ENGINEERING AND TECHNOLOGY IN INDIA
Volume 4 | Issue 1 | April, 2013 | 17-21

A CASE STUDY

Cost effective opportunities in electrical energy management for dairy industry

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ABSTRACT : Energy is a critical input for the production and consumption activities in the development of economy of any country. In addition to land, labour and capital, energy are the four factors for the production of dairy product. In dairy industry, Energy conservation (EC) is not the suppression of demand for energy use in dairy industry, but efficient use of more and more energy and steep rejection of its wastage. Electrical energy is the most widely used form of convectional energy. Processing of milk and milk products require considerable amount of energy in the terms of the heat and electricity. A major amount of electricity is used for running motors, fan, blowers, and lighting the plant building. Typically, in dairy plant, 80 per cent cost is of milk and remaining 20 per cent comprises of the other variable and fixed costs. The energy cost reflects to ~ 4 per cent of the expenditure. Hence, any attempt to efficiently manage the energy costs will influence the processing costs. The use of energy efficient pump set, soft starter for motor control, variable frequency drive, DG set, etc. in dairy industry would save immense electricity. The removal of incandescent lamps and the use of higher power factor tube light would also save electricity. In the advanced countries, fluorescent tubes are manufactured which are five times as efficient as incandescent lamps. Installing high efficiency motors can reduce energy use, as pumps and aeration systems can contribute 50-90 per cent of the total energy and Capacitor can be connected across large motors to maintain healthy P.F.(between 0.9 to 0.98) correction.

KEY WORDS : Energy, Electrical energy, Soft starter, Dairy industry VFD: (Variable frequency drive)

Article Chronicle : Received : 15.10.2012**; Accepted :** 20.03.2013

How to cite this Article : Chaudhary, D.A., Upadhyay, J.B. and Chaudhari, A.G. (2013). Cost effective opportunities in electrical energy management for dairy industry. *Engg. & Tech. in India*, **4**(1) : 17-21.

INTRODUCTION

Energy is a critical input for the production and consumption activities in the development of economy of any country. In addition to land, labour and capital, energy are the four factors for the production of dairy product in dairy industry, the importance of energy conservation and efficient use of energy is in view of widening gap between demand and supply in all energy sectors, *i.e.* coal, gas, petroleum, electricity, fine wood, new and renewable resources of energy The increased trend in the cost of energy is having a vital energy economical impact on the cost of the manufactured dairy products, transport, cost of storage and associated comfort in dairy industry. Energy conservation (EC) is not the suppression of demand for energy use in dairy industry, but efficient use of more and more energy and steep rejection of its wastage.

Electrical energy is the most widely used form of convectional energy. The total electrical energy production in the India was 1, 67,480MW in march2008. Of this, 144,130MW were accounted by Utilities and 23350MW capacity by captive power plants. Amongst Utilities, 64 per cent capacity was accounted by thermal power plant, 25 per cent capacity by Hydro; 3 per cent capacity by nuclear and 8 per cent capacity by renewable energy sources based power plants. It is observed that 80 per cent of the world's population of the developing countries consumes only 40 per cent of the world total energy consumption and rest is consumed by developed nations.

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Processing of milk and milk products require considerable amount of energy in the terms of the heat and electricity. A major amount of electricity is used for running motors, fan, blowers, and lighting the plant building. Approximately 80 per cent of a dairy plant's energy needs is met by the combustion of fossil fuels (coal, oil or gas) to generate steam and hot water for evaporative and heating processes. The remaining 20 per cent is met by electricity for running electric motors, refrigeration and lighting. Typically, in dairy plant, 80 per cent cost is of milk and remaining 20 per cent comprises of the other variable and fixed costs. The energy cost reflects to ~ 4 per cent of the exependiture.Hence, any attempt to efficiently manage the energy costs will influence the processing costs.

The India possesses the necessary capability to manufacture energy efficient equipments. The use of energy efficient pump set, soft starter for motor control, variable frequency drive, DG set, etc. in dairy industry would save immense electricity. The removal of incandescent lamps and the use of higher power factor tube light would also save electricity. In the advanced countries, fluorescent tubes are manufactured which are five times as efficient as incandescent lamps.

Cost effective electrical gazettes :

Use of soft starter :

A soft starter is another form of reduced voltage starter for A.C. induction motors. The soft starter is similar to a primary resistance or primary reactance starter in that it is in series with the supply to the motor (Three wire or standard connection). The current into the starter equals the current out. The soft starter employs solid state devices to control the current flow and ,therefore, the voltage applied to the motor. In theory, soft starters can be connected in series with the line voltage applied to the motor, or can be connected inside the delta loop of a delta connected motor, controlling the voltage applied to each winding (Six wire or Inside Delta connection).

A soft starter has different characteristics to the other starting methods. It has thyristors in the main circuit, and the motor voltage is regulated with a printed circuit board. It can control the current flow to motor more efficient and stability.

Table 1 : Specific electric energy requirement in modern milk processing

Section / product	KW/ton
In Bottle- pasteurized milk	55
Sterilized milk	70
Skim milk powder and butter	90
Full cream milk powder	80
Ripened cheese-without whey processing	75
With whey separation	100
Evaporated and concentrated	60

*Required including CIP

Soft starter is the common application for electric motor control driven for dairy industry. Soft starter now more advance technologies and can replaced conventional motor starter such as star delta starter, auto transformer or Direct Online starter. It already built in the motor control system and easy to install and wiring to our application. The soft starter makes use of the fact that when the motor voltage is low during start, the starting current and starting torque is also low. This type of motor starting is common used for air-conditioning and chiller system in dairy industry because it can reduce starting current in rushes and can made a compressor more life span.

Normally in the market now it has three different types of soft starter which offer different features and control the motor in different ways.

One phase controller :

This type controlled the torque only one phase during start the motor. It reduce the shock forced during starting but does not reduce the start current value. This type commonly used in conjunction with a direct on line starter.

Two phase controller :

For this type, soft starters control only two phases of motor and it can reduce starting ampere current. The main purpose is to eliminating the torque transients.The suitable application for this types used for normal function and heavy duty loads. The starting current on the uncontrolled phase is slightly higher than the two controlled phases.

Three phase controller :

This type of soft starters control for all three phases. It provides the high level of controlling system. It is more efficient and proper control for motor driven. It is suitable for severe duty application and commonly used for industry machine and equipment system.

Cost benefits of soft starter are :

– During the first part of the start the voltage to the motor is so low that it is only able to adjust the play between the gear wheels or stretching driving belts or chains etc. In other words, eliminating unnecessary jerks during the start chain conveyor motor in food industry.

– It can make possible to adjust the torque to the exact need, whether the application is loaded or not for them.

– It possesses the soft stop function, which is very useful when stopping pumps where the problem is water hammering in the pipe system at direct stop as for star-delta starter and direct-on-line starter used in piping system for dairy industry.

– The soft stop function can also be used, when stopping conveyor belts to prevent material from damage when

the belts stop too quickly in butter manufacturing unit.

Uses of variable frequency drive (VFD) :

A viable-frequency drive (VFD) is an electronic controller that adjusts the speed of an electric motor by modulating the power being delivered. Variable-frequency drives provide continuous control, matching motor speed to the specific demands of the work being performed. Variable-frequency drives are an excellent choice for adjustable-speed drive users in the dairy industry because they allow operators to fine-tune processes while reducing costs for energy and equipment maintenance. Variable-frequency drives are reliable, easy to operate, increase the degree of flow control, and reduce pump noise.

For applications where flow requirements vary, mechanical devices such as flow-restricting valves or moveable air vanes are often used to control flow, which is akin to driving a car at full throttle while using the brake to control speed. This process uses excessive energy and may create punishing conditions for the mechanical equipment involved. Variable-frequency drives enable pumps to accommodate fluctuating demand, running pumps at lower speeds and drawing less energy while still meeting pumping needs. Fig. 1 illustrates the reduced energy consumption of variable-frequency drives over valve control systems.

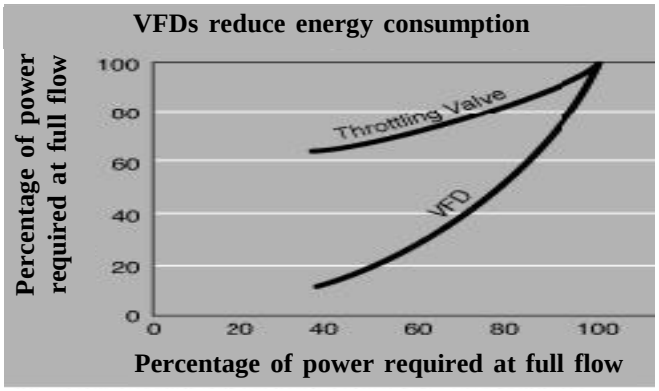

Fig.1: Energy consumption of VRDS and throttling valves

Variable-frequency drives work with most three-phase electric motors, so existing pumps and blowers that use throttling devices can be retrofit with these controls. Variable-frequency drives can also be specified for new equipment.

Cost benefits of VFD :

Energy savings :

Many fixed-speed motor load applications that are supplied direct from AC line power can save energy when they are operated at variable-speed, by means of VFD. Such energy cost savings are especially pronounced in variable-torque centrifugal fan and pump applications, where the loads' torque and power vary with the square and cube, respectively, of the speed. This change gives a large power reduction compared to fixed-speed operation for a relatively small reduction in speed. For example, at 63 per cent speed a motor load consumes only 25 per cent of its full speed power. This is in accordance with affinity laws that define the relationship between various centrifugal load variables.

Control performance :

AC drives are used to bring about process and quality improvements in industrial and commercial applications' acceleration, flow, monitoring, pressure, speed, temperature, tension and torque. Fixed-speed operated loads subject the motor to a high starting torque and to current surges that are up to eight times the full-load current. AC drives instead gradually ramp the motor up to operating speed to lessen mechanical and electrical stress, reducing maintenance and repair costs, and extending the life of the motor and the driven equipment.

Variable speed drives can also run a motor in specialized patterns to further minimize mechanical and electrical stress. For example, an S-curve pattern can be applied to a conveyor application for smoother deceleration and acceleration control, which reduces the backlash that can occur when a conveyor is accelerating or decelerating.

Use of high efficiency motor :

In dairy industry, motors are generally used for driving pumps, compressors, boilers, fans, agitators machine tools etc. as they consume bulk of electrical energy, they require an utmost attention. The oversize motors or running of idle motors should be avoided. The size of motors applied for a pump varies depending upon the duty. The size of motor in boiler, refrigeration, ETP (Effluent treatment plant),

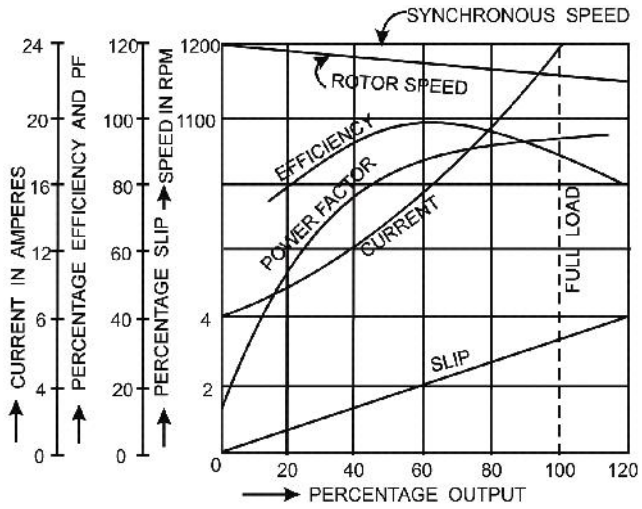

Fig. 2: The performance characteristic of induction motor varses load

processing section ranges between 2 to 12 Hp,5 to 100 Hp,1 to 15 Hp,1 to 15 Hp, respectively. Planning should be made to use the appropriate size of motor with high efficiency, which in turn improves the overall performance of the motor throughout the life. The performance characteristic of induction motor verses load is shown in Fig.2

Efficiency of electric motor is defined as the ratio of mechanical energy output to the electrical energy input.

Efficiengy = [Output/Input] = [1 – (Losses/Input)] = [Output/(Output + Losses)]

Efficiency of the electrical motor depends on the electrical load and its power factor. It is observed from Table 2 that motors operated at full load and at higher power factor, run at higher efficiency. The efficiency of motor is low when it runs at a speed other than the optimized one. Solid like drive-Thyrister converter DC motor drive is much better alternative as efficiency of this drive even at low speed is also quite good. It is costlier but advantageous in saving energy consumption ,therfore, appropriate size of motor having improved power factor avoiding idle running time and improved efficiency of driven equipment reduce the energy consumption. Installing high efficiency motors can reduce energy use, as pumps and aeration systems can contribute 50-90 per cent of the total energy in waste water treatment for dairy industry.

Table 2 : electrical motor efficiency

Loading (%)	100	75	50	40	25
Power factor	85	82	77	70	60
Efficiency	85	84	82	80	70

Power factor correction/improvement :

Electrical energy is mostly utilized in the form of alternating current (AC).By switching on the heating load like an electric heater or a lamp, most of the energy is converted to heat or light. But we encounter problems with induction motors, which are mostly used in dairy industry. The motor winding is in the form of coil of insulated conductor, which opposes the supply distributing the synchronism of the voltage and current. The opposition (*i.e.* resistance) is called inductive reactance which makes the current out of the steps with voltage and lags behind.hence, actual power obtained is splits into two components, active and reactive. The ratio of active and apparent power components is called the power factor (PF).If the power factor is unity we can say that there is no reactive component and full power is put to work.

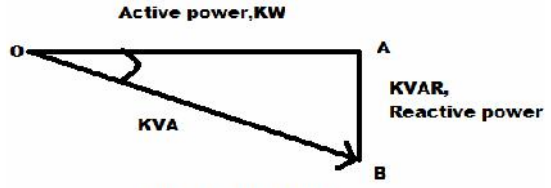

Fig. 3: Power triangle

Here OA is active component; OB is apparent components.

$$\text{Cos}\varphi = \frac{OA}{OB} = \frac{KW}{KVA}$$

$$KVAR = KVA \chi \sin\varphi = KW\tan\varphi$$

Capacitor :

Induction motor take active current as well as magnetizing current (also called wattless current).Capacitor can be connected across large motors to maintain healthy P.F. (between 0.9 to 0.98) correction. Power factor in large establishment can be improved by employing a synchronous motor with over excited field (synchronous condenser) which will act as capacitor.

Load factor improvement :

Load factor represents the capacity utilization of the power by the industries and can be calculated as:

$$\text{Load factor} = \frac{\text{KWH consumption}}{\text{Max. Demand x power factor x No.ofworkinghours}}$$

In many industries, maximum demand occurs only for short period. Users should analyze the demand pattern in terms of daily and seasonal variations. Many non-essential loads like lighting and smaller loads can be switched off during peak hours. Large drives for pumping of water, heating or chilling plants which run for few hours in a day can be scheduled during off peak hours. The improvement in load factor will help in accomonding more loads.

Illumination and lighting :

Selection of the proper type of reflecting and diffusing equipment is more important today than it has been at any time in the history of illumination earlier. Excessive lighting can damage the eyes and can give a raise in the energy consumption bill.

Table 3: Recommended minimum standards of illumination for dairy plants

Section	Minimum Lumen/M^3	Illumination W/m^2
Receiving room	530	20
Scales	750	29
Can washing	330	13
Filling	1080	41
Processing	1080	41
Inspection	1080	41
Laboratories	1080	41
Cold storage room	330	13
Boiler room, compressor room	330	13
Office	800	301
Corridor and stairway	220	9
A toilet and wash room	330	13

Source: Tifail Ahmad(1997)

Recommended minimum standards of illumination for the dairy plants are presented in Table 3. While considering lighting of the plant, the following points may be taken into consideration.

- Lighting level required for different work areas.
- Light sources-fluorescent tubes instead of incandescent lamps.
- Maintenance and control of illumination
- Use of day light for illumination.
- Using electronic chokes
- Accommodation of light sources at lower ceiling height will reduce number of light sources for same illumination level.

The following measure may be kept in mind of the employees for the conservation purpose.

- When plant or portion of building is unused, their respective light should be switched off.
- As far as possible decoration with light should be avoided.
- Likewise it should be a habit of the employees to switch off the fans and lighting when they leave their work place.
- There shall be a provision of operating the lighting at low wattage at night time in the passage areas.

Energy saving electrical devices :

Now a days several new systems have been developed to reduce the electrical power consumption. Some of them are listed below. They can be installed with existing load for electrical energy conservation.

- Shunt capacitors and synchronous condenser system.
- Automatic power cut off device (Relays) mounted on the individual motors and their regular maintenance.
- Automatic voltage controller
- Power factor controller for A.C. motors
- Solid state devices for controlling motor speeds/soft started motor.
- Thermally energy efficient device.

Conclusion :

For electrical energy conservation in dairy industry, focus point include use of the 1) Soft starter to reduce starting current in rushes and can made a compressor of refrigeration plant, more life span; 2) Variable frequency drive (VFD) to reducing maintenance and repair costs, and extending the life of the motor and the driven equipment; 3) Installing high efficiency motors can reduce energy use, as pumps and aeration systems can contribute 50-90 per cent of the total energy; 4) Capacitor can be connected across large motors to maintain healthy P.F.(between 0.9 to 0.98) correction . The improvement in load factor will help in accomonding more loads. Accommodation of light sources at lower ceiling height will reduce number of light sources for same illumination level. Adopting recommended minimum standards of illumination for dairy plants can save energy as well as eyes.

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