UNIT 14 EQUIPMENT AND MACHINERY

Structure

14.0 OBJECTIVES

After studying this unit, you should be able to:

- know how the equipment are selected, installed and maintained in a food processing plant;
- visualise how the different ergonomical factors influence the design and arrangement of equipment and work area; and
- acquaint yourself with different managerial skills such as proper maintenance planning, management of inventory of spare parts and good manufacturing practices, which help in improving the performance of equipment and workers in an industry.

14.1 INTRODUCTION

In this unit we shall discuss about the different factors for selection of equipment for a fruit and vegetable processing plant. You will observe that the

entrepreneur can himself decide the type of equipment with a proper understanding of different unit operations that are to be carried out in the processing plant. Then we will discuss how the human factors such as body posture, selection of tools, environmental factors, etc. affect the selection and installation of different equipment and improve the work efficiency. You will also know about the different maintenance and inspection schedules, workers' safety and spare parts management aspects. Our basic objective in this unit will be to understand the skills needed to upkeep the operational area and equipment, minimise the plant downtime, and to improve overall performance of the setup.

14.2 SELECTION OF EQUIPMENT

In the previous unit, we discussed about the plant layout and how a proper plant layout helps in maximisation of profits. After we have decided the process, prepared a good plant layout, and have constructed the building as per requirement, the next job is the selection of equipment and their installation. In fact these considerations start even before the civil construction work is started. We must remember that the equipment constitutes a major part of the initial investment and if not decided properly, may create problems in future. The problems could be of many types, such as low performance than rated capacity or frequent disorders. Sometimes the workers do not find the equipment comfortable to work with. Therefore, we must be very careful for selection of each individual equipment for the processing plant.

14.2.1 Selection Procedure

The selection of the types and sizes of equipment for the process plant requires considerable experience. However, as most of the food processing operation that we will be dealing with are established ones and are in operation elsewhere, the task becomes chiefly of comparative evaluation of standard equipment available from different manufacturers, scaling of the equipment and accessories up and down, and incorporating pertinent improvements that previous users have suggested.

First, we have to list the required equipment from engineering flow sheets. The next step is to make the necessary design calculations with the help of an expert and prepare the specifications for each equipment. The equipment not only include the major processing equipment and boilers, but also other accessories as suitable weighing scales, small hand tools, sieves, basins, buckets, and quality assurance equipment. If outside bids are required, detailed specification sheets must be presented to suppliers.

Standard vs. special equipment

We may use standard equipment already available in the market, or may design and fabricate equipment as per our need. However, use of the standard equipment is always better as it has the following advantages over the specially fabricated equipment.

- The initial investment for standard equipment will be significantly lower as compared to the special equipment.

- The duplication of equipment is easier.

- The repair and maintenance are easier and standard spares are easily available. Most often the equipment comes under a guarantee of satisfactory performance.

- Standard equipment has gone through long periods of experimentation and has been tested elsewhere. Usually it is the result of many modifications of its original design.

Hence, unless it is absolutely necessary, we should not be involved in the design of equipment. When we are sure that we have completely exhausted the trade literature for our requirements, then only we should think of design of a special equipment.

Specifications and competitive bidding

As we discussed earlier, a range of equipment for almost all types of operations in any food processing plant are available; our job is to specify our requirement for a particular duty and then select suitable machines from the above range. The specification should contain all essential information such as characteristics of the material handled, kind and quality of service requirements, delivery requirements and quotation. A comparison of the different machines available in the market often helps our decision with respect to principal components, materials of construction, service requirements, and accessories furnished along with the cost. Minor modifications may be suggested for an equipment for particular applications. We must also consider the delivery time, experience, and reliability of the supplier before final selection of the supplier.

14.2.2 Example of Selection of Equipment

Standard guidelines for selection of different types of process equipment are available in different *Chemical Engineers Handbooks*. For a general understanding of these guidelines, we will discuss about the selection of a dryer in the following paragraphs.

Drying equipment can be classified according to the following design and operating features.

1. Batch or continuous.
2. Physical state of feed: liquid, slurry, wet solid.
3. Method of conveyance of the solid: belt, rotary, fluidised.
4. Heating system: conduction, convection, radiation.

Dryers can be either batch type or continuous type. Batch dryers are normally used for small-scale production and where drying cycle is likely to be long. Continuous dryers require less labour, less floor space and produce a more uniform quality product.

The choice of suitable drying equipment cannot be separated from the selection of the upstream equipment feeding the drying stage. The main factors in the selection of drying equipment are the nature and concentration of the feed. For

example the dryer to be selected for drying tomato paste will be different from the dryer for drying peas. For the first case a drum or spray dryer is considered suitable, and in the second case a fluidised bed dryer is better as it gives a more uniform product with higher drying rate for particulate solids.

In general with solids feeds, the material should be placed in the drying chamber in such a way that it will produce a bed of solids with an open, porous structure. For pastes and slurries, some form of pre-treatment such as extraction or granulation is often needed.

Besides the feed condition and the initial liquid content, the other product factors, the required quality of the end product such as its physical form and dryness, and the heat sensitivity of the product also play a major role in selection of the dryer. Hot air is mostly used as drying medium in industrial dryers. The air is directly heated by electrical heating coils, gas or oil, or indirectly heated, usually by banks of steam-heated finned tubes.

A range of dryers is available for use in a food processing industry, viz. tray dryers, conveyor dryers, rotary dryers, fluidised bed dryers, pneumatic dryers, spray dryers, drum dryers, infrared dryers. Our type of dryer should be picked from these available types depending on our requirement. After the type of dryer to be installed has been decided, the capacity of the dryer is decided based on the throughput required.

14.2.3 Other Considerations

After a brief discussion on some general guidelines, some more points that need consideration before making the final selection for any equipment are:

- How many operators are required to operate the equipment and the kind of technical knowledge they must possess?
- Whether servicing the equipment needs outside technicians or can it be serviced by available staff?
- What is the power consumption of the equipment?
- Whether the equipment can be easily cleaned and sanitised?
- What is the durability of the material used in the equipment?
- Whether the equipment is silent or noisy when operating?

14.3 MOVEMENT AND INSTALLATION OF EQUIPMENT

In our every day experience we observe many physical equipment and facilities, which are not suitable to use because of their installation features. Examples include kitchen sinks that are too low, uncomfortable chairs, narrow staircases, very little space near a equipment that needs repair, and so on. Therefore, installation of the equipment is as important as the selection of proper equipment.

In most of the cases the manufacturers take up the responsibility of proper packing of the equipment so that it does not damage during transit. The

movement within the plant is done by labour or by trolleys or cranes. They may also take up the installation job with or without charging an extra amount. However the plant manager has the responsibility to check that the machine/equipment is properly installed for convenient working, cleaning and maintenance operations. The machine should have a proper foundation. In particular the machines which produce significant vibration and noise should have a proper base. Sufficient working space should be kept around the machine.

Almost all equipment are designed for standard people. But installation is very important for comfortable working for a special group of people. The physical location and arrangement of such items (and of their specific features) can affect the comfort of the users as well as physical well being. For example, the comfortable working height of the tables and control panels will differ for ladies and gents. Therefore, special care should be taken during installation of equipment, working tables, etc. which could ultimately affect the work performance.

14.4 ELECTRICAL WIRING

A factory generally needs 3 phase 4 wire supply. For motors whose ratings exceed 2 or 3 kW, 3 phase 3 wire supply is required; and for light and fan circuits single-phase supply is required.

For internal wiring for supply to motors, conduit system of wiring with vulcanised Indian rubber (VIR) or PVC insulated cables of suitable size are used. The conduits are usually run on surface rather than laying them in covered trenches to facilitate additions and alterations. Use of separate conduit for every motor is preferred. The conduit used in power wiring should be electrically continuous throughout and connected to the frame of the motor. The frame of the motor is to be earthed by two separate and distinct connections to earth. Under-ground cables are preferred for very large capacity motors.

In domestic installations single earthling is sufficient but in an industry double earthling of motors, medium voltage regulating or controlling equipment etc. is necessary. Circuits and sub-circuits to 400 V motors must be provided with fuses on all poles, i.e. on all three phases of the a.c. supply.

In a large industry, power distribution is made from a suitable location, known as distribution centre, through a switchboard. This switchboard consists of a set of insulated bus bars. Each incoming and outgoing circuit is controlled by an automatic circuit breaker (or linked switch and cutouts). The outgoing circuits feed different sub-distribution boards erected at convenient places, which further distribute power to a number of equipment. A line diagram, showing the tapping supply from bus bar chamber to the individual machine is shown in Figure 14.1. In small industries, sub-distribution boards are not needed and a switchboard or distribution board is used for distribution of power. All equipment used in power wiring should be of iron clad construction and wiring shall be of the armoured cable or conduit type. Every motor, regardless of its size, shall be provided with a switch fuse close to it, and with a suitable starter placed at a convenient place. The starters are used to limit the starting current to a desirable value. Electrical wiring diagrams must be prepared for all

sections and a qualified/trained personnel should be given the responsibility of electrical wiring of the complete plant.

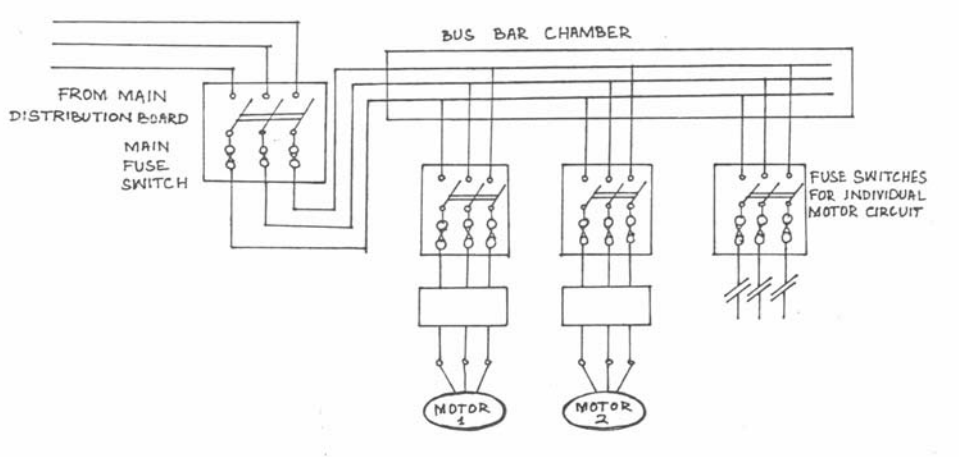

Figure 14.1: Supply from busbar chamber to individual machines

14.5 ERGONOMIC CONSIDERATIONS

The word ergonomics is derived from the Greek words 'ergon' (work) and 'nomos' (law). In the United States, the term 'human factor' is used for ergonomics. It is defined as the scientific discipline concerned with understanding the interactions among humans and other elements in a system, and the profession that applies theory, principles, data and methods to design, in order to optimise human well being and overall system performance. In other words ergonomics aims to design appliances, technical systems and tasks in such a way as to improve human safety, health, comfort and performance at work and everyday life. Motivating the man at work and making the work to suit him is the prime objective of ergonomics.

The application of ergonomics includes plant and workspace layouts, selection, training and placement of personnel, design of equipment, power tools, displays, jigs, fixtures, and even furniture, motivation of the worker, working conditions and environments, and computation of relaxation allowances.

The ergonomical factors include body posture and movement (standing, sitting, lifting, pulling and pushing), environmental factors (noise, vibration, illumination, climate, chemical substances), information on different machines and operational characteristics (information gained visually or through other senses, controls), as well as work organisation (type of task, nature of job, etc., whether the job is interesting or not?). Brief descriptions on these factors is given below.

14.5.1 Body Posture and Movement

Posture and movement play a vital role in ergonomics. Poor design or installation of equipment, technical systems and tasks has often reported to cause back pain, psychological illness (e.g. stress) and occupational disability. In addition, it also reduces performance and sometimes leads even to accidents. Some of the ergonomic considerations may be that the important components should be placed in convenient locations. The body size of the workers should be kept in mind for designing the working tables. Particularly the assembly

tables and packaging section need special attention as in a food processing plant the workers need to stand or sit at a constant place for longer times. During movements, the body joints ought to be kept as far as possible in a neutral position. The workers should not be overloaded during conveyance of loads. Lifting accessories like lever, raising platforms and cranes and transport accessories such as conveyor, sack barrow, mobile raising platform, forklift, etc. should be used wherever possible.

14.5.2 Environmental Factors

The environmental factors such as noise, vibration, lighting, and climate can affect people's safety, health and comfort. The chemicals do also affect. The presence of high noise levels during a task can be annoying and prolonged exposure can result in impaired hearing. The noise level should be below specified levels; in most cases it is 80 decibels.
Ensure that floors are hard and even, and machines have proper foundation. It not only reduces vibration and noise, but also avoids other types of accidents. Well-maintained machines are quieter. There must be proper illumination in all parts of the factory. The air temperature, humidity and ventilation affect the comfort and productivity of the workers. The location of the building and its surroundings, convenience of transportation, size and number of rooms, design of ceiling heights and slopes, windows, style of architecture, type of building materials, colour, cleanliness, etc. are considered under environmental factors, which affect the work performance.

14.5.3 Information and Operation

The workers should be well informed about the work they are doing, with their important contribution in the work. They should feel responsible for their role in the final product development. This way they will be more involved in the work and their performance will increase. Suitable warnings at desirable places, display of the steps of operation and maintenance of the machines, putting different colours for different switches, etc. are some ways to improve the performance of equipment and workers, and reduce accidents.

14.5.4 Work Organisation

The worker must find the equipment comfortable, and he must enjoy the technical systems and tasks, which can be achieved by proper work organisation. Selection of the right kind of tool come under this category. Suppose we use a dull knife in cutting of vegetables, we expend a lot of extra energy that is, in effect, wasted. It is also important to train the workers on the proper way of using the tools. Further, the tools can not be designed in isolation. Often a redesign of the workspace, which includes the work envelope, work surfaces (such as desks, tables, etc.) and seats (if used) as well as the design and relocation of equipment used. The important components need to be placed at convenient locations.

You must bear in mind that safety can be improved by 3 E's, viz. education, engineering and enforcement. A range of ergonomic subjects is covered by international ISO standards, European EN-standards, as well as national standards. In addition, there are specific ergonomic standards, which are

applied to individual companies and industrial sectors. These should be followed for the overall effectiveness of the industry.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the advantages of standard equipment over special equipment?

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2. What are the main ergonomic considerations during arrangement of work space and design of tools?

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14.6 UPKEEP OF OPERATIONAL AREA

Proper upkeep of operational area improves performance of workers and increases production. A systematic and scientific maintenance of operational area assures instant operational readiness and optimal availability for production at all times without compromising on the safety of man and machine. It also reduces worker frustration and improves job satisfaction, which in turn improve the working life of personnel, and productivity.

The health and safety of both workmen and machines need careful maintenance. This is more important for a fruits and vegetables processing plant where they affect food safety. The orderliness and cleanliness of the workplace has to be assured to improve total productivity and the conditions of the labour force, and to avoid accidents. There should be proper light and aesthetic environment.

For most projects, a maintenance planning system is included in the preparation stage of the project to protect the investment in machinery, plant and buildings through regular and adequate maintenance. These all help in reduction in downtime, which is very significant in a food processing plant, as we have the responsibility to process the produces within the shortest possible time after harvest. Further, with ever increasing cost of labour and material, this is good economy also. It maximises the utilisation of labour and other resources and prevent waste of spares, tools and materials.

14.7 MAINTENANCE AND INSPECTION SCHEDULE

14.7.1 Maintenance Scheduling

You must have experienced the importance of scheduled maintenance for the performance of any machine. For example, we change the gear oil of our motorcycles after every 3000 km of running as a scheduled maintenance practice. A **maintenance schedule** is the sequential arrangement by which maintenance is done. In an industry, the schedule indicates, what is the work to be done, how often it is to be done, by which it is to be done, and the estimated time required to complete the work. Separate schedules have to be prepared for each type of maintenance activity, and for each equipment/machine.

The decision on a sequence is based on the priority, the availability of spares, materials and specific tradesman. It should be remembered that most critical equipment has to receive prompt attention in maintenance caring and should be the first items to be scheduled. The other priorities could be emergency breakdown, preventive maintenance, predictive maintenance, and/ or other maintenance systems prevalent in the organisation.

The guideline for the maintenance are often laid down by the manufacturer. But the actual conditions of operation, the severity of use, and the skill level of operators are also to be considered. Schedules must be made in two parts: the **long term schedule** to be made 8-12 weeks in advance, and the **short term schedule**, just a week or two in advance. This will help in preparing and planning in advance for materials, spares, tools, and test equipment. The short-term schedule is finally broken up into daily schedules for day-to-day implementation and for assuring that close control would be exercised. The supervisor assigns work individually to each worker and keeps him informed as to what work is expected of him within a small frame of time limit, may be the next morning. This allows the worker to plan his own activities. Revisions in schedules are expected, and hence, they must be kept flexible enough to accommodate any change.

14.7.2 Inspection Scheduling

Inspection is the examination of equipment and machines or their parts to determine their condition. Periodic inspection helps detect extent of deterioration and plan for its repairs and rectification, or if need be, even make replacements before an actual breakdown occurs.

Take for example the daily inspection routine for a fan or a pump would involve carrying out checks for:

a) any abnormal vibrations, or any abnormal noise;

b) the temperatures of all the bearings to ascertain that they are at acceptable levels and that there is no overheating;

c) leakages from the glands and gauge to see whether they are excessive;

d) oil levels in cups; and

e) grease nipples to ensure that they are not dry.

Different checklists are required for the same machine, depending on whether the machine needs a weekly, monthly or annual check up.

The frequency of inspection is affected by many factors, such as:

a) age of the machine or equipment, its condition and value;
b) severity and intensity of service;
c) hours of utilisation- are they prolonged- or intermittent;
d) susceptibility to wear and tear or any other damage;
e) susceptibility to losing adjustment during use- Will the maladjustment and non-alignment affect the accuracy or functioning? Will the lack of proper balancing affect performance?
f) safety requirements and considerations;
g) criticality of item- if the item is very critical, then it may need daily inspection.

14.8 PERIODIC MAINTENANCE PRACTICES

14.8.1 Classification of Maintenance System

The different maintenance systems can be classified as: a) Breakdown maintenance, b) Routine maintenance, c) Planned maintenance, d) Preventive maintenance, e) Predictive maintenance, f) Corrective maintenance, g) Design out maintenance, h) Total productive maintenance, and i) Contracted out maintenance.

Breakdown maintenance or repair maintenance is carried out only in case of a need of repair or when the machine ceases to work. **Routine maintenance** involves routine checks such as daily lubrication and inspection of the machines, monthly inspection of motors. **Planned maintenance** is maintenance organised and carried out with a predetermined plan depending on the machine's needs, expected requirement of the machines and manufacturer's recommendation.

Preventive maintenance system refers to the steps taken to reduce the likelihood of failures to the absolute minimum. **Predictive maintenance** can be defined as "methods of surveillance used to indicate as to how well the machine is, while performing its intended tasks". **Corrective maintenance** is defined as maintenance carried out to restore (including adjustment and repair on item) machinery, which have ceased to meet an acceptable condition. **Design out maintenance** (DOM) tries to eliminate or to minimise the need for maintenance to the lowest possible level.

The basic concept of **total productive maintenance** is to change the attitude and improve the skill of all personnel by using quality equipment. **Contract maintenance** is using specialised maintenance personnel on contract basis, mostly for specific equipment.

Each individual organisation, big or small, simple or complex, or using highly advanced or simple technology must choose the maintenance system that suits it best. Total maintenance planning includes: a) inspection, b) lubrication, c) planned maintenance, d) preventive maintenance, e) predictive maintenance,

f) corrective maintenance, g) modifications h) retrofits, i) refurbishing, j) overhaul, k) replacement of equipment, l) discarding of equipment, m) standardisation, n) material requirement planning, o) spares planning, p) documentation, q) spare parts manufacture, r) exercising of spare parts and sub-assemblies held under long term storage (Particular attention should be given to rubberised components).

14.8.2 Maintenance Steps in a Fruit and Vegetable Processing Plant

In general the maintenance steps for a general food processing plant includes following steps.

- Carry out a visual check of the equipment and all operational area for cleanliness.
- Check if safety devices are present and functional. If not, do not operate the equipment.
- Operate the machine and check for any unusual noise, vibration, friction and instruction.
- Check if lubrication cups are replenished to correct levels and grease nipples so that they are not dry; then operate the machine. This is mainly required for conveying machines and elevators.
- Never operate the machine beyond laid down conditions of speed and feed.
- Make sure that no tools or any smaller parts of containers, glass pieces, etc. have dropped inside any equipment.
- Follow the manufacturer's recommendations for maintenance of each individual equipment.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. How proper maintenance and inspection help improve performance of a food processing plant?

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2. What is a maintenance schedule?

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14.9 INVENTORY OF SPARE PARTS

An **inventory** is a stock of materials used to facilitate production or to satisfy customers. All idle resources other than materials are considered as capacity, e.g. equipment or idle workers. Capacity is used to produce, while inventories are the products at some point in conversion and distribution process.

Spare parts are those parts of machines, which because of wear and tear, use or breakage, need replacement. However, it is often not possible to obtain each and every spare in the market as and when needed. Besides, purchasing anything in small quantity is expensive also. There is also chance of getting improper spares. Hence it is necessary for any industry to carry inventories of frequently used spare parts. In particular, in a food industry when the work is in progress inventories of spares are an absolute necessity.

The finance department generally prefers to keep the inventory level low to conserve capital, marketing prefers high levels of inventories to enhance sales, while operations department prefer adequate inventories for efficient production and smooth employment levels. Inventory management must balance these conflicting objectives and manage inventory levels in the best interests of the factory as a whole.

The decision problems in inventory management are a) which items should be carried in stock, b) how much should be ordered, c) when should an order be placed, d) what type of inventory control should be used. Whether to buy a spare or make it in the workshop / local market is another criteria. This decision is dependent on the cost, assurance of availability, opportunity to control quality, availability of equipment and expertise, desire to preserve confidentially, and saving in transportation costs.

14.9.1 Optimisation of Total Cost of Inventory

What is the quantity to be purchased is one major decision in inventory management. The **economic order quantity (EOQ) model** is a tool, which helps to know the quantity that will optimise the total cost. The motivating factor to control inventory is the cost incurred by carrying it. The different costs involved in the calculation of the total cost are:

1. **Item cost** or the cost of buying or producing the items;
2. **Ordering** or **setup cost,** which is the cost of getting an item including the cost of transportation, and salary of personnel working in stores and stock verification department;
3. **Carrying** or **holding cost,** which includes capital cost, storage cost or rents, depreciation charges, cost due to deterioration of the part or obsolescence; and
4. **Stock-out cost**, which reflects the economic consequences of running out of stock, since the sale is lost if material is not on hand. The profit is lost on sale, and good will in the form of future sales.

The quantity, which optimises total cost, is known as **economic order quantity (EOQ)**. For a general case, EOQ is given by,

$$\text{EOQ} = \sqrt{2C_o M /(C_c p)}\,,$$

where, C_0 is the order cost or setup cost, Rs. per order,

C_C is the carrying cost, expressed as percent of Rs. values per year,

M is the annual consumption, units per year, and

p is the unit price, Rs. per unit.

We will see the applicability of this formula with the help of a small example. A fruit processing plant purchases 600000 bottles per year for handling juice. The order cost is Rs. 70 per order, and the carrying cost is 15% per year. If each bottle costs Rs.2 only, find out the economic order quantity?

Solution

$$\text{EOQ} = \sqrt{2\frac{(70)(600000)}{(0.15)(2)}} = 16733 \text{ units.}$$

It means that the plant should purchase 16733 bottles at a time. This will result in 600000/16733 = 36 purchases per year, i.e. one purchase almost in every 10 days. This quantity will involve minimum total cost for maintaining the inventory. Now, check that if the order cost is increased to Rs. 210 per order, the EOQ will be 28983, i.e. the plant has to purchase 28983 bottles in each order to minimise the total cost. In that case it will go for 20 purchases in the year.

We suggest you to change the unit price and other parameters and see how these changes affect the EOQ. You will observe a definitive change in the EOQ with changes in the above parameters. Even though the EOQ model has several limitations as it assumes a constant demand, a constant unit price, a constant setup cost, etc. throughout the year, still it is widely used in the industry as a standard tool for the inventory management.

14.10 MINIMISATION OF EQUIPMENT DOWNTIME

As we have already discussed, the downtime for any equipment or for the complete plant can be reduced by proper upkeep of operational area, by properly scheduling the maintenance and inspection, and judicious management of the inventory of spare parts. In this section we will give a closer look at this area.

14.10.1 What is Downtime?

Downtime in general may be considered as the time when the plant or any specific equipment is down or not performing. Thus the downtime directly affects the production. However, downtime does not always imply / cause a direct production loss. There are certain conditions under which downtime does not create a production loss, e.g. when the plant does not operate at full

capacity utilisation level, or when the completely processed product is not lifted for delivery to customers but is stored.

14.10.2 Reasons of Downtime

The main reasons for downtime in an industry or a section are as follows:

- Breakdown of a machine due to any reason.
- Failure in power supply or load shedding.
- Non-availability of suitable raw material.
- Improper planning, scheduling or machine loading.
- Lack of proper tools, jigs or fixtures.
- Non-availability of calibrated test equipment.
- Shortage or absence of operator.

14.10.3 How to Reduce Downtime

Once we know the different possible reasons for downtime in our plant, the planning to reduce the downtime becomes much easier. Both the operator and the maintainer have to jointly make efforts to lower and control down time.

Simple dos and don'ts are to be specified for an operator, which if followed can eliminate a large number of breakdowns. For example, before the start of the machine the operator should check all the safety devices, lubrication points and cleanliness. Then he should operate the machine for a short time to check for the presence of any unusual noise, vibration, friction, etc. The management should have the responsibility to educate and train the workers on these aspects.

Some basis steps that are useful in reduction of downtime are as follows:

- Adopt proper maintenance planning, maintain and carry out repair of buildings, utilities and allied equipment.
- Ensure scheduled inspection and lubrication of all necessary points
- Adopt rapid fault-finding systems and the use of diagnostic charts
- Ensure and carry out faithful recording and documentation of all maintenance work, and review of the records. Analyse repetitive failures of any particular equipment and replace the faulty parts / redesign the machine.
- Standardise equipment for replacement and purchase.
- Monitor procurement of spare parts and material for maintenance.
- Design and enforce safety standards.
- Recruit and train personnel to carry out maintenance work.

It is very important to record all breakdowns with care and absolute accuracy, so that the parts that have failed may be segregated and analysed to find out the

reasons for the failure. Every single person working in the maintenance department must know his or her exact function. Once the cause has been diagnosed, corrective actions are to be planned and taken. We must understand that it is a collective job and all persons associated in the plant operation have individual important responsibilities for reduction of downtime.

14.11 MAINTENANCE OF RECORDS

It is very important for an organisation to maintain different records and document them properly. This is quite beneficial. For example, if the job cards and history record cards are properly maintained, one can choose machine or equipment wise information about how much has been the annual maintenance cost on each of them.

Facility register: A facility register is a complete list of all the machinery, plant, equipment and buildings, which have to be maintained. If the number of such items is very large, then they can be maintained in different groups depending on their usage, technical practices, or by the maintenance methods which are being used. For example, a food processing plant can be divided into sections by their maintenance needs. The shut down can be done section-wise for maintenance. This can help in working at all other sections while a particular section is undergoing maintenance. Such types of information are maintained either by cards or by computers.

Equipment record card: An equipment record card or **Plant record card** keeps all information about each individual machine, such as the name and address of supplier, date of purchase, price, etc. It is very useful when a repeat order has to be placed for procurement after many years and the necessary information is not available from any other source.

History record card: A history record card or **Log card** carries information on all corrections, replacements, repairs, and other modifications that have been carried out on a particular equipment from the day it was inducted to the day it is scrapped, or disposed of. If an equipment is moved from one section to another, its History record card has also to move along with it. The card is quite helpful in analysing the total downtime, the frequency of occurrence of specific faults, and which parts or spares are frequently being replaced. Thus it will help in making standardisations and replacement decisions.

Defect analysis record: This is another type of record, where the focus is on defect analysis.

Besides, the food processing plant has to maintain several other records related to financial and marketing departments, operation departments, etc., which help in the analysis of raw materials status, production status, money flow and similar factors of interest to the plant manager.

14.12 CERTIFICATION

In India, the fruit and vegetable processing industry come under the **Fruit Products Order (FPO)** issued by the Govt. of India. No person shall carry on the business of a manufacture except under and in accordance with the terms of

an effective license granted to him. A manufacturer using different manufacturing premises for manufacture of fruit products shall take out a separate license from each such premises.

The FPO has many quality standards relating to production, quality of processed products, and packaging aspects. It also covers the **Prevention of Food Adulteration (PFA)** Act. FPO has standards for the sanitary requirements of a factory manufacturing food products. The 2nd part of the 2nd schedule has specifications for different types of processed fruits and vegetable products. This is just to acquaint you with the FPO. For details, I suggest you to go through the draft of the FPO.

You must have also heard about **International Organization for Standardization (ISO)** certification. At present there are two series: ISO 9000 series and ISO 14000 series. ISO 9000 is concerned with "quality management". This means what the organisation does to enhance customer satisfaction by meeting customer and applicable regulatory requirements and continually improving its performance in this regard. ISO 14000 is primarily concerned with "environmental management". This means what the organisation does to minimise harmful effects on the environment caused by its activities, and continually to improve its environmental performance. The vast majority of ISO standards are highly specific to a particular product, material, or process.

ISO standards contribute to making the development, manufacturing and supply of products and services more efficient, safer and cleaner. They make trade between countries easier and fairer. ISO standards also serve to safeguard consumers, and users in general, of products and services. This certificate is very useful to industrial and business organisations of all types, and to suppliers and customers of products and services in both public and private sectors.

There are several methods and tools to help with the implementation of a Food Safety Management System, such as **HACCP (Hazard analysis and Critical Control Points)**, **Good Hygiene Practice (GHP)** and **Good Manufacturing Practice (GMP)**. Together with a Quality Management System, e.g. ISO 9001, they form the basis for an overall Food Safety Management System.

Hazard analysis is the identification of all ingredients, stages in progress, environmental features and human factors that can lead to hazards for the customers. The risks and likelihood of their occurring is estimated. Critical Control Points are the points at which control is essential to guarantee that potential hazards do not become actual hazards. A CCP is a location, a practice, a procedure or a process, which if not controlled, can result in an unacceptable risk. Examples include inspection of goods at delivery or before use, correct temperature ranges during sterilisation or blanching, etc. Thus HACCP is preventive in nature and it protects the consumers from exposure to potential food hazards. Thus HACCP should be the top priority in any food firm.

A HACCP certificate proves that our food safety system has been measured against a best practice standard and found compliant. Issued by a third party accreditation body/registrar, the certificate proves to customers that we have implemented the necessary routines to ensure food safety. It is a prevention-

based food safety system. It provides a systematic method for analysing food processes, determining the possible hazards, and designating the critical control points necessary to prevent unsafe food from reaching the consumer. HACCP is based on the Codex Alimentarius developed by the Food and Agricultural Organisation of the United Nations and the World Health Organisation.

14.13 GOOD MANUFACTURING PRACTICES

A food processing industry has the responsibility to make safe and wholesome processed food available to the consumers. In addition, it has to take care of the sustainability of the industry. Hence, good manufacturing practice (GMP) should look at the above two factors.

The aim of good manufacturing practice in the food industry is to provide food that meets the consumers needs and wants, and also to give them the security of safety ad reliability. GMP is based on the knowledge and skills throughout the food system, from primary production of the raw materials, through processing of the industrial ingredients, manufacturing of the consumer products, distribution of the final retail products till the cooking and eating of the final food. The objectives of GMP are to control the changes in the food materials so as to develop desired qualities in the product, to ensure that the food is safe to eat, and to stop or slow down any deterioration in the food. GMP means understanding, analysing and controlling the manufacturing process.

GMP guidelines include location requirements, design of facilities, facilities to be provided such as supply of potable water and water standards, equipment selection, storage, pest control, packaging, transportation, personal hygiene, etc. It also includes training, maintenance of records, quality control, inspection and testing, verification, etc. It means it covers all aspects of food processing operation and management.

For example, GMP says that the food plant establishment should be located away from environmentally polluted areas and industrial activities, which pose a threat of contaminating food; areas subject to flooding unless sufficient safeguards are provided; areas where wastes can not be removed effectively; and areas prone to infestation of pests. GMP requires that the equipment should be located and installed in a manner that permits adequate maintenance and cleaning, functions in accordance with its intended use, facilitates good hygiene practices including monitoring. The equipment should be installed at a distance from the floor and walls to allow proper cleaning and avoid dirt accumulation (recommended minimum 30 cm from floor and minimum 60 cm from walls and other equipment). GMP requires that the conveyors in dry product area should be covered. Guidelines for plant layout, upkeep of operational area, electrical wiring, ergonomic considerations in arranging the work space and almost all the aspects that we have studied in this unit and previous unit come under the purview of GMP. Personal hygiene is a very important component of good manufacturing practice.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What do you call the quantity of purchase, which optimise total cost in inventory management?

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   ……

   ……

   ……

2. What are the different costs involved in the analysis of inventory?

   ……

   ……

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   ……

3. What are the main reasons for downtime?

   ……

   ……

   ……

   ……

4. Name some records that are maintained for equipment/machinery management?

   ……

   ……

   ……

   ……

5. Expand the following abbreviations?

   FPO – ……

   ISO – ……

   GHP – …..……..

   GMP – ……

14.14 LET US SUM UP

In this unit we have discussed about the different guidelines for selection of equipment for a fruit and vegetable processing plant, and other commissioning

features as movement and installation of equipment, electrical wiring. We also studied the ergonomic considerations for selection and installation of equipment for improvement in workers' performance. The different aspects of maintenance and inspection of equipment and inventory of spare parts are also covered which are very important for reduction of downtime. We also studied about the maintenance of different records, which are helpful in analysis of performance of specific equipment and make replacement decisions. Brief discussions on the certification aspects and Good Manufacturing Practice for a plant are also made at the end of the unit.

14.15 KEY WORDS

Ergonomics : The scientific discipline concerned with understanding the interactions among humans and other elements in a system, and the profession that applies theory, principles, data and methods to design, in order to optimise human well being and overall system performance.

Inventory : It is a stock of materials used to facilitate production or to satisfy customers

EOQ : It is the quantity, which optimises total cost in inventory management.

Downtime : It is the time when the plant or any specific equipment is down or not performing.

14.16 SELF TEST FOR THE COMPLETE UNIT/ ASSIGNMENT

1. Explain the different steps for upkeep of operational area and reduction of downtime?

2. Write short notes on (a) Ergonomics in a food plant design, (b) Inventory management, (c) Selection of equipment.

14.17 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. The initial investment for a standard equipment is lower and duplication of equipment is easier. The repair and maintenance are easier as standard spares are easily available. Standard equipment usually come under some guarantee and are usually the result of many modifications of its original design.

2. The ergonomical factors include body posture and movement, environmental factors (noise, vibration, illumination, climate, chemical substances), information and operation, and the work organisation.

Check Your Progress Exercise 2

1. Proper inspection and maintenance reduce the total downtime, ensure operational readiness, improve job satisfaction and improve safety of workers. Proper inspection helps detect the extent of deterioration of any equipment/machine or their parts, which helps repair/replacement before an actual breakdown occurs.

2. A maintenance schedule is the sequential arrangement by which maintenance is done.

Check Your Progress Exercise 3

1. Economic Order Quantity.

2. The different costs involved in the analysis are the item cost, ordering or setup cost, carrying or holding cost, and stock-out cost.

3. Zmain reasons for downtime are breakdown of a machine, failure in power supply or load shedding, non-availability of suitable raw material, and improper planning, scheduling or machine loading.

4. Facility register, Equipment record card or Plant record card, History Record Card or Log card and Defect analysis record.

5. Fruit Products Order
   International Organization for Standardization
   Good Hygiene Practice
   Good Manufacturing Practice

14.18 SOME USEFUL BOOKS

1. Dul, J. and Weerdmeester (2001). Ergonomics for Beginners 2nd Edition. Taylor and Francis, London.

2. Gopalkrishnan, P. and Banerji, A.K. (1997). Maintenance and Spare Parts management. 2nd Edition, PHI, New Delhi.

3. Gupta, J.B. (198)1. A Course in Electrical Technology. Vol.1, 7th Edition, B.D. Kataria & Sons, Ludhiana.

4. Lal, G., Siddappa, G.S. and Tondon, G.L. (1986). Preservation of Fruits and Vegetables. ICAR, New Delhi.

5. Vilbrandt, F.C., Dryden, C.E. (1959). Chemical Engineering Plant Design. 4th Edition, McGraw Hill, Tokyo. pp.1-188.