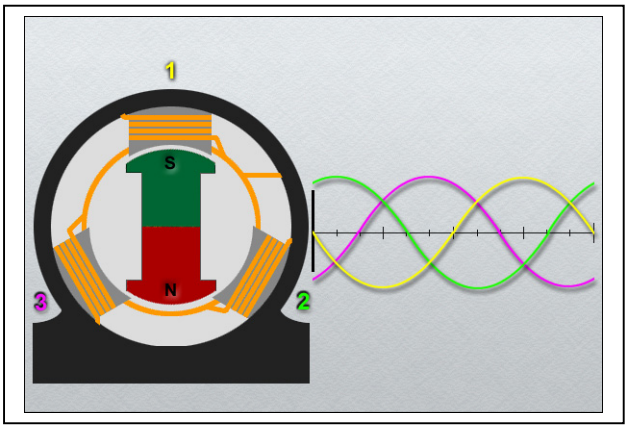
1. Basic Principles

Electricity is considered to be one of the most versatile energy forms. It can be used for the production of light, power output, cold and heat. Because electricity is very expensive to produce and storage is costly, it belongs to the most expensive of energy forms.

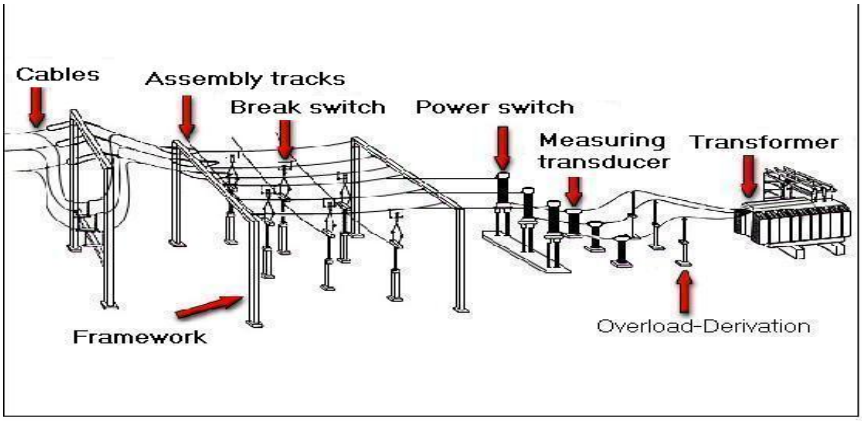
1.1 Electrical Network

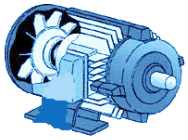
The electrical network starts at production units and finishes at final consumers.

Power is produced with generators that have 3 phases, alternated voltage.
The voltage level is increased by power transformers to levels up to 400 kV.



After this operation, the electricity is applied to many transmission lines and transported to power stations in order to reduce the tension level. This cycle could happens two our three times until reaching the common used voltage (400 V).
In the next figure, it is possible to understand the several steps that occur from electricity production to final users. There is safety equipment, transformer stations, break switch. In this installation, besides these equipment exists also the measuring transducer in order to get the consumption at real time.





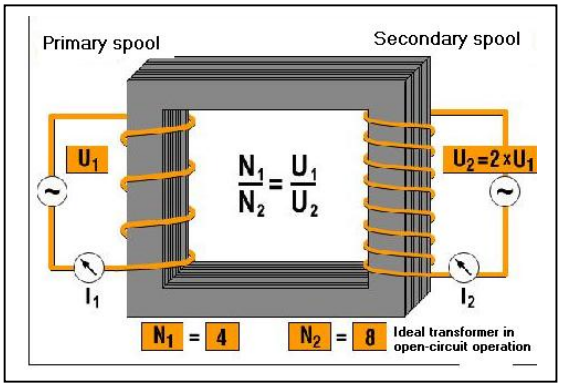
1.2 Losses

Any equipment produces losses. Starting in power station until the final equipment of the line.

In almost all f them, the losses measurement can be quantified. It is possible by the equipment specification according with application.

This fact is very important because in the majority of cases it is possible to reduce losses by choosing well the equipment according to the application and in others cases by controlling and adapting the equipment to the process.

1.3 Transformers



This equipment is applied in many ways.

It could be used immediately in power station, increasing the voltage level in order to keep the losses in the transmission path to a minimum, by reducing the current.

It could be used for decrease high voltage into the level of the voltage to be used by the final consumer.

The picture exemplifies the ideal transformer, but like any equipment it produce losses.

Its efficiency is normally round 98 %.

The losses measurement just could be interesting in distribution transformers with a significant consumption.

The generation and transmission of electrical power are more efficient in polyphase system employing combinations of three phases.

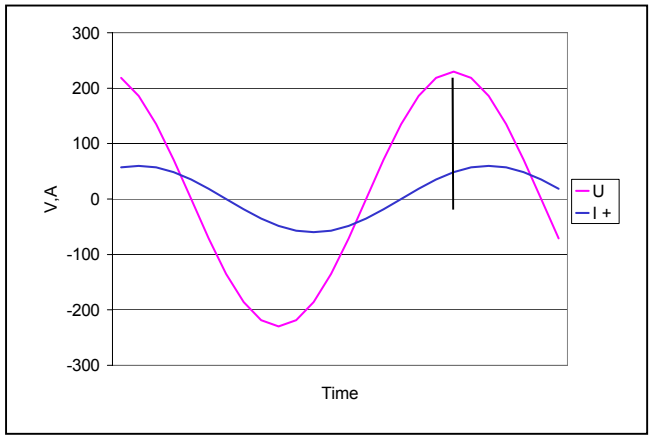
1.3 Power Factor Concept

This term is applied to the alternate current and it means or measure the difference angle between the current and voltage.

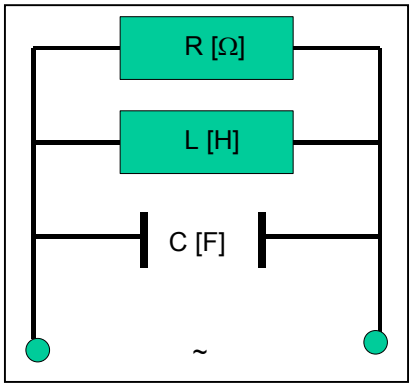
Alternating current has a frequency of 50Hz [1/s] (60 Hz in USA); that means 100 passes through zero per second.

In the next figure it is possible to see that the current waveform passes through zero after the voltage wave that means that the load has a inductive character.

The majority of cases it is what happens.

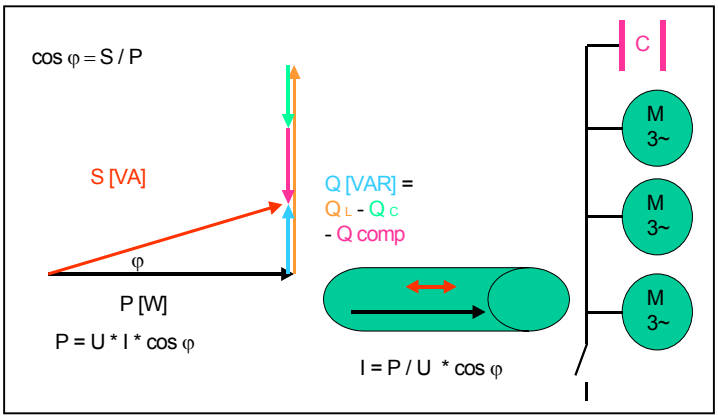


The better example to justify this fact is that, in the majority of installation the biggest Consumption is from electrical motors that have normally power factor around 0,8.



This picture could represent the process load.
Besides the resistance R, the components of an alternating current circuit also include an inductive portion L and a capacitive portion C. The induction L (coil) causes a sequential pre-effect on the alternating current, die capacitance C (condenser) a post-effect. As a rule L>C is a valid measure for power consumers.

The idle current Q only places a load on power lines without performing any useful work output. In addition, the cable becomes heated by the current flow and so the resistance increases. That is why the idle current should be held down at the lowest possible level.



1.3.1 Power Factor Compensation

This can be achieved by switching on condensers (compensation). This operation not only should be done to reduce the idle current into power lines but also to keep power factor above the minimum according to the electricity supplier. The consumer that has consumption of reactive energy above the established limit has to pay to the supplier not only the active energy consumed but also the reactive energy above the allowed limit.

2. Motors

The performance data for power motors (>1kW) is always related to the delivered shaft output Pw , not to the electric power taken in.

Pel: η**= Pw / P el,** **Waste heat Q motor = Pel - Pw**

2.1- Direct Current Motor

The direct current motor distinguishes itself by means of a linear characteristic (current = torque, voltage = revolutions per minute (rpm)), is simple in assembly and uncomplicated in regulation (tachometer, Thyristor). The motors require maintenance (brushes, bearings).

R&D on electronic power devices had been a very big impact in many technologies. Variable Speed Drives is one of them. They have improved very much its characteristics and nowadays they can perform on three-phase induction motors speed/torque control actions that, for some applications, are similar to ones achieved by direct current motors.
Electrical induction motors are less expensive, initial cost and maintenance, than direct current motors. For that reason all dc motors utilization should be analysed in order to be sure if the substitution is possible or not.

2.2.3-Phase Current – Asynchronous Motor

The electromagnet in the asynchronous motor produces a rotating field, is stimulated by the mains supply and induces an alternating current in the rotor, even when not in motion. Common models are squirrel-cage rotors and slip-ring rotors. The torque curve does not follow a straight-line path but rather follows the path characteristic for the motor being examined. Because the start up current is larger than the rated current (1.8 –3.5 times), these are often governed with the Y-delta connection. The motor has a fixed number of rpm that depends upon the number of pairs of poles: rpm n= frequency*60/ pole pairs. The synchronous rpm is dependent upon mains power frequency.
Rpm regulation can be achieved by means of pole conversion or a frequency inverter.

2.3.3-Phase Current – Synchronous Motor

The synchronous motor is actually used as a generator.
It cannot start on its own and therefore must be controlled by an electronic switch. Once the motor has almost reached the set rpm, it runs further on its own. These motors have a high degree of efficiency and allow for variable rpm levels because of the electronic regulation.

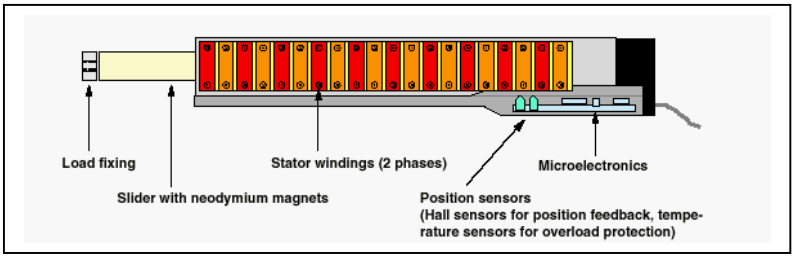

Synchronous motors

2.4 High Speed Motor


High speed motor

Up to 80.000rpm for turbo compressors etc

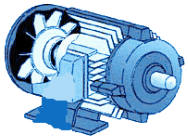
2.5 Linear Motor



Linear motors are 3-phase or direct current motors, that perform a linear motion, such as pneumatic / hydraulic cylinders.

2.6 Selection of the Motor

The selection of the electric motor is made according to the response characteristic desired in the installation and the required torque. Required torque is related with power e speed of the motor. Another important factor is choosing well the construction material of motor according to environment and hazards areas.



2.7 Gearboxes

One of the most difficult problems for process engineers has been to adequate the speed of the electrical induction motors with the necessary process equipment speed.
As we know electrical induction motor speed are related with the speed of the magnetic field that depends on the supplied voltage frequency. For that reason we are constrained to theoretical speeds of 3.000, 1.500, 750 rpm. Real speed is a little bit lower.
If the equipment required rotating speed is not one of above mentioned, what usually happens, the use of a gearbox is necessary.
Related to gearboxes each one has its own advantages and disadvantages, loss factors, depending upon its type and construction.
At same time, if same speed variation was need, mechanical speed variation equipment is available (conical poulies belt drives, spheres on conical surfaces and hydraulic) but all of them with poor efficiency and little variation range. Most part of them is nowadays-archaeological technology.

3. Variable speed drives – Application

The main purpose when using the variable speed drives is to reduce the energy consumption.

They commonly used in:

- Air Compressors in order to adjust the energy supply to the desired air consumption.
- Blowers adjusting the power to the demand air/gas output
- Pumps
- Any electric motor to change its power according with the process requirements
- To perform specially actions like getting a sudden stop of the motor or to change in a fast way the sense of rotation.

4- General remarks

- Optimisation the equipment to the process should be done in order to get the better efficiency.
- It is important to listen the employee's ideas, especially those coming from the maintenance people. They knows well how the process works and could give us ideas how to improving it.
- Involve production people on data acquisition system in order to involve them into the company general goals.
- Use the checklist to find where the possibilities of improvements.