CHAPTER 5

IMPLEMENTATION OF BPR: A CASE STUDY

5.1 COMPANY PROFILE

The research work is conducted in M/s Balaji Distilleries Limited, Chennai which commenced its production in 1984 of reputed brands of liquor such as Premium range Signature Whisky, Vintage Whisky, Bag Piper Gold Whisky, Cesar Brandy, Ramanov Vodka and Blue Riband Gin; Medium range McDowell No.1 Whisky, McDowell No.1 Brandy, Bag Piper Whisky, Diplomat Whisky, Honey Bee Brandy and Celebration Rum; and Ordinary range Golden Grapes Brandy and Old King Rum. It has grown from strength to strength since its establishment. The production has gone up, from 0.3 million cases in 1985-86 to 3.76 million cases in 2002-2003.

The unit has three stages of operations, re-distillation, blending and bottling and the process flow diagram is shown in Figure 5.1. In the re-distillation process Extra Neutral Alcohol (ENA) is produced from Rectified Spirit (RS) by removing all impurities. The process of re-distillation or purification of spirit is carried out in distillation columns using steam. ENA is stored in stainless steel tanks before pumping for blending operation. De-mineralized water and other ingredients are mixed with ENA depending upon the brand. Before bottling, the liquor strength and colour is checked and then through filters the product is collected in service tanks. The washing machines
Figure 5.1 Distillery Operation Flow Diagram
wash the bottles, which are then filled, sealed and labeled. Depending on the type of packing required in a case, 48 bottles of 180 ml, 24 bottles of 375 ml or 12 bottles of 750 ml are packed in master cartons and premium products are packed in monocartons. Carton boxes bear the date, batch number and brand name on the outer side for identification. The cartons are sealed and stocked on pallets for despatch to market.

5.2 FIELD STUDY

In this research MEPIM covers the techniques and concepts employed for the integrated management of business as a whole, from the viewpoint of the effective use of management resources, to improve the efficiency of the manufacturing unit. IMS software is designed to automate many of the basic processes of a company, from finance to the shop floor, with the goal of integrating information across the company. The subsystems integrated within an organization (Stephan Thangaiah and Radhakrishnan 2001c) of manufacturing unit are:

- Strategic and Operational planning
- Finance and Accounts
- Sales and Distribution
- Production Planning and Quality Control
- Inventory Control
- Plant Engineering
- Energy Management
The latest wave in the manufacturing industry is to implement Integrated Management Systems. The goal is worthy having a cohesive information system to cover all business. IMS, in short, should provide information to all employees for supporting them in performing their jobs.

Re-engineering is a modern management concept that is widely used along with Information Technology. The re-engineering process is essential for examining the current activities in terms of how work flows through a typical operational problem space. This is done with the intent of identifying significant bottlenecks, disconnections between related activities, and unnecessary or redundant steps that become candidates for deletion.

BPR brings out deficiencies of the existing operation and attempts to maximize productivity through restructuring and reorganizing the resource as well divisions and departments in the organization. In this study BPR involves the following steps (Stephan Thangaiah et al 2002b):

- Study the current system
- Design and develop new system
- Define process, organization structure and procedure
- Train people
- Implement new system

The power of IMS is the easy access to, and interchanges of, information through all parts of the organization. The reengineered process versus old process (Stephan Thangaiah, Radhakrishnan and Sundharam 2002c) is illustrated in Table 5.1.
Table 5.1 Changes in process after implementation of MEPIM

<table>
<thead>
<tr>
<th>Old Process</th>
<th>Reengineered process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-point interactions.</td>
<td>Single point interactions at decision making level</td>
</tr>
<tr>
<td>Multi-channel services</td>
<td>Single channel services with proper internal integration</td>
</tr>
<tr>
<td></td>
<td>within the organization through intranet (MS-Exchange)</td>
</tr>
<tr>
<td>Function oriented approach</td>
<td>Process oriented approach</td>
</tr>
<tr>
<td>Administrative and managerial</td>
<td>Administrative and managerial</td>
</tr>
<tr>
<td>responsibilities to separate entities.</td>
<td>responsibilities to same head</td>
</tr>
<tr>
<td>Uncharted cycle time and flexibility</td>
<td>Charted cycle time for every operation</td>
</tr>
<tr>
<td>resulting in delay in some major</td>
<td>and adhering to time schedule</td>
</tr>
<tr>
<td>operations, like, purchase order, work</td>
<td></td>
</tr>
<tr>
<td>order, payment, despatch, etc.</td>
<td></td>
</tr>
</tbody>
</table>

5.3 INVENTORY CONTROL

In industries, well-planned and effectively controlled inventories can contribute to effective operation and profit. The very challenging task is to determine the inventory level that works most effectively with the operating systems existing within the organization and that which realistically is the most feasible in dealing with given suppliers and material markets.

The Distillery unit is producing different brands of product with various packing volume. The materials required for producing these are very limited in terms of number of items but very high in value. The raw materials RS, ENA and Special Spirit are stored in tanks which are purchased in bulk and stored in advance. There is no system available to monitor the stock status of
various materials. Similarly the packing materials bottles, carton boxes, labels and caps are stored in large volume which occupies more space in the plant.

This plant is having lot of machineries and equipment like process vessels, storage tanks, bottling equipment, packing machines, boilers, pumps, motors, pipelines, electrical transformers, generator sets, air compressors, forklifts and trolleys for its operations. Regular updating of the Maintenance, Repair and Operating inventory (MRO) stock is very important as non-availability of spare parts stops the production causing loss to the company. Approximately six thousand various types of spare parts are available in store. Hence, it requires inventory management strategy and information system to control the operation.

The existing inventory control systems activities are very little, such as maintaining books for inward and outward flow of materials. The drawbacks of the existing systems are overcome by implementation of a sophisticated, user-friendly and efficient enterprise-wise integrated system.

Considering the usage of large quantity, high value and less number of items, JIT concept is introduced (Stephan Thangaiah et al 2001d) to control the production inventories. The materials can be received as per immediate requirement based on the production plan of the individual brand, on a long-term contractual basis. The developed system links sales and production to provide information for raw materials movement and stock position. The system generates purchase order based on available storage capacity, production plan and dispatch schedules.
Table 5.2 Activities and Characteristics of JIT (Dobler and Burt 1996)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase lot size</td>
<td>Exact quantities in small lot-sizes.</td>
</tr>
<tr>
<td>Number of Suppliers</td>
<td>Fewer in number, ideally one for each material or class of parts</td>
</tr>
<tr>
<td>Supplier selection and evaluation</td>
<td>Based on quality, mutual relationships, delivery performance, etc.</td>
</tr>
<tr>
<td>Quality inspection</td>
<td>Performed at supplier's plants</td>
</tr>
<tr>
<td>Design specifications</td>
<td>More freedom given to suppliers to meet design specifications</td>
</tr>
<tr>
<td>Bidding</td>
<td>Stay with same suppliers</td>
</tr>
<tr>
<td>Paperwork</td>
<td>Informal paperwork</td>
</tr>
<tr>
<td>Packaging</td>
<td>Standard containers and rack utilized</td>
</tr>
</tbody>
</table>

The Table 5.2 shows the major impact of JIT concept on purchasing and supply activities.

Since a distillery is a continuous operation industry; its consumption of spare parts are more non-availability of spare parts stops the production causing loss to the company but at the same time keeping non moving high cost items in the inventory is to be avoided. Using integrated system, based on annual consumption value, spare parts such as bolts, nuts, rubber components, electrical items and pipeline fittings are grouped under Always Better Control (ABC) model and based on the rate of movement and need the spare parts of the machinery are categorized under Vital, Essential and Desirable (VED). Hence ABC - VED (Gopalakrishnan 1999) inventory model is followed for MRO inventory stock. The inventory controls such as order quantity, reorder
level, maximum and minimum and critical stock position is fixed for all these MRO materials by using the cyclical or fixed order interval time inventory system. The processes developed in the system are

- Receipts
- Issues
- Rejections
- Stock Adjustment
- Query
- Daily Production
- Despatch Schedule

The important benefits of the new system (Stephan Thangaiah and Radhakrishnan 2001h) are:

- It ensures smooth production flow by having a centralized monitoring and controlling, over the movements of the materials.
- It can have strict control while receiving materials from suppliers or while sending materials to production centres.
- It can have estimates of the shortage of materials for a given future period, well ahead of time.
- It can have estimates of the shortage of materials for a current production plan.
- It can arrive at the inventory value at any instant of time, both consolidated over all the production centers and individual center.
- It can obtain an optimum product mix to be produced, with the available inventory.
• It can cut down telephone bills; fax bills and postage bills to a great extent, if it properly utilizes the available communication facilities. This reduction itself can justify the costs invested in communication facilities.

This system also helps to

• Evaluate alternatives, considering cost, ease of implementation, pay back and benefit to environment.
• Inventory control: use a "first in, first out" policy for raw materials to prevent them from becoming too old to be used.
• Test raw materials before accept them from the supplier. This can help eliminate the production of off-spec products.
• Protect items stored outdoors from temperature extremes, rain, snow and wind, etc.
• Prevent and contain spills/leaks via proper equipment maintenance and increased employee training and supervision.

The system also covers the following processes.

• Vendor Performance analysis
• Quality Control
• Materials Requirement Planning
• Purchase Ordering System
• Bills Processing System
• Monitoring of various stages of production
5.3.1 SOS Control

Most of the industries are not giving much importance to the management of Surplus, Obsolete and Scrap (SOS) inventory because of not knowing the cost involved. It is regrettable, because firm’s total cost of production is the sum of the cost of labour, materials and overhead, minus any return from a successful sale, use of all kinds of surplus materials and reduction of wastage. The SOS management plays a major role in inventory management in view of the technological changes and financial stringency. The problem of obsolescence is more acute in spare parts intensive industries like process industries. Holding obsolete and surplus stocks is costly. These costs include inventory carrying charges, cost of periodic stock taking, cost of maintaining the records, cost of security, cost of preservation, working capital tied up in inventories, cost of additional staff for stores work, cost of storage space, cost of lower morale due to seeing the same non-moving item every day, etc. In view of the cost impact of the redundant and obsolete stocks, special effort must be made to avoid keeping them. Scrap is another classification which is usually tagged into obsolete and surplus materials. It arises due to number of reasons such as a residue from manufacturing process, breakage, spillage, condemnation and distortion. The amount of wastage as a percent of the total production is certainly a measure of the working efficiency of the plant.

5.3.2 Sources of SOS

Industrial surplus is defined as those materials which are in excess of a firm’s operational requirements. Surpluses typically originate from three primary sources: scrap and waste; surplus, obsolete or damaged stocks and Surplus, obsolete or damaged equipment (Stephan Thangaiah et al 2001g).
• Some surplus from production processing is inevitable. Not all production materials are wholly consumed in most manufacturing processes: frequently, a residue is left. For example, during purification of rectified spirit into extra neutral alcohol, a small percent of spirit comes out as impure spirit which can not be used in the firm’s operation. This excess, called scrap, must be disposed of as surplus. It is impossible to eliminate this type of surplus: however, by intelligent planning and effective production controls it can be minimized. Surpluses also result from the inefficient use of production machinery, carelessness, and poor purchasing. This type of surplus is called waste. Effective management does everything possible to keep waste at minimum.

• The production planning is based on sales forecasting. The sales may not be always as expected. In cases of over anticipation, material excesses above actual requirements inevitably result. A liquor company, for example, to face the competition in the market, changes the design and specifications of products to meet market demand. As a consequence, obsolete products and their parts constitute a continuing source of surplus materials. Planned over buying and over production represent still other sources of surplus stocks like producing more quantity in a particular brand of liquor. Any warehousing operation, due to poor control, accumulates some surpluses from breakage, deterioration, and errors in record keeping.

• All machineries and equipment at some point of time become surplus for either of the two primary reasons: they wear out, or
they become technologically obsolete. In today's rapidly advancing technological world, major packing machines, seldom wear out; more frequently they are replaced because they have become technologically obsolete.Installing new and more efficient equipment and in some case modifying the existing equipment will reduce the wastage and greatly increase productivity.

5.3.3 Strategic Planning for SOS Reduction

Once a management strategy has been established, it can identify some general SOS reduction activities, which apply to a variety of waste types and will go a long way towards meeting the reduction goals:

- Segregate all waste streams to reduce contamination of recoverable materials.
- Investigate waste exchange programs for both solid and liquid waste.
- Establish quality assurance/quality control procedures to reduce the generation of rejected products.
- Replace disposable materials with reusable and recyclable materials.
- Investigate the use of returnable and/or recyclable containers and pallets.
- Identify specific waste materials that could be recycled either on-site or off-site.
• Provide employee training for source separation, reuse and any other reduction activities that will require a change in behavior.

• Establish an incentive program that encourages personnel to suggest changes, which will reduce waste.

• Identify potential production changes, which will improve efficiency.

• Control inventory to reduce waste; rotate stock, using oldest purchases first.

• Invest in products and equipment that are durable, easily repaired and/or recyclable.

• Ask vendors to minimize unnecessary packaging, use recycled materials and use returnable packaging.

• Determine if outdated stock can be returned to suppliers for regeneration.

This system helps to

• Identify wastes to be targeted for reduction.

• Identify in-house resources, such as equipment that might be necessary to implement a reduction program.

• Develop cost-benefit analysis that accounts for all of the costs of waste disposal.

• Use an accounting system that identifies waste handling, treatment and disposal expenses as direct cost of production.
• Designate raw material and waste storage areas. Provide protection and spill containment. Keep the areas clean and organized and give one person the responsibility for maintaining the areas.

• Return obsolete raw materials to the supplier if possible.

From the inventory audit analysis, after the MEPIM is implemented from April 2002, it is evident that significant amount of SOS reduction potential is available in the plant. To study the effect of the new system, data is gathered of statistics about the production, inventory value along with scrap, surplus and obsolete materials. The new system is capable of enabling to reduce the stock level of production inventories from a month requirement to a week without affecting the production, Figure 5.2 (Appendix). Similarly in MRO inventory stock is also reduced about 36.4% of value, Figure 5.3 and once the management decides to replace the machinery with new technology, the MRO inventory of obsolete items are identified easily and disposed.

With the help of online data available in the system, SOS audit is carried out to define sources, quantities, types of surplus generated; identifies where, how, why these wastes are generated; identifies areas of wastage, establishes targets and priorities for waste reduction. This audit can be also used to ensure external regulatory compliance, develop base-line data and evaluate alternatives to minimize wastage of resources. Implementing this module is also resulting in productivity improvements, greater control between various production stages; diminished raw materials, work in progress and finished products inventories; reduction in manufacturing cycle times and improved
inventory turnover rates. The SOS is controlled through the measure of Waste index.

\[ \text{Waste Index} = \frac{\text{Quantity of waste produced}}{\text{Quantity of total output}} \] (5.1)

After the implementation of new strategy, it is found that savings from the wastage reduction, Figure 5.4; due to replacement of outdated bottle washing machine, stainless steel slotted chain bottle conveying system with variable drive motor to adjust the conveyor to the required speed, improved way of packed case by using carton sealing by bi-axially oriented polypropylene self adhesive tape sealing machine in place of wire type stitching machine and packing materials supply quantities are calculated for the payment based on the final product with some permissible wastage; hence the transit, handling and storage responsibility entirely lies on vendor. Also, requested the vendors to change the method of packing from gunny bags into plastic crates to avoid handling and storage wastage.

Organizational Change: With the help of on line data available in the system, reengineering process is carried out to define the functioning of the production, engineering, purchase, accounts and stores departments. MRO items purchase cost is about 2% of the total value but large in number of items. The Engineering Manager with the help of IMS can operate these items. Hence the role of Materials Manager can be redefined as (Stephan Thangaiah et al 2001e) instead of wasting time in planning of MRO materials; he can be given a new role in logistics planning and marketing coordination along with purchase of production inventories. Implementing this resulting in direct control over the inventory monitoring in various production stages; diminished raw materials,
finished products inventories, reduction in processing times and reduction in wastage. The purchase and store related to MRO inventories should work under Engineering Manager in addition to plant maintenance who has got the power to contact vendor, place the purchase order and sign work contract. It eliminates redundant activities between the departments. This reduces the delay in taking decisions in connection with plant operation and maintenance issues.

5.4 PLANT ENGINEERING

Plant Engineering and management is an empirical science. It is a productivity improvement process that depends on measuring performance and sustaining motivation. Its purpose is to ensure the best utilization of human, technical and financial resources. It requires specific relationships with accounting, personnel, engineering and production management. On the whole, it is an integral part of the planning, operation and control of a plant. The maintenance function acts as a supporting role for effective equipment operation and to maintain quality standards of the output. "Technology permits changes in work, and work must change radically in order to take advantage of technology." It is often very tempting for management to sidestep, difficult but necessary decisions by seeking to re-engineer an organization through systems implementation (i.e.) let the system force the decisions.

Plant Maintenance is very important to extend the useful life of an asset. Proper maintenance management could improve existing capacity utilisation rather than going for additional capacities to meet the ever increasing demand for a large number of products and or services. Maintenance is usually viewed only as a repair function. It is, however, a combination of any action carried out to restore it, to an acceptance condition. In fact maintenance keeps
or ensures that the entire production system is kept reliable, productive and efficient. Maintenance work can be planned or unplanned which are classified as

- Preventive Maintenance
- Break down Maintenance
- Planned Maintenance
- Running Maintenance
- Shutdown Maintenance
- A time-based Preventive Maintenance
- Condition - Based Maintenance
- Corrective Maintenance

The manufacturing industries have a number of machineries and equipments for their operations. Also they require thousands of spare parts to maintain the machineries. Hence, they require large amount of operation management strategy and information to control day-to-day operation. The system is developed to cover all functional areas of maintenance, such as

- Preventive and Predictive maintenance
- Replacement Analysis

All equipment and machineries are classified into four main categories as machineries/equipment, pumps, motors and electrical components. Equipment details such as date of purchase, manufacturer particulars, specifications, warranty period are created. Preventive and predictive schedules are predefined as per the manufacturer guidelines.
The collected data are analyzed daily in the system and the following reports are generated to monitor the plant operation.

- Production efficiency
- Downtime index
- Maintenance cost
- Equipment performance details
- Preventive and predictive maintenance schedule status

Production Efficiency = \( \frac{\text{Actual Production in cases}}{\text{Rated Production in cases}} \) \hspace{1cm} (5.2)

Downtime Index = \( \frac{\text{Downtime hours}}{\text{Production hours}} \) \hspace{1cm} (5.3)

Maintenance cost index = \( \frac{\text{Maintenance cost}}{\text{Quantity of Production in cases}} \) \hspace{1cm} (5.4)

Spare parts stock position, machinery wise consumption, status of pending order, reorder level and critical stock reports are generated. Reports like vendor competitive price details and delivery schedules are generated for efficient control. Reports like payment schedule is generated for better vendor relations. The plant maintenance information system comprises of production, machine hour, machine preventive maintenance and predictive maintenance, lubrication practices, component replacement analysis and spare parts management.
After the implementation of the computerized management of information system in plant operation and maintenance field, the past and current data are processed. The variation of production quantity in cases is shown in Figure 5.5. The production efficiency increased from 82.84 to 93.14 percentage (Stephan Thangaiah and Radhakrishnan 2001b) because of online data availability and continuous follow up as shown in Figure 5.6. The hours of breakdown time in bottling plant decreased with the help of preventive maintenance. The breakdown percentage came down to 1.22 % against 3.24% as shown in Figure 5.7. Also the maintenance cost per case is reduced from Rs 2.61 to 1.62 due to proper planning, Figure 5.8.

The information system has helped the company to improve its productivity. The production loss and spare parts consumption has came down. The online query facility is helping the Engineers to know the inventory stock status, competitive price structure, preventive and predictive schedule status, equipment history and break down detail. Also this online information system is helpful to identify and rectify the problems immediately to improve the plant performance.

After the implementation of the computerized management of information system along with process control instrumentation in plant operation, the past and current data are processed. The information system has helped the company to improve and maintain the quality output, as shown in Figure 5.9 sensory score from 5.8 to 6.8. The online query facility is helping the operators’ to know the performance of the plant. Also this online information system is helpful to identify and rectify the problems immediately to improve the plant performance.
5.4.1 Equipment Replacement Analysis

The goal of any well run industry is to have the lowest cost of the sum of two quantities, that is maintenance cost and production loss which includes lack of ability to produce. Maintenance itself can result in excessive downtime and costs. This results from the requirement to take the machinery off-line to carry out maintenance. The danger of infant mortality after it is put back on line again and also the costs of the maintenance action itself contribute to costs. Hence if a firm wants to operate with high productivity, it has to take a decision on whether to replace the old equipment or to retain it by taking the cost of maintenance and operation into account. This work analyzes replacement of capital equipment in the manufacturing unit using Data Warehouse.

Plant Engineers are finding themselves competing more and more for financial resources. Until recently, sound engineering analysis alone was adequate to convince management that maintenance expenditures were necessary. However, corporate resources in many industries have tightened, and engineering analysis alone can no longer justify maintenance resources. Increasingly, the control of maintenance resources in many industries is in the hands of financial decision-makers using quantitative financial and decision analysis. Traditionally, engineers are ill equipped to convincingly “tell their story” in these terms. MEPIM offers a process that aids in this communication and guides maintenance resources into financially viable repair/replacement strategies.

The limitation on maintenance resources due to lower prices, and the increased need for maintenance resources because of aging, has placed
maintenance decision-makers in a dilemma. Quantitative financial and decision analysis techniques are now needed to properly select maintenance actions.

The replacements of equipment are due to physical impairment of the various parts or obsolescence of the equipment. Physical impairment refers only to changes in the physical condition of the machine itself. This would lead to a decline in the value of the service rendered, increase in operating cost, increased in maintenance cost or a combination of both. Obsolescence is due to technological changes over a period of time, which results in low productivity. So, it would be uneconomical to continue production with the same machine under any of the above situations. Hence, the machines are to be periodically replaced.

Plant Maintenance activity mainly can be classified into two types: preventive maintenance and breakdown maintenance. Preventive maintenance is the periodical inspection and service activities, which are aimed to detect potential failures and perform minor adjustments or repairs that would prevent major operating problems in future. Breakdown maintenance is the repair that is generally done after the equipment has attained down state. It is often of an emergency nature, which results in considerable increase in cost of maintenance and loss due to the machineries being idle. Preventive maintenance is reducing such cost up to a point. Beyond that point, the cost of preventive maintenance is also more and the total cost is increasing. Hence it is better to take a decision to replace old machines with new ones.

When maintenance costs are at a minimum the cost of lost production is at its highest. As maintenance effort and costs are intelligently increased the production loss gradually decreases until the lowest combined cost is achieved.
This is the maintenance goal. Maintenance effort applied beyond this point, increases costs. Maintenance can increase costs because of the need to take equipment off line to carry out maintenance, infant mortality after being put back in service, etc. There are also the costs of the maintenance itself with labour and material costs.

5.4.1.1 Financial Decision Model

Maintaining equipment involves the collection of large amounts of information to record historical equipment performance, identify spares, etc. Historically this information has been held in paper-based records. Handling large amounts of paper-based records can become difficult and expensive to store and analyze. Errors and omissions can also easily take place. The development of the IMS has been followed by an increasing choice of Data Warehousing system, which replaced the paper-based records, Figure 5.10.

The repair and maintenance costs of equipment increase with time and a stage may come when these costs become so high that it is more economical to replace the equipment by a new one. Since both of these costs tend to increase with time, they are grouped while analyzing a problem. If these costs decrease or remain constant with time, the best policy is never to replace the
item. However, this condition is hardly encountered in practice. If these costs fluctuate with time, the equipment should be replaced only when they are increasing, of course, the analysis becomes more involved. Generally, all maintenance costs must be taken into account while analyzing the decision of its replacement.

The equipment deteriorate with time; the equation to analyze the replacement is:

Total annual equivalent cost

\[
\begin{align*}
    \text{Cumulative sum of present worth as of beginning of year 1 of operation and maintenance costs} & + \text{Purchase price} - \text{Present worth as of beginning of year 1 of salvage value} \\
    & \times (A/P,i,n) \\
\end{align*}
\]

(5.5)
where,

\[(A/P,i,n) = \text{Equal - Payment Series Capital Recovery Amount}\]

(Panneerselvam 2001)

\[P = \text{Present worth}\]

\[A = \text{Annual Equivalent payment}\]

\[i = \text{Interest rate}\]

\[n = \text{Number of years the equipment is in use}\]

Table 5.3 (Appendix) shows the equipment down time year-wise and Table 5.4 gives the details about the operating maintenance cost of individual equipment for the replacement analysis.

The information system is designed and developed to cover entire area of operations management of the plant. Equipment details such as date of purchase, manufacturer particulars, specifications, warranty period are created. Preventive and predictive Schedules are predefined as per the manufacturer guidelines. It provides information at the various levels for monitoring the equipment. The system captures the following data for better control of the plant operation:

- Equipment operation and down time
- Spare parts consumption
- Line-wise daily production

The collected data are analyzed in the system and the following reports are generated to monitor the plant operation.
- Yearwise equipment operating maintenance cost
- Yearwise equipment break down time
- Equipment replacement analysis

From the analysis using the equation (5.5), with the help of integrated information management system; Table 5.5 indicates when the equipments are to be replaced (Stephan Thangaiah and Radhakrishnan 2002a) to improve the plant performance.

Decision analysis, supported by financial analysis and optimization techniques, are routinely used for large investment decisions. The decision-making methods already developed to account for conditions of uncertainty can be successfully employed along with IMS. It is well suited for maintenance decision-making also because of the uncertainties in maintaining equipment during its aging phase. Thus using Data Warehousing most companies are able to take decisions on a fully quantitative basis.

Organizational Change: Earlier bottling and blending operations were under one head who had experience only on blending. There was always delay in taking decisions and corrective measures; also lot of conflicts on reporting problems arose. After implementation of MEPIM, it is identified that the bottling operations required immense knowledge on resource planning and Engineering. So the bottling operation is brought under the control of Engineering Manager along with machine maintenance.
5.5 ENERGY MANAGEMENT

5.5.1 Energy Conservation

The energy management plays a major role in view of the technological changes and financial stringency. The amount of energy saved is certainly a measure of the working efficiency of the plant and increase in profit. With the growing demand for energy worldwide and with the fast depletion of energy sources, it becomes imperative that energy audit management should be carried out, consolidated and necessary measures are followed effectively. A study carried out and brought out in detail the various sources where energy conservation is profitable with the help of Data Warehousing.

IMS is a powerful tool to monitor energy conservation strategies effectively in process industries. The wastage of the energy in industries is due to various causes such as human error in process, the sequence of process, the process being unable to sense and control from a distance and data non-availability for continuous follow up. MEPIM can support virtually every step in creation, implementation and maintenance of new energy conservation strategies. The study of plant operation with respect to energy needs is undertaken with the following objectives:

- To study the present performance characteristics of the plant in all its aspects.
- To identify and delineate the critical parameters which contribute to the enormous consumption of both electrical and steam energy during the last few years.
- To suggest effective ways for minimizing the energy consumption.
• To monitor the energy conservation measures.
• Based on the energy audit, the energy conservation recommendations are analyzed for financial benefits.
• To monitor the energy conservation measures with the help of information system covering all area of energy management and providing information at various levels for monitoring energy conservation measures.

5.5.1.1 Energy Conservation Planning Strategies

Support and direction from top management are critical to the development of company-wide energy conservation policies. Examine all energy conservation streams for source reduction, reuse and recycling - in that order. Develop a written energy conservation policy such as:

• Establish ambitious and measurable energy reduction program goals
• Plan a “brainstorming” session to generate energy conservation ideas.
• Conduct a plant-wide energy consumption assessment.
• Prioritize or rank energy conservation procedures, such as source reduction, reuse, on-site recycling, off-site recycling and waste exchange
• Identify energy to be targeted for conservation.
• Develop cost-benefit analysis which accounts for all of the costs of energy savings
• Develop an implementation schedule.
• Establish an incentive program which encourages personnel to suggest changes which will reduce waste.
• Explore the use of waste heat recovery equipment for reducing energy waste.

5.5.1.2 Action Plan

Some of the major critical parameters to be considered in conserving energy (Stephan Thangaiah and Radhakrishnan 2001a) in a manufacturing unit are

• The heat exchangers surface become fouled with scaling, it reduces the heat transfer rate; so, the energy consumption increases for the same output. This problem is solved by using right quality water.
• Heat energy is recovered from the condensate.
• Heat losses reduced in the process equipment, Boiler, Feed water tank, Steam and Condensate pipelines to minimum with proper thermal Insulation.
• Improving the power factor reduces electrical energy consumption.
• Higher capacity pumps, frictional loss and leakage are eliminated replacing gland packing rope by mechanical seal which saves the electrical energy.
• A higher capacity induction motor is provided with energy saving soft starter controllers. It reduces the energy consumption.
• Due to poor combustion of fuel in the boiler, there is lot of furnace oil wastage; it is reduced by proper combustion control system. It is achieved by combustion with correct air fuel ratio.
• Energy saving devices in lighting distribution are incorporated since most of the lighting is with fluorescent lamp.
• Electrically driven exhaust fans are replaced with Turbo-vents which avoids electrical power consumption.

The following data are captured information for better control of the operation of the plant,

• Daily ENA production
• Electrical energy consumption area wise
• Boiler Fuel consumption
• Captive Power generated
• Diesel consumption

The collected data are analyzed daily in the system and the following reports are generated to monitor the energy consumption (Stephan Thangaiah et al 2001f)

• Specific Electrical Energy Consumption
• Fuel factor per unit product output
• Captive power generated per litre of fuel

Specific Electrical Energy Consumption

\[
\text{Specific Electrical Energy Consumption} = \frac{\text{Electrical energy consumption in KWH}}{\text{Production in cases}}
\]  \hspace{1cm} (5.6)
Fuel Factor

\[ \text{Fuel Factor} = \frac{\text{Furnace oil Consumption to generate Steam in litres}}{\text{ENA Produced in Litres}} \] (5.7)

Capitive Power Unit generated

\[ \text{Capitive Power Unit generated} = \frac{\text{Electrical unit in KWH}}{\text{Diesel Consumption in litres}} \] (5.8)

Distillation Efficiency

\[ \text{Distillation Efficiency} = \frac{\text{Quantity of Output}}{\text{Quantity of RS feed}} \] (5.9)

Improving the efficiency of a plant operation can significantly reduce energy consumption at the source itself. Several cost-effective conservation techniques are included; many methods are simple and consist of relatively inexpensive changes in production procedures. Energy conservation techniques are introduced to improve the operation and maintenance methods for reuse/recycle and equipment modification to eliminate energy wastage. However, Technology alone will not reduce energy waste - only a comprehensive energy conservation program will be successful. Such a program should include management commitment, data collection, cost-effective technology selection and implementation, employee training and involvement, and program monitoring. Using this information a range of reduction techniques are identified and evaluated, and cost-effective options implemented to conserve energy.
With up-gradation of technology in distillation efficiency increased from 95.3 to 97.4% from April’ 2002, Figure 5.11; decreased the wastage and evaporation losses. Also reduced the energy consumption, Figure 5.12 due to energy efficient operation, condensate recovery, proper thermal insulation of columns, steam pipeline, hot water pipelines and by operating the plant at full capacity; the fuel required per litres of ENA produced is reduced from 0.249 to 0.204 litres. The Generator Set produced 3.22 kwh against earlier 2.68 kwh per litre of diesel, Figure 5.13. The specific electrical energy consumption reduced to 0.53 KWH from 0.65 KWH per case, Figure 5.14.

5.5.2 Water Conservation

With the higher rate of population growth and industrialization, requirement of water will continue to expand at an alarming rate. But good quality water resources are fast depleting and the level of ground water is decreasing day by day. Also disposal of wastewater is becoming more critical to protect the environment. Water conservation is an absolute must for the process industries which consume large amount of water and it becomes imperative that water management should be carried out, consolidated and followed effectively. This means that proper water conservation methods should be adopted in order to reduce the consumption in the plant. In this research, an attempt is made to reduce the water consumption. An audit has been done to study the water usage, its requirements and steps to be taken to minimize the consumption and decide on the conservation measures. Such a study leads to the identification of stages where water wastage could be reduced, recycled and thereby results in additional earnings for the company and also it protects the society from health hazards due to treated effluent water disposal. The analysis has been meticulously carried out and specific
Suggestions have been made which resulted in significant reduction in raw water usage.

It is the prime obligation of everyone to minimize water usage and dispose the used water to streams, lakes, land and oceans as clean as possible and without pollutants particularly from industries. People can alter the water cycle but little, so their primary supply of water is firmly fixed. But it has to be managed and conserved.

5.5.2.1 Wastewater Reduction

Successful wastewater reduction begins with a commitment to reduction policies and goals. Examine all wastewater streams for source reduction, reuse and recycling - in that order.

- **Source Reduction**: Do not produce it in the first place; Prevention of wastewater generation is the ultimate and perhaps most cost-effective waste management strategy.
- **Reuse**: Give it a second life; reuse the water wherever possible
- **Recycling**: Recover the resources; Recycle to reduce wastewater generation; these approaches should be considered after source reduction and reuse.

Other important components of minimization of waste policy are

- Establishment of wastewater reduction goals. A goal of “zero waste” is something to work toward. A zero waste goal targets all wastewater for reduction.
• Making waste reduction a part of doing business, just as worker safety and production quality.
• Select a wastewater task force or committee. This is a vital step for reviewing waste reduction and recycling alternatives, overseeing program development, recommending an action strategy and monitoring program implementation.
• Planning for waste reduction begins with prioritizing wastewater streams on the basis of toxicity, volume, cost and ability to reuse.

5.5.2.2 Water Conservation Team

Successful water conservation and wastewater reduction implementation requires teamwork. If managers and employees work together and are committed to the goal of reducing waste, it will see positive results. The evaluation team can also

• Educate managers and employees about wastewater management issues in general.
• Enhance communication between managers and employees about business processes and procedures
• Encourage employees and managers to voice their opinions and suggestions about wastewater reduction.

The manufacturing unit generates large quantities of low solids waste water from washing down of plant equipment, such as tanks, filter presses and bottling plant. The effluent water contains a low level of Biochemical Oxygen Demand from extra neutral alcohol (ENA) distillation process. The load factors are not hazardous, but the sheer volume of wastewater can cause problems. The
wastewater quality fall into three categories of low level bottling, medium level-distillation to get extra neutral alcohol from rectified spirit and zero level-cooling towers. The wastewater does not biodegrade easily and quickly generates offensive odours if left to stand in ponds. Suggested modifications and resources recovery are

- High pressure spray nozzles in bottle washing machine
- Spray balls for cleaning tanks
- Portable high pressure jet pump for cooling tower cleaning.
- Wiper blades to physically wipe down the sides of caramel mixing tanks.
- Use pumps with mechanical seals to eliminate gland leakages.
- Use control valves to avoid overflow
- In-process recycling; Reuse spent-lees as hot process water for dilution of RS in distillation plant.
- Collect and utilize Bottle rinsed water or water runoff from bottling areas for use/reuse as Cooling Tower, Boiler or Floor wash water
- Collect the low suspended solid Sand Bed & Activated Carbon Filters back wash water and reuse after treatment
- Improve recyclability: Segregate the various process waste streams. Using specialized treatment systems can be more cost effective than utilizing a large complex treatment system for combined waste streams.

The information system is designed and developed to cover entire area of water management of the plant. It provides information at various levels
for monitoring water conservation measures. The system captures the following data for better control of the plant operation:

- Water consumption area-wise
- Energy consumption for water pumping area-wise

**Specific water consumption**

\[
\text{Specific water consumption} = \frac{\text{Volume of water consumption in litres}}{\text{Volume of product in litres}} \tag{5.10}
\]

From the analysis, after the implementation wastewater reduction strategies and continuous follow-up with the help of MEPIM, it is evident that the significant raw water usage reduction is achieved in the plant (Stephan Thangaiah et al. 2001i). The water consumption pattern area-wise is given in Table 5.6.

After implementation of new strategy, it is found that the quantity of recycle water from bottle rinsing to cooling tower, boiler, toilet flushing and floor washing after treatment is 69 million litres per year. Reuse of used water within the system in distillation process and back wash water from sand bed and activated carbon filtration plant is 72 million litres per year. Because of this recovery the raw water pumping from bore well is 50.53% only, i.e., 144 million litres per year against the earlier requirement of 285 million litres per year. The specific water consumption is reduced from 7.05 to 3.53 volumes per one volume of liquor.
Table 5.6 Water Consumption Area-wise

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water Consumption, KL</th>
<th>Distribution in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottling - Block I (6 Lines)</td>
<td>170 51000</td>
<td>18.78</td>
</tr>
<tr>
<td>Bottling - Block II (4 Lines)</td>
<td>130 39000</td>
<td>14.36</td>
</tr>
<tr>
<td>Process Water - distillation</td>
<td>180 54000</td>
<td>19.89</td>
</tr>
<tr>
<td>Product Water - blending</td>
<td>72 21600</td>
<td>7.96</td>
</tr>
<tr>
<td>Cleaning Tanks</td>
<td>8 2400</td>
<td>0.88</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>100 30000</td>
<td>11.05</td>
</tr>
<tr>
<td>Boiler</td>
<td>95 28500</td>
<td>10.50</td>
</tr>
<tr>
<td>Water treatment back wash</td>
<td>120 36000</td>
<td>13.26</td>
</tr>
<tr>
<td>Canteen</td>
<td>40 12000</td>
<td>4.42</td>
</tr>
<tr>
<td>Toilet and Floor Washing</td>
<td>35 10500</td>
<td>3.87</td>
</tr>
</tbody>
</table>

With the reuse of spent lees at 95°C as a hot process water for dilution of rectified spirit in ENA distillation reduces the process water requirement of 180 KL per day; also saves the furnace oil of 372 KL per year. The water conservation methods reduces the raw water usage from 950 to 480 KL per day, which is a total reduction of 141 million litres of water per year.

The treated effluent water of 263 KL per day is used for gardening instead of the earlier quantity of 728 KL per day. The day to day operation of collecting water for recycling, pumping and irrigation system using treated effluent water are monitored with the highest priority to protect the environment.
Wastewater generation reduction techniques available range from the elimination of leaks in process equipment to the installation of state-of-the-art technology in production equipment. The techniques may be classified as improved operation and maintenance methods for reuse/recycle and equipment modification to eliminate wastage. Using this information a range of reduction techniques is identified and valuated, and cost-effective options implemented to conserve water.

**Organizational Change:** In a distillation plant, capacity utilization, efficient running of the plant and upkeep of the plant and machinery play a major role on energy and water conservation. With the help of IMS, the information about water usage, fuel consumption, RS feed, ENA produced, fuel factor, yield percentage and specific electrical energy consumption are available on line for controlling and monitoring. After implementation of MEPIM, it is found that the furnace oil is major factor in increase of cost in the process of converting RS into ENS. Its consumption is highly related to capacity utilization of plant. So controlling the boiler operation and fuel account should be the responsibility of Process Manager along with running the plant.