CHAPTER – 1

INTRODUCTION AND RESEARCH METHODOLOGY

1.1: Introduction:

Spare parts inventory is required for repairs and maintenance of machinery. Managing spare parts inventory is different from managing other type of inventories. Spare parts inventory management is complex due to large number of different items and uncertainty in the consumption of spares.

A huge amount of fund is blocked in spare parts inventory. An amount over Rs.1, 50,000 crore is blocked in inventory in India. The excessive inventory acts as a parasite and affects the performance of a company. It restricts the organization in investing the funds in other profitable operations.

In Mining operation, very costly machineries like Excavators, Wheel loader, Hydraulic drilling machines, Dumpers are used. Spare parts inventory management plays an important role in assets intensive industry like mining. The performance of a mine depends upon the efficient utilization of these assets and the performance of these equipment depends upon the maintenance & proper spare parts inventory management.

Spare parts are defined as parts of the machines which are kept as standby to be substituted when a part of the machine break-downs or is worn out. Uncertainty in the consumption of spare parts is a major problem in forecasting the spare parts requirement. It is extremely difficult to know exactly which and when a part of the machine will fail.

Spare parts inventory plays an important role in reducing down time of the machines and helps in optimum utilization of the machineries of a company.
Inventory is defined as materials kept in stock to meet future demands of production, repairs, maintenance etc. Thus, spare parts inventory can be defined as list of the spare parts kept in stock to replace worn out or defective parts during regular maintenance of machine or whenever machines breakdown. Spare parts inventory blocks the working capital of an organization.

Inventory is broadly classified into four broad categories as below

- Production inventory
- Work in progress inventory
- Finished goods inventory.
- MRO (Maintenance, repairs & operating supplies) inventory

Production inventory includes raw materials, parts & components directly used in the production process and go into making of the final product. It may either consist of standard items, off-the-shelf or especially tailor-made items. The production inventory can be further grouped as raw materials inventory and bought-out inventory. Raw materials are items purchased and further processed by the organization. These are major inputs which get converted into output or finished products. Bought-out items are components procured by an organization from their regular vendor. They find it cheaper and more convenient to buy some components from outside vendor and concentrate more on critical parts and assemblies.

Work in progress inventory are raw materials, components which are under manufacturing process.
Finished goods inventory are the final items or components which are ready for sale.

MRO (maintenance, repairs and operating supplies) inventory consist of spare parts inventory, consumable inventory and packing material inventory. Spare parts inventory consist of spares which are kept in stock as stand by and used when a part of the machine breaks down or worn out. Spare parts can be further broadly classified as capital spare & insurance spares, rotatable spares, maintenance spares, and overhauling spares. Capital and insurance spares are those critical parts of a machine which have life nearly equal to the life of the machine itself. Maintenance spares are required for replacement of old parts due to breakdown caused by wear and tear. These spares are generally fast moving and requirement is repetitive in nature. Rotatable spares can be usually interchanged. They are repaired and stored as assemblies. Overhauling spares are replaced periodically after predetermined number of hours of working based on planned overhauling schedule.

Whenever a new machine is procured, it is necessary to plan the spares required to be stocked at stores. Generally, it is observed that as per the recommendation of the Original Equipment Manufacturer, many spares are procured and stocked at stores. These spares remain unmoved and block the inventory, which results in unnecessary waste. Therefore, it is necessary to carefully decide the spares to be stocked before procuring the same.

Companies incur following cost on the inventory held in stock.
- **Ordering cost:** This is the cost incurred by the purchase dept. in calling the quotations, scrutinizing the quotations, issuing purchase orders, follow-ups, receiving materials, inspection etc.

- **Inventory carrying cost:** Inventory carrying cost consist of the various costs incurred to maintain the stock of items in the stores like interest on capital blocked in inventory, taxes payable, insurance on the goods, obsolescence, shrinkage of materials, evaporation loss, deterioration of goods, rental charges, labour cost in operation of the stores, overheads like electricity, water, maintenance cost etc.

  All these costs accounts to approx. 20-25% of the total cost of inventory per annum. This is a wasteful and hidden expenditure for an organization.

- **Difference between Production inventory and Spare-parts inventory:**
  The production items inventory or raw material inventory can be planned based on the quantum of finished goods to be produced. For example inventory for production of cars etc. can be worked out based on the bill of materials of the car and number of cars to be manufactured.

  In spare-parts management, the future consumption of spare parts cannot be forecasted directly. The consumption of spares is uncertain and depends on various factors and it is difficult to forecast the spares requirement. It is therefore difficult to manage the spare parts inventory.

1.2: **Problems in Spare Parts Management:**

  The problems faced in Spare Parts Management are listed below.

  - There is uncertainty in consumption of spares and it is difficult to forecast the future requirement of spares.
A huge spare parts stock is maintained by the organizations resulting in blockage of the working capital.

The available literature is scanty and highly theoretical and deter the initiative of a professional manager.

Managers are accountable for stock-outs and there is ‘play safe tendency’ resulting in overstocking of spare parts.

There is no pressure or incentive to reduce high spare part inventories.

There is no clear-cut responsibility on maintenance or stores department for holding high spare parts inventory.

Spares are increasingly used with age of machine.

Spare parts function is mostly neglected in an organization with maintenance and materials departments blaming each others for stock-outs or high inventory.

There are no norms to decide how much inventory should be held per machine.

1.3: Need of the Study:

A preliminary study at the mining division of MSPL Ltd revealed that the stock of the spare parts held in stores for various machinery groups ranges as high as 66 months i.e. more than 5 years requirement and the inventory turnover ratio were very low. This blocked the working capital and resulted in unnecessary waste and huge loss to the company. A similar problem was faced by most of the mining companies.
In order to ensure that these expensive equipment does not remain idle for want of spare parts most of the companies procure a huge stock of spare parts at the time of procuring machines as per the recommendation of the original equipment manufacturer. Most of the times, it is found that these spares remain unmoved or become obsolete leading to wasteful expenditure and huge loss to the companies.

Most of the inventory solutions are designed for manufacturing industries where the consumption of items is based on the production schedules and quantity requirement can be easily worked out. In case of spare parts, the uncertainty in the consumption of spares is a major problem in deciding the inventory to be stocked.

Without proper consumption data and spare parts stocking norms, it is difficult to decide how much inventory of spare-parts should be stocked per machine when new machine is procured? It is also difficult to know which items are to be stocked. It is also difficult to forecast what is the quantity of each item to be stocked?

There are no definite norms to decide the amount of spare parts inventory to be stocked per machine. This leads to very high inventory and blocks the working capital in the spare parts inventory which restricts the organization in investing the funds in other profitable operations.

The present academic sources in inventory models provide answer for two primary questions that deal with a replenishment system. i.e. when to order and what quantity should be ordered. It only deals with minimum, reorder level, maximum levels, and economic order quantity pertaining to individual items based on consumption.
The purpose of this study is to recommend the norms to limit the spare parts inventory per machine at mining division of MSPL Ltd and to suggest strategies to reduce spare parts inventory. The study will also provide solutions to other mining companies facing similar problems to limit and reduce the spare parts inventory.

1.4: PROFILE OF THE COMPANY

MSPL Limited is a flag ship company of Baldota group. The Baldota group was founded by late shree Abheraj H. Baldota, a visionary entrepreneur. The Baldota group was established in 1961. It is one of the India’s leading iron ore mining companies. It is also into business of wind power, shipping, iron ore pellets, industrial gases and environmental solutions.

MSPL is also one of the largest producers of wind power in India. It has seven operating wind farms in India producing over 7 MW power. The company entered into shipping business in 2011 and owns four post panama dry bulk vessel of capacity 1,00,000 DWT. MSPL has iron ore pelletisation plant at Koppal in Karnataka. MSPL Gases started in 1983. It has six plants manufacturing oxygen and other industrial gases.

Vyasanakere Iron Ore (VIO) Mines is one of the open cast mine of Baldota group. It is also one of the largest Iron ore mine in private sector in Bellary, Hospet region. This mine is located within a 347.22 hector area and is located 23KM south of Hospet, Karnataka.

VIO mine started iron ore mining since 1962. The company introduced mechanize mining since 1977 with introduction of excavators, pay loaders etc. Presently, the mine is mechanized to handle approximately 7 million tons of ore and waste per annum.
The Product of the mine is categorized into three major categories:

- Iron Ore Fines 0-10 mm
- Calibrated Ore 10-35 mm
- Over size Ore +35 mm

The Iron ore fines are further classified as:

- Concentrates – 0-1mm
- Aggregates – 1-10mm

The Vyasankare mine has high grade ore with 62 to 64% Fe content. The company also operates 4 other mines. The study is carried out at Vyasankare Iron Ore Mine which is one of the major mine of MSPL.

PVS mine is a partnership firm of MSPL ltd. It is located in Sandur Taluka of Bellary district in Karnataka with area of approx. 49.31 ha.

1.5: Problems faced by the company:

- **Spare Parts Inventory.**
  
  In order to carry out mining operations, mines have to deploy many heavy earth moving equipment like excavators, wheel loaders, hydraulic drill machines, dumpers etc. It is necessary to maintain these equipment in healthy conditions to achieve better productivity. The repair & maintenance of these equipment is one of the important activities in the mining operations. To ensure maximum availability and utilization of these machines, it is necessary to stock spare parts and reduces break-down hours of the machines. Therefore, it is necessary to keep adequate inventory of spare parts in stock.
The summary of the year end spare parts inventory held at MSPL Vyasnakare Mine is shown by a bar chart below.

Graph 1.1

Year-end closing inventory
From the above bar chart, it can be seen that the inventory as on 31.3.07 was Rs. 3.01 crore. The inventory on 31.3.08 was Rs. 4.45 crore and on 31.3.09 was Rs. 6.29 crore. The inventory on 31.3.10 reduced to Rs. 5.63 crore, and on 31.3.11 was Rs. 4.64 crore. The maximum inventory was during financial period 2008-2009.

- **Machinery/ Group wise inventory:**
The Machinery-Group wise inventory held by the Mine as on 31.03.2011 is given below. The inventory held by each group is arranged in descending order. The detail is given below.

**Table 1.1**

Summary of the inventory of major machinery groups.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Description of Machine / Item Group</th>
<th>Inventory in Rs</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>12,861,298.94</td>
<td>27.66</td>
</tr>
<tr>
<td>2</td>
<td>Dumpers</td>
<td>8,167,555.46</td>
<td>17.57</td>
</tr>
<tr>
<td>3</td>
<td>Drilling Machine</td>
<td>8,045,617.41</td>
<td>17.31</td>
</tr>
<tr>
<td>4</td>
<td>Screening Plant</td>
<td>5,194,896.31</td>
<td>11.17</td>
</tr>
<tr>
<td>5</td>
<td>Wheel Loader</td>
<td>4,004,203.53</td>
<td>8.61</td>
</tr>
<tr>
<td>6</td>
<td>Other / Misc Spares</td>
<td>2,901,068.14</td>
<td>6.24</td>
</tr>
<tr>
<td>7</td>
<td>Explosives</td>
<td>2,350,815.70</td>
<td>5.06</td>
</tr>
<tr>
<td>8</td>
<td>Tyres, Tubes &amp; Flaps</td>
<td>1,431,308.02</td>
<td>3.08</td>
</tr>
<tr>
<td>9</td>
<td>Oils &amp; Lubricants</td>
<td>990,272.37</td>
<td>2.13</td>
</tr>
<tr>
<td>10</td>
<td>Fuel</td>
<td>545,218.68</td>
<td>1.17</td>
</tr>
</tbody>
</table>
It can be seen from the above table that the Excavator group held highest inventory of Rs. 128.61 lac which constituted to 27.66 %. This is followed by Dumper group holding Rs. 81.67 lac inventory equivalent to 17.57 %. The third highest group is Drilling Machine group holding Rs. 80.45 lac which constitute to 17.31 %. The wheel loader group held an inventory of Rs. 40.04 lac which is equivalent to 8.61 %.

It is found that there are 5 major groups of machineries which constitute almost 85.28% of the total inventory. These groups are excavator, dumper, drilling machine, screening plant and wheel loader groups. The details of the percentage inventory held by each group are given in the table below.

Table 1.2

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Machinery Group</th>
<th>Inventory in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>27.66</td>
</tr>
<tr>
<td>2</td>
<td>Dumpers</td>
<td>17.57</td>
</tr>
<tr>
<td>3</td>
<td>Drilling Machines</td>
<td>17.31</td>
</tr>
<tr>
<td>4</td>
<td>Screening plant</td>
<td>11.17</td>
</tr>
<tr>
<td>5</td>
<td>Wheel loaders</td>
<td>8.61</td>
</tr>
</tbody>
</table>
Graph 1.2

Inventory in percentage.

**Inventory in %**

- **Excavators**: 27.66%
- **Dumpers**: 17.57%
- **Drilling Machines**: 17.31%
- **Screening Plant**: 17.31%
- **Wheel Loaders**: 11.17%
- **Others**: 8.61%
- **Others**: 17.68%
It can be seen that out of total inventory, 71.15% inventory is held by Excavator, Dumper, Wheel loader and drilling machine group.

- **Inventory held by each group:**
  The inventory held by each group in terms of number of month’s consumption is shown in the below chart.

  **Table 1.3**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Category</th>
<th>OP Stock</th>
<th>Receipt</th>
<th>Consumption</th>
<th>CI Stock</th>
<th>No. of Months Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>12,393,451.03</td>
<td>2,793,633.23</td>
<td>2,325,785.32</td>
<td>12,861,298.94</td>
<td>66.36</td>
</tr>
<tr>
<td>2</td>
<td>Wheel Loader</td>
<td>5,109,959.41</td>
<td>1,226,682.14</td>
<td>2,332,438.02</td>
<td>4,004,203.53</td>
<td>20.60</td>
</tr>
<tr>
<td>3</td>
<td>Screening Plant</td>
<td>5,706,286.40</td>
<td>1,575,132.15</td>
<td>2,086,522.24</td>
<td>5,194,896.31</td>
<td>29.88</td>
</tr>
<tr>
<td>4</td>
<td>Drilling Machine</td>
<td>12,130,192.95</td>
<td>1,865,173.15</td>
<td>5,949,748.69</td>
<td>8,045,617.41</td>
<td>16.23</td>
</tr>
<tr>
<td>5</td>
<td>Other / Misc Spares</td>
<td>4,127,101.54</td>
<td>3,898,329.74</td>
<td>5,124,363.14</td>
<td>2,901,068.14</td>
<td>6.79</td>
</tr>
<tr>
<td>6</td>
<td>Dumpers</td>
<td>12,671,343.01</td>
<td>11,786,086.21</td>
<td>16,289,873.76</td>
<td>8,167,555.46</td>
<td>6.02</td>
</tr>
<tr>
<td>7</td>
<td>Oils &amp; Lubricants</td>
<td>1,051,685.60</td>
<td>9,009,296.67</td>
<td>9,070,709.90</td>
<td>990,272.37</td>
<td>1.31</td>
</tr>
<tr>
<td>8</td>
<td>Explosives</td>
<td>1,648,646.14</td>
<td>4,988,211.44</td>
<td>4,286,041.88</td>
<td>2,350,815.70</td>
<td>6.58</td>
</tr>
<tr>
<td>9</td>
<td>Tyres, Tubes &amp; Flaps</td>
<td>1,271,318.57</td>
<td>8,249,450.81</td>
<td>8,089,461.36</td>
<td>1,431,308.02</td>
<td>2.12</td>
</tr>
</tbody>
</table>
Machinery-Group wise Inventory held in No. of month's stock

It can be seen from the above table, that the excavator group held the stock of Rs.128.61 lacs inventory whereas it consumed only Rs.23.25 lacs worth spares per year. It means the excavator group held an inventory of 66.36 months stock.

The consumption of wheel loader group was Rs.23.32 lacs per year whereas the inventory held by this group is 40.04lac which was equivalent to 22.6 months stock. Similarly, the screening plant and drilling machine group held a stock of 29.88 months and 16.23 months stock respectively.

The study of the stock held by each group in terms of the consumption amount per month shows that the stock hold by excavator, dumper, drilling machine, screen plant and wheel loader groups are is very high. The stock held by excavator group was as high as 66 months i.e. more than 5 years stock in terms of month’s consumption. The detail is given below in the table.

**Table 1.4**

**Summary of inventory held in number of months consumption.**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Machinery Group</th>
<th>Inventory in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>66.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th>Fuel</th>
<th>230,064.20</th>
<th>36,619,927.14</th>
<th>36,304,772.66</th>
<th>545,218.68</th>
<th>0.18</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grand Total</td>
<td>56,340,048.85</td>
<td>82,011,922.68</td>
<td>91,859,716.97</td>
<td>46,492,254.56</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Equipment</td>
<td>No. of Months Stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------------</td>
<td>---------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Wheel loaders</td>
<td>20.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Screening plant</td>
<td>29.88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Drilling Machine</td>
<td>16.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dumpers</td>
<td>6.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Graph 1.3**

No. of months stock.
The above report shows that a huge spare parts inventory is held by the company blocking the working capital in the inventories.

- **Inventory Turnover ratio of major machinery groups.**
  In order to maintain low inventory, it is necessary that the inventory turnover ratio is very high. The inventory turnover ratio of the major machinery groups are given below. It can be seen from the below chart that the inventory turnover ratio of the major machinery groups is very low.

### Table 1.5

**Inventory turnover ratio of major machinery groups.**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Category</th>
<th>Consumption</th>
<th>Cl Stock</th>
<th>Inventory turnover ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>2,325,785.32</td>
<td>12,861,298.94</td>
<td>0.18</td>
</tr>
<tr>
<td>2</td>
<td>Dumpers</td>
<td>16,289,873.76</td>
<td>8,167,555.46</td>
<td>1.99</td>
</tr>
<tr>
<td>3</td>
<td>Drilling Machine</td>
<td>5,949,748.69</td>
<td>8,045,617.41</td>
<td>0.74</td>
</tr>
<tr>
<td>4</td>
<td>Screening Plant</td>
<td>2,086,522.24</td>
<td>5,194,896.31</td>
<td>0.40</td>
</tr>
<tr>
<td>5</td>
<td>Wheel Loader</td>
<td>2,332,438.02</td>
<td>4,004,203.53</td>
<td>0.58</td>
</tr>
<tr>
<td>6</td>
<td>Other / Misc. Spares</td>
<td>5,124,363.14</td>
<td>2,901,068.14</td>
<td>1.77</td>
</tr>
<tr>
<td>7</td>
<td>Explosives</td>
<td>4,286,041.88</td>
<td>2,350,815.70</td>
<td>1.82</td>
</tr>
<tr>
<td>8</td>
<td>Tyres, Tubes &amp; Flaps</td>
<td>8,089,461.36</td>
<td>1,431,308.02</td>
<td>5.65</td>
</tr>
<tr>
<td>9</td>
<td>Oils &amp; Lubricants</td>
<td>9,070,709.90</td>
<td>990,272.37</td>
<td>9.16</td>
</tr>
</tbody>
</table>
Inventory turnover ratio indicates how efficiently the inventory is rotated. The inventory management is considered to be efficient when the inventory turnover ratio is high and vice versa. From the above table, it is found that the inventory turnover ratio of excavator group is 0.18 which is very low it indicates that there are many items which are either overstocked or unmoved lying in stock. The inventory turnover ratio of wheel loader group is 0.58 and that of screening plant group is 0.40. The inventory turnover ratio of drilling machine group is 0.74 which is also very low.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Fuel</td>
<td>36,304,772.66</td>
<td>545,218.68</td>
<td>66.59</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td>91,859,716.97</td>
<td>46,492,254.56</td>
<td></td>
</tr>
</tbody>
</table>
The below reports also show that the inventory turnover ratio in case of excavator, wheel loader, screening plant and drilling machines are also very low.

Table 1.6

Summary of the inventory turnover ratio.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Machinery Group</th>
<th>Inventory Turnover Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excavators</td>
<td>0.18</td>
</tr>
<tr>
<td>2</td>
<td>Wheel loaders</td>
<td>0.58</td>
</tr>
<tr>
<td>3</td>
<td>Screening plant</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Drilling Machines</td>
<td>0.74</td>
</tr>
</tbody>
</table>
All the above reports indicate that the inventory held by the company is very high and it is necessary to decide the strategy to bring down the inventory.

**This indicates that these groups are holding very high slow moving and unmoved stock.**

This is a peculiar problem comeacross by the mining companies. This research work will help to provide solution to this specific problem faced by most of the mining companies

**1.6: Research Methodology**

Research Methodology is a method to solve the research problems systematically. It involves gathering of data, use of statistical techniques, interpretation and drawing conclusions about the research data. It is a scientific way to solve research problem.
1.7: Research Design

Research Design is a plan, structure and strategies of investigation concerned so as to achieve research objectives. It contain the statement of objective, statement of data input, method of data analysis.

Research Design can be further classified as exploratory and conclusive design. The exploratory design is further classified as literature search, experience survey, focus group and casestudies.

The conclusive design is classified as descriptive design and experimental design.

The research design used in this study is a combination of exploratory and conclusive. It is exploratory because it is a case study of MSPL Ltd and it is conclusive since it uses descriptive type design wherein hypotheses are tested.

Title of the Study:
Spare-parts Inventory Management – A case study of Mining Division of MSPL Limited.

1.8: OBJECTIVE OF THE STUDY:

The objectives of the study are as follows

➢ To study the practices followed in spare parts management by mining industries at Hospet – Bellary region, Karnataka.
➢ To study relationship between consumption of spare parts and machine operation hours.

➢ To find out whether the consumption of spares can be related to the cost of the machine.

➢ To make a comparative study of spare parts consumption between different mines of MSPL ltd.

➢ To recommend norms to limit spare parts inventory per machine at mining division of MSPL limited.

➢ To evaluate strategies to reduce the spare parts inventory in mining division of MSPL Ltd.

1.9: Sources of Data Collection

The methodology used to gather data is explained below.

- **Primary Data:**
  A survey was carried out to know the practices followed in spare parts inventory management by mining industries at Hospet - Bellary region in Karnataka. A questionnaire was prepared and circulated to the companies to study the practices followed by mining industries in in Bellary- Hospet region, Karnataka registered with Mines Safety Association of Karnataka (MSAK).

  The data was collected by questionnaire method from the stores and maintenance representative of the companies. A format of the questionnaire is attached at Annexure 3.1. Field surveys, personal visits, interviews were
arranged with the stores and the maintenance personnel of the company wherever required.

- **Secondary Data:**
  The secondary data was collected from the existing records of the Stores and Maintenance departments of MSPL and PVS mines.

- **Data Analysis:**
  The data collected was analyzed by various statistical methods, graph etc. The analytical tools like Correlation, ANOVA were used to understand the relationship between cost of equipment and spare parts consumption cost.

- **Samples:**
  To examine the spare parts inventory practices followed by mining industries in Hospet- Bellary region, Karnataka, companies were selected from the list of the companies registered with MASK. Out of 63 companies registered, 26 companies were selected having more than thirty machines and questionnaire was circulated to these companies. Out of 26 companies 22 questionnaires were collected and other companies refused to provide the information for the reason of confidentiality.

  To study the relationship between the spare parts consumption cost, machine operation hours and the cost of equipment, the samples were selected from the machines working at MSPL Vysankare mine. The samples were also selected from PVS Mines for comparison. The machines were selected based on the following criteria.

  - The machines which were used for more than 5000 hours.
- The machines which worked in similar working conditions
- The machine used for iron ore mining applications.

The operations department of the company was consulted in selections of the machines to ensure that the machines worked in the similar working conditions.

- **Sampling Method:**
  The non-Probabilistic, Judgment sampling method is used for the purpose of sampling.

- **Sample Size:**
  26 companies who were having more than thirty machines were selected to examine the practices followed in spare parts inventory management in Hospet- Bellary region, Karnataka.

  To study the relationship between the spare parts consumption cost and machine operation hours, ten samples of different make and model of machines were selected from MSPL Vysankareand PVS mine.

1.10: **Limitations of the Study:**

1. The cost of the machine may vary from buyer to buyer based on negotiations with the suppliers.

2. Machine may be subjected to different working conditions at different mines.

3. The spare parts cost may vary from company to company.
4. The spare parts consumption may vary from maintenance practices followed by different company.