UNIT 9 PLANT LAYOUT, OPERATION, AND MAINTENANCE

Structure

9.0 OBJECTIVES

After studying this unit, you should be able to:

- list the various machines involved in a rice mill;
- understand the operation and maintenance of an Induction Motor;

- explain what is power factor and need for power factor correction;
- explain various types of power transmission;
- tell what is an Energy Meter and specify energy requirements of a typical rice mill; and
- understand the maintenance procedures in a rice mill.

9.1 INTRODUCTION

Even after paddy is harvested, threshed, winnowed and cleaned, it is still not yet ready to be eaten. In order for the rice to be ready for cooking, it has to undergo the process of milling. Paddy is milled in modern rice mills.

Paddy is an edible grain inside an inedible protective tough outer husk, which is called the hull. This hull or shell must be removed (shelled) before the rice can be eaten. Beneath the hull is a bran layer, which forms the skin of the seed. After it is hulled (the husk is removed), the grains are pearled, which means their bran layers are removed. This can also be called milling or polishing the rice. Because most consumers like white rice, an abrasive process often also polishes the grains where the grains are rubbed against each other and the special surface of the polishing machine. Rice is mostly eaten as a whole grain.

Paddy crop is processed in large modern rice mills, which can mill as much as one thousand tonnes of paddy a day. Paddy is poured in at one end of the mill. It is winnowed and re-winnowed to clean it of the last bits of unwanted chaff (seed covering) and dirt.

The finished rice is graded according to the amount of broken rice it contains. The lower the proportion of broken grain, the higher the quality of rice. Machines do the grading. Modern electronic sorting machines classify the color of each batch of rice; and automatically separate the different grades for packing. These modern sorting machines have electric "eyes" that look at each grain of rice. Rice that is broken or discolored is not accepted. These machines make rice sorting very fast and efficient. Some rice producing countries like Indonesia and India, do have large commercial mills. After this long process rice is finally ready to be traded, and consumed.

9.2 FLOW DIAGRAM OF INTEGRATED RICE PLANT

The basic rice milling processes thus consists of :

9.2.1 Process Definition

1. Pre Cleaning : Removing all impurities and unfilled grains from paddy
2. De-stoning : Separating small stones from paddy
3. Parboiling (Optional) : Helps in improving the nutritional quality by gelatinization of starch inside the rice grain. It improves the milling recovery percent during de-shelling and polishing / whitening operation
4. Husking : Removing husk from paddy
5. Husk Aspiration : Separating the husk from brown rice / un-husked paddy
6. Paddy Separation : Separating the un-husked paddy from brown rice
7. Whitening : Removing all or part of the bran layer and germ from brown rice
8. Polishing : Improving the appearance of milled rice by removing the remaining bran particles and by polishing the exterior of the milled kernel

9. Length Grading : Separating small and large broken(s) from head rice

10. Blending : Mixing head rice with predetermined amount of broken(s), as required by the customer

11. Weighing and bagging : Preparing the milled rice for transport to the customer

The flow diagram of the various unit operations is shown in Fig.9.1.

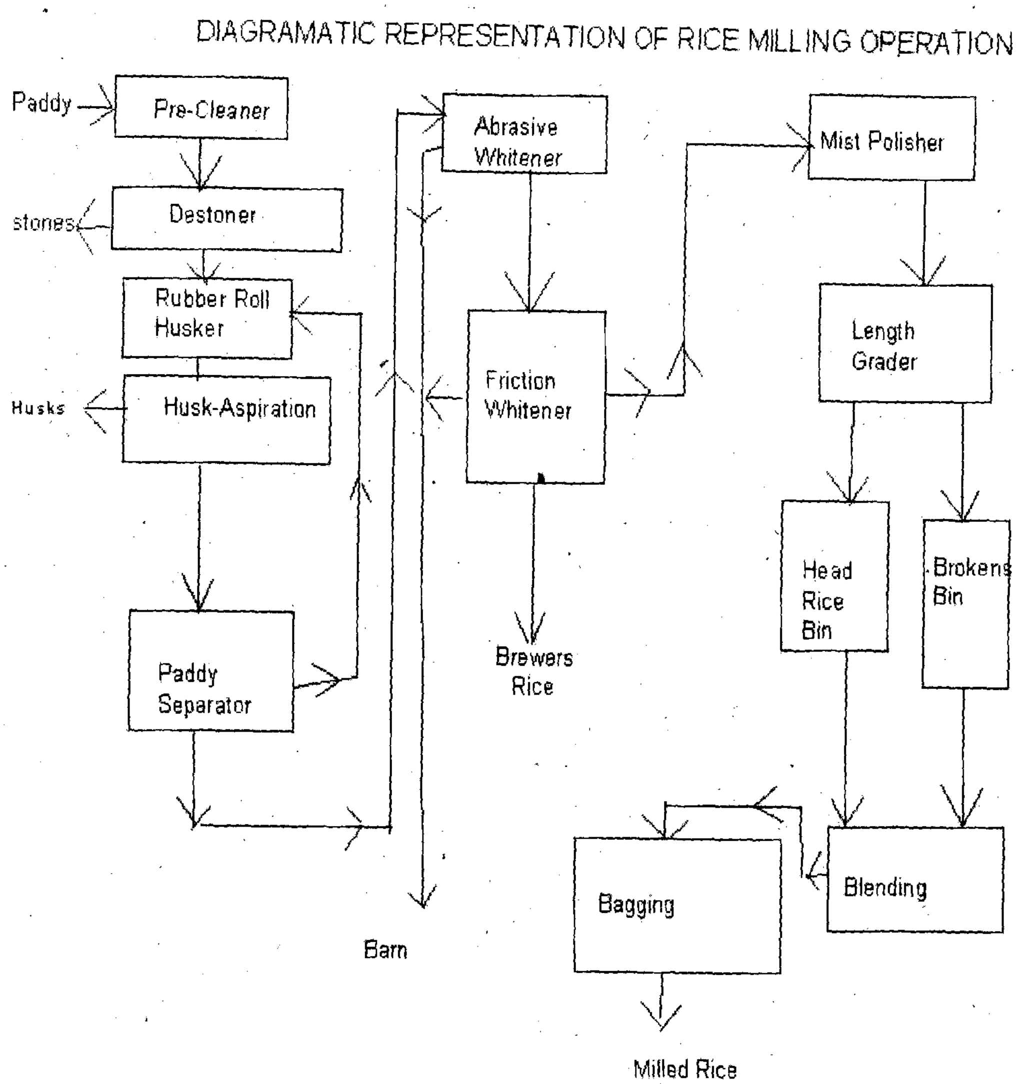


Fig. 9.1: Layout of a Rice Milling Unit

9.3 LAYOUT PLAN AND SITE DEVELOPMENT REQUIREMENT

The land requirement for establishing a rice milling unit will depend upon

1. Whether the unit will be using a parboiling unit for pre-treatment of paddy before commencement of milling operation or it will be directly milling raw paddy.

2. Whether a single pass or a multi-pass milling unit is to be installed.

Generally 2.00 to 2.50 acre of land is required for establishing an improved rice milling unit having an installed processing capacity of 2 MT/ hr; operating for single shift / day of 8 hr duration; 300 days per annum; i.e. 4800 MT /annum. The land should be with proper elevation. Low lying areas should be avoided. Else proper land filling, compaction and consolidation should be done. Drainage and linkages with road and other communication should also be ensured. The layout of the rice milling plant should be done in a manner that helps in smooth operation of various unit operations in tandem to bring about optimal capacity utilization and economizing power consumption.

9.4 CIVIL CONSTRUCTION

The various construction requirement of an improved rice milling unit are as follows:

1. Raw paddy godown : RCC (Reinforced Cement Concrete) framed superstructure with 10' thick brick walls, flooring with damp proof treatment of floor area and base of the side walls, roofing consisting of galvanized asbestos sheets affixed with J hooks, bolts and other accessories to steel truss made of MS (mild steel) angle of desired section.
2. Cleaning unit - Similar to the raw paddy godown
3. Drier and necessary supporting structures such as, boiler /blower system etc.
4. Milling section RCC framed superstructure with brick walls, damp proof flooring and roofing consisting of galvanized asbestos sheets affixed with J Hooks and nuts to steel trusses made of MS angle of desired section and strength bearing capacity.
5. Finished product stores
6. Machine rooms with masonry structure with galvanized asbestos sheet roofing on lean truss
7. Auxiliary structures such as office, watch and ward etc.

The size and civil cost of these structures depend on the production capacity of the project.

9.5 PLANT AND MACHINERY AND ELECTRICALS

The details of the nature and type of plant and machinery, their capacity, power consumption, level of automation varies upon the market needs, nature and type of the end products and the investment capacity. The details of plant and machinery for the rice milling unit are as follows:

1. Paddy cleaner : Raw paddy cleaner cum aspirator consisting of large aspiration of desired suction width fitted with double fans with necessary damper controls. The pre-cleaner is also provided with a magnetic separator for removing iron particles (for avoiding damage to other machines in the rice mill) feed hopper and other accessories viz. bearings, block sockets, shafting pulley, holding bolt etc.
2. Rubber Roll Paddy Sheller : Rubber roll paddy sheller for de-husking of paddy.
3. Paddy Separators: Paddy Separator for separating un-de-shelled paddy from de-shelled paddy.
4. Blowers : Husk and Bran Aspirators: Blowers, husk and bran aspirators for aspiration of light particles, separating husks from de-husked kernels and for separating bran from milled rice
5. Paddy Polishers: Cone type paddy polishers of suitable capacity for polishing and whitening rice grains to the desired degree
6. Rice grader/ aspirator : Rice grader/ aspirator for purification and grading of polished rice grains and for separation of the fine broken(s), coarse broken(s) from whole rice.

7. Bucket Elevators: Bucket elevators for bulk transport and conveyance of raw paddy, milled rice from one unit operation to another in a rice milling unit.

Each of the machine is operated by an AC-3 phase induction motors with a Direct Online Starters. There is a control panel for monitoring the supply voltage, current and power factor of the incoming power. In addition, each machine has its own control panel for adjustment of appropriate parameters.

The approximate power requirement for various equipments for the rice milling unit running at 3 T/hr are indicated in Table 9.1:

Table 9.1 : Power requirement for various equipments for the rice milling unit

S.No.	Equipment	Electric Motor (hp)	Rating in (kW)
1	Paddy cleaner	5	3.73
2	Rubber Roll Paddy Shellers	15	11.19
3	Paddy Separators	5	3.73
4	Blowers , Husk and Barn Aspirators	7.5	5.59
5	Paddy Polishers (3 nos. in series each with 15 hp motor)	45	33.56
6	Rice grader/ aspirator	5	3.73
7	Bucket Elevators	7.5	5.59
8	Internals (like power to control panel, lighting of the mill)	10	7.46

Each of the machines used for undertaking various rice processing operations is provided with its own independent power source and is driven by a AC-3 phase induction motor.

9.6 ELECTRICAL CONNECTIONS

The Electrical Power supply to the Rice Mill is at 11 kV, which is stepped down to 440 V by a step down transformer, which may be located outdoor or indoor. Normally, there is a power room, which houses the main circuit breakers, switches and other protection systems. If individual motors operate each one of the units, then each one of them has a separate circuit breaker connection. The internal lighting and powering the control panel too are drawn from this source.

All connections must be firm and there should be no loose or hanging electrical wire. The power room must be cordoned off and must be accessible to only authorized and skilled persons. All interconnecting wiring for controls and grounding should be in strict accordance with the Indian Electricity rules. Each motor should be independently grounded (earthed) and the ground voltage should not exceed permissible limits. Wiring of motor and control, overload protection and grounding should follow the instructions of connection diagrams attached to the motor.

9.7 CONTROL PANELS

An electrical cabinet provided for monitoring and control is called control panel. The control room thus has a control panel which indicates the incoming voltage, the current and the power factor at which it is drawn. It should be possible to start the motors, control their speed and stop them from the control panel. Suitable interlocks are provided to prevent the motors from running on no load. Interlocks are control circuits that prevent malfunctioning of any device. The current and power drawn by the individual motor units, machine load, ambient temperature, product temperature and operation hours are also indicated. Each one of the milling units has an independent control panel for the adjustment of parameters, for e.g., the gap between conical whitening rotor and sieve cage.

9.8 THE OVERALL FLOW DESCRIPTION

The pre-cleaned paddy, dried down to a moisture content of 13 - 14%, is conveyed to the rice mill through a belt conveyor. The paddy is discharged into the intake hopper and conveyed by a bucket elevator to the cleaner, where final impurities are removed. The impurities are bagged off on bagging benches. The cleaned paddy flows through a magnet, retaining iron particles. Stones and mud balls are removed afterwards by (a) dry-stoner(s). An intake weigher controls the paddy quantity. The cleaned paddy is conveyed to the rubber roll sheller(s), where it is subjected to shelling, via the pneumatically controlled inlet bin(s) of the rubber roll sheller(s). The mixture of paddy, cargo and husk enters the closed circuit husk separator(s) on its feeding screw. This screw distributes the mixture over the entire suction width of the husk separator(s). The husk separator(s) separate(s) the product into three fractions. Husk and light particles are blown to the outside by a husk blower system. The middle fraction (immature grain etc.) is fed back to the combi-hull (rubber roll sheller and husk separator). The mixture of paddy and cargo is fed to the paddy separator(s). The paddy separator(s) separate(s) paddy from cargo. The paddy is returned to the shelling section, the cargo flows into an elevator to enter the whitening section.

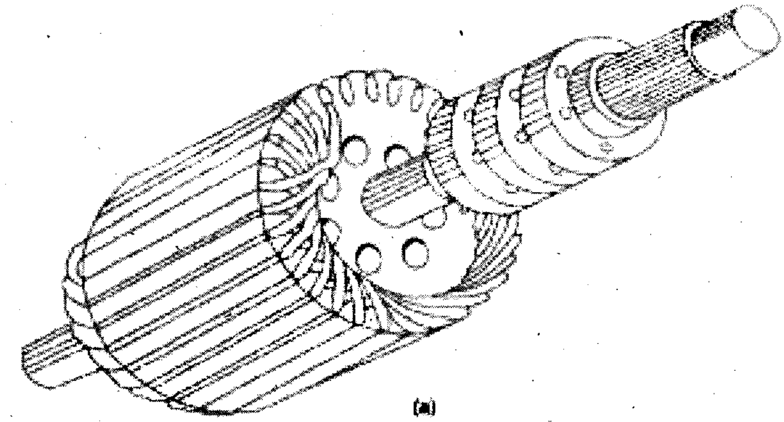
In order to protect the whitening machines a magnet is installed in front of the machines, retaining iron particles. The machines operate one after the other (3-pass system). The bran is sucked off by a pneumatic bran removal system. The bran is separated within the bran collector(s) and leaves the collector(s) through (a) bran dust lock(s). A plan-sifter divides the white rice in four fractions:

- head rice
- a mixture of head rice and broken(s) (½ to ¾)
- ¼ - ½ broken(s)
- fine broken(s) and tips

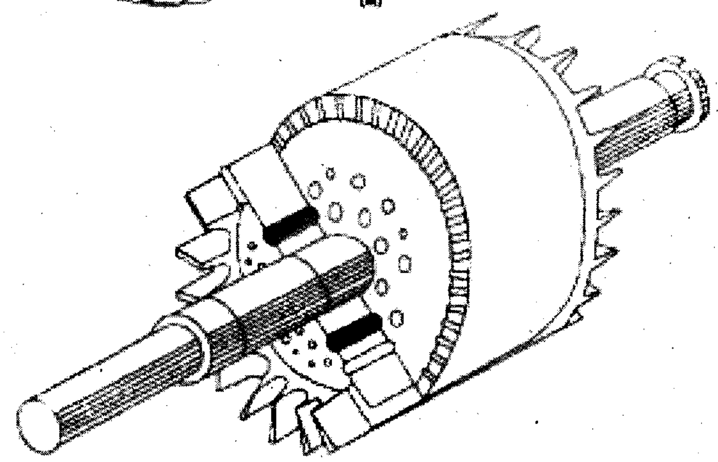
The fine broken(s) are bagged off. The ¼ to ½ broken(s) are bagged off or conveyed into a silo - depending on the size of the mill. The mixture of head rice and broken(s) is separated by an indented cylinder(s) into ½ to ¾ broken(s) and head rice. An elevator into a silo conveys the broken rice. The head rice separated by the indented cylinder(s) and the separated head rice of the plan-sifter is conveyed into the polishing section. (A) water rice polisher(s) or (a) dry polisher(s) take care of a smoother outer surface of the white rice. The polishing degree is determined by movable weights at the outlet. The bran is sucked off as described in the whitening section. Various silos are designed for the storage of the broken rice and head rice. The rice can be blended according to the requirements and bagged off by a bagging scale.

9.9 INDUCTION MOTORS

As seen above the three phase induction motor is the heart of all rice milling equipment. An **electric motor** converts electrical energy into mechanical motion through a coupling. The induction machine comprises of a stator which is fed with 3 phase electric supply and a rotor. There is an air gap between the stator and the rotor. The phase differences between the three phases of the three phase electrical supply create a rotating electromagnetic field in the motor. Through electromagnetic induction, the rotating magnetic field induces a current in the short circuited conductors in the rotor, which in turn sets up a counterbalancing magnetic field that causes the rotor to turn in the direction the field is rotating. The rotor tries to catch up with the rotating magnetic field. The rotor must always rotate slower than the rotating magnetic field produced by the three phase electrical supply; otherwise, no counterbalancing field will be produced in the rotor. Figure 9.2 shows rotors for a wound rotor and squirrel cage induction motor.



(a)



(b)

Fig. 9.2: Rotor for (a) Wound Rotor (b) Squirrel Cage Induction Motor

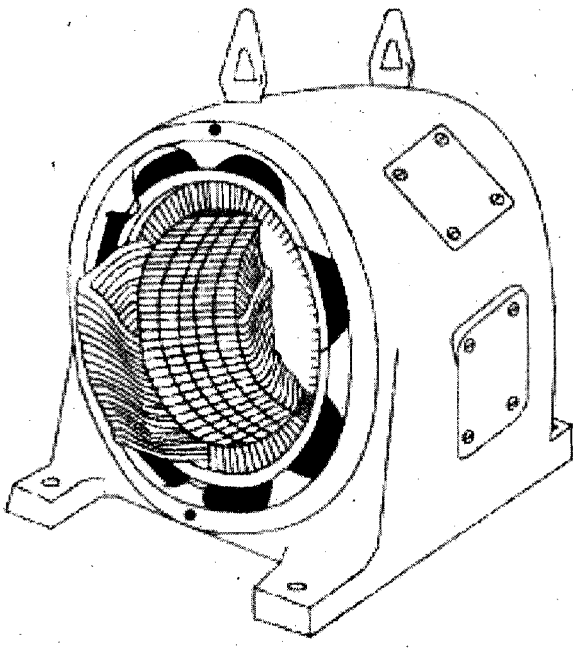


Fig. 9.3: Typical Stator of a three phase Induction Motor

Figure 9.3 shows the construction of stator for a three phase induction motor. Induction motors are the **workhorses** of industry and motors up to about 500 kW in output are produced in highly standardized frame sizes, making them nearly completely interchangeable between manufacturers.

There are two types of rotors used in induction motors. Most use the squirrel cage rotor. An alternate design, called the wound rotor, is used when variable speed is required. In this case, the rotor has the same number of poles as the stator and the windings are made of wire, connected to slip rings on the shaft. Carbon brushes connect the slip rings to an external controller such as a variable resistor that allows changing the motor's slip rate. In certain high-power variable speed wound-rotor drives, the slip-frequency energy is captured, rectified and returned to the power supply through an inverter. Figure 9.4 shows the speed torque characteristics of a typical Induction Motor.

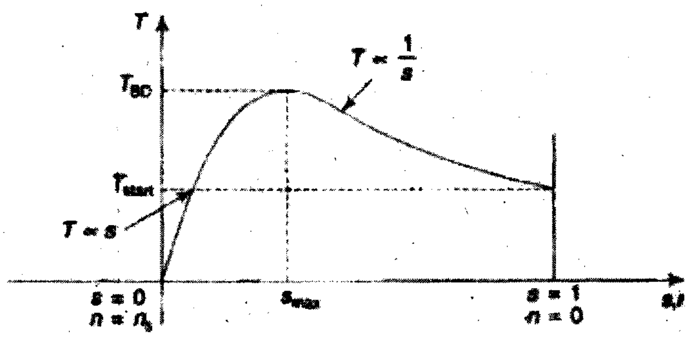


Fig. 9.4 : Typical Speed Torque Characteristics of an Induction Motor

Compared to squirrel cage rotors, wound rotor motors are expensive and require maintenance of the slip rings and brushes, but they were the standard form for variable speed control before the advent of compact power electronic devices. Transistorized inverters with variable frequency drive can now be used for speed control and wound rotor motors are becoming less common. (Transistorized inverter drives also allow the more efficient three-phase motors to be used when only single-phase mains current is available.)

Several methods of starting a three phase motor are used. When motor starts from stand still due to the absence of counter balancing magnetic field a large current, any where up to 6 times rated current called Inrush current is drawn. Where the large inrush current and high starting torque can be permitted, the motor can be started across the line, by applying full line voltage to the terminals. Where it is necessary to limit the starting inrush current (where the motor is large compared with the short-circuit capacity of the supply), reduced voltage starting using either series inductors, an autotransformer, thyristors, or other devices are used. A technique sometimes used is star-delta starting, where the motor coils are initially connected in wye for acceleration of the load, then switched to delta when the load is up to speed. Power Electronic drives can directly vary the applied voltage as required by the starting characteristics of the motor and load.

The speed of the AC motor is determined primarily by the frequency of the AC supply and the number of poles in the stator winding, according to the relation:

$$N_s = \frac{120f}{p} \qquad (1)$$

where

N_s = Synchronous speed, in revolutions per minute

f = AC power frequency

p = Number of poles, usually an even number but always a multiple of the number of phases

Actual RPM for an induction motor will be less than this calculated synchronous speed by an amount known as *slip* that increases with the torque produced. With no load the speed will be very close to synchronous. When loaded, standard motors have between 2-3% slip, special motors may have up to 7% slip, and a class of motors known as *torque motors* are rated to operate at 100% slip (0 RPM/full stall).

The slip of the AC motor is calculated by:

$$S = (N_s - N_r) / N_s \tag{2}$$

Where

N_s = Synchronous speed, in revolutions per minute

N_r = Rotational speed, in revolutions per minute.

S = Slip, in percent.

As an example, a typical four-pole motor running on 50 Hz might have a nameplate rating of 1725 RPM at full load, while its synchronous speed is 1800.

The speed in this type of motor has traditionally been altered by having additional sets of coils or poles in the motor that can be switched on and off to change the speed of magnetic field rotation. However, developments in power electronics mean that the frequency of the power supply can also now be varied to provide a smoother control of the motor speed.

9.9.1 Power Factor Correction

The **power factor** of an AC electric power system is defined as the ratio of the real power to the apparent power.

In a purely resistive AC circuit, voltage and current waveforms are in step (phase) i.e. reach peak value (or zero value) simultaneously , changing polarity at the same instant in each cycle. Where reactive loads are present, such as capacitors or inductors, energy storage in the loads result in a time difference (called phase difference) between the current and voltage waveforms. Since this stored energy returns to the source and is not available to do work at the load, a circuit with a low power factor will have higher currents to transfer a given quantity of power than a circuit with a high power factor.

Real power is the capacity of the circuit for performing work in a particular time. Due to reactive elements of the load, the apparent power, which is the product of the voltage and current in the circuit, will be equal to or greater than the real power. The reactive power is a measure of the stored energy that is reflected to the source during each alternating current cycle.

AC power flow has the three components: real power (P), measured in watts (W); apparent power (S), measured in volt-amperes (VA); and reactive power (Q), measured in reactive volt-amperes (VA_r).

The power factor can be expressed as:

$$\frac{P}{S} \tag{3}$$

In the case of a perfectly sinusoidal waveform, P, Q and S can be expressed as vectors that form a vector triangle such that:

$$S^2 = P^2 + Q^2 \tag{4}$$

If ϕ is the phase angle between the current and voltage, then the power factor is equal to $|\cos\phi|$, and: (5)

$P = S\,|\cos \Phi|$

Let us say the time difference between Current & voltage be 't', then we say

$$\Phi = t * f * 360 \text{ in degrees} \qquad (6)$$

Where f is the frequency of supply in Hz.

By definition, the power factor is a dimensionless number between 0 and 1. When power factor is equal to 0, the energy flow is entirely reactive, and stored energy in the load returns to the source on each cycle. When the power factor is 1, all the energy supplied by the source is consumed by the load. Power factors are usually stated as "leading" or "lagging" to show the sign of the phase angle.

The power factor is determined by the type of loads connected to the power system. These can be

- Resistive
- Inductive
- Capacitive

If a purely resistive load is connected to a power supply, current and voltage will change polarity in phase, the power factor will be unity (1), and the electrical energy flows in a single direction across the network in each cycle. Inductive loads such as transformers and induction motors (any type of wound coil) generate reactive power with current waveform lagging the voltage. Capacitive loads such as capacitor banks or buried cable generate reactive power with current phase leading the voltage. Both types of loads will absorb energy during part of the AC cycle, only to send this energy back to the source during the rest of the cycle. Major electrical loads in a rice mill being induction motors, they are usually loads having lagging power factor

For example, to get 1 kW of real power if the power factor is unity, 1 kVA of apparent power needs to be transferred (1 kVA = 1 kW × 1). At low values of power factor, more apparent power needs to be transferred to get the same real power. To get 1 kW of real power at 0.2 power factor 5 kVA of apparent power needs to be transferred (1 kW = 5 kVA × 0.2).

It is often possible to adjust the power factor of a system to very near unity. This practice is known as *power factor correction* and is achieved by switching in or out banks of inductors or capacitors, as the case may be. For example the inductive effect of motor loads may be offset by locally connected capacitors.

Energy losses in transmission lines increase with increasing current. Where a load has a power factor lower than 1, more current is required to deliver the same amount of useful energy. Power companies therefore require that customers, especially those with large loads, maintain the power factors of their respective loads within specified limits or be subject to additional charges. Engineers are often interested in the power factor of a load as one of the factors that affect the efficiency of power transmission.

Power factor correction is achieved by complementing an inductive or a capacitive circuit with a (locally connected) reactance of opposite phase. For a typical phase lagging p.f. load, such as a large induction motor, this would consist of a capacitor 'bank' in the form of several parallel capacitors at the power input to the device.

Instead of using a capacitor, it is possible to use an unloaded synchronous motor. This is referred to as a synchronous condenser. It is started and connected to the electrical network. It operates at full leading power factor and puts VARs onto the network as required to support a system's voltage or to maintain the system power factor at a specified level. The condenser's installation and operation are identical to large electric motors.

9.10 METHODS OF POWER TRANSMISSION

In this section we will describe the mechanical devices that are used for transmitting power.

9.10.1 Common Shaft

A shaft is a long, generally cylindrical bar that rotates and transmits power from the engine or motor to the point where useful work is applied. Motors deliver power as torque through a rotary motion. From the point of delivery, the components of power transmission form the drive train. Drive shafts are carriers of torque i.e., they are subject to torsion and shear stress, which represents the difference between the input force and the load. They thus need to be strong enough to bear the stress, without imposing too great an additional inertia by virtue of the weight of the shaft. Some of the older rice mills are driven by a common shaft. Most of the Modern high capacity rice Mills, do not use a common shaft, as this will make the control of the individual milling equipments difficult and involved.

9.10.2 V-Belt Transmission

Belts are used to mechanically link two or more rotating items. They may be used as a source of motion, to transmit power between two points, or to track relative movement. As a source of motion, a conveyor belt is one application, where the belt is adapted to continually carry a load between two points. A belt may also be looped (or crossed) between two points so that the direction of rotation is reversed at the other point. Power transmission is achieved by specially designed belts and pulleys. The demands on a belt driven transmission system are large and this has led to many variations on the theme. The earliest was the flat belt, used with line shafting. It is a simple system of power transmission that was well suited to its time in history. The flat belt pulleys need to be carefully aligned to prevent the belt from slipping off. The flat belt also tends to slip on the pulley face when heavy loads are applied. **Vee belts** (also known as **v-belt** or **wedge rope**) are an early solution that solved the slippage and alignment problem. The "V" shape of the belt tracks in a mating groove in the pulley (or sheave), with the result that the belt cannot slip off. The belt also tends to wedge into the groove as the load increases — the greater the load, the greater the wedging action — improving torque transmission and making the vee belt an effective solution. They can be supplied at various fixed lengths or as a segmented sections, where the segments are linked (spliced) to form a belt of the required length. For high-power requirements, two or more vee belts can be joined side-by-side in an arrangement called a multi-V, running on matching multi-groove sheaves. Vee belts are used for transmitting power in certain parts of rice mill and also within the parts of a particular equipment. The bucket elevator for example uses this principle. This type of transmission is most commonly used for the rubber roll hullers.

9.10.3 Independent Power Units

Most modern rice mills use independent power units for each one of the milling equipments. While this arrangement calls for a greater amount of land space, this gives rise to a greater degree of flexibility in controlling each one of the units. This also calls for greater amount of capital investment.

9.10.4 Energy Meters

As we have seen electric power is vital for running a rice mill. It is important to know the energy consumed for the milling operation and other miscellaneous requirements in a rice mill. An energy meter is used for the purpose of measure the power consumed over a period. We all know that energy by definition is work done and power work done per unit time. We also that instantaneous power is a product of applied voltage and current drawn. Hence, energy is obtained by integrating power.

An **energy meter** is a device used to measure the amount of electricity, consumed by a residence or business. Utilities record the values measured by these meters to determine consumption during a specific time period. These consumptions are used to generate an invoice for the consumption. Energy meters have come a long way from being just passive instruments determining consumption of energy during a predetermined period. The high-end meters today come packed with a plethora of features, with major breakthroughs in being tamper-proof and highly accurate at the same time.

Modern electricity (energy) meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, kilowatt-hours etc). Figure 5 shows the connections for a single phase Induction Type Energy Meter.

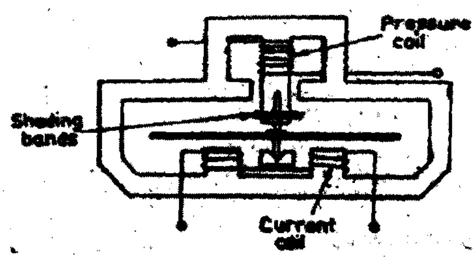


Fig. 9.5 : Single Phase Induction Type Energy Meter

The most common type of electricity meter is the electromechanical induction meter. This consists of an aluminum disc which is acted upon by two coils. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc - this acts as a brake which causes the disc to stop spinning when power stops being drawn, rather than allowing it to spin faster and faster. This causes the disc to rotate at a speed proportional to the power being used.

The aluminum disc is supported by a spindle which has a worm gear which drives the register. The register is a series of dials, which record the amount of energy consumed. The dials may be of the cyclometer type where for each dial a single digit is shown through a window in the face of the meter, or of the pointer type where a pointer indicates each digit. It should be noted that with the dial pointer type, adjacent pointers generally rotate in opposite directions due to the gearing mechanism.

The type of meter described above is used on a single-phase AC supply. Different phase configurations use additional voltage and current coils.

Some newer meters are solid state and display the power used on an LCD display. Most solid-state meters use a current transformer to measure the current. This means that the main current-carrying conductors need not pass through the meter itself and so the meter can be located remotely from the main current-carrying conductors, which is a particular advantage in large-power installations. It is also possible to use remote current transformers with electromechanical meters though this is less common.

Solid state meters can also record other parameters of the load and supply such as maximum demand, power factor and reactive power used etc.

The most common unit of measurement on the electricity meter is the kilowatt-hour which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000 joules.

9.11 INSTALLATION

The following precautions must be taken when the motors and the rice milling equipments are installed:

(a) Ambient temperature should be: -10 ~ 40°C

(b) Humidity: Relative humidity below 90% RH for totally enclosed types, and below 80% RH for semi-enclosed types.

(c) Elevation: below 1000 meters or 3300 feet.

(d) Harmful gases, liquids, dust, high moisture should be absent.

(e) Foundations should be strong and free of vibration.

(f) Installation area should be well ventilated and well lit

(g) The installation space should be large enough to facilitate heat dissipation and maintenance.

9.12 OPERATION AND MAINTENANCE OF ELECTRICAL MOTORS

As seen in the previous sections, the three phase induction motor is the heart of a Rice Mill. Most modern rice mills have equipments which are driven by independent motors. It is important to determine the condition of these in-service motors and carry out periodic maintenance so that there are no forced outages. The forced outages will bring the milling process to a standstill, thereby resulting in a great loss of revenue.

The following points must be observed during the operation :

- There should be no skip, jumping, vibration or unusual noises.
- The rated conditions of operation for the motor are as shown on the nameplate. Within the limits, given below, of voltage and frequency variation from the nameplate values, the motor continues to operate but with performance characteristics that may differ from those at rated conditions:

  ±10% of rated voltage

  ±5% of rated frequency

±10% combined voltage and frequency variation so long as frequency variation is no more than ±5% of rated.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to or failure of the motor.

- Ensure that the grounds are proper and firm.

The rotation direction of the motor will be as shown by either a nameplate on the motor or the outline drawing. The required phase rotation of the incoming power for this motor rotation may also be stated. If either is unknown, the correct sequence can be determined in the following manner: While the motor is uncoupled from the load, start the motor and observe the direction of rotation. Allow the motor to achieve full speed before disconnecting it from the power source. Refer to the operation section of these instructions for information concerning initial start-up. If resulting rotation is incorrect, it can be reversed by interchanging any two (2) incoming cables.

9.12.1 Examination Before Start

When motors are installed in good manner, ensure the wiring is according to the diagram. Also, the following points should be noted:

(a) Make sure all wiring is proper.

(b) Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.

(c) Ensure all connections are properly insulated for the voltage and temperature they will experience.

(d) Ensure the capacity of fuses, switches, magnetic switches and thermo relays etc. are appropriate and the contactors are in good condition.

(e) Make sure the frame and terminal box are grounded.

(f) Make sure that the starting method is correct.

(g) Make sure switches and starters are set at their right (initial) positions.

(h) Motor heaters must be switched off when the motor is running.

Ensure that there is adequate guarding so that no live part is touched.

Make sure that the transmission system, including belts, screws, bolts, nuts and set pins are in good condition .

9.12.2 Starting Operation

Initially run the motor unloaded prior to coupling to other machines. Unless otherwise specified, a motor usually starts with light load, which is then gradually increased, proportional to the square of the speed and at last reaches 100% load at full load speed.

Too frequent starts can be harmful to the motors. The following restrictions should be observed:

(a) Motor can be restarted should the initial start fail. Two starts are generally permissible when the motor is cold.

(b) Motor can be started only once when it is at normal running temperature.

Ensure the motor phase currents, when without load, are within ±5% of the average

(c) Should additional starts be necessary beyond the conditions stated above, the following restrictions should be noted:

(1) Let the motor cool down for 60 minutes before restarting, fully loaded.

(2) Let the motor cool down for 30 minutes before restarting, unloaded.

(3) Two inching starts can be regarded as one normal start.

9.13 MAINTENANCE

Major points in regular inspections and maintenance are:

For safety, properly trained personnel must only carry out maintenance and repairs. Some testing, such as insulation resistance, usually requires the motor to be stopped and isolated from power supply. Looking, listening, smelling and simple meters usually perform routine inspection and maintenance. High temperatures may arise under operating conditions on the motor surfaces, so that touching should be prevented or avoided. Keep away from moving and live parts. Unless deemed necessary, do not remove guards whilst assessing the motor. Timely replacement of worn parts can assure longevity and prevent breakdown. Routine inspection and regular inspection and maintenance are important in preventing breakdown and lengthening service life.

Owing to the varied time and circumstances, motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically according to factory maintenance program. Generally, the inspection scope determined by the following factors :

(a) Ambient temperature.

(b) Starting and stopping frequency.

(c) Troublesome parts usually affecting motor functions.

(d) Easily abraded parts.

(e) The important position of motor in the operational system of a factory should be duly recognized. Therefore, its health and wellbeing should be fully protected especially when it is operating in severe conditions.

9.13.1 Motor Windings

(a) Measurement of insulation resistance and standards to determine quality of insulation resistance

(b) Inspection of coil-ends:

   (1) Grease and dust accumulated on coils may cause insulation deterioration and poor cooling effect.

   (2) Moisture must not accumulate. Keep coils warm when motor is not in use if moisture can be seen.

   (3) Discoloring. Overheating mainly causes this.

(c) Ensure no untoward change of wedges from original position.

(d) Ensure the binding at the coil end is in its normal position.

9.13.2 Clean the Interior of the Motor

(a) After a motor is in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. Regular cleaning and examination is necessary to assure top performance.

(b) Points to note during cleaning:

(1) If using compressed air or blower:

   (a) Compressed air should be free of moisture.

   (b) Maintain air pressure at 4 kg/cm^2, since high pressure can cause damage to coils.

   (2) Vacuum

Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding without scattering. Vacuum cleaning tools should be non-metallic to avoid any damage to thee winding insulation

(3) Wiping

Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material. If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent. In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.

9.13.3 Clean the Exterior of the Motor

(a) On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement. Screens and louvers should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

(b) If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.

(c) Totally enclosed air to air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

9.13.4 Maintenance of Bearings, Slip Rings and Mechanical Parts

Machined components should be carefully inspected. Bearings and shafts are normally covered with a corrosion resistive barrier. If this coating is damaged it should be made good. The component should be cleaned and the protective coating reapplied. Under no circumstances should rust be merely covered over. Motors provided with drain holes have drain plugs either provided loose in the terminal box for small sizes or fitted on frames for larger sizes. The drain holes must be positioned at the lowest point.

To avoid static indentation the storage area should be vibration free. If this is not possible, it is strongly recommended that the motors be stood on thick blocks of rubber or other soft material. Shafts should be rotated by hand one quarter of a revolution weekly. Where the exposure to some vibration is unavoidable the shaft should be locked in position to avoid static indentation of the bearings. Roller bearings may be fitted with a shaft-locking device. This should be kept in place during storage. The bearings and slip rings (for a slip ring induction motor) must be inspected at periodic intervals during the operating period for any visible damages. Re-greasing and re-lubrication must be performed when necessary. If re-lubrication is to be performed when the motor is running, stay clear of rotating parts. It is advisable to re-grease when the motor is running to allow the new grease to be evenly distributed inside the bearings. Before re-greasing, the inlet fitting should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The outlet of grease drainage should be opened to allow the proper venting of old grease. Use a grease gun to pump grease through grease nipple into the bearings. After re-greasing, operate the motor for 10-30 minutes to allow any excess grease to vent out.

Grease

Factory fitted bearings use a lithium based grease with a recommended shelf life of two years. If stored for a longer period, grease may need to be replaced. Shielded bearings have a storage life of five years and a further two years operational life following installation. Wash all bearing parts with a non-contaminating solvent. Lightly pack the bearings with grease applying a 33% fill by volume into the bearing and housings. Wound rotor motor brushes should not be in contact with the slip-rings during storage as there is a risk of corrosion. Brushes should either be lifted off the slip-rings or stored separately.

Free rotation

The rotor must be free to rotate with in its housing. Where uneven or bumpy rotation occurs the bearings should be inspected to establish that they have not been damaged during transportation or storage.

Slide rails

Slide rails are available for all motors to provide adjustable mounting. Fabricated steel rails are suitable for all mounting arrangements. Aluminium slide rails are used only for floor mounting. Slide rails must be installed on a flat surface. Rails must have a secure location. Drive and driven shafts must be parallel.

Running

After one hour of running, check the general vibration levels. If these are excessive, check alignment (and belt tensioning if belt driven).

Some initial bearing noise may be present during the running in period. This is normal because the grease has to settle down within the bearing.

The noise should disappear after a few hours of operation. Check that the motor runs up smoothly and with in the permitted run-up time. Note that repeated starting in quick succession may lead to a thermal overload of the motor.

Re greasing

Motors without grease nipples have sealed for life bearings. An over greased bearing will cause over-heating of the bearing with the possible escape of the grease. Loss of lubrication qualities, leads to ultimate bearing failure.

Lubrication procedure

The following procedure should be adopted.

1. Wipe clean the grease gun fitting and the regions around the motor grease fittings.
2. Remove the grease relief plug if fitted. Some motors will have one way grease values which should be left in place.
3. Add a small quantity of grease, approximately 4 to 10 shots be left in place.
4. Allow motor to run for about ten minutes in order that excess grease may be excelled before refitting the relief plug. Bearings fitted with rotating grease relief or through grease valves relieve automatically
5. On initial start up or after re-lubrication, 'bearing noise' may around the bearing. This noise is normal and will disappear after a few hours of running

Bearing Change

When fitting new bearings the parts should be lightly lubricated with grease. The bearing should be driven on to the shaft by pressure on the inner race only using a short length of tube placed over the motor shaft. On larger motors it is easier to raise the temperature of the bearing using an oil bath, oven, or induction heating. The temperature must be controlled to 120°C maximum.

The bearing should then be quickly slipped into place, ensuring that the bearing is in contact with the shaft shoulder. When cool, ensure that the bearing is clean and charge the bearing with the recommended quantity grease. Bearings and housings should be one third full.

9.14 LET US SUM UP

The various stages of rice milling and the kind of equipment needed at stage. Most modern rice mills use 3 phase ac power. The rice mills are driven by 3 phase induction motor. The induction motor works on the principle of electromagnetic induction and makes the mechanical power available at the rotor. From this point the mechanical power can be transmitted to the other parts of the milling machine through pulleys,chains, gears or belts.

The ratio of the actual power drawn to the apparent power drawn in a mill is called as power factor. The power factor must be kept close to unity.The induction motor driven rice mill is a lagging industrial load and draws power from the mains at a power factor less than unity.Power factor correction by using capacitors are done to improve the power factor.

The power consumed in a rice mill is metered by using energy meters. This is important both from the point of view of billing and also to monitor and control the amount of power consumed and avoid wastage. The most common type of electricity meter is the elctromechanical induction meter. The most common unit of measurement on the electricity meter is the kilowatt-hour.

To prevent forced outages and to improve the efficiency of the milling operation it is essential to perform periodic maintanence of the milling equipment. The mainetence procedure includes inspecting,cleaning and lubricating the mechanical parts. Checking the soundness of the motor insulation by making insulation resistance measurements. These values must be within safe limits.

Check Your Progress

Note: a) Use the spaces given below for your answers.

b) Check your answer with those given at the end of the unit.

1. List the equipments that are used in a rice mill?

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2. Explain in brief the principle of operation of an induction motor?

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3. What are common methods of transmitting mechanical power? Which method is most suitable for a modern high capacity rice mill?

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4. What is meant by power factor?

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5. What kind of a electrical load does a rice mill constitute?

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6. Why is it essential to correct the power factor?

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7. What is an Energy meter?

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8. Typically how much power would be consumed if a 5 hp motor runs for two hours?

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9. What are the ways in which the equipments of a rice mill are maintained?

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9.15 KEY WORDS

Parboiler : For producing parboiled rice paddy is passed through a steam boiler called parboiler

Cleaner : Pre cleans rice prior to processing to remove dirt and stones

Husker : Machine employed to remove the husk

Whitener : The rice is said to be whitened where it is used to remove bran fully

Grader : The one that eanables grading rice as brokens and full grains

Blender : Blends full grains with predetermined half brokens

Polisher : Polishes rice grains to make them suitable for end use

Induction Motor : Electric Motor working on Induction Principle used in Rice Mills

Squirrel Cage : Rotor of an Induction Motor resembling a squirrel cage

Lagging Load : Typically inductive load where current reaches peak after voltage reaches its peak,

Power Factor : Factor by which RMS Voltage is multiplied by RMS current to arrive at power

Power Factor Correction : Methods adopted to make power factor unity

Energy meter : Meter employed to measure the energy consumed

Power Transmission : Transfer of mechanical power out put of the motor to the plant components in a rice mill

Common Shaft : Single shaft coupled to rotor shaft for transmission of power

Vee belt : Typical belt employed for power transmission

Control Panel : Panel where complete metering to control monitor and record status of various components of plant, Insulation Check-checking the condition of electrical insulation

9.16 SOME USEFUL REFERENCES

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9.17 ANSWERS TO CHECK YOUR PROGRESS

1. Various Machines employed in a rice mill are : Pre cleaner, De stoner, Par boiling Unit, Husker, Paddy separator, Whiteners, Graders, Polishers and Blender.

2. The induction machine comprises of a stator which is fed with 3 phase electric supply and a rotor. There is an air gap between the stator and the rotor. The phase differences between the three phases of the three phase electrical supply create a rotating electromagnetic field in the motor. Through electromagnetic induction, the rotating magnetic field induces a current in the short circuited conductors in the rotor, which in turn sets up a counterbalancing magnetic field that causes the rotor to turn in the direction the field is rotating. The rotor tries to catch up with the rotating magnetic field.The rotor must always rotate slower than the rotating magnetic field produced by the three phase electrical supply; otherwise, no counterbalancing field will be produced in the rotor.

3. Common methods of mechanical power transmission are: Common Shaft, Vee belt and Independent Power units. Most modern rice mills employ independent power units connected on the shafts of the induction motors attached.

4. Power factor is the factor by which product of (RMS)Voltage and (RMS) current in ac circuits read on meters needs to be multiplied to arrive at power.

5. A typical Rice mill is electrically an inductive load. As most of the load is induction motors. It is called as lagging type of load.

6. As load is lagging, if power factor is not corrected for the same useful power, higher currents flow through leads leading to higher line losses.

7. An energy meter which records the energy consumed. It works on the principle of Electromagnetic Induction, Unlike other \instruments, it is an integrating instrument.

8. 5 hp is equivalent to 2.46 kW. If it runs for two hours, then energy consumed would be 2.46 x 2 kWhr = 4.92 kWhr (4.92 units).

9. Maintenance of equipment in a rice mill consists in maintaining periodically all electrical connections, insulation checks for motors, bearings and mechanical parts of motors and other equipment.