OPTIMIZING POWER CONSUMPTION OF COMPRESSORS THROUGH THE IMPROVEMENT OF EFFICIENCY

Thesis submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF ENGINEERING IN MECHANICAL ENGINEERING (INDUSTRIAL ENGINEERING)
of BHARATHIAR UNIVERSITY

By

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CERTIFICATE

This is to certify that this thesis work entitled **"OPTIMIZING POWER CONSUMPTION OF COMPRESSORS THROUGH IMPROVEMENT OF THE EFFICIENCY "** being submitted by N.SARAVANAN (REG. No. 0137H0015) for the award of degree of MASTER OF ENGINEERING IN MECHANICAL ENGINEERING (INDUSTRIAL ENGINEERING) is a bonafide work carried under my guidance. The results embodied in this thesis have not been submitted to any other university or institute for the award of any Degree or Diploma.

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ACC

The Associated Cement Companies Limited

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<u>TO WHOMSOEVER IT MAY CONCERN</u>

This is to certify that Mr. N. Saravanan, II - M.E. (Industrial Engg.), a student of Kumaraguru College of Technology, Coimbatore has done his Project titled "Optimising Power Consumption of Compressors through the Improvement of Efficiency" at our Works during the period from 25.05.2002 to 28.11.2002.

For THE ASSOCIATED CEMENT COS. LTD.

MANAGER HR & ADMN.
MADUKKARAI CEMENT WORKS

A.C.C. LTD.

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SYNOPSIS

Continuous scientific and technological development has been accompanied by the growing misuse of power and a lack of concern for its wastage. This is more so in case of process industries. The number of industries all over the world, especially in India has grown rapidly leading to alarm levels of pollution and power wastage.

It is believed and often proved by actual studies that reduction in power consumption by about ten to fifteen percentage is a realizable goal in a large number of industries by better and effective power measures at unit level. And this can generally be achieved with little or more additional investment. Much more is achievable with some investment.

This project intends to create awareness for the need of system efficiency and power savings, especially for compressors in Associated Cement Companies Ltd., Madukkarai.

In ACC, Madukkarai, it is seen that compressors are used in various departments such as Raw Mill, Kiln, Packing house, Cement Mill departments for mixer basin agitation, slurry agitation, silo aeration, cleaning requirements, cement pumping and etc. The study revealed that most of compressors where operating much lower efficiencies. The objective of this project in to improve efficiency of these compressors and hence reduce the power consumption.

This project was carried out in four stages. First stage was to study a complete picture about the operations that are under going in the company. Second stage was to get through knowledge about the compressors in various departments. Third stage was the evaluation of the volumetric efficiency of the compressors and finding out the causes for inefficiencies.

The last stage was for finding solutions and studying the improvements after their implementations.

The major causes for poor efficiencies of many of the compressors were malfunctioning of lubrication circuit and after cooler, failure of delivery valve, worn out piston rings, etc. The solutions to solve the problems were proposed and implemented in a time span of 3 months. After implementation it is observed that there is a power saving of about 5% and hence a cost saving of about Rs. 2,00,000.

CONTENTS

1.INTRODUCTION

1.1 GENERAL

The manufacturing Industry in India accounts for about half the total commercial energy used in the country. The high-energy intensity of Indian industry compared with advanced countries and the problem of availability of energy and their escalating cost strongly point to the immediate need for effective control on the use of energy.

Any saving that can be achieved in the energy cost can be directly added to the profit figures. While this is also true, in respect of other direct cost as well i.e., labour and material cost. But it is much harder and more difficult to achieve reduction in added management and marketing efforts.

Another area by which profitability of an enterprise can be improved is by increasing production and market shares. But this obviously requires additional investments on expansion of manufacturing facilities and resources and involves added management and marketing efforts.

The real benefit that can be derived from improved energy usage is not fully projected in this report. But improving volumetric efficiency of the compressors in ACC, Madukkarai and their impact on power consumption and energy savings is showed in this report.

It is seen that in most cases where energy cost from significant share of manufacturing cost. A ten percent savings in energy cost could have improved their profit figures by twenty-five percentages. The potential for improving profit through increased energy efficiency is truly enormous.

The situation from industry to industry may vary. Energy cost savings to the extend of ten to thirty percent is very feasible at least in those industries where serious studies has not yet been attempted and five to twelve percent even in well managed industries with good record of energy studies were carried out.

By this report one can visualize the improvement in the performance of the compressors in ACC, Madukkarai with reduction in energy cost could result in with out any major investment.

1.2 MADUKKARAI CEMENT WORKS

As a leading and a pioneer organization in the cement industry in Tamilnadu, Associated Cement Companies Ltd., Madukkarai Cement works has completed sixty seven years of its valuable contribution to the nation with the cement it manufactures as one of the vital elements for the growth of the nation at large.

The factory is situated on NH 47 with its two captive limestone Mines, one at Madukkarai and the other at Walayar. By virtue of its dedicated and systematic networking in all the areas like, procurement, production, quality and marketing. ACC has excelled and remains as a pioneer in the cement industry in Tamilnadu.

Madukkarai cement works is a semi-wet process plant uses the unique technology of vacuum filtration. It happen to be the largest semi dry process plant with this known how in the world. The enrichment of lime stone slurry by froth flotation process is required due to the deviated levels of silica clay content in limestone, a primary raw material to manufacture cement. The cement industries contribute to the air pollution mainly in the form of particulate matter flow. Ever at ACC-MCW particulate emission is reduced due to state of the art manufacturing and controls like Electrostatic precipitator. And the plant has got a production line capacity of 2350 TPD.

The company has a progressive management system in place and is one of the few companies in the sector to obtain both the ISO 9002 and ISO 14001 certification. It is constantly striving to incorporate then latest innovations and technologies to achieve optimum production and cost minimization.

Production of cement during the year 1999-2000 compared to the previous year went up to ten percent. This plant produces Ordinary Portland cement (OPC-43) and Pozzolona Portland cement (PPC-Suraksha) grade cement. The major inputs are limestone, bauxite, gypsum, iron ore, fly ash, mill scale will got into the output.

Caustic soda, Soap and Rosin are used for the beneficiation of limestone.

Packing materials (50Kg bags) used are either PP/HDPE or paper bags.

PROCESS DESCRIPTION

Cement is a power produced from a variety of naturally occurring material. It is need as a binding agent most often as a component of mortal or concrete the cement manufacturing process consists of the following stages.

1. Lime stone mining
2. Crushing of limestone
3. Wet grinding of lime stone in raw mills
4. Floatation for beneficiation of high-grade lime stone slurry
5. Filtration
6. Drying
7. Pyro processing
8. Finish grinding
9. Cement packing

The limestone obtained from the mine is powered and it is send to raw mills and ball mills where the water is added to form slurry. The slurry is beneficiated by using froth flotation process. The slurry from the flotation department is process through vacuum drum filters to obtain cake.

The dried cakes are then fed in to kiln through top cyclone in preheater. Partial calcinations takes place in preheater and calcinations is completed in kiln. The intermediate product from kiln is clinker (of used power or module formed in kiln), which is cooled in grate cooler and stored in silo.

The clinker stored in silo is conveyed to cement mill for grinding.

For Ordinary Portland cement (OPC-43), Clinker 95% ground along with gypsum 5%

For Pozolonna Portland cement (PPC-Sureksha), Clinker 80% is ground along with gypsum 5% and fly ash 15%

The cement is then stored in the silos and subsequently packed before being shipped out of the plant.

The process flow chart of A.C.C, Madukkarai is shown in Fig .1

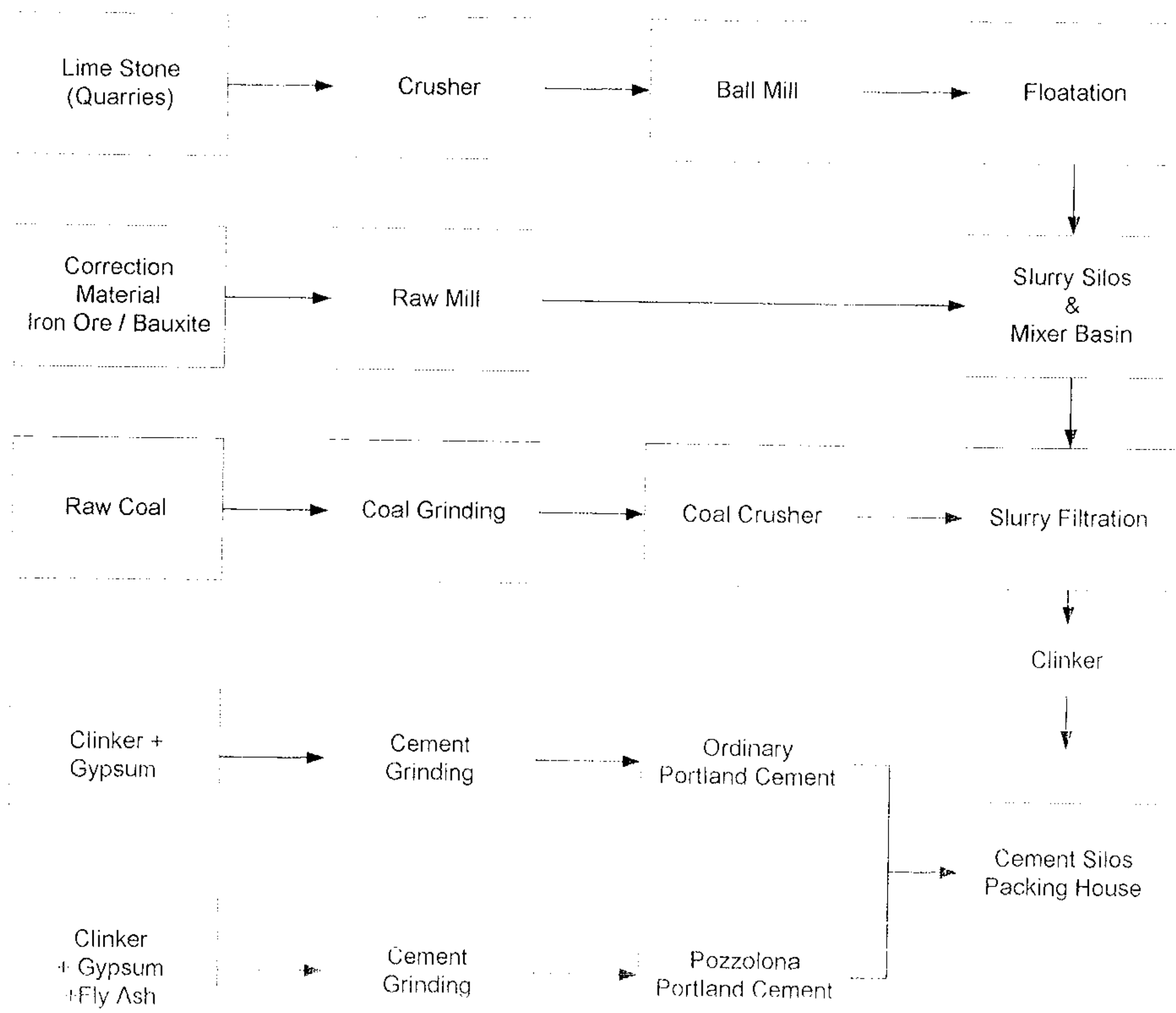


Figure No:1 MANUFACTURING PROCESS IN ACC, MADUKARAI

2. PROBLEM DEFINITION

The requirements and design keep on changing due to continuous improvements and in process industries this continuous scientific and technological development has been accompanied by the growing misuse of power and lack of concern for its wastage. The wastage of power is one of the causing phenomenons for profitability.

This project is focused towards improving the efficiency of compressors and thereby reducing the wastage of power. Compressors are used in various departments for mixer basin agitation, slurry agitation, silo aeration, cleaning requirements, cement pumping and etc.

There are totally 26 compressors in the ACC plant. The efficiencies of the entire compressor were studied. It is found that among the 26 compressors studied, eight compressors were found to have efficiencies much lower than the optimum. The problem is to identify the reasons behind the poor performance of the compressors and suggesting recommendation for their improving their efficiency.

The improved efficiency of the compressors means reduction in power consumption.

The details of the compressors with lower efficiency are

Compressor No	**Department**	**Compressors Application**
1	Kiln	Poking air for cleaning
2	Cement mill	Cement pumping
3	Cement mill	Fly ash unloading
4	Cement mill	Process and instrumentation
5	Raw mill	Slurry agitation
6	Raw mill	Slurry agitation
7	Packing house	Silo aeration
8	Packing house	Silo aeration

To confirm the problem we conducted free air delivery test is conducted for the above listed compressors and their volumetric efficiency is calculated.

Free Air Delivery Test Result:

Compressor No	Design FAD M^3/min	Actual FAD M^3/min	volumetric Efficiency %
1	8.41	6.98	83
2	31.40	27	86
3	15.37	8.26	54
4	8.33	4.16	50
5	22.2	11.91	54
6	30.02	11.17	37
7	1.4	0.98	68
8	1.4	0.68	48

Calculation and results are explained in Chapter 6

3. PROBLEM SOLVING

3.1 Objectives

1. Identifying the factors affecting the compressor efficiency and to come out with recommendations to increase the efficiency.

2. To bring down the power consumption cost by identifying and eliminating the reasons behind the poor performance of the compressor.

3. To maintain compressed air system utilization at optimum level by the compressors performance through better maintenance practices.

3.2 Measures To Be Taken To Reduce Power Loss

The following factors considered for reducing power loss in compressor.

1 Compressor selection

2 Location of the compressor

3 Cooling water circuit

4 Controls and its operation

5 Compressor plant maintenance

6 Capacity assessments

7 Effective air distribution

8 Efficient running of driven equipment

3.3 Methodology

The following approach has been adopted for preparing the project.

1. Short listing of energy efficient units in compressors cement industry.
2. Mailing of questionnaires of the short listed units requesting for information on the improvement case studies along with cost benefit analysis.
3. Review of data, wherever required.
4. Completion of the collected case studies as a project.
5. The case studies have been projected with relevant technical details and financial analysis.

3.4 Description of Events:

This study was undertaken mainly in four stages.

1. Understanding the company
2. Understanding the compressor
3. Evaluation of compressor performance
4. Results

3.4.1 Understanding The Company

In this stage the main objective is to know the operations that takes place in the company. This is important to make a study on a production line for a person who is going to analysis compressed air system.

3.4.2 Understanding The Compressor

This is the second stage of study. This stage is to get a thorough knowledge about the compressors. i.e., to study the compressor, their power consumption and about the existing conditions and specifications regarding the system.

3.4.3 Evaluation Of Compressor Performance

This is one of the important stages that a person who is analysing has to go through. In this stage, we have to calculate the volumetric efficiency of each and every compressor in the plant and energy consumption.

3.4.4 Recommendation & Results

This is final step of the study. In this step, the recommendations for improving the system are to be suggested.

4. IMPROVING THE EFFICIENCY OF THE COMPRESSORS

Introduction:

Compressors play a vital role in cement industry for material conveying requirements. The compressors are power-absorbing units raising the pressure energy of air. The required power is provided by prime movers like electric motors. The air can be compressed at constant volume and constant temperature and constant pressure. The pressure, temperature, volume varies during compression process and there is an exchange of heat energy between the system and surroundings. The constant temperature process is very difficult to achieve in practice. The compressor maintenance cost is very high compare to purchase cost. In general about 10% of all electrical power used in cement industry is employed in compressed air [11].

4.1 Classification Of Compressors:

Compressors can be broadly classified into two types [12]

1. Dynamic Compressors
2. Positive Displacement Compressors.

Dynamic Compressors

Dynamic Compressors can be classified into two types

1. Radial Flow Compressors
2. Axial Flow Compressors

Dynamic Compressors are called centrifugal compressor. In centrifugal compressor, which increase the velocity, which is then converted to increase at the outlet. Centrifugal compressors are necessary wherever high quantity compressed air constantly required. A small change in compression ratio change produces a marked change in compressor output and efficiency.

Radial Flow Compressor

The air enters the diffused where a satiate part of its kinetic energy is converted into static pressure. The air enters the casing and outlet pipe, where some more kinetic energy is converted into pressure energy.

Axial Flow Compressors

The Axial Flow Compressor, the working fluid enters and leaves the compressors in axial direction. It consists of adjacent rows of stator and rotor. The rotor blades are mounted on a rotating wheel and the stators are fixed to the casing. The passage formed by two compressors is essentially a diffuser in which the kinetic energy of fluid particles is converted into pressure energy. The pressure continuously rises through the successive stage of the compressor, when the fluid particles flow either over rotating blades.

Positive Displacement Compressors:

Positive Displacement Compressors can be classified into two types.

1. Reciprocating compressors
2. Rotary compressors

In positive displacement compressors, increase the pressure of the air by reducing the air volume.

Reciprocating compressors

The Reciprocating compressors, the working air is compressed a cylinder piston assembly. The piston moves up and down inside a cylinder, which has two openings inlet valve and outlet valve. The piston is filled with the working fluid to be compressed say air, the volume occupied by air is raised or upward stroke of the piston when the inside the cylinder equals the delivery pressure. The delivery valve open, the piston continues of move upward and compressed air pushed out of the cylinder to a receiver at constant pressure.

Air taking volume $= \Pi/4\ d^2 l$

D = piston Diameter

L = stroke length

Rotary compressors

They have two intermeshing rotors with helical lobes, which are designated as male and female. When the male and female rotor lobes engage, they form a cell in which the air is enclosed. As the rotors rotate the volume of the cell is reduced compression begins. Further rotation causes the line of engagement of rotors to travel towards the outlets with the result that the air is displaced from the cells under pressure.

Suitable capacity and compression ratio of different type of compressor

Table 4.1.1

Type	Capacity cm^3/min	Compression ratio
Reciprocating compressor	0-500	2.5-1000
Rotary compressor	0-500	3-12
Centrifugal compressor	100-4,000	3-20
Axial compressor	100-15,000	2-20

In cement industry, reciprocating compressor only used. The benefits of using reciprocating compressor compare than other compressor is showed the following comparison table 4.1.2.

COMPARISON:

Table 4.1.2

FEATURE	CENTRIFUGAL	RECIPROCATING	ROTARY
Capacity	Very high	Low to moderate	Low
Pressure	Moderate	High	Low
Specific power consumption	Sec best	Lowest up to second of capacity	Highest
Reliability	Better	Better	Good
Oil compressed air	Oil free	Oil free(if resd.)	Second best
Speed	Very high	Lowest	Second lowest
Floor space	Compact	Slightly higher	Compact
Foundation needs	Light	Massive	Light
Varies	Not suitable	Most flexible suitable for an type of demand	Flexible up to working range of pressure
Maintenance cost	Lowest	Higher	Second highest
Dusty condition	Second best	Best suitable	Not suitable

4.2 TESTS TO BE CONDUCTED

Following are the important tests that have to be carried out periodically to make sure that entire compressed air system operates at maximum efficiency and without waste.

FREE AIR DELIVERY CAPACITY

All compressors are designed to deliver certain cubic feet of free air per minute at a specified led pressure. M^3/min of tree air is the standard unit by which compressed air flow rate is measured and related to air at atmosphere. This test is conducted to confirm whether compressor is working at its rated capacity.

It is calculated by measuring the time taken to till air receivers up to its designed pressure. By knowing receiver volume, interconnecting pipeline volume and outlet air temperature it is possible to estimate the present FAD capacity.

CALCULATION

Volume of air receiver + inter connecting pipe lines	= A m^3
Time taken to fill receiver	= B minutes
Air receiver pressure	= C Kg/cm^2
Compressed air exit temperature	= D^0K
inlet air temperature	= E°K
Atmosphere air pressure	= Kg/cm^2
Actual F A D of compressor in m^3/min	= (Ax C/F x E/D) x 1/B
Volumetric efficiency m3/min	= Actual capacity/design capacity.
Percentage of deviation	= rated capacity – actual capacity

4.3.2 Quantification of Compressed Air Leakage

Leaks obviously waste energy, but also reduce the effective capacity of compressor plant and may, in extreme cases, reduce significantly the performance of the equipment used. Leaks should he always be rectified before any increase in compressor capacity is contemplated.

With all air operated equipment shut off, run the compressor until the system reaches full set pressure and the compressor unloads; note the time. Due to air leaks the system pressure will fall, and the compressor wilt come on load again; note the time. The period for which the compressor is 'on load' and 'off load' should be recorded at least four times to give a mean value of each.

Let T minutes = time on load

t minutes = time off load

Q = Actual free air delivery capacity compressor in m^3/min

L = system leakage in m^3/min.

$$L = Q * T / (T+t) * m^3/min.$$

Pressure Drop In Air Distribution System

The air mains and their associated branches, hoses, couplings and other accessories offer considerable opportunities for energy conservation. Excessive pressure drop due to inadequate pipe sizing, choked filter elements, improperly sized couplings and hoses represents energy wastage, as do leaking pipe joints and couplings.

This loss is identified by noting line receiver pressures at different locations simultaneously. The difference in pressure at the generating and farthest point will indicate the drop in pressure resulting energy waste. This can be minimized by properly sizing the main and distribution line.

Pressure drops through pipes can be obtained from the formula

Pressure drop (bar) KLQ/5.3 >R*d

Where K = 800

L = Length of pipe in metres (Equivalent diameter for all fittings)

0 = Volume of free air lit/sec

R = Compression ratio

d = Internal pipe diameter in cm

General Observations

Apart from measuring above parameters and conducting above tests, general observations pertaining to the energy saving aspects, listed .below, have to be looked into [9] :

a) Cooling tower performance

b) Quality of cooling wafer

C) Effectiveness of infer and alter coolers

d) General location of compressors

e) Receiver size

f) Cooling tower pump and tan capacity

g) Misuse of compressed air

h) General operation and maintenance of compressors

I) Other house keeping measures

These factors sometimes affect the efficiency of compressors and its use.

4.3 Planned Programme For Energy Savings

Energy saving areas/opportunities in compressed air system may be generally classified into two categories as

a) Compressed air generation

b) Distribution and utilisation of compressed air

Above two sections can be further divided into different small areas, which can be examined as part of a planned programme aimed at cutting the cost of compressed air.

These areas are

1. Compressor selection
2. Location of compressors
3. Cooling water circuit
4. Pressure settings, controls and its operation
5. Effectiveness of inter and after coolers
6. Compressor plant maintenance
7. Capacity assessment
8. Effective air distribution
9. Avoiding leaks and wastages.
10. Efficient running of air driven equipment
11. Using lower Pressure

4.3.1 Compressor Selection

Compressor selection should be based on the pressure required and the average and maximum loads. Two stage or multistage compression is generally more efficient especially where the gas is cooled between stages. A comparative costs for different stage compressors are given in Exhibit-2. In very general terms, for air requirements of 6001ctm or less, the cost efficient is the reciprocator, centrifugal (small Sizes). Rotary screw and vane compressors are less efficient. Above 6000 ctm the centrifugal compressor provides better efficiency. Rotary vane compressors for ratings of 93 KW and over will consume 6-20% more energy than reciprocating compressor having the same capacity.

4.3.2 Location Of Compressors

Location of air compressors within the building can have a significant bearing on the amount of energy used by the compressor and cool, clean and dry intake air will lead to more efficient compression.

Cool Air Intake

For every 4°C (7°F) rise in inlet, temperature there will result a 1 percent rise in energy consumption to achieve equivalent output. Hence it is preferable to locate compressors in well-ventilated places or draw air from outside the building because its temperature will be lower than the room.

Dust Free Intake Air

For every 25 mbar (10 in WG) pressure lost at the inlet the compressor performance is reduced by 2 percent

Intake filters should be regularly cleaned well before dirt causes significant pressure restrictions.

Dry Air Intake

Atmospheric air always contains a proportion of water vapour. The value of this proportion will depend on the relative humidity. It wilt be high in foggy or rainy weather or if the inlet of the compressor is over a pond or stream or other damp area. Moisture carrying capacity of air increases with a rise in temperature and decreases with rise in pressure. By drawing low % RH air, energy saving is possible, which would be otherwise used for compressing water vapour.

Precooled Air Intake

By cooling the air prior to the compressor, the efficiency of the compressor set can be further improved. This cooling, usually to - 25°C, is achieved using refrigeration. As the temperature of air is reduced, its volume decreases and a greater volume of air is available to the compressor. Therefore, due to pre-cooling, either more air is delivered for a given power input or the power input is reduced for a required volumetric flow rate. 20 - 30% of compressor power requirement (after deducting energy required for refrigeration) can be saved by taking free cooled dry air.

4.3.3 Cooling Water Circuit

Most of the industrial compressors are water-cooled two stage-reciprocating compressors. Cooling water is circulated through cylinder heads, intercooler and alter coolers to remove the heat of compression. Warm water is cooled in a cooling tower and circulated back to compressors. Cooling water temperature and quality also affect the efficiency of compressor.

Cooling Tower Performance

Main purpose of cooling tower is to reduce the inlet warm water temperature close to the wet bulb temperature of ambient air. Practically achievable approach temperature is 2-5°C depending upon the type of cooling tower employed. Because of algae growth, scale formation and corrosion, intimate contact between air and water tampered resulting high temperature approach, which will affect compressor capacity. Proper maintenance of cooling tower is very important.

Cooling Water Pump

Generally cooling water is supplied to compressors through centrifugal pumps at a particular pressure and the rate. Any change in water flow rate will affect compressor capacity. Generally all pumps installed in a central compressor house are over designed (for safety reasons) and are capable of catering more than 5 compressors. During lean seasons only one or two compressors will be running but cooling water will be circulated through all (including idle) compressors, which is a waste of energy.

Cooling Tower Fans

Cooling tower fans are provided to facilitate more air throughput in the tower. Cooling water temperature and ambient air conditions vary depending upon the season. Once cooling water temperature approaches the wet bulb temperature, cooling tower fan can be switched off or operated intermittently. Interlinking water temperature arid fan operation can provide a control circuit.

Cooling Water TDS

Generally ordinary raw water is used for compressor cooling. After a few days of operation, some quantity of cooling water is lost due to evaporation, entrainments, drift and wind age, resulting increased TDS levels in water. This will reduce the heat exchanger effectiveness and compressor free air delivery capacity. It is recommended to use treated water or purge portion of cooling water periodically to maintain the TDS levels within acceptable limits.

4.3.4 Compressor Pressure Reduction, Controls And Its Operation

Pressure Reduction

Power consumed by a compressor mainly depends on its operating pressure arid rated capacity. Compressors should not be operated above its recommended operating pressures or optimum pressures as this not only wastes energy but can also lead to excessive wear with further energy wastage. It any process or equipment does not need high-pressures, then, operating compressor at elevated pressures is a waste of energy. A reduction in the delivery pressure of a compressor would reduce the power consumption as shown in the Table.4.3.4.1

TABLE 4.3.2.1

Pressure reduced From - to	Power Reduction		
psig psig	Single stage	two stage	two stage
		water cooled	water cooled
100 — 100	-	-	-
100 — 90	4%	4%	2.6%
100 — 80	9%	11%	6.5%

Controls

The control system, which governs the running of the compressor, should be matched to its duties and may need rematching if these change. Generally all compressors are fitted with some form of control system, which varies the volume of air delivered to suit demand so that a constant delivery pressure is maintained. General forms of controls for small compressors are on-off type with pressure limit switch. Big compressors will off load once required pressure is reached. This is done by either fully opening or closing the inlet valve. If differential pressure in the pressure switch is too narrow hunting will take place or if it is too wide, power is wasted in high-pressure operation. Optimum pressure differential (0.5 - 1.0 kg/cm2) have to set with a receiver of adequate capacity.

Compressor Operation

Where more than once compressor is feeding to a common header, compressors have to be operated in such a way that only one compressor should handle the load variation whereas other compressors will operate more or less at full load. Generally smaller capacity compressor is allowed to modulate. Where only one equipment needs compressed air at elevated pressure, it is advisable to use a separate compressor or booster compressor to boost air from base pressure to required pressure, instead of operating all the compressors at high pressure.

Variable Speed Motors/Drive

The ideal control for positive displacement compressors to conserve energy is by varying the speed. In the case steam or diesel engine compressors, it is easy, but it is difficult in AC induction motors which will call for a bulky and expensive gear assembly. Recent developments in electronics and microelectronics have resulted in a more reliable control gear to allow a conventional AC induction motor to operate in a variable speed mode at high efficiency and in the long term, such systems could become the standard for air compressors. The newer controls also provide a "soft start" feature which can provide a variable start time with minimum starting current thus cutting out surge currents and damage to the motor.

4.3.5 Effectiveness Of Inter And After Coolers

The main aim of providing inters and after coolers in a multistage compressor s to cool the air in between two stages and also to remove excess water from compressed air.

Fouled intercoolers will allow high temperature air to the second stage, which will affect the efficiency of the second stage and finally the overall efficiency. Fouled after - coolers causes more water condensation in air receivers and distribution lines resulting increased corrosion. Periodic clearing of both heat exchangers and cylinder heads will avoid these shortcomings.

4.3.6 COMPRESSOR PLANT MAINTENANCE

Well maintained plant, in line with Maker's instructions, leads not only to the preservation of rated capacity but also to optimum thermal efficiency in energy savings. Different items in a compressor, which must he Checked periodically, are driving belts for tightness. Valve gear, piston and piston rings of reciprocating compressors, vanes of rotary compressors and blades of turbo compressors Apart from these, other housekeeping measures have to be followed periodically. All instruments should be accurate, checked regularly and well maintained.

4.3.7 compressor Capacity Assessment

Compressor capacity is expressed in terms of quantity of tree air delivered at a particular pressure. Various parameters such as poor maintenance, fouled heat exchanger, altitude, etc. will lead to reduced tree air delivery than the designed values. The power wastage (compressor runs more time for the designed output) depends on the percentage deviation of FAD capacity.

4.3.8 Efficient Air Distribution System

Pressure Drop In Lines

The air mains and their associated branches, hoses, couplings and other accessories offer considerable opportunities for energy conservation. Excess pressure drop due to inadequate pipe sizing, choked filter elements, improperly sized couplings and hoses represents energy wastage.

The following table demonstrate the penalty in energy wastage if the pipes used are too small.

Table 4.3.8.1

Sl. No	Pipe Normal bore (mm)	Pressure drop (bar) per 100 metres	Equivalent power losses KW
1	40	1.8	9.5
2	50	0.65	3.4
3	65	0.22	1.2
4	80	0.04	0.2
5	100	0.02	0.1

Selection Of Dryers

There are applications whore the air must be not only clean, but have a reduced dew point. This will call for more sophisticated and expensive methods to lower the dew point of compressed air. Three common types of dryer employed are heatless absorption (adsorption), absorption and chiller dryers. They produce dry air with - 10°C to - 40°C due point. Heatless absorption system will require 10% of free air to regenerate saturated bed. In chiller units electrical energy is used to condense water vapour. For energy conservation consideration should be given to air driers with heal regeneration, which make use of some of the heat of compression in their operation.

If chiller plant is used for air-drying, attempt has to be made in chilling the inlet air to the compressor which will not only increase the compressor efficiency but also remove all moisture. Oil and dirt can be removed in later stage.

Receiver Size

The main purpose of receiver is to act as a pulsation damper and also as a power storage vessel, allowing intermittent high demands for compressed air to be met from a smaller compressor set with correspondingly low energy use, At points of sudden high demand, an extra receiver near the point of take-off may avoid the need to provide extra capacity

Line Moisture Separators And Traps

Although in an ideal system all cooling and condensing of air should be carried out before the air leaves the receiver, this is not very often achieved in practice. The amount of condensing which takes place depending on the efficiency of moisture extraction before the air leaves the receiver and the mains itself. In general, the main should be given a fall of not less than I m in 100m in the direction of air flow and the distance between draining points should not exceed 30m.

Drainage points should he provided by using equal tees and it assists in the separation of the water whenever a branch tine is taken all the main it should leave the lop of it so that any water in the main does not fall straight into the plant and the bottom of the falling pipe should be drained

For most everyday applications much of this water from air water must can be by fitting a separator in the distribution mains, An automatic device such as trap be used to drain water from different parts of the compressed air installation. Generally, the ball float type of drain trap is the most common because it gives a positive shut oft opening only to the presence of water and closing immediately the water has been cleared.

4.3.9 Avoiding Leaks And Energy Wastage

Another major opportunity to save energy is in the prevention of leaks in the compressed air system. Leaks frequently occur at air receivers, relief valves, pipe and hose joints, and shut of valves, quick release couplings, tools and equipments. In most cases they are due to poor maintenance and some times improper installation like underground lines. If the resultant power wastage were fully appreciated it would be seen that any expenditure on sealing leaks could be easily recovered in energy savings.

A simple method of measuring the total leakage of the system, which should be part of the planned maintenance programme, has been already illustrated in the quantification of compressed air leakage.

4.310 Efficient Running Of Air Driven Equipment

Worn out seals and other moving parts of a pneumatic tool will inevitably lead to loss in operating efficiency with possible leakage of compressed air and consequently energy wastage. The use of compressed air as a continuous source of power (pneumatic grinder, driller) should always be challenged and that economics of direct electric considered for such applications.

Filters

Filters must be regularly serviced to clear or renew the elements which gradually become choked with dirt, thus causing excessive pressure drop and energy wastage

Using Correct Pressure

Pneumatic equipments should not be operated above its recommended operating pressure as this not only wastes energy but can also lead to excessive wear with further energy wastage. In certain cases such as below guns, ejection nozzles etc., where air is discharged direct to atmosphere for the purpose of cleaning or cooling, operating at high pressure causes excessive energy wastage.

Lubricating Equipment

All pneumatic equipments should be properly lubricated which will reduce friction, prevent wear of seals and other rubber parts thus prevent energy wastage due to excessive air consumption or leakage.

4.3.11 Using Lower Pressures

In a factory, equipments Such as spray gun, cooling jet, hoists and control systems etc., may be operating on supply pressures in excess of that required for that operation. Considerable air consumption savings and thus energy can be directly made by simple fitting of a standard type of pressure regulator to keep the pressure supply being fed to the equipment to minimum necessary.

Misuse of compressed air such as body cleaning, agitation, general floor cleaning, driving mosquitoes, for comfort air, equipment cooling and others similar uses have to be discouraged in order to save compressed air and energy.

4.4 Standard Routines To Improve Efficiency

In order to keep compression systems operating efficiently, various checks and inspections are recommended. These are summarized in the form of check fists as follows:

Operating Considerations

- Check pressures, take gauge readings regularly, because inadequate pressures indicate valve problems or air leaks [10]
- If reservoirs fail to charge, check for leaking bypass valves.
- Check manual drains for proper drainage to prevent condensation build up.
- Check safety valves; manually pop valves to prevent excessive pressure and wear.

- It the compressor knocks or vibrates, check for excessive discharge pressure, inadequate lubrication, or loose compressors components.
- Check the temperature; check for worn valves, excessive discharge temperature and inadequate cooling and lubrication; check for defective capacity control and dirty inter cooler or cylinder jackets [10]
- Size air hoses for minimal pressure drop to air tools.
- Ensure that air filters specifications meet requirements of 100% removal efficiency for 10—micron particles, 99.5% for 2—micron and 97% for 1—micron.
- Install manometer across the filter and rnonitor the pressure drop as a guide to element replacement.
- Check titter housing and piping to compressor flange for leakage at seals or flanges; if suction piping is long, provided support and flexible connection to remove weight from compressor housing.
- Keep suction air velocity below 1400m/min.
- Check lubricating oil condition weekly by spectrographic analysis to detect incipient wear by finding presence of trace metals.
- Check lubricating oil consumption from performance records and manufacturers' specifications; for three- or four-stage compressors, lube oil consumption of 0.11 litres/100 Kwh is typical.
- Read pH value of intercooler condensate for acidity and indication of leakage from waterside into tubes.
- Monitor vibration of each impeller, in nuts amplitude, at a central control panel or scanning console; excessive vibration suggests misalignment foundation settlement, debris in impeller rotors, out of balance rotors, worn

out bearings, bent halting, or damaged drive coupling. Programme the procedures for chiller driers and automatic-trap drain to cut air waste.

- Provide adequate receiver capacity where reciprocating compressors are part of the system to prevent pulsations in piping that could damage check valves in the centrifugal compressor discharge piping.
- Conduct in plant seminars on m stress reduction of air waste and improvement of air equipment performance.
- Ensure the compressed air intake is in a cool location. Every 4°C drop in intake air temperature results in a 1% increase in compressed air volume for the same power requirements.
- Inspect instrumentation frequently to ensure that operating oil pressure and temperature agree with m. specifications.
- Look for unusual compressor operation, such as continuous running or frequent stopping and starting other of which car indicate inefficient operation, determine the cause and, if necessary, correct.
- Consider reducing the operating speed/pressure on air-operated paint pumps and pain agitators during off-shift hours; depending on pigmentations and metallic content, it might be possible to stop all agitation or circulation of some enamels or lacquers during off hours.
- Prohibit use of compressed air-operated fans or compressed hoses for personal cooling.

Maintenance Considerations

- Perform the following on a regular, planned basis;
- Inspect for, locate, and repair all leaks; most leaks are from loose pipe fittings, valve packing, shut-off valves, worn-out filters, quick couplers, and unused air tools.

- Test for correct pressures; make necessary adjustment matching compressor pressure to system requirements. Replace worn valves, which can reduce efficiency by as much as 50%.
- Keep compressed air clean and dry; be sure air intake is in cool location.
- Remove scale build up; flush, if possible, with chemicals; use discretion because mechanical damage can occur.
- Clean and replace damage intercooler and after cooler tubing and fins.
- Adjust tension in drive belts.
- Clean and replace damaged compressor valves.
- Keep fan belt drive and motor properly aligned and lubricated.
- Inspect refrigeration-piping connections to the condenser coil or lightness; repair all leaks.
- Keep condenser coil face clean to permit airflow.
- Determine if hot air is being bypassed from the fan outlet to the coil inlet; if so, correct the problem.
- Inspect air compress intake fitter pads and clean or replace as necessary.
- Lubricate compressor motor bearings according to manufacturer's recommendations.
- Listen to compressor noise; excessive noise might be a sign of loose drive coupling or excessive vibration; tighten compressor and motor on the base: if noise persists, call a mechanic.
- Check all compressor joints for leakage; seal as necessary.
- Inspect air pressure in supply lank and pressure regulator adjustment in supply line for proper limits.

- Keep compressor valves in good condition for maximum efficiency; worn valves can reduce compressor efficiency by as much as 50%; many compressor manufacturers recommend removal and inspection every 6 months. Check for water contamination: water or combustion Of lube and water can cause pipe corrosion, instrument malfunction, and other problems; visually inspect the system for the contaminations. -
- Check air compressor logs regularly for abnormal readings, especially motor amps, cooling water flow and temperature, inter- stage and discharge pressures and temperatures, and compressor load cycle.
- Check air system for leaks by operating one compressor when production is shut down; the percentage of time the unit operates loaded compared to the time of complete cycle (loaded and unloaded) will be the percentage of that compressor's capacity used to supply plant air leakage.

5.CASE STUDY

Analysis Of The Volumetric Efficiency Of The Inefficient Compressors

COMPRESSOR S.NO	UNIT	1	2	3	4
Application		Cleaning requirements	Cement pumping	Fly ash unloading	Process and instrumentation
Design Pr	Kg/m^2	8	4	4	7
Design FAD	m^3/min	8.41	39.00	15.37	8.33
Derated FAD	m^3/min	8.41	31.4	15.37	8.33
Receiver capacity	m^3	2.34	20	3	1
Time taken	sec	130	147	82	95
Dist.of pipe line	m	16	14.3	25.6	41.35
Pipe line diameter	m	0.09	0.2	0.15	0.1
Volume of pipe line	m^3	0.1	0.45	0.69	0.32
Total volume	m^3	2.44	20.45	3.69	1.32
Air receiver pressure.	Kg/cm^2	8	4	4	7
Compressor air exit temperature	Degc	75	90	110	90
Inlet air temperature	Degc	30	30	30	30
Atmosphere pressure	Kg/cm^2	1.03	1.03	1.03	1.03
Actual FAD	M^3/min	6.98	26.78	8.26	4.16
Volumetric efficiency	%	83	86	54	50

Analysis Of The Volumetric Efficiency Of The Inefficient Compressors

COMPRESSOR .NO	UNIT	5	6	7	8
Application		Silo Aerasion	Silo Aerasion	Slurry Agitation	Slurry Agitation
Design Pr	Kg/cm^2	4	5	7	7
Design FAD	m^3/min	22.2	30.02	1.4	1.4
Derated FAD	M^3/min	22.2	30.02	1.4	1.4
Receiver capacity	M^3	2.8	1.80	0.5	0.5
Time taken	Sec	45	48	104	147
Dist.of pipe line	M	40.15	50.55	11.29	11.29
Pipe line diameter	M	0.15	0.10	0.06	0.06
Volume of pipe line	M^3	0.36	0.41	0.03	0.031
Total volume	M^3	3.16	2.24	0.55	0.55
Air receiver pressure.	Kg/cm^2	3.5	5	3.5	3.5
Compressor air exit temperature	Degc	90	90	35	35
Inlet air temperature	Degc	30	30	30	30
Atmosphere pressure	Kg/cm^2	1.03	1.03	1.03	1.03
Actual FAD	M^3/min	11.94	11.17	0.98	0.68
Volumetric efficiency	%	54	37	70	42

PROBLEM NUMBER 1

Effect of condition of piston ring on compressor efficiency

Application: poking air for cleaning requirements

Background:

Reciprocating, lubricated, horizontal, two stage type of compressor are used for providing air to air blasters, dust collectors and manual cleaning etc.,

The design air capacity and pressure is mentioned below

Compressor design air capacity = 8.41m^3/min

Compressor design pressure = 8 kg/cm^2

Previous Status:

The lubrication method used in this compressor is mechanical lubrication. In this mechanical lubrication system oil circuit tube is damaged. The flow is improper in the cylinder on high-pressure side. If the flow of lubrication oil is less, then the friction occurs between the piston and cylinder. Causes a wear in the piston and piston rings. The oil pressure gauge showed the low pressure i.e., 1.5kgcm2 instead of 2.0kg/cm2) indicating the malfunctioning of the circuit.

The previous status of the compressor is mentioned below

Actual air capacity = 7.53m3/min,

Compressor Volumetric efficiency =90%

Project concept:

The lubrication circuit is replaced with a newer one and the flow of the lubricating oil is sufficient to the cylinder. The friction developed in between the piston and cylinder is reduced for the smooth operation of the piston movement. The piston rings are changed as they were worn. The lubricating oil pressure shows design oil pressure (i.e., 2 kg/cm) indicating the proper working of the circuit.

Energy saving project:

When the circuit is changed the power consumption reduced from 38.5 Kw to 36.75 Kw. The reduction in power was 1.75kw by changing the oil tube and piston ring.

The volumetric efficiency is increased 90% to 95% and the actual air capacity is increased 7.53m3/min to 8.03m^3/min.

Financial analysis:

Number of running hours/day =6 hours

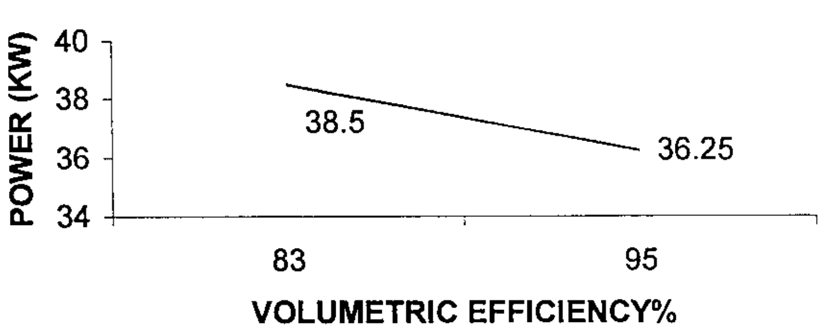
Number of day / year=330 days

Power rate = 4.5 kw/hr

Annual savings=kw*number of hours/year*power rate

= Rs 20,800/-

Fig no.6.1.Graphical Result



PROBLEM NUMBER 2

Effect of after cooler water circulation on compressor volumetric efficiency

Application: Cement Pumping

Background:

In cement mills, reciprocating, lubricated, horizontal, single stage, double suction type compressor. The compressed air is used for transporting the cement to silos.

The design air capacity and pressure is mentioned below

Compressor design air capacity = 39.00m^3/in

Derated air capacity = 31.40 m3/min

Compressor Design pressure = 4 kg/cm^2

Previous status :

The compressor air discharge temperature is 113^0 c instead of acceptance temperature 90^0 c. The water circulation in the after cooler of the D-pump compressor water circulation is found as very low due to the formation of sludge in the pipeline of the after cooler. So, the water flow is reduced in the pipeline (or) insufficient water flow in the pipeline. Because of the reduced water flow, the temperature of the delivery air increases to 113° C FROM 80^{O}C.

The previous status of the compressor is mentioned below

Actual Air Capacity = 27m3/min.

Volumetric Efficiency = 86%

Project concept:

After cooler pipeline is changed with the newer one for the proper flow of cooling water. The Cooling water rèduced the temperature discharge air . As the result of reduction in temperature, the compressors efficiency gets increased.

Energy Saving Project:

As the result of concept the power gets reduced from 94.16 Kw to 89.56 Kw by the compressor pipeline changed. Resulting in reduction of power is 4.6. Kw.

After implementing the concept to the compressor, the following results obtained below

The savage is 5 Kw (i.e. 94.16 Kw to 89.56 Kw).

Compressor actual air capacity =30.04 m3/min.

Volumetric efficiency = 96%

Financial Analysis:

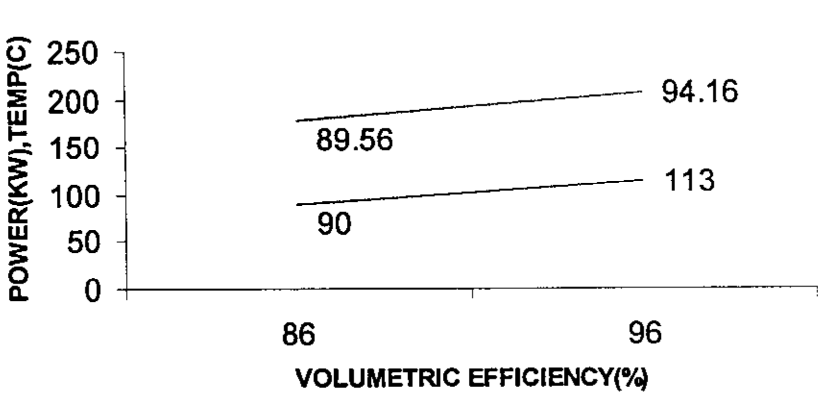
Number of operating hours/day = 7 hours

Number of days/year = 330days.

Annual savings /year = kw*number of hours/year*power rate

= 4.6*7* 330*4.5 = Rs.47,500.

Fig No.6.2.Graphical Result



PROBLEM NUMBER 3

Optimisation of cleaning frequency of water jacket for efficient cooling

Application: Fly Ash Unloading

Background:

In cement mill 8, reciprocating, non-lubricated, horizontal, double suction, single stage type compressor is used for unloading the fly ash from the bukers to the silos.

The design air capacity and pressure is mentioned below

Design air capacity = 15.37m^3/min

Design air pressure =4 kg/cm^2

Previous status:

The temperature of the discharge air is higher (100°C) than the normal (80°C). this is because of the insufficiency of the cooling water due to fouling in the water jacket. The fouling reduced the water flow and reduces the density of air.

The previous status of the compressor is mentioned below

Actual air capacity = 8.26m^3/min

Compressor volumetric efficiency =54%

A reduction of cooling water in passage is directly contributed in decrease the efficiency of the compressor.

Project concept:

In order to increase the flow of water in the circuits, the water jacket should be cleaned by using high-pressure splash water, which removes the fouling. The cooling water absorbs the extra heat form the discharge air and compressor body and reduces the discharge air temperature. The reduction of temperature in the compressor is directly proportional to the volumetric efficiency of the compressor.

Energy saving project:

As a result of implementing the concept the power consumption reduced from 28 Kw to 23 Kw.

by removing the foul form the water jacket for reducing compressor temperature. After implementing the concept to the compressor, the various results obtained below

1. Power savage is 5Kw (i.e., 28 Kw to 23 Kw)
2. Actual compressor air/capacity =15-11m^3/min
3. Compressor volumetric efficiency = 98.3%

Financial Analysis:

No.of operating hours/day=5hours

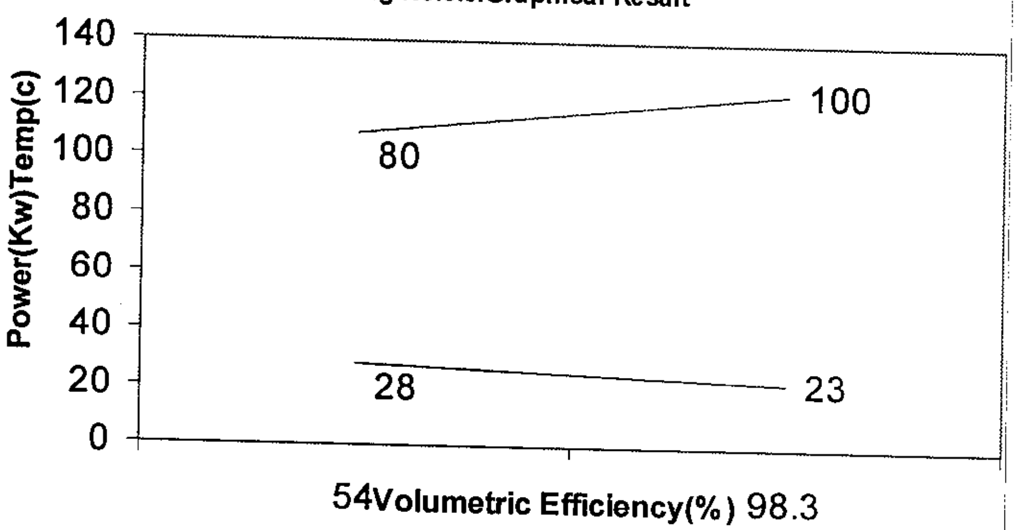
No.of days/year=330 days

Annual savings/year=kw*No.of operating hours/year*power rate

= 5*5*330*4.5

= Rs 37,125/-

Fig No.5.3.Graphical Result



PROBLEM NUMBER 4

Air loss prevention through delivery valve

Compressor Application: process and instrumentation

Background:

In cement mill8, reciprocating, lubricated, horizontal, double acting, single stage type of compressor. The compressed air is used for unloading the fly ash from the bulker to silos.

The design air capacity and pressure is mentioned below

The compressor design air capacity = 8.33 m^3/min

Design pressure = 4kg/cm^2

Previous Status:

The delivery valve of the fly ash unloading compressor is damaged due to poor compression and hence the temperature of the discharge air rises. The valve is very sensible to the temperature variation and often opened during the compression of air resulting in air leakage. This damage affects the efficiency . The previous status of the compressor is mentioned below

Actual air capacity = 4.16 m3/min

Volumetric Efficiency of the compressor= 50%

Project concept:

The delivery valve is changed for increasing the discharge air capacity and to avoid the over heating of the discharge air. The delivery valve function is properly when it temperature is comes down to normal. The valve is very sensible at hot condition and leads to damage. If damaged valve is changed, then the temperature comes to normal sensible at hot condition and leads to damage. If damaged valve is changed, then the temperature comes to normal

Energy saving project:

As a result of implementing the concept the power consumption reduced from 39.20 kw to 33.46 kw by replace the delivery wear parts.

After implementing the concept to the compressor, the various results obtained below

1. Power wastage is 5.54 Kw(I.e. 29 kw to 23.4 kw)
2. Actual air capacity = 7.99 m^3/min
3. Compressor efficiency =96%

Financial analysis:

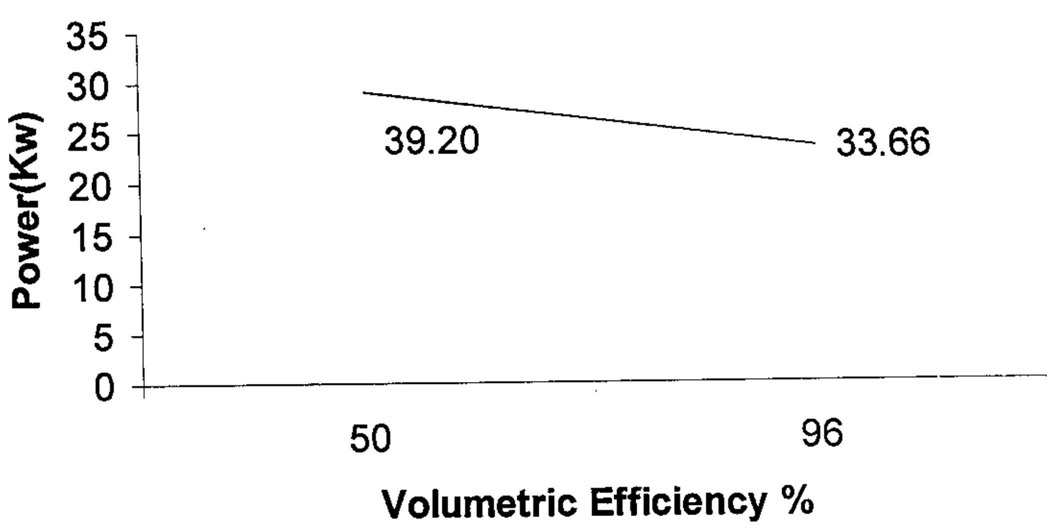
Annual savings/year =kw*no.of operating hour/year*power rate

Number of operating hours/year = 4 hours

Number of days/year=330 days

Annual savings = Rs 32,900/-

Fig No.6.4.Graphical Result



PROBLEM NUMBER 5

Effect of reduced clearance volume on compressor efficiency

Compressor Application: Silo Aerasion

Background:

In raw mill department reciprocating, lubricated, double acting, single stage compressor used for slurry agitation.

The design air capacity and pressure is mentioned below

Compressor design air capacity = $32.2m^3/min$

Design pressure = $4kg/cm^2$

Previous status:

The compressor piston head hitting the cylinder head. The clearance is reduced due to loose the piston push lock nut by vibration of the compressor. Noise obtained by hitting the piston to cylinder head.

The previous status of the compressor is mentioned below

Actual air capacity = $11.91m^3/min$

Compressor volumetric efficiency =54%

Project concept:

Changing the piston push lock nut and adjust the clearance between piston and cylinder head. (i.e., 1mm,50nicron), cover plate is changed and the bolts and nuts are tighten and checked the compressor belt tension and correct. Because loose the foundation bolts and nuts, improper belt tension make vibration to the compressor.

Energy saving project:

As the result of concept the power gets reduced from 40.9kw to 34.9kw by setting proper clearance between piston and cylinder head, and fitting new piston push lock nut and tighten.

After implementing the concept to the compressor, the various results obtained below

1. Power savage is 6 Kw(I.e. 40.9kw to 34.9kw)
2. Actual air capacity = 20.61m^3/min
3. Efficiency of the compressor = 90%

Financial analysis:

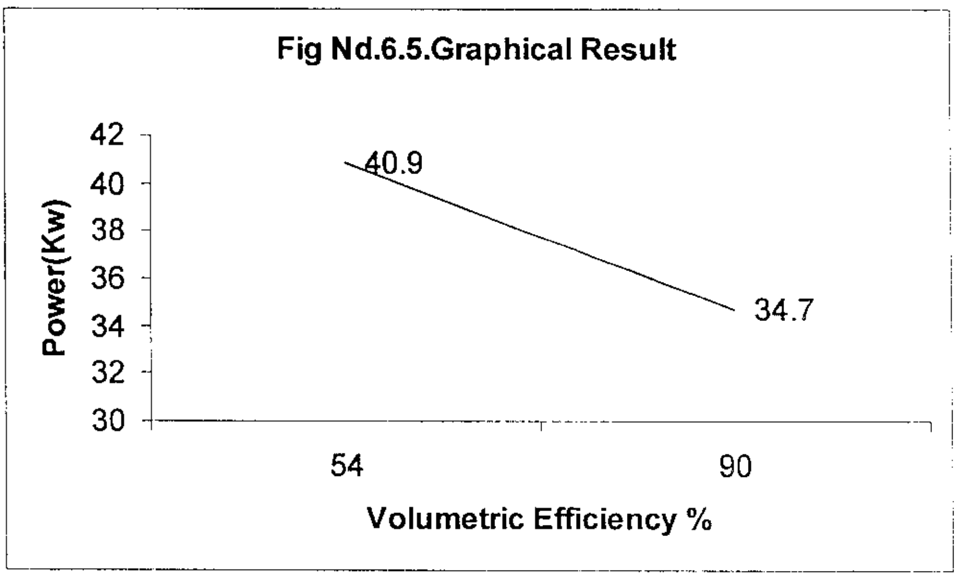
No. of operating hours/day = 4 hours

No. of days/ year = 330 days

annual saving /year = kw*no.of hours/year*power rate

= 6*4*33*4.5

= Rs 35,650



PROBLEM NUMBER 6

Effect of frequency of cleaning air filter for getting sufficient air:

Compressor Application: Silo Aerasion

Background:

In raw mill department reciprocating, lubricated, double acting, single stage compressor is used for slurry agitation.

The design air capacity and pressure is mentioned below

Compressor design capacity =30.02 m^3/min

Compressor design pressure = 5kgcm^2

Previous status:

Air intake filter is clogged with dust. The pressure dropped and the suction pressure is high. Hence the air capacity volume reduced and the airflow velocity is increased. The air is insufficient to compress in the cylinder. So the discharge air capacity is very low compared to design air capacity.

The previous status of the compressor is mentioned below

Actual air capacity = 11.17m^3/min

Compressor volumetric efficiency = 37%

Project concept:

Changing the air intake suction filter for improving the air sucking capacity in the suction side. The pressure drop is decreased to normal level, i.e., atmospheric air pressure (1.03kg/cm^2). The scheduling to checking air flow at filter for maintaining optimum efficiency.

Energy saving method:

The compressor power-consuming rate is reduced from 53.1kw to 49kw by cleaning the air filter.

After implementing the concept to the compressor, the following results were obtained below

1. Power reduction is 4.1Kw
2. Actual air capacity = 19.2 m^3/min
3. Compressor volumetric efficiency = 64%

Financial analysis:

No.of operating hours/day= 4 hour

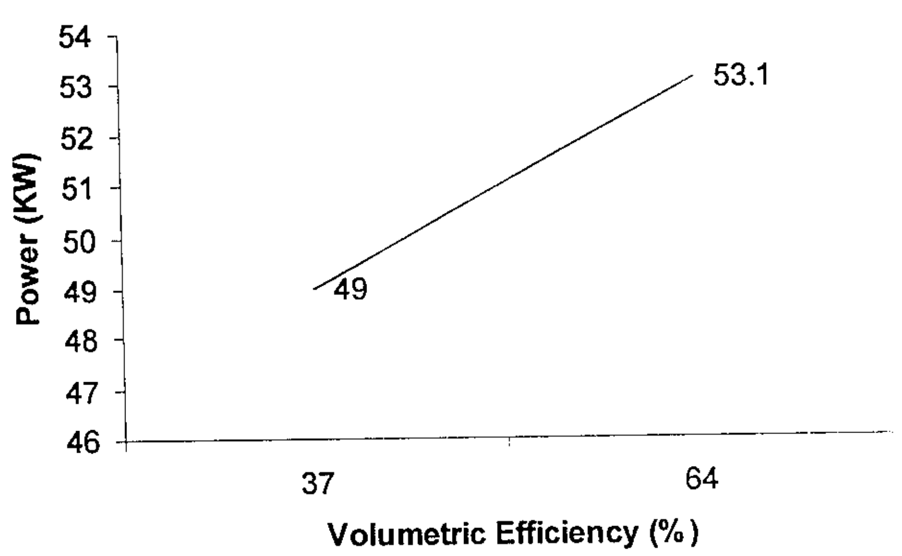
No.of days/ year =330

Annual saving/year =kw*no.of.operating hours*power rate

= 4.1*4*330*4.5

= Rs 24,350/-

Fig No.6.6.Graphical Results



PROBLEM NUMBER 7

Maintenance of lubrication oil filter and its impact on power consumption
Compressor Application: Cement Silo Aeration

Background:

In packinghouse, reciprocating, lubricated, single stage, single action type of compressor is used for transferring cement-to-cement silos.

The design air capacity and pressure is mentioned below

Design air capacity = 1.4 m^3/min

Design pressure = 5 kg/ cm^2

Previous status:

The oil filter is blocked by accumulation of foreign materials and dust. So the oil flow reduced to compressor parts. The oil velocity increased due to reduction in volume of lubrication oil. And oil pressure gauge shows less pressure. Instead of design pressure of lubrication oil. Lack of lubrication oil flow in compressor effects the function of compressor. i.e., it increase the compression ratio, chance for ceasing. So, the discharge air volume reduced instead of design capacity.

Project concept:

Cleaning the lubrication circuit for smooth flow of lubrication oil in the compressor parts. The oil filter changed for getting sufficient lubrication oil to the compressor parts. So it increases the compression ratio and also increases of oil pressure to design pressure.

Energy Saving Project:

The compressor power-consuming rate is reduced from 5.4 Kw to 4.8 Kw.

After implementing the concept to the compressor, the various results obtained below

1. Power savage is 4.1 Kw(i.e. 5.4 Kw to 4.8 Kw)
2. Actual air capacity = 1.33 m^3/min
3. Volumetric efficiency = 94.6%

Financial Analysis:

No of operating hours/day = 6hours

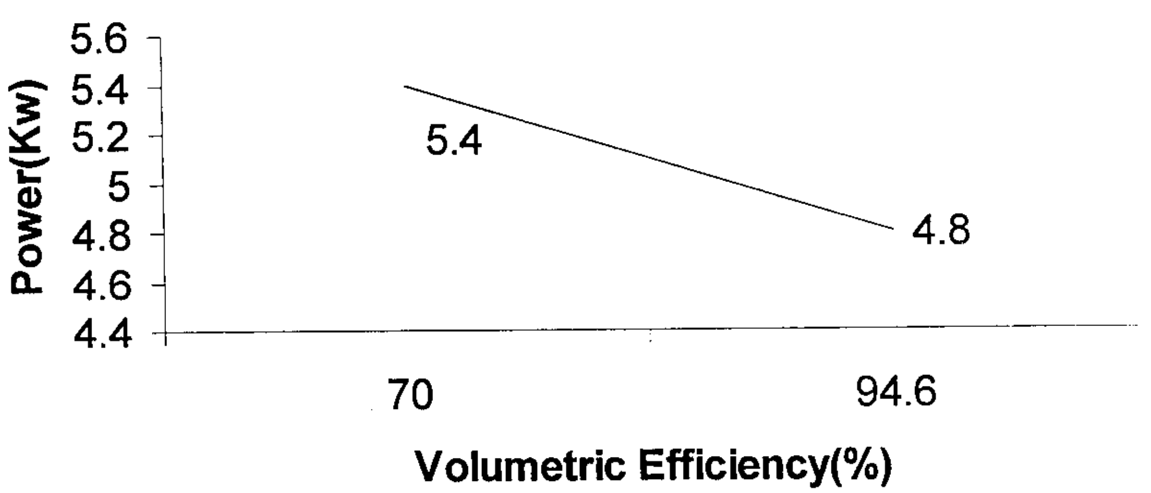
No of days/year = 330days

Annual saving =kw*no.of.operating hours*power rate

= 0.6*6*330*4.5

= Rs 5,350/-

Fig No.6.7.Graphical Results



PROBLEM NUMBER 8

Effect of condition of unloading springs on compressor efficiency

Compressor Application: Cement Silo Aeration

Background :

In packinghouse, lubricated, single stage suction type of compressor air used to cement transfer to silo 67.

The design air capacity and pressure is mentioned below

Compressor design air capacity = $1.4 m^3/min$

Compressor design pressure = $5 kg/cm^2$

Previous status:

The compressor unloader plunger is chattering due to not proper opening and closing of the unloading valve. The unloading springs stiffness is high compare to suction valve. The heat increased in unloader parts. The valve is broken. Improper closing and opening is due to air leakage through unloading value in suction side. The air enter in to cylinder is reduced.

The previous status of the compressor is mentioned below

Resulting in air capacity = $0.68 m^3/min$

Volumetric compressor efficiency =48%

Project concept:

The unloading springs changed, the springs stiffness is lighted to suction value springs because, the unloading valve operate with proper closing and opening when it required. The broke unloading parts changed for reduction of chattering and noise from the unloading valve. Proper closing and opening unloading valve is increase to air intake capacity to cylinder near to design air capacity.

Energy saving project:

The compressor power-consuming rate is reduced from 6n kw to 4.8 kw by change the unloading valve.

Power savage is 1.2 Kw.

Actual air capacity = 48 m^3/min

Compressor volumetric efficiency = 97.5%

Financial analysis:

Number of hours/day=6hours

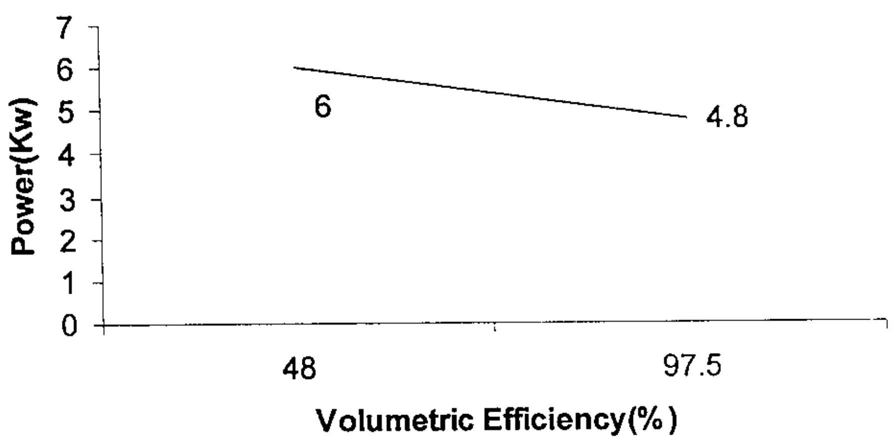
Number of days/year=330 days

Annual savings = kw*Number of operating hr/day*number of days/yr *power rate

= 1.2* 6*330*4.5

= Rs 35,64

Fig No.6.8.Graphical Results



6. RESULTS AND DISCUSSION

The various reasons behind the poor performance of the inefficiencies of the compressors are studied and the suggestions are recommended. The following table lists the details of the improvement in efficiencies and the savings in power and cost, after the implementation of the recommendations.

Comp.No	Comp. Location	Volumetric Eff.Before Imple.(%)	Volumetric Eff. After Imple. (%)	Power saving (kw)	% Power saving	Cost saving (Rs)
1	Kiln	83	95	1.75	4.5	20,800
2	Cement mill	86	96	4.6	5	47,800
3	Cement mill	54	98.5	5.54	19	37,125
4	Cement mill	50	97	5	16	32,900
5	Raw mill	54	90	6	14.6	35,650
6	Raw mill	37	64	4	7.7	24,350
7	Packing house	70	94.6	0.6	11.11	5,350
8	Packing house	48	97.6	1.2	2	10,700
					TOTAL	2,14,675

After recommendations were implemented, Total power savings is 29.7 KW per day and total cost savings per year is (around) Rs 2,14,675 through improved compressors efficiency.

6.CONCLUSION

Energy conversion in an industry is not one shot affair. Rather it should be a continuing programme where focus and strategies may change over time. The overall objectives are however invariant.

Results after implementation shows on expected savings have been achieved.

Technological development should be continuously monitored and evaluated employee motivation should be sustainable. Only by sustaining the momentum and effects will energy savings continue to accrue.

This project work gave me an opportunity to interact with the dignitaries in the industry and study the system in a better manner.

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