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COMPARATIVE PERFORMANCE ANALYSIS OF SEMI-AUTOMATIC AND AUTOMATIC CEMENT PACKING PROCESS

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ABSTRACT
The packaging of cement is an important factor for improved productivity and maintaining the quality of packed cement. Because of steady growth of demand, supply and requirements of quality packed cement with right quantity, more emphasis should be given on packaging system and it is necessary to modernize the packing system of a cement plant. In this connection, two case studies have been conducted in two different organizations. The study extracts the overall scenario of the packaging system, packing performance, critical problems and other aspects in connection with quality of packed cement and efficiency of packing technology. It has been found from the study that the organization which is using stationary packing machine for cement packing is facing a lot of problems that reduce the packing performance and the quality of the packed cement. In contrast, the organization that uses rotary packing machine for its packing purpose is in better position in context of packing capacity, weighing system, manpower requirement, and quality of packing. However, the research work proposes some recommendations for the studied organization to improve the packing performance.

Key words: Cement packaging, Semi-automatic and automatic cement packing process, Packing machine.

1. INTRODUCTION
Cement (a fine hygroscopic powdery and granular material) is one of the most important components of concrete, which has the most critical role on the quality of construction as it plays a significance function as a binding material for building construction. The production, storage and packaging of cement are very important issues. Currently, the cement industries are providing 85% of total demand of Bangladesh [2]. The market for cement in Bangladesh is still growing at the rate of 8% per annum, which in a worldwide comparison is high [2]. Though the overall condition in connection with production of the existing units is in satisfactory level, some of the units are facing some problems in different areas. Packing problem is one of the major problems. The packaging of cement is an important factor for improved productivity and maintaining the quality of packed cement. Because of steady growth of demand, supply and requirements of quality packed cement with right quantity more emphasis would be given on packaging system. To meet the cement demand growth potential inherent in the market, it is necessary to modernize the packing system of a cement plant. In this connection two case studies of different organizations have been conducted. ‘Organization-1’ is using ‘Row or In-line packing machine’ for packaging of cement. This packing machine has low capacity and is only suitable for mini-cement plant [1]. The packing process using this machine is semi-automatic because of operator’s handling, where the empty cement bags are attached to the filling spouts manually. ‘Organization-2’ is using ‘Rotary packing machine’ which is the ideal type of packing machine for high filling rates and accurate filling, the weighing system of which is fully digital electronic weighing system.

In the present competitive environment, the success of a plant is possible by application of continuous improvement techniques and by adopting technically upgrade technology such as modern high capacity ‘Rotary packing machine’ incase of packing system. With the introduction of rotary-packing machines, the stationary packing machines for large sized cement plants have been receded in the past [1]. The preference for rotary packing machines is affected due to the scope of additional filling stations and also due to increased packing capacity by incorporating automatic bag filling and module weighting system.

1.1 Justification of the Study
In our country, a number of major cement plant projects and clinker factories are being planned and built in the last few years to meet the continuous demand for cement. The cement demand growth is currently very healthy [6] and it is continuing to rise faster than cement plant production [6]. So, for cement manufacturers it is important to concentrate on the cement demand growth potential inherent in the market. Cement production should be consistent with the cement consumption level

and at the same time cement-packing capacity of an individual cement plant should go upright of demand to ensure the timely delivery of cement with right quantity.

Cement is supplied to the consumer site as well as to the market in a closed pack. The package should contain the right amount (wt.) with better quality. That is why the packaging material, the packaging process and the weighing system demand more attention. After completing the production of finished powdery cement, the packaging of cement in right time is very important upon which customer's order as well as delivery schedule is directly dependent.'Organization-1' has been using stationary packing machine for it's packing purpose for last 10 years, the packing capacity of which is very low (900 MT/Day) in comparison with others. To improve its position among the other competitive cement-manufacturing units, it is important for 'Organization-1' to increase the packing capacity to at least 2000 MT/day to satisfy the consumer demands timely. The main aims acting here are to increase the packing capacity of stationary packing machine used in semi-automatic packing process, reduce the manpower required, simplify the maintenance procedure and bring down the operating and packing costs.

With the implementation and operation of new cement plants and capacity expansion of the existing units, the present competitive environment is always compelling the cement manufacturers to deduct cost from every cost components of the total cost of production as far as possible. To pack cement most economically in a widely acceptable manner, it would be beneficial to adopt modern packing and bagging technology comprising 8-16 spouts automatic rotary packing machine [4].

2.1 In-line or Stationary Packing Machine

In stationary packing machine, several filling stations are arranged in one row or line. That's why it is called 'Row or In-line Packing machine'. The HAVER Valve Bag Filling Machine, Type: Impeller, is designed for semi-automatic weighing and filling of all powdery products into bags with gross weights of 25 to 50 kg. The output of this bagging machine is in the range of 150 to 2000 bags per hour, depending on the number of filling stations. The packing machine used in organization-1 has 3 stations and it has the capacity of 5 bags per station per minute.

2.2 Rotary Packing Machine

Rotary packing machine as well as automatic packing process plays very important role in case of cement packing, which is the ideal type packer for high filling rates. Pneumatic rotary packers are the most suitable type of packing machine for all types of bulk materials from fine through to coarse-grained products, including mixed grades [5]. The HAVER ROTO-Packer, Type: Compact, is a rotating valve sack filling machine with 3 to 16 nozzles and it can be set to any required filling weight in the range of 25 to 50 kg. Weighing of the filled product guarantees very high capacity per filling station. It has got high filling capacity in the range of 2000 to 2400 sacks per hour, depending on the number of filling nozzles. In rotary packing machine, the filling spouts are mounted in a rotary fashion on the bottom of a cylindrical container rotating on a vertical shaft. The roto-packer used in 'Organization-2' has eight (8) filling spouts, each 4 spouts completing the filling cycle at a m/c revolution of only 180^0, thus requiring two bag fillers. Here, the empty valve bag feeding to the rotating filling spouts is done by only one operator as the bags pass in front of the operator.

3.1 Material Feeding and Bagging Line of 'Semi-Automatic' Packing Process

The material to be bagged is supplied to the packer bin installed above the bagging machine. The material supply is monitored by means of a 'Bin-level Indicator' which is used to control the constant level of material in packer bins. This constancy of maintaining material level is of great importance for the material flow as well as for weight precision. The bagging line of 'Organization-1' includes a few steps, the flow diagram of which is shown in the figure 3.1 below.

1. Vertical material supply from the 'storage silo' to the 'packer bin' is carried out by 'bucket elevators'.
2. A 'trash / rotary screen' installed above the 'packer bin' is used to retain foreign matters.
3. Constant material level in the 'packer bin' is maintained by a 'pre-bin level indicator'.
4. Required material supply to the 'packing machine' is carried out by a 'rotary-valve feeder'.
5. The cement bags packed by 'Impeller packer' are transported to the belt conveyor/ bag take-away belt.

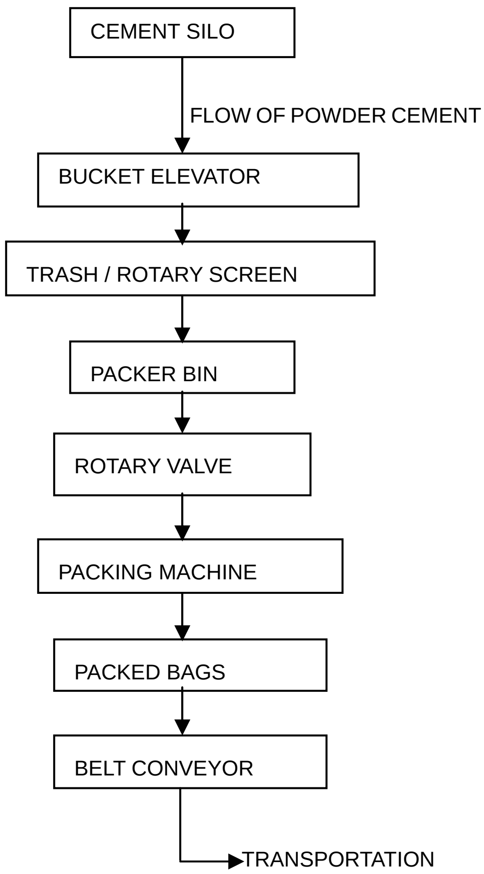

Fig 3.1 Flow Diagram of Cement Packing Process in 'Organization-1'

3.2 Findings of Monthly Total Packing in Year-2002

Total amount of cement packing in a year
= 113237.35 MT

The average amount of packing from January to June
= 10754.275 MT/Month
= 215086 Bags/Month

The average amount of packing from July to December
= 204166 Bags/Month

Hence, Average amount of cement packing in a year
= 9436.45 MT/Month

3.3 Findings of Monthly Defective Cement Bags (Year – 2002)

Total number of cement bags packed in a year
= 2264747 Bags

The average number of defective cement bags from January to June = 232 Bags/Month

Total number of defective cement bags in a year
= 2591Bags

Hence, Average number of defective bags in cement packing in a year = 216 Bags/Month

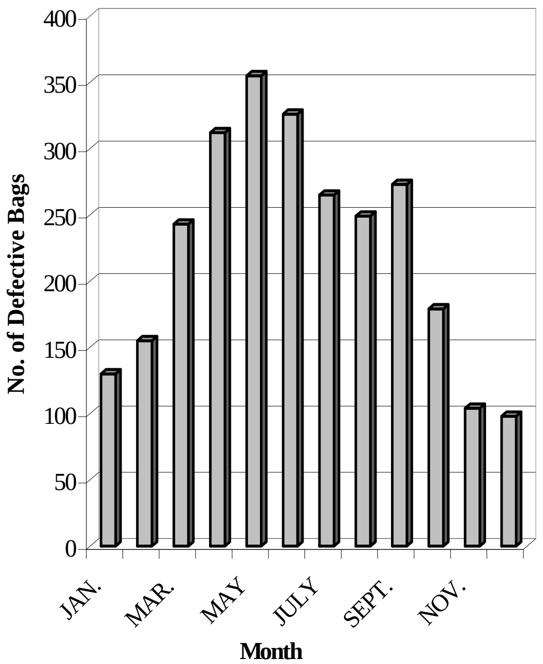

Fig 3.2 Monthly defective bags (Year- 2002)

For every 10^4 packed bags, the variation of monthly defective cement bags is shown in the figure 3.3.

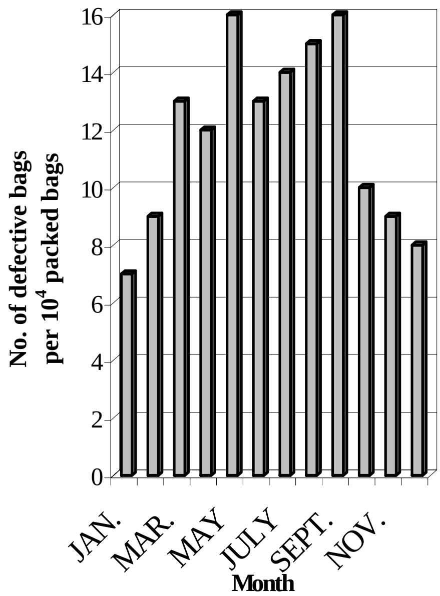

Fig 3. 3 Monthly defective bags for every 10^4 packed bags

3.4 Findings of Elements of Packing Cost [3]

The average operating cost = 764171 Tk./Year

The average wages of Packer = 1,48,466.2 Tk./Year

The average maintenance cost = 94,870 Tk./Year

The average insurance = 57,531 Tk./Year

The average power cost = 335664 Tk./Year

3.5 Findings of the Average Weight of Packed Bags

Total number of packed bags in a day = 5057 Bags

Number of shifts included in each day =3 shifts

Number of checking hours in each shift = 2 times
(First Hour & Last Hour)

Average weight of each bag in first hour of 1st shift
= 49.33 KG

Average weight of each bag in last hour of 1st shift
= 50.33 KG

Hence, Average weight of each bag in 1st shift
= 49.83 KG

And, Average weight of each bag in 2nd shift
= 50.67 KG

Average weight of each bag in 3rd shift = 50.5 KG

3.6 Overall Findings from the Semi-automatic Packing Process

The 'Organization-1'using stationary packing machine faces some kinds of problems during packing operation. The problems encountered at the packing area are given below-

- Inadequate packing capacity due to long filling time and defective packing
- No training program for packers.
- Dusty environment at packing place.
- Bending or badly aligning of filling shaft.
- Cracking of filling nozzles.
- Weight variation (over weight and under weight) of packed bags
- Presence of foreign particles in bagged cement.
- Pressure fluctuation of compressed-air during bag filling.

4.1 Material Feeding and Bagging Line of Automatic Packing Process

In 'Organization-2', in case of automatic packing process, the material to be packed in valve bags is supplied to the packing hopper installed above the rotary packing machine. In most cases a cellular feeder for one type of product is provided which is controlled automatically by the pre-bin level indicator during operation. The feeder may only supply products (powdered cement) into the roto-packing machine while the packing machine turns. The flow diagram of integration of bagging line providing the flow of cement in filling process is similar to the flow diagram of bagging line of 'Organization-1' as shown in the figure-3.1 except the following steps.

1. A 'vibrating screen' also called 'reject screen', with a mesh aperture of 4×4 mm is used instead of rotary screen to reject foreign particles.
2. The cement feed to the packing hopper is maintained by the 'hopper-level indicators' installed above the packing hopper.
3. Constant material supply to the 'roto-packing machine' is carried out by 'cellular vane feeder' instead of rotary-valve feeder with high accuracy.

4.2 Findings of Monthly Packing in Year-2002

Total amount of cement packing in a year
= 283102.75 MT

The average amount of packing in a year
= 23591.9 MT/Month

Total number of cement bags packed in a year
= 5662055 Bags

Hence, Average number of cement bags packed in a year
= 471838 Bags/Month

4.3 Findings of Elements of Packing Cost [2]

The average operating cost = 678275 Tk./Year

The average maintenance cost of packing machine
= 63400 Tk./Year

The average insurance = 272360 Tk./Year

The average wages of Packer = 35802.4 Tk./Year

The average power cost = 147600 Tk./Year

4.4 Overall Findings from the Automatic Packing Process

The 'Organization-2' using Rotary packing machine has many advantages during packing operation as well as some disadvantages, which are given below-

Advantages:

- High rate of packing.
- High weight precision.
- No defects during packing.
- Better quality of packing.
- Less manpower requirement.
- No dust at packing place.
- Less downtime of packing machine.
- Easy and fast erection into an existing building in limited space.
- Low power consumption.

Disadvantages:

- High initial cost.
- Significant idle time in packing operation due to improper filling of some filing spouts.

5. ANALYSIS ON THE FINDINGS OF SEMI-AUTOMATIC PACKING PROCESS

5.1 Graphical Analysis of Defective Cement Bags

Figure 3.2 and 3.3 presented previously represent the monthly defective cement bags in a year and the number of defective bags in a month for every ten thousand packed bags in 'Organization-1' respectively. It is observed from the figure 3.2 that the number of defective bags increases for first five months and maximum in the month May. After the month May, the number of defective bags decreases at a relatively low rate, but not totally reduces to zero level. From the figure 3.3 it has been shown that the number of defective bags for every ten thousand packed bags varies throughout the year. However from the month March to September the number of defective cement bags produced are relatively high because of high packing rate in those months. From the analysis it has been found that besides some other factors, the main reasons behind the production of defective cement bags are of presence of foreign particles, weight variation in packing and excessive pressure during packing operation which causes bursting of bags etc. The graph also shows that, the packing plant of 'Semi-automatic cement packing process' always produces defective bags throughout the year due to the above-mentioned factors. This reveals the fact that, though the production of defective bags in some months is low but it cannot be neglected because it causes a great impact upon the total cost of production.

5.2 Problems of the Existing Stationary Packing Machine

From the analysis of stationary packing machine's performance, it has been observed that the following problems are commonly occurred in line packing machine during operation. The effects of problems identified from the analysis of findings are also listed below:

a. Filling Time Too Long

Effect of Problem: Inadequate packing capacity is encountered.

b. Filling Shaft (Impeller shaft) Bent or Badly Aligned

Effect of Problem: Shaft is to be replaced, which results in increased maintenance and repair cost.

c. Ball Bearing Problem

Effect of Problem: Defective bearing is to be replaced through a new one, which incurs higher repairing cost

d. Filling Nozzles Crack or Broken

Effect of Problem: The cracked nozzle is to be changed by a new one that increases the cost of packing.

5.3 Analysis of Defective Cement Bags

The following table shows different categories of problems and the percentage of defective cement bags effected from each problem. On the basis of the table, a graph is drawn which is also called horizontal Pareto chart.

Table 1: Percentage of defective cement bags (Data of May 2002) for different categories of problem

Category of Defects	No. of Defective bags	Percentage of Defective bags
Weight Variation	124	35
Bursting of bags During Packing	106	30
Bursting of bags During Conveying	71	20
Presence of foreign particles	36	10
Loose Sealing	18	5
TOTAL	355	

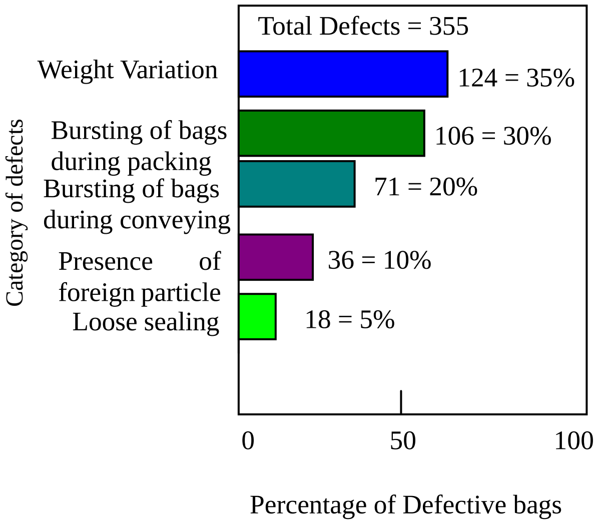

Fig 5. Horizontal Pareto Chart

From the Pareto diagram shown above it is identified that, some category of problems cause a large percentage of the defective cement bags while a less important problem causes small number of defective bags. Through the analysis of the chart and graph, the classification and the relative frequency of various problems can be determined so that the greatest amount of attention can be given to the most critical problems causing the highest number of defects. The causes and effects of different categories of problems that are identified are given below:

1. Weight Fluctuation

Cause of problem: Defective packing, bags are standing unevenly on tilting saddle; switching points for coarse and fine flow mode are inaccurate.

Effect of Problem: Packed bags weight is more or less than normal acceptable weight and bad impact on customer requirements resulting in customer complaints

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2. Foreign Particle in the Filling Channel

Cause of problem: Improper functioning of trash or rotary screen and inadequate dust collection.

Effect of Problem: Presence of foreign materials in the finished bagged cement and product’s credibility decreases.

3. Pressure Fluctuations of Compressed-Air during Filling:

Cause of problem: Improper compressed-air setting, incorrect positioning of the piston of the compressed-air cylinder.

Effect of Problem: Low pressure of compressed-air during bag filing resulting in defective packing process, excessive pressure of compressed-air might cause bursting of bagged cement during packing.

This analysis would be beneficial in establishing priorities in terms of the costs caused by the problem. From the analysis of Pareto chart the vital few causes or problems & effects can be highlighted which result in focusing on finding effective solutions to the most pressing (costly) problems. After finding the effective solutions on corrective reactions, the necessary improvement efforts can be developed.

6.1 Analysis of Rotary Packing Machine’s Performance

From the analysis of performance of rotary packing machine in context to operations, weighing system, bagging line and filling process, it is found that the rotary packing machine is more efficient in comparison to stationary packing machine because of the following significant reasons-

- Compact construction of the machine
- Clear layout and accessibility.
- The ease with which it can be cleaned when changing products.
- Clean and first filling
- Digital Electronic weighing system with display board.
- Easier to service.
- Minimum maintenance.
- Dust-free environment at packing place.

6.2 Weak Point of Rotary Packing Machine

In general an automatic packing machine does not produce any defective cement bags. However there is a significant weak point in filling process of packing machine during operation. The problem is that, if a filled bag does not reach its rated weight i.e., the filling operation is not completed due to some reasons, then the tilting saddle does not throw-off the under weight bag to bag take-away belt instantly. In this situation, after rotating several times with the defective bag, the saddle ejects the bag out of the turning area of the packing machine automatically. The time during which a defective weight bag stays in the filling spout, is considered as idle time for that spout. During this time no other empty bag can be attached to this spout, which results in decreasing the packing capacity. This is because of improper clamping of the empty bag to the spout and improper opening of the filling turbine.

7.1 Graphical Analysis of Comparison of Total Packing Process

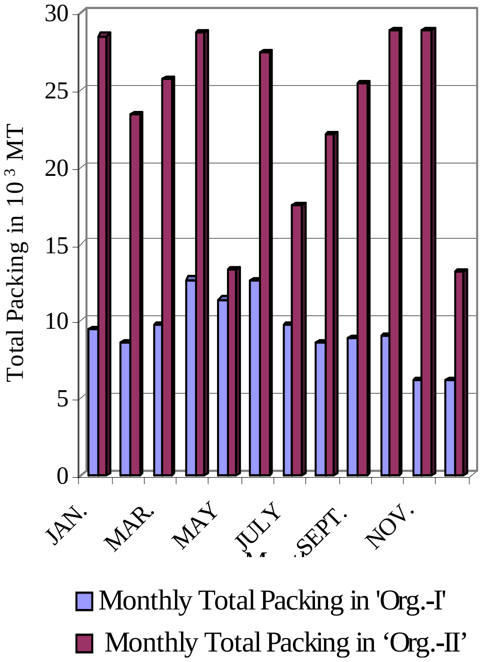

Fig 6.1. Comparison of the Total Packing

Figure 6.1 shows the comparison between 'Organization-1' and 'Organization-2' in terms of monthly total packing for the year 2002. It is shown that, the amount of packed cement in 'Organization-2' is always higher than that in the 'Organization-1'.It can be said that the reasons for high rate of packing in 'Organization-2' are of using up-to-date technology, high capacity of packing machine, low maintenance which leads to less downtime of packing machine and no defects during packing. On the other hand, in 'Organization-1', because of using obsolete technology, low capacity of packing machine, high maintenance and defective packing, the rate of cement packing is low.

7.2 Graphical Analysis of Comparison of Wages of Packer

The figure 6.2 represents the comparison between

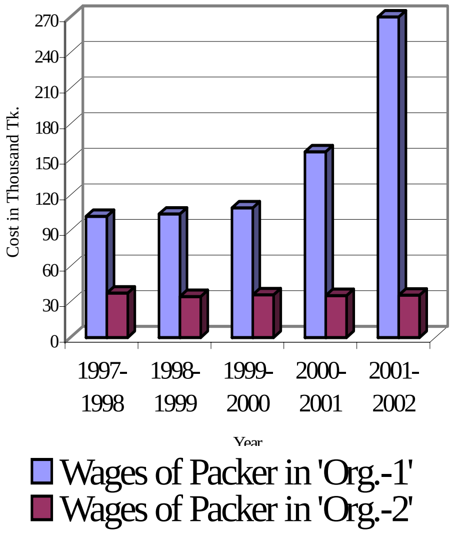

Fig 6. 2. Comparison of Yearly Wages of Packer.

'Organization-1' and 'Organization-2' in terms of yearly wages of packer required to operate the two packing machines respectively. From the graph it is observed that, the yearly wages of packer of 'Organization-1' is higher than that of 'Organization-2'. This is because; the stationary packing machine used in 'Organization-1' requires more manpower to operate the machine. The number of packers needed is dependent on the number of filling spouts in packing machine. On the other hand, the rotary packing machine is being used in 'Organization-2' to reduce the manpower in packing operation. Whatever the number of filling spouts in machine, the empty bag feeding to the rotating spouts is done by only one packer, as it is a rotary packing machine, which leads to the reduction of manpower required.

7.3 Graphical Analysis of Comparison of Maintenance Cost

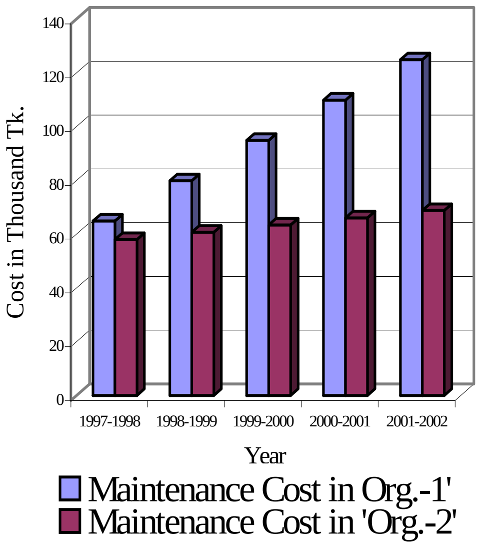

Fig 6. 3 Comparison of Yearly Maintenance Cost

The figure 6.3 shows the comparison of yearly maintenance cost between ‘Organization-1’ and ‘Organization-2’. From the graph it is observed that, the year-wise maintenance cost of ‘Organization-2’ is always less than that of ‘Organization-1’.This is an indication of better efficiency of rotary packing machine used in ‘Organization-2’ than stationary packing machine used in ‘Organization-1’. Maintenance cost is a function of operation disturbances, different working conditions, machine overhauling etc. From the analysis, it can be mentioned that in ‘Organization-1’, the maintenance cost varies considerably by a higher amount, because the stationary packing machine of obsolete technology used in ‘Organization-1’ requires more maintenance work. This is due to frequently occurring problems in stationary packing machine, which lead to more down time and a reasonable impact upon the maintenance costs.

8. CONCLUSIONS

This case study research has extracted a comparative picture of semi-automatic and automatic cement packing process in the context of stationary and rotary packing machine. It has been found from the ‘Organization-1’ that the stationary packing machine’s performance is not significantly efficient due to frequently occurring problems in packing machine during operation. It draws an attention that with the introduction of modern rotary packing machine, the stationary packing machine has been receded in the past. On the other hand, it could be inferred from ‘Organization-2’ that it has been using new technology rotary packing machine for its packing purpose with the aim of reducing the manpower required, increasing the packing capacity and the efficiency of packing technology. In practice, the performance of rotary packing machine is better than that of existing stationary packing machine in the context of packing capacity, weighing system, manpower requirement, maintenance etc. On the basis of the study, it can be concluded that if the existing stationary packing machine fails to deliver its desired capacity level and to meet the demand of the present competitive market, it will be wise to be replaced by an automatic rotary packing machine regardless of its age or condition, the decision of which might be more feasible in the long run.

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