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SPARE PARTS INVENTORY OPTIMIZATION FOR AUTO MOBILE SECTOR

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Abstract

In this paper the objective is to determine the optimal allocation of spares for replacement of defective parts on-board of a usage. The minimization of the total supply chain cost can only be achieved when optimization of the base stock level is carried out at each member of the supply chain. A serious issue in the implementation of the same is that the excess stock level and shortage level is not static for every period. This has been achieved by using some forecasting and optimization techniques. Optimal inventory control is one of the significant tasks in supply chain management. The optimal inventory control methodologies intend to reduce the supply chain cost by controlling the inventory in an effective manner, such that, the SC members will not be affected by surplus as well as shortage of inventory. In this paper, we propose an efficient approach that effectively utilizes the Genetic Algorithm for optimal inventory control. This paper reports a method based on genetic algorithm to optimize inventory in supply chain management. We focus specifically on determining the most probable excess stock level and shortage level required for inventory optimization in the supply chain so that the total supply chain cost is minimized . So, the overall aim of this paper is to find out the healthy stock level by means of that safety stock is maintained throughout the service period.

Keywords: genetic algorithm, optimization, Inventory

I. INTRODUCTION

A. Spare part management systems

The design and operation of spare part management systems is very important for automobile sector, Prior relevant system could be grouped in two categories. It is aimed to find optimal demand for a given spare parts management system; that is, how to determine optimal inventory level in order to reduce cost. This paper attempts to solve a comprehensive design problem for a spare part management system. Every automobile sector should proceed systematically and establish an effective Spare parts management system. Inventory encompasses all raw materials, work in process, and finished goods within the supply chain. Changing Inventory policies can dramatically alter the supply chain's efficiency and responsiveness. Inventory is an important cross functional driver of supply chain performance. An important role that can be satisfied by having the product ready and available when the customer wants it to reduce the customer waiting time in the service sector. Inventory is held throughout the supply chain in the form of raw materials, work in progress, and finished goods.

II. LITERATURE REVIEW

Supply chain network is a complex network, which consists of multiple manufacturers, multiple suppliers, multiple retailers and multiple customers.

The accomplishment of beam-ACO in supply-chain management has been proposed by Caldeira et al.[12]. Beam-ACO has been used to optimize the supplying and logistic agents of a supply chain. A standard ACO algorithm has aided in the optimization of the distributed system. The application of Beam-ACO has enhanced the local and global results of the supply chain.

A beneficial industry case applying Genetic Algorithms (GA) has been proposed by Wang et al.[13]. The case has made use of GAs for the optimization of the total cost of a multiple sourcing supply chain system. The system has been exemplified by a multiple sourcing model with stochastic demand. A mathematical model has been implemented to portray the stochastic inventory with the many to many demand and transportation parameters as well as price uncertainty factors. A genetic algorithm which has been approved by Lo [14] deals with the production inventory problem with backlog in the real situations, with time-varied demand and imperfect production due to the defects in production disruption with exponential distribution. Besides optimizing the number of production cycles to generate a (R, Q) inventory policy, an aggregative production plan can also be produced to minimize the total inventory cost on the basis of reproduction interval searching in a given time horizon.

P. Radhakrishnanet. al.[18] developed P.Radhakrishnan et. al.[18] developed a new and efficient approach that works on Genetic Algorithms in order to distinctively determine the most probable excess stock level and shortage level required for Inventory optimization in the supply chain such that the total supply chain cost is minimized. Many well-known algorithmic advances in optimization have been made, but it turns out that most have not had the expected impact on the decisions for designing and optimizing supply chain related problems. Some optimization techniques are of little use because they are not well suited to solve complex real logistics problems in the short time needed to make decisions and also some techniques are highly problem dependent which need high expertise. This adds difficulties in the implementations of the decision support systems which contradicts the tendency to fast implementation in a rapidly changing world. IO techniques need to determine a globally optimal placement of inventory, considering its cost at each stage in the supply chain and all the service level targets and replenishment lead times that constraint each inventory location.

V. Determination of Stock Level

A company needs to decide how many items at least it wants to keep on stock. This is an important decision because it can cost a large amount of money when the wrong decision is made. This decision can be wrong in two ways: too much or too little. In the first case the company holds too many items on stock and this will result in high holding costs.

In the other case there is a large probability of needing an item when it is not on stock, which results in (high) penalty costs. Therefore it is necessary that a company makes the best possible decision. The objective is to compute the minimum level of inventory for which it is necessary to place a new order when the stock drops below this level. While determining the reorder level, maximum &minimum stock following factor plays the vital role.

C. Determination for Reorder Level for P & Q System

From the collected data the following procedures are performed for the calculation of reorder level

Data's collected from service sector:

Annual demand of spare parts, D = 6000

Average Lead time = 5 weeks

Ordering cost = 120

Probability of delay = 0.38

Assume a service level = 0.95

Max lead time = 3 weeks

Standard deviation =25

Carrying cost per unit year = 12.5% of purchase price

Purchase price, K = 10

- **P-system** - inventory levels for multiple stock items reviewed at same time - can be reordered together
- **Q-system** - each stock item reordered at different times - complex, no economies of scope or common prod./transport runs

Order quantity $= \sqrt{\left(\frac{2CoD}{P \ast Cc\%}\right)}$

$$= \sqrt{\left(\frac{2 \ast 120 \ast 600}{10 \ast 0.14 \ast 0.125}\right)}$$

$= 1073.3126 \approx 1073$ units

1) Determination of Reorder Level for "Q System"

i) Demand during lead time, PLT $= \left(\frac{6000}{52}\right) \times 5$

$= 576.92$

≈ 577 units

ii) SD in demand during lead time = $\left(Lead\ time^{1/2}\right) \times Standard\ deviation\ per\ week$

$= \sqrt{5} \times 25$

$= 55.90 \approx 56$ units

iii) Safety stock $= k * \delta$

$= 1.64*56$

$= 91.676$

≈ 92units

iv) Average demand during delivery delays

$= \left(\frac{D \times Maximum\ delay}{No.of\ weeks\ per\ yr.}\right) \times Probability\ of\ minimum\ delay$

$= 131.53 \approx 132$units

v) Reorder level = Demand during lead time
+Variation in demand during lead time
+Average demand during delivery (Avg. stock)
= 577+92+132
= 801 units

2) Determination of Maximum Inventory Level for Periodic system

i) Review period $= {EoQ}/{D}$

$= {}^{1073}/_{6000}$

= 0.178 years*52

= 9.256 weeks

The review period can either be 9weeks (or) 10weeks

ii) Specification of review period

Total cost when review period = 9 week

Total cost =Ordering cost + Carrying cost

=(52/9)*120+ (6000/52*9)/2* 10*0.125

= Rs 1342.3675

= Rs 1343

Total cost during review period =10 weeks

Total cost = Ordering cost + Carrying cost

= (52/10)*120+ (6000/52*9)/2*10*0.125

= 1345.15

≈ Rs 1346

The total cost is minimum when the review period is 9 weeks

Hence the review period is 9 weeks

Demand during lead time and review period $=\left(\frac{6000}{52}\right) \times (3+9)$

= 1385 units (Approx.)

Safety stock during lead time and review period

$$= (3+9)^{1/2} \times \sigma\, per\ week \times k$$

= 142.028 units

Where k = 1.64,Service level = 0.95

Avg. demand at delivery delay (Reserve stock)

$$=\left(\frac{D \times Max\ delay}{No.of\ weeks\ per\ year} \times Probability\ of\ \max delay\right)$$

$$= \frac{6000}{52} \times 3 \times 0.38$$

= 132 units

Maximum inventory level= Demand during lead time & review period+ Safety stock during lead time & Review + Avg. demand during delivery delay

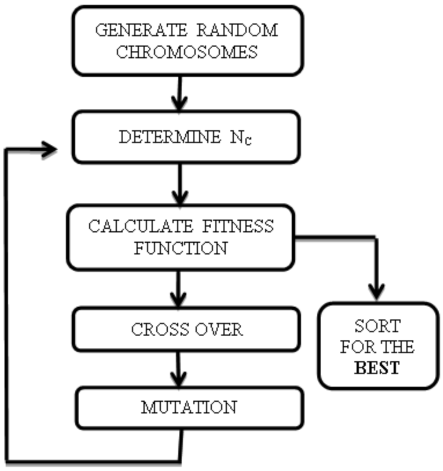
= 1385+142+132

= 1659 units

XI. Inventory Optimization in Spare Parts Using Genetic Algorithm

A. Introduction

The proposed method uses the Genetic Algorithm to study the stock level that needs essential inventory control. This is the pre-requisite idea that will make any kind of inventory control effective. Our exemplary supply chain consists of weeks 1 to 4. The responsibility of our approach is to predict an optimum stock level by using the past records and so that by using the predicted stock level there will be no excess amount of stocks and also there is less means for any shortage. Hence it can be asserted that our approach eventually gives the amount of stock levels that needs to be held in the automobile sector. In our proposed methodology, we are using genetic algorithm for finding the optimal value. The flow of operation of our methodology is clearly illustrated in



B. Genetic Algorithm Using C Programme

```
#include<stdio.h>
#include<conio.h>
main()
{
clrscr();
int a[12][5],f[12],i,j,k,l,temp,sum,nc=0,np;
for(i=0;i<12;i++)
{
k=i+1;
Printf("\nEnter the data for month %d:\n",k);
for(j-1;j<5;j++);
{
printf("\nEnter the parts per week:");
scanf("%d",&a[i][0]);
```

```
  printf("\nWeek %d=",j);
  scanf("%d",&a[i][j])
  }
  }
  for(i=0;i<12;i+=2)
  {
  //Crossover
  j=i+1;
  temp=a[i][2];
  a[i][2]=a[j][2];
  a[j][2]temp;
  temp=a[i][3];
  a[i][3]=a[j][3];
a[j][3]temp;
  //Mutation
  temp=a[i][1];
  a[i][1]=a[i][4];
  a[i][4]temp;
  temp=a[j][1];
  a[j][1]=a[j][4];
  a[j][4]temp;
  }
  //Finding Nc
  for(i=0;i<12;i++)
  for(j=0;j<5;j++)
  {
  if(a[i][j]>>0)
  nc++;
  }
  //Finding Np and F
  for(i=0;i<12;i++)
  {
  j=i+1;
  np=a[i][0]+a[i][1]+a[i][2]+a[i][3]+a[i][4];
  f[i]=log(1-(nc/np));
  printf("\nFittness function %d=%d",j,f[i]);
  }
  getch
  }
```

C. Genetic Algorithm

In this algorithm initially the parent chromosomes are randomly generated in the following format.

The general parent chromosome format is as follows.

Example:

Nth month	*Initial stock level*	*Spare availability by 1st week*	*Spare availability by 2nd week*	*Spare availability by 3rd week*	*Spare availability by 4th week*

Original data, Chromosome RepresentationThe randomly generated initial chromosome is created by having the stock levels within the lower limit and the upper limit. Each gene of the chromosome is representing the amount of stock that is in excess or in shortage. These kinds of chromosomes are generated for the genetic operation. Initially, only two chromosomes will be generated and from the next generation a single random chromosome value will be generated.

i)Crossover

A single point crossover operator is used in this study. Chromosomes in the mating pool are selected for crossover operation. The crossover operation that is performed for an exemplary case is shown in the following figure.

Cp Cp

↓ ↓

1st month	4170	-1160	1627	-981	1216
	5126	-750	1324	1476	1257

The genes that are right of the cross over point in the two chromosomes are swapped and hence the cross over operation is done. After the crossover operation two new chromosomes are obtained.

After crossover

Parent species 1 &2 (TATA INDICA VISTA &TATA SUMO VICTA)

	Parts/week	1st week	2nd week	3rd week	4th week
1st month off spring	4170	1216	1627	-981	-1160
2nd month off spring	4250	2310	-1910	1172	795
3rd month offspring	4035	1792	-958	1273	1325
4th month off spring	4155	1630	1292	-1100	1473
5th month off spring	4285	1521	-1156	1218	2472
6th month offspring	4175	2126	1513	-1210	1732
7th month off spring	4350	1921	1215	-1350	-1123
8th month off spring	4300	-1123	-1356	-790	-790
9th month off spring	4280	1516	-2256	-1892	-1812
10th month off spring	4155	1916	-768	1366	1416
11th month offspring	4310	1321	-1996	669	1220
12th month offspring	4310	-786	1145	-865	-560

ii)Mutation

The newly obtained chromosomes from the crossover operation are then pushed for mutation. By performing the mutation, a new chromosome will be generated.

This is done by a random generation of two points and then
Performing swaps between both the genes. The illustration of mutation operation is shown

MpMp

↓ ↓

1st month	**4170**	**-1160**	**1627**	**-981**	**1216**
	5126	-750	1324	1476	1257

After mutation

Parent species 1 &2 (TATA INDICA VISTA &TATA SUMO VICTA)

	Parts/week	1st week	2nd week	3rd week	4th week
1st month	4170	-1160	1627	-981	1216
2nd month	4250	795	-1910	1172	2310
3rd month	4035	1325	-958	1273	1792
4th month	4155	1473	1292	-1100	1630
5th month	4285	2472	-1156	1218	1521
6th month	4175	1732	1513	-1210	2126
7th month	4350	-1123	1215	-1350	1921
8th month	4300	-790	-1356	-790	-1123
9th month	4280	-1812	-2256	-1892	1516
10th month	4155	1416	-768	1366	1916
11th month	4310	1220	-1996	669	1321
12th month	4310	-560	1145	-865	-786

The mutation operation provides new chromosomes that do not resemble the initially generated chromosomes. After obtaining the new chromosome, another random chromosome will be generated. Then again the process repeats for a particular number of iteration while the two chromosomes that are going to be subjected for the process is decided by the result of the fitness function. Each number of iteration will give a best chromosome and this is will be considered to find an optimal solution for the inventory control. When the number of iterations is increased then they obtained solution moves very closer to the accurate solution. More the number of iterations results in more accurate optimal solution. Eventually with the help of the Genetic algorithm, the best stock level to be maintained in the members of the supply chain could be predicted from the past records and so that the loss due to the holding of excess stock level and shortage level can be reduced in the upcoming days.

iii) Generating fitness function

N_C = No. of positive counts

N_P = Sum of the terms in a month

Fitness function F = log $\left(1 - \left(\frac{N_C}{N_P}\right)\right)$

Fitness functions ensure that the evolution is toward optimization by calculating the fitness value for each individual in the observed data. The fitness value evaluates the performance of function.

Fitness function

Parent species 1 &2 (TATA INDICA VISTA &TATA SUMO VICTA)

	Parts/week	1st week	2nd week	3rd week	4th week	Fitness function
1st month	4170	-1160	1627	-981	1216	-0.006828
2nd month	4250	795	-1910	1172	2310	-0.005017
3rd month	4035	1325	-958	1273	1792	-0.004443
4th month	4155	1473	1292	-1100	1630	-0.004453
5th month	4285	2472	-1156	1218	1521	-0.003976
6th month	4175	1732	1513	-1210	2126	-0.003978
7th month	4350	-1123	1215	-1350	1921	-0.006635
8th month	4300	-790	-1356	-790	-1123	-0.164538
9th month	4280	-1812	-2256	-1892	1516	0.165367
10th month	4155	1416	-768	1366	1916	-0.004102
11th month	4310	1220	-1996	669	1321	-0.006017
12th month	4310	-560	1145	-865	-786	-0.010296

Table 10.d

The minimum Fitness function value = - 0.0085

The maximum Fitness function value = 0.165367

Inventory management is a significant component of supply chain management. Supply chain costs need to be minimized by handling inventory levels in numerous production and distribution operations related with divers Chain stages and the members of a supply chain are responsible for the same. Innovative and efficient methodology that works with the aid of Genetic Algorithms in order to facilitate the precise determination of the most probable excess stock level and shortage level required for inventory optimization in the supply chain such that minimal total supply chain cost is ensured.

X. CONCLUSION

All the works that carried out here in this paper aims to keep up optimal inventory level in an automobile sector. This is the case for all problem sizes, for various part types and spare type. By doing so far the shortages in the spare parts and unavailability of spares can be made minimum compared to the previous methods which are adopted in the automobile sector. In future the further analysis is made to check out for the spare parts unavailability by using some other optimization techniques.

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