.2584	18	1.2	Buyer’s	Local	Truck
60	720	1200	7800	2.5	20	680	Standard	National	Truck
61	2	40	20	1.8518	15	1.2	commercial	National	Truck
62	352	420	480	2.5487	15	250	Standard	Foreign	Ship
63	5	10	159	0.1547	18	3	commercial	Local	Truck
64	254	25	320	0.1721	20	180	Buyer’s	Local	Train
65	450	60	3520	4.7691	15	360	Buyer’s	Local	Truck
66	120	40	258	1.8769	18	90	Standard	Local	Train
67	361	80	652	0.3347	20	250	commercial	Local	Truck
68	900	90	650	0.5834	18	750	Buyer’s	Local	Truck
69	771	40	184	1.1904	15	625	Buyer’s	Local	Train
70	124	35	450	1.2563	18	120	Standard	Local	Truck
71	254	80	251	1.6543	20	180	commercial	Local	Truck

72	320	40	250	0.2412	15	245	Buyer's	National	Train
73	954	90	500	0.6921	18	780	Buyer's	Local	Truck
74	3000	1200	200	0.4742	20	2565	commercial	Local	Truck
75	140	90	270	1.1904	18	100	Buyer's	Local	Truck
76	150	70	4200	0.25	15	110	commercial	National	Truck
77	265	45	250	1.4653	18	180	Buyer's	National	Truck
78	874	220	500	0.6345	20	650	commercial	Foreign	Ship
79	30	320	2000	0.6097	15	2510	Buyer's	Local	Truck
80	120	25	80	1.8934	18	10	Standard	Local	Train
81	458	65	62	0.5789	20	320	commercial	Local	Truck
82	5741	356	357	1.2676	18	4561	Buyer's	Local	Train
83	850	652	450	1.8763	18	680	Buyer's	Local	Truck
84	954	420	120	0.0045	15	852	Standard	Local	Truck
85	963	120	254	2.7734	18	863	commercial	Local	Train
86	357	120	500	1.8473	20	250	Buyer's	Local	Truck
87	952	90	625	1.0084	15	850	Buyer's	Local	Truck
88	431	80	780	0.0765	18	380	commercial	National	Train
89	940	20	1640	0.2487	20	880	Buyer's	Local	Truck
90	963	80	900	1.4376	18	620	Standard	Local	Truck
91	258	25	5000	0.2623	15	120	commercial	Local	Truck
92	456	50	1541	0.2541	18	400	Buyer's	National	Truck
93	621	80	650	1.0258	20	550	Buyer's	National	Truck
94	120	160	1320	0.4901	15	90	Buyer's	Foreign	Ship
95	900	220	500	0.2777	18	750	commercial	Local	Truck

IV. METHODOLOGY

For this Work we have investigated data from ved analysis and then xyz analysis. By applying both ved and xyz analysis we can find out such items which are very critical and important from research point of view. So, methodology is applied on these 12 items. For finding out the optimum R.O.P. In a manufacturing plant in India shown in table1. On all the items we applied firstly we use the regression modeling with the help of Mat Lab software.

A. VED Analysis

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 plant:

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 weight age according to their importance for R.O.P. For weight age of factors we draw a table as follows:

Table 2 : factors considered for ved analysis with the plan for weight age & point

S.r NO.	Factors	First Degree	Second Degree	Third Degree
1	Ordering coast(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 (60)	Train (60)	Ship (90)_

On the basis of this table we categorized all the items into V or E or D as shown in table 3;

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

Table4: Categorization of item into V/E/D

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	5	20	20	25	30	100	D
2	5	20	20	25	30	100	D
3	5	20	40	25	30	120	D
4	10	20	40	25	30	125	D
5	5	20	40	25	30	120	D
6	5	20	20	25	30	100	D
7	5	20	20	50	60	175	E
8	5	20	60	50	60	195	V
9	5	20	20	25	60	130	D
10	10	20	40	50	30	145	D
11	5	20	20	25	30	100	D
12	10	40	60	50	30	190	V
13	10	20	60	50	90	220	V
14	5	20	40	50	60	175	V
15	5	20	40	50	30	150	D
16	5	20	40	25	30	120	D
17	10	20	40	25	30	125	D
18	10	20	40	25	60	155	E
19	10	20	40	25	60	190	V
20	10	20	40	25	30	125	D
21	5	40	40	25	60	170	E
22	5	20	40	50	30	120	D
23	5	20	40	50	30	185	V
24	5	20	60	25	60	170	E
25	10	40	40	25	60	175	V
26	10	20	60	25	60	250	V
27	10	20	60	25	60	200	V
28	5	20	40	50	20	135	D
29	5	20	40	50	30	145	D
30	5	20	40	25	60	160	E
31	10	40	40	25	30	145	D
31	15	20	40	50	30	145	D
33	5	20	40	50	30	145	D
34	5	40	40	25	30	140	D
35	5	40	60	75	90	270	V
36	5	40	60	50	60	220	V
37	10	20	60	75	90	250	V
38	5	20	60	25	30	140	D
39	5	20	40	25	30	125	D
40	5	20	40	25	30	120	D
41	5	20	40	25	60	150	E
42	5	20	40	25	60	150	E
43	5	20	60	25	60	170	E
44	5	20	40	50	30	165	E
45	5	20	40	50	30	145	D
46	5	20	90	50	60	225	V
47	5	20	40	50	60	200	V
48	5	20	60	50	30	165	E

49	5	40	60	50	30	175	E
50	5	60	60	50	60	235	V
51	5	40	60	75	60	140	D
52	5	60	60	50	60	235	V
53	5	20	40	50	30	145	D
54	5	20	40	25	30	120	D
55	5	20	40	25	30	125	D
56	10	40	40	25	60	175	E
57	10	40	20	50	30	150	E
58	10	40	40	50	30	170	E
59	15	60	40	50	60	225	V
60	5	40	40	25	60	170	E
61	10	60	40	50	60	215	V
62	5	40	60	25	30	160	E
63	10	20	20	75	90	215	V
64	5	20	40	75	30	170	E
65	10	20	60	50	30	170	E
66	10	20	60	50	30	170	E
67	10	20	40	50	30	150	E
68	5	20	40	50	30	145	D
69	15	20	40	50	30	155	E
70	5	40	40	50	30	165	E
71	10	40	60	25	30	165	E
72	5	40	60	25	30	160	E
73	10	20	60	25	30	145	D
74	10	20	60	50	30	170	E
75	5	20	60	50	60	195	V
76	5	20	60	50	60	195	V
77	5	20	60	50	30	165	E
78	5	20	60	50	30	165	E
79	10	40	60	50	30	190	V
80	5	20	60	25	30	140	D
81	5	20	60	50	30	165	E
82	5	20	60	25	30	140	D
83	5	20	60	25	30	140	D
84	5	20	40	50	60	175	E
85	5	20	40	50	60	175	E
86	5	20	60	50	30	165	E
87	5	20	40	50	60	170	E
88	5	20	40	50	60	170	E
89	5	20	60	50	60	190	V
90	5	20	40	50	30	140	D
91	5	20	20	25	30	95	D
92	5	40	60	25	30	155	E
93	15	40	40	25	30	135	D
94	10	60	40	50	60	210	V
95	5	20	40	25	30	115	D

B. XYZ Analysis

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 .

The following formula of Economic Order Quantity (EOQ) and Inventory carrying Cost (I.C.C.) is used for all 12 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

Combined result of VED & XYZ

Categorization of items into X/Y/Z
Using the 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

Parameter	Category		
	X	Y	Z
Inventory carrying coast(I.C.C.)	I.C.C.>200	200>I.C.C._>100	I.C.C<100

Sr.NO.	Name of item	V/E/D	Category X/Y/Z
A	8	V	X
B	12	V	Y
C	13	V	X
D	14	V	Z
E	19	V	Z
F	23	V	X
G	25	V	X
H	26	V	X
I	27	V	Z
J	35	V	X
K	36	V	X
L	37	V	Y
M	46	V	Y
N	47	V	Y
O	50	V	X
P	52	V	X
Q	59	V	X
R	61	V	X
S	63	V	X
T	75	V	Y
U	76	V	Y
V	79	V	Z
W	89	V	Y
X	94	V	Z

Nine point matrix

	X	Y	Z
V	a,c,f,g,h,j,k,o,p,q,r,s	b,l,m,n,t,u,w	d,e,i,v,x
E	7,9,21,30,42,43,71,81,87, 88,92		
D	1,2,3,4,5,6,31,41,38,39,53 ,54,73,80,82,90,91,93,95,		

By this table , we find out 12 items a,c,f,g,h,j,k,o,p,q,r,s that comes into category of X and V so these 12 items are very critical from research point of view so we applied methodology on these 12 items only.

C. calculation for Re-order point(R.O.P):

For calculation of R.O.P we consider the following steps for all 12 items

For item a:

Annual consumption = 6 kg

EOQ = 3.0045

Lead time = 21 days =21/365 =0.057 year

As 6 kg consumed in 1 year so as the 3.0045 will consume in 0.50075 year but lead time of the items is 0.057 year so the re-order of items a should be at least 0.057 year before so, appropriate re-order point of items 'a' is 0.50075-0.0575 =0.4432 year

Some calculation is applied for items c,f,g,h,j,k,o,p,q,r,s

For item c: ROP= 0.2712 year

For item f: ROP= 0.4597 year

For item g: ROP= 0.1986 year

For item h: ROP= 0.1792 year

For item j: ROP= 0.0253 year

For item k: ROP= 0.0639 year

For item o: ROP= 0.2594 year

For item p: ROP= 0.2928 year

For item q: ROP= 0.1482 year

For item r: ROP= 0.9454 year

For item s; ROP= 0.0336 year

D: Modeling of parameters

To generalize the results, the modeling of input parameters (consumption rate, lead time, & unit cost) and re-order point (R.O.P) is done using regression modeling and mat lab software R2011b

The parameters under consideration are

1) Consumption Rate (C.R)

2) Lead time (L.T)

3) Unit cost (U.C)

The re-order point is a function of C.R., L.T., and U.C so we can take R.O.P.as

In (R.P) = C1 in (C.R) + C2 in (L.T)+ C3 in (U.C)

Where C1, C2, C3 are constant which are to be determined by regression modeling and using MATLAB software.
The output parameter re-orders 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] where as natural logarithms of C.R =[X1]
In (R.P.) = C_1, C_2, C_3 are constants which are to be determined by regressing Modeling and using MATLAB software. The output parameter Re-order point and input parameter are converted from actual absolute valves 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], DELL

L.T. =[X_2],U.C. =[X_3] has been taken as input parameters X = [X_1 X_2 X_3].

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 parameter [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 for product [X'*Y].

6. Step 4$[X'*X]^{-1}$ was multiplied with step 5 [X'*Y] to obtained the product of $[X'*X]^{-1}$ and [X'*Y].
7. The final matrices found in the form of :

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

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

- $C_1 = \beta_1$
- $C_2 = \beta_2$
- $C_3 = \beta_3$

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

B = - 0.9474 0.2706 - 0.7543 5.3323

From this result we get
β = 5.3323
β = -0.9473
β = 0.2706
β = -0.7543
the values of constants obtained are :
C_1 β = 5.3323
C_2 β = -0.9474
C_3 β = 0.2706
C_4 β = -0.7543
Substituting these value then equation of R.O.P becomes

$$R.O.P. = (C.R)^{-0.9474} (U.C)^{0.2706} (L.T)^{-0.7543}$$

V. RESULT

Finally from the R.O,P formula the comparison between actually R.O.P.and calculated R.O.P.by modeling is to be done ,which is shown in below table.

S.No.	Actual Calculation		Calculation by modeling	
	R.O.P	100-R.O.P.	R.O.P	100-R.O.P.
a	0.4432	99.5568	0.3691	99..6924
c	0.2712	99.7288	0.4076	99.5924
f	0.4597	99.5403	0.5392	99.4604
g	0.1986	99.8014	0.1458	99.8542
h	0.1792	99.8208	0.2329	99.7671
j	0.0253	99.9747	0.0218	99.9782
k	0.0639	99.9361	0.0566	99.99431
o	0.2594	99.7406	0.2599	99.7401
p	0.2928	99.7072	0.2206	99.7794
q	0.1482	99.8518	0.1364	99.8636
r	0.0461	99.9539	0.0632	99.9368
s	0.0336	99.9664	0.0386	99.9614

VI. CONCLUSION

The basic aim of this research was to develop a 'Nine point competitive matrix for pull system' which will incorporate XYZ & VED analysis with, Kanban system, so as to optimize the inventory & reducing the number of stock out. In line with that, a competitive matrix has been developed.

Inventory carrying cost is a vital part of economic analysis. It varies with no. of items and its re-order point by mathematically modeling we find out that R.O.P. of every item directly proportional to its consumption rate, lead time , inventory investment and unit cost.

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