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Review Article

Solution Offers For Efficiency and Savings in Industrial Plants

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Abstract

Energy consumption has become an important problem with the rapid energy consumption today. Industrial enterprises who have the largest share in the energy consumption are the consumers who have the biggest problem. Turkey is foreign-dependent in energy production and try to find energy by spending billions of dollars, and its energy need continues to increase. In this context, the most urgent and important thing is energy efficiency. In industrial enterprises, energy efficiency studies to decrease foreign-dependency for energy are dealt. Energy saving studies will be useful as industrial companies are designed without making required feasibility study. Our country will both solve energy problems and increase its competency power with other countries with the serious energy policies in this field. So, studies on important energy saving clues and solutions in compressors, electric motors, pumps and lightening which mostly use energy are done.

Keywords: Energy efficiency, Efficiency and savings.

1. Introduction

Compressor users begin to realize the heat which exists in compressor potentially and sends out without being used. Compressor producers remove heat or water rising during pressing process with exchanger. 90% of the electricity used to obtain compressed air can be regained. If electricity, gas or liquid fuel is used in production or process period, it is possible that one of these methods give its place to heat energy. While specifying the regained heat gained heat levels determine possible usage fields. For example; when it is thought that 94% of the energy spent for water cooling compressor without oil can be regained to gain 90°C water, this saving will decrease cost (Cengiz & Mamiş 2015).

Over heating in the compressor while working makes compressor to cool down to continue working. For example; we can talk about cooling with water system which is mostly used. Basically, compressor can be cooled a little with the help of oil and water's circulation with compressor. After the circulation, the heat of these increases. This heat given out under normal conditions can be regained by economic energy saving methods. In companies which need hot water heat of nominal water can be increased without using extra fuel. If the company does not need hot water fort he process, energy saving can be possible by using it for healing system. It is possible to give more examples. It is frequently seen that the system can pay its cost itself in 2 years when all of the heat can be used. For example: weather cooling, 59lt/sec. Capacity compressor spends in full force. When it is considered that compressor works 48 hours in a week and 52 weeks in a year, total heat which can be regained will be per year. When it is assumed that the heat is used with the electricity the cost of which is 0.07 € per one kWh, the amount of yearly saving will be nearly 9,347 € (Cengiz & Mamiş 2015).

The amount of the compressed air used in industrial plants changes constantly. For instance, the amount of the compressed air can change 50% according to the fiber used in textile sector. Or in the machinery sector , it changes according to production and shift circulation. The researches of European Union EU show that nearly 20-30% of energy used by compressor which are designed to work constantly are consumed unnecessarily an can be regained (Dalgakıran 2014:21.02.2014). Generally, it is the running of the change of the compressed air given to compressor which does not work in full force with inverter. Energy saving can be accomplished with a sensitive check by making the motor run in nominal level when the increases and making the compressor slow down by checking the motor speed when the need for compressed air decreases.

2. Energy Saving in Electricity motors

According to the data of Elektrik İşleri Etüt İdaresi (EİE) 48.000 GWh of 68.000 GWh which is used in industry in 2006 is spent for electric motors. When it is adapted to 2008 data, it is not hard to calculate that 66.000 GWh of 94.500 GWh electricity used in the industry is spent for electricity motors. Almost in all parts of the industry, it is clear why electricity motors are so important in energy consumption. According to these data, even the smallest amount of energy saving will make large amounts of energy saving possible when the whole country is considered. Before buying motor, the cost of energy is not considered unfortunately. But, 97% of the total cost of a motor in its running process, consists of energy costs as seen in Figure 1. The remaining 3% consists of buying, montage and maintenance cost (Cengiz & Mamiş 2015).

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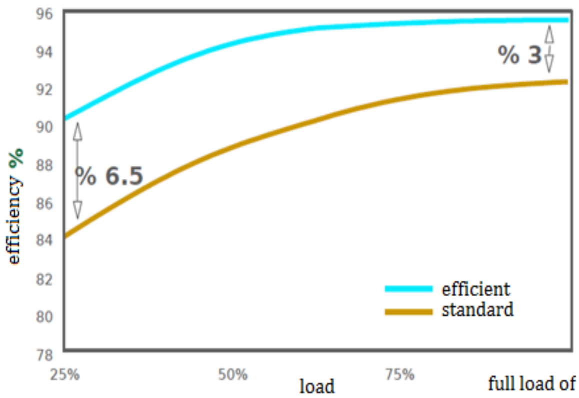

Figure 1. The effect of burden in motor mil on the efficieny [4]

In the determination on 2500 motors used by 25 companies , it is observed that the use of EFF3 25 efficiency class motor is 85%, EFF 2 efficiency class motor is 14%, and EFF1 efficiency class motor is 1%. When an expired motor (12 years) with EFF1 instead of EFF 2 is exchanged, payback period is 5-21 months. When a motor not expired yet is exchanged with EFF1, the payback period is 16-56 months. If speed drive is used in compressed air systems the payback period is 5-18 months. Energy saving potential in electricity motors is stated in Table-1 (Enerji Verimliliği 2008:20.02.2014).

Table 1. Energy saving potential in electricity motors [3]

Precaution	**Saving potential (GWh/year)**
Running with the burden close by its power	400
Use of highly efficient motor (EFF1)	1.300
Use of Changeable speed driver	2.000
Re-wrapping of the fired motor	600
Removal of the loss in compressed air systems	2.600

Motors should be chosen in accordance with the burden and the habit of choosing bigger motor than required should be left. So, it should be prevented that they are in lower power than the written nominal powers in their plates and they work in low efficiency. When the burden increases in motors efficiency does so and motor efficiency reaches maximum level in 75% burden. The electricity used in low burden transforms into raising heat instead of mechanical power and shortens lifetime of motor by increasing the risk resulting from over-heating (Enerji Motor Verimliliği 2008:20.02.2014).

A fan runs with a medium efficient asynchronous motor which is 75 kW. Measurement devices show that only 22,5kW is used in reality. A sample saving calculation;

It is seen in the motor efficiency graphics that efficiency decreases to 72% (power factor to 0,48).

Required real mechanical power: 225 x 0,72 = 16,2 kW and in full force 20 kW efficient motor has % 89 efficiency (power factor 0,9).

Run power : 16,2/0.89 = 18,2 kW

Power save: 22,5 -18,2 = 4,3 kW

If runtime for one year is 8400 hours;

Yearly save: 4,3 x 8400 = 36,120 kWh (also power gets better) (Sanayide Enerji Tasarrufu, 2012:20.02.2014).

One of the most important saving points in electricity motors is the use of motor drives designed with power electricity devices. High level of first take-off current especially in medium and big sized motors both damages motor winding and results in decrease in the lifetime of other equipment. By using soft starter and motor drivers, this situation can be easily prevented. Save in large amounts can be made with motor drives in cycle change need and frequent start stop need. This motor drive can pay for itself in short times depending on the company's condition. Engineers will see net energy save by making comparisons with millimeters and operating motor without driver at the same time controlling motor with the driver.

The information about working condition, plate and the features of motors should be noted periodically. Intervention on time can be made for the maintenance of motors by making constant voltage and current measurements especially in highly powerful motors and important points. Thus, burning in the wraps should be prevented by controlling motors, saving can be made with the control of rulman maintenance, fan and elements. Unstable supply voltage results in positive and negative component current, and this affects motor efficiency (Cengiz & Mamiş 2015).

For example; while in a 75 kW asynchronous motor, efficiency difference between EFF1 and EFF3 motor is 1%, instability of 2,5% in supply voltage can reduce the efficiency of an asynchronous motor at the rate of 1,3% or looseness in belt and pulley mechanism can result in 5% loss.

So, watching motor parameters and early diagnosis of motor breakdown is important for an efficient company. Because motor parameters can not be observed online , the loss resulting from breakdown and negative company conditions cannot be determined. So, condition monitoring and predictive maintenance become more important than ever. In order to talk about enhancing motor efficiency in the industry, online monitoring and predictive maintenance are required. Efficiency change is shown when unstable supply voltage is applied on 100 HP, 1800 RPM motor in Table 2 (Cengiz & Mamiş 2015).

Table 2. Motor Efficiency Under Unstable Voltage Conditions

Motor Efficiency under Unstable Voltage Conditions			
% Motor burden	% Motor Efficiency		
	Voltage unstability		
	Nominal	1%	2,50%
100	94,4	94,4	93
75	95,2	95,1	93,9
50	96,1	95,5	94,1

High level of voltage instability results in serious effects in induction motors. Unstable voltage even results in huge loss in stator and rotor and affects its operation negatively (Cengiz & Mamiş 2015).

3. Energy save in pumps

In the studies about energy save in enterprises, pumps have an important share in energy save. In a study conducted by American Hydraulic Institute, 20% of the energy consumed in developed countries is used by pumps. It is stated that 30%of the energy can be saved by choosing appropriate pumps and good system design (Cengiz & Mamiş 2015). This situation results in researches on efficient production and operation of system in pump producers and users. Also, in some countries legal legislations on this subject is started to be done. For example in European Community (P < 2,5 kW) labeling of the circulation pumps is in its last stage. Putting the letters showing energy efficiency on circulation pumps produced in Germany becomes obligatory. Also, , after the studies conducted for customers to control centrifugal pump efficiency while purchasing it in European community, diagrams showing how its flow, pump head and rotation speed should be (Eren 2008).

Pump systems are generally built for three main purposes. These are : individual, industrial and agricultural. The system has criteria about choosing no matter which aim it is for. While choosing a pump system generally purchase and montage costs are examined. Purchasing and montage costs can be very little when compared to costs of system operation, yet. It can be seen in Figure 2 that how important energy efficiency cost of a pump system when compared to its purchase (Nalbantoğlu 2001).

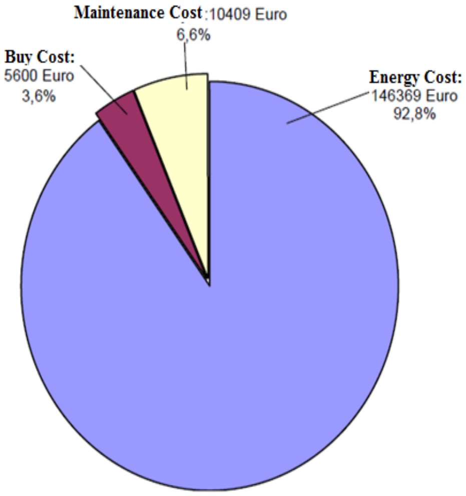

Figure 2. Energy share in a pump's lifelong cost

Important features about pump selection and energy save (Çuha 2005);

- While calculating H and Q, security shares should be big, otherwise pump can not work in max. efficient points.
- It should not be prevented that manufacturers choose max efficient pumps by putting unnecessary limits in pump contracts and some limits should be avoided; pump choosing till 95% of max. wheel caliber, pump choosing in the max efficient point, limiting pump speed
- In the systems in which capacity need is changeable, number of pumps should be increased as many as possible and parallel running can save energy.
- High speed pumps have bigger efficiency, exceptions, mud pumps and situations requiring low NPSHr may exist.
- The use of changeable speed pumps saves energy especially in systems in which static pump head is small.
- Big pumps should be avoided to run in low capacity.
- Max efficient area od pumps which work in a wide range should be in a wide range,too.
- Covering inner parts of worn pumps and overhauling them increase efficiency 1-2%.
- The system should be chosen to meet maximum capacity, but it should be known that the which capacity the system works most of the time. After this analysis, pump system can be designed. If it works in high capacity for a short time, there is no need for full scale pumps or vice versa.

Another important energy saving method applicable in pumps is that one of the weak points of squirrel-cage asynchronous motors is that their power parameter decrease in low levels especially in low burdens. If system runs with a low parameter ,it means little use of consumed energy ,and do the rest is loss . In such a condition, for example, approaching system parameter to 1 with a condenser creates 5% and 30% restoration in energy save. Increasing power parameter decreases pump current and so the loss. For example, the loss of a pump parameter of which is 0,5 four times more than that of power parameter approaches to 1 with correction. Because loss is directly proportional with the square of current. For example, 20% decrease in the current decreases the loss nearly 36%. It shows that how important power parameter restoration is important in energy saving. Power parameters of high efficient motorsa re higher than others as they require low magnetic current. Thus, power parameters of high efficient motors emerging as a result of development project mentioned above are higher than the old serial. This increases energy save (Ögüt 2001).

4.1. Energy save in pump choose

It hould be taken into consideration that the chosen pump runs most efficiently in terms of desired flow and pressure. Let's analyze it with an example. Let's determine the most appropriate pump for a system which needs $198m^3/h$ and $115mSS$ water by determining pump type from Q,Hm curved lines (Nalbantoğlu 2001). In Table 3 , sample pumps and their features are given.

Table 3. Sample pumps and their features

	Q	H	η_P	η_M	η_S	P_1	Pump type
A choice	$198m^3/h$	$115mSS$	%62	%80	%49,6	$119,24kW$	10150/8A
B choice	$198m^3/h$	$115mSS$	%72	%80	%57,2	$108,4kW$	10200/5A

$$P_{1A} = \frac{QH}{3,6.102.\eta_S} = \frac{198m^3/h.115mSS}{3,6.102.0,496} = 125,02kW \quad (1)$$

$$P_{1B} = \frac{QH}{3,6.102.\eta_S} = \frac{198m^3/h.115mSS}{3,6.102.0,572} = 108,4kW \quad (2)$$

Run time of pumps (t) = 3000h
Unit cost of electricity (p) = 0.06 $/kWh

$$\Delta E = \Delta P.t = 16,62kW.3000h = 49.859,3kWh \quad (3)$$

$$\Delta EM = \Delta E.p = 49.859,3kW.0.06\$/kWh = 2991.6\$ \quad (4)$$

As it can be seen above, 10150/8A pump in A choice consumes 49.859,3 kWh more energy than 10200/5A type in B choice. This requires nearly 3000$ extra cost for operator. Investment cost of 10150/8a pump in A choice is 7.960$, and that of 10200/5a pump in B choice is 6.450$. as it can be seen in Table 4, high operation costs because of wrong choice make extra expense which is in the same amount as investment cost in a short time as 2,5 years (Nalbantoğlu 2001).

Table 4. Recovery Cost of Wrongly Chosen Pumps

	10150/8a	10200/5a
Investment cost	$ 7.960	$ 6.450
Wrong choice cost	$ 2.991	-
İnvestment cost/operation cost	$ 2.6613	-

This study was performed between January 2007 and August 2010 in the Burdur Lake, the Lake Van Basin and the Sultan Marshes. These areas were chosen by considering the habitat preferences of the species. Researches about the species were carried out at observation stations designated in the study areas. Stations were established based on population density, nest sites, food availability, predator pressure, suitabilty for observation, intensification of anthropologic pressure and wetland accession (by boat) to monitor breeding data. The Point counts and Line Transect methods were used for a quantitative assessment of the population. To get accurate values about population density, photographs of large groups were used for census. The large groups were counted by dividing the photographs taken in the field into squares.

For determining the population density, monthly observations from the breeding to the non breeding season were conducted. All data were pooled for a 3-year period, together with the mean counts of each year.

4. Energy save in lightening

When electric energy consumption is examined, 19% of it is used for lightening worldwide. (this is nearly 20% for our country). The rest is used for fields called as Professional fields such as industrial plantations, offices,shops,ways and parks (Cebeci 2009).Energy save in the lightening should be accomplished by meet the conditions of a good one and without decreasing the quality. As a good lightening can be accomplished with more efficient lightening elements, it is possible to reach the same level with less energy consumption. By using efficient lightening ,it will be possible both to consume less energy and protect eye health. It is expected from a good and qualified lightening that it sends enough light to the area desired to be lightened.

Lightening dead space or lightening used space more than required will result in energy loss. Inadequate lightening is dangerous in terms of security and comfort. Excessive lightening can deteriorate view completely because of glare problems (Gençoğlu & Özbay 2007). In order to make use of daylight in maximum level, light sensors, motion detectors in places where no one uses, time hours to control lightening according to working hours, astrologic time hours to program environmental lightening economically can save energy in maximum level (Cengiz & Karakaş 2015).

Also, energy saving can be accomplished by using automatic lightening programs which can be designed differently for times when electricity is expensive and cheap (Bozkurt 2009).

In all applications, armatures light sending to space rate of which is not over 20% should be used. Huge amount of energy can be saved in both first plant and operation phases by using active light sources among the armatures which have proper photometric features. When incandescent lamp is exchanged with compact fluorescent lamp, lightening cost decreases nearly 80 %. For example; while monthly consumption of a family with 100 W incandescent lamp is 100 kW, that of a family using compact fluorescent lamp which gives same light current is 20 kW. When we think that 25% of total electric energy consumption in Turkey consists of lightening , this small change means 1.120.000.000 kWh save throughout Turkey (Bozkurt 2009).

In Table 5, economic analysis of CFL (compact fluorescent lamp) and halogen lamps are compared by assuming that lightening is used for 3 hours daily and ' by basing on the electricity unit cost of an abroad country on 01.04.09. (Cengiz & Mamiş 2015).

Table 5. Comparison of Economic Analysis of CFL and Halogen Lamps

Valid Normal Lamp Watt Value	Approximate equivalent CFL Value	Yearly Save Per CFL	Equivalent Halogen Watt Value	Yearly Save Per Halogen
150	23 watt	€25.88	105 watt	€9.17
100	20 watt	€16.30	70 watt	€6.11
75	15 watt	€12.22	53 watt	€4.48
60	11 watt	€9.98	42 watt	€3.66
40	9 watt	€6.31	28 watt	€2.44

5. Results

As many industrial institutions are designed and manufacture insensibly without making required feasibility studies, energy can be used more efficiently with energy save plans.

The energy emerging as excessive heat with compressor operations is sent outside. This excessive heat can be used for hot water production. Also, the compressed air needed by the company can differ constantly according to the condition of the process. Important amounts of energy can be saved with the use of inverter in compressors. The researchers conducted in EU countries show that 20-40% of the energy used in compressors designed to work constantly is consumed redundantly and can be recovered.

Systems can pay for themselves by choosing high efficient motors while buying electricity motors, thinking about the needs of the process by choosing motors, and choosing nominal power motors and making periodical maintenance and using motor drive in variable speed, constantly on- off motors.

It is known that 30% of the energy can be saved by using a good system design and choosing proper pumps. (Cengiz & Mamiş 2015). While choosing pumps, it is necessary to analyze required parameters of the pump. Also, energy can be saved by increasing the power parameter of the used pump. Lightening in the industrial plants has an important share in energy consumption. Use of lightening products can save great energy without compromising on the quality of lightening.

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