ISSN: 2455 - 1597

ijergs Open Access

International Journal of Engineering Research and Generic Science (IJERGS)
Available Online at www.ijergs.in

Volume - 5, Issue - 1, January – February - 2019, Page No. 10 - 18

Overview of Air Compressor and Their Application

[1]Ankit Agarwal, [2]Ravinder Maan, [3]Rakesh Sharma, [4]Archana Mourya

Assistant Professor, Department of Electrical Engineering, ACERC, Jaipur

Abstract

Air compressors are used as versatile tool throughout the industries for a variety of purposes. They are used for various applications in manufacturing plants such as driving pneumatic tools, air operated controlling equipment's, conveying of fly ash etc.. . Air compressors are one of the major sources of energy consumption in industries. In the present scenario, the importance of energy conservation is increasing day by day. For a manufacturing plant, improving energy efficiency or replacement of less energy efficient equipment with energy efficient ones can earn significant savings. In the manufacturing plant, it was found that compressors which are running were installed in the earlier stages. Due to aging, the efficiency of compressor decreased and it resulted in huge expense. As a solution, the performance assessment of the compressors were done. Compressor with an energy efficiency less than 35% is replaced with energy efficient Compressor. Modification in the compressor air system was done to improve efficiency.

Keywords: Compressor, energy efficiency, Performance assessment, Modification.

Introduction

An air compressor is a device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its engineered upper limit, the air compressor shuts off. The compressed air, then, is held in the tank until called into use.

The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank. An air compressor must be differentiated from from a pump because it works for any gas/air, while pumps work on a liquid.

In present scenario the demand of energy efficiency is increasing day by day. Improved energy efficiency can earn significant to the plant. This motivated me to do the analysis of compressors in the manufacturing plant. Twelve compressors were analyzed. Least efficient compressor is replaced with energy efficient one. For other compressors preventive maintenance practices are suggested to improve efficiency. In manufacturing plant, compressors are running in a corrosive and high temperature conditions. So upgrading the design of the compressor unit can increase the reliability, safety and overall efficiency of the screw compressor. As a solution, modification in air compressor system was suggested to improve energy efficiency.

Performance Assesement Parameters

The performance assessment parameters of compressors include the calculation of FAD (free air delivery), volumetric efficiency and power consumption.

Calculation of FAD

The free air delivery of the compressor can be calculated by receiver filling method. The volume of the receiver is noted if mentioned on the name plate. If the receiver volume is not known it should be physically measured by pouring water from a calibrated measuring can. Dished contours cannot give correct volume when calculated analytically. The compressor is kept running on load and no load for some time so that the temperature of the compressor increases. The compressor is then stopped. The sizes of pipes up to isolations valves is measured and volume of pipe is calculated. The volume is added to the receiver volume and called 'effective receiver volume'. The valves which isolate the compressor receiver from the delivery lines are closed. Pressure gauge reading is noted. It should read zero because all the air in the receiver is drained. The compressor is started and kept on full load. This should be kept in full load mode, if controlled by an external control panel. Time taken by the compressor, in seconds to reach a cut-off pressure is recorded.

FAD = (effective volume of receiver in liters)*60*(p2-p1) (Time to reach set pressure in sec)*p0

P0=Atmospheric pressure

P1=Initial pressure

P2=Final tank pressure

Calculation Of Volumetric Efficiency

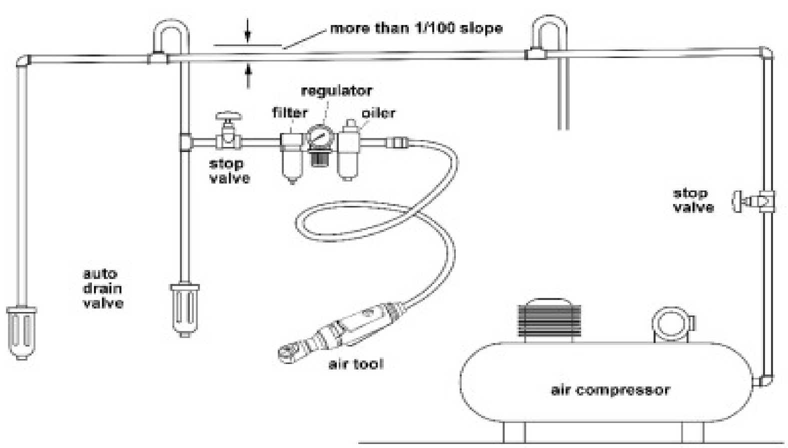
The volumetric efficiency of the compressor is calculated by the ratio of actual free air delivery of the compressor to specified free air delivery of the compressor. Volumetric efficiency = (Actual Output of Compressor/Specified Output of compressor).

Calculation of Power Consumption

Power consumption is calculated by: Power consumption =√3*V*I*Cosø V = Voltage (V) I = Current (A) Cosø = 0.98.

Performance Analysis of Compressors

In the manufacturing plant, twelve compressors were taken under study. The performance parameters such as free air delivery, volumetric efficiency and power consumption were calculated:



© IJERGS, All Rights Reserved.

Sample Calculation

Location: Raw mill Purpose: Raw mill grease spray and free jacking K.G khosla make, three cylinder (two LP and one HP) two stage, air cooled, belt driven, oil lubricated, and electrically driven mounted compressor with start-stop regulation having the following name plate details: Internal number: 30077 Model: 2 BC 26 Rpm: 750 FAD: 736*10-3 m3/min Actual rpm was found to be 716 Safety valve, drain cock and pressure gauge were found to be ok. The compressor was found to be cutting off at 7 kg/cm2 Discharge temperature was found to be 490c Maximum current drawn at the time of unloading was found to be 7.2 to 7.4 A Receiver filling time to reach 7 kg/cm2 from atmospheric pressure was found to be 206.5 sec .

The isolation valves are very close to the receiver and the additional volume because of the pipes are negligible.

Output of the compressor = (250*60*7)/206.5=508.47* 10-3 m3/min

Volumetric efficiency = (508.47/736)*100=69.08%

Power Consumption:

Full load power = 5.5 kW

Intake current = 7.3 A

Full load current = 11A

Power consumption = √3*V*I*Cosø

Power consumption = √3*415*7.3*0.98 = 5.1Kw

Table -1: Analysis Results

Compressor No:	Actual FAD (m3/min)	Volumetric efficiency %	Power consumption (kw)
1	0.506	69.00	5.2
2	0.230	30.8	3.68
3	1.598	93.80	10.70
4	1.181	68.10	9.160

Preventive Maintenance

The majority of compressors working in the plant have less efficiency. Due to cost problem, all compressors cannot be replaced. The compressor having an efficiency of 30.7 is to be replaced by energy efficient one .For the other compressors preventive maintenance practices can be followed in order to improve energy efficiency.

- Leakage and wastage were checked and found to be absolutely minimum. Rigorous monitoring were done by the plant.
- Suction filters of the compressor in raw mill & packing plant should be changed as per the details mentioned later. The design separates and holds quiet some dust before the filter element. In case of compressors all the suction filters should be like the ones fitted on the compressor used for raw mill grease spray. The only difference between these

© IJERGS, All Rights Reserved.

filters and the old ones is provision of two plastic cases outside which create centrifugal action and which remove lot of dust before air reaches the filter element.

- Routine periodic maintenance of valves, cooling system, lubricating system, unloading system etc. Should be done Preventive maintenance should be done condition based rather than the calendar based.
- In suction filters of the compressors lot of gaps are found between the filter frames and inlet filters of compressors. As a result unfiltered air is likely to enter in to the compressors. It is recommended to clean the filters more frequently and observe the pressure drop across the suction filter.

Replacement of Compressor

The compressor having an efficiency of 30.7% is to be replaced. Selection of new compressor is very important here. At present screw compressors are more efficient than any other compressors available. The annual energy savings that the plant can acquire is shown below:

OLD COMPRESSOR:

Discharge pressure = 9 kg/cm2

Motor Kw = 5.5 kW/7hp

FAD =736*10-3 m3/min

Cut-off pressure: 6 kg/cm2

Cut-in pressure: 5 kg/cm2

Annual Energy cost = (Full load power (kW) *annual running hours* electricity cost/kWh) / motor efficiency

Full load power = 5.5 kW

Motor efficiency = 65.4 %

Electricity cost is 5.25 Rs /kWh

Annual energy cost = (5.5*7920*5.25) / .654 = 3,49,678 Rs

New Compressor

Discharge pressure = 7 kg/cm2

Motor Kw = 4 kW/5.5 hp

FAD = 670*10-3 m3/min

Annual Energy cost = (Full load power (kW) *annual running hours* electricity cost/kWh) / motor efficiency

Full load power = 4 kW

Motor efficiency = 85 %

Electricity cost is 5.25 Rs /kWh

Annual energy cost = (4*7920*5.25) / .85 = 1, 95,670 Rs

Cost savings = 1,54,008 Rs

The cut-off pressure of old compressor is at 6Kg/cm2 but the discharge pressure is 9kg/cm2.So that much power can be saved. The new compressor should have discharge pressure near to the cut-off of compressor. Also the newly replaced system have better motor efficiency than the old one.

© IJERGS, All Rights Reserved.

Compressed Air Safety

The Following precautions pertain to the use of compressed air in machine shops:

1. All pipes, hoses, and fittings must have a rating of the maximum pressure of the compressor. Compressed air pipelines should be identified(psi) as to maximum working pressure.
2. Air supply shutoff valves should be located (as near as possible) at the point-of-operation.
3. Air hoses should be kept free of grease and oil to reduce the possibility of deterioration.
4. Hoses should not be strung across floors or aisles where they are liable to cause personnel to trip and fail. When possible, air supply hoses should be suspended overhead, or otherwise located to afford efficient access and protection against damage.
5. Hose ends must be secured to prevent whipping if an accidental cut or break occurs.
6. Pneumatic impact tools, such as riveting guns, should never be pointed at a person.
7. Before a pneumatic tool is disconnected (unless it has quick disconnect plugs), the air supply must be turned off at the control valve and the tool bled.
8. Compressed air must not be used under any circumstances to clean dirt and dust from clothing or off a person' s skin. Shop air used for cleaning should be regulated to 15 psi unless equipped with diffuser nozzles to provide lessor pressure.
9. Goggles, face shields or other eye protection must be worn by personnel using compressed air for cleaning equipment.
10. Static electricity can be generated through the use of pneumatic tools. This type of equipment must be grounded or bonded if it is used where fuel, flammable vapors or explosive atmospheres are present.

Safety Requirements for Operating & Maintaining Compressed Air Machinery:

All components of compressed air systems should be inspected regularly by qualified and trained employees. Maintenance superintendents should check with state and/or insurance companies to determine if they require their own inspection of this equipment. Operators need to be aware of the following:

Air receivers

1. The maximum allowable working pressures of air receivers should never be exceeded except when being tested. Only hydrostatically tested and approved tanks shall be used as air receivers.
2. Air tanks and receivers should be equipped with inspection openings, and tanks over 36 inches in diameter should have a manhole. pipelug openings should be provided on tanks with volumes of less than five cubic feet.
3. The intake and exhaust pipes of small tanks, similar to those used in garages, should be made removable for interior inspections.
4. No tank or receiver should be altered or modified by unauthorized persons.
5. Air receivers should be fitted with a drain cock that is located at the bottom Of the receiver.
6. Receivers should be drained frequently to prevent accumulation of liquid inside the unit. Receivers having automatic drain systems are exempt from this Requirement.

© IJERGS, All Rights Reserved.

7. Air tanks should be located so that the entire outside surfaces can be easily inspected. Air tanks should not be buried or placed where they cannot be seen for frequent inspection.
8. Each air receiver shall be equipped with at least one pressure gauge and an ASME safety valve of the proper design.
9. A safety (spring loaded) release valve shall be installed to prevent the receiver from exceeding the maximum allowable working pressure.
10. Only qualified personnel should be permitted to repair air tanks, and all work must be done according to established safety standards.

Air Distribution Lines

1. Air lines should be made of high quality materials, fitted with secure connections.
2. Only standard fittings should be used on air lines.
3. Operators should avoid bending or kinking air hoses.
4. Air hoses should not be placed where they will create tripping hazards.
5. Hoses should be checked to make sure they are properly connected to pipe outlets before use.
6. Air lines should be inspected frequently for defects, and any defective equipment repaired or replaced immediately.

Compressed air lines should be identified as to maximum working pressures (psi), by tagging or marking pipeline outlets.

Pressure regulation Devices

1. Only qualified personnel should be allowed to repair or adjust pressure regulating equipment.
2. Valves, gauges and other regulating devices should be installed on compressor equipment in such a way that cannot be made inoperative.
3. Air tank safety valves should be set no less than 15 psi or 10 percent (whichever is greater) above the operating pressure of the compressor but never higher than the maximum allowable working pressure of the air receiver.
4. Air lines between the compressor and receiver should usually not be equipped with stop valves. Where stop valves are necessary and authorized, ASME safety valves should be installed between the stop valves and the compressor.
5. The Safety valves should be set to blow at pressures slightly above those necessary to pop the receiver safety valves.
6. Blowoff valves should be located on the equipment and shielded so sudden blowoffs will not cause personnel injuries or equipment damage.
7. Case iron seat or disk safety valves should be ASME approved and stamped for intended service application.
8. If the design of a safety or a relief valve is such that liquid can collect on the discharge side of the disk, the valve should be equipped with a drain at the lowest point where liquid can collect.
9. Safety valves exposed to freezing temperatures should be located so water cannot collect in the valves. Frozen valves must be thawed and drained before operating the compressor.

Air Compressor Operation

1. Air compressor equipment should be operated only by authorized and trained personnel.
2. The air intake should be from a clean, outside, fresh air source. Screens or filters can be used to clean the air.
3. Air compressors should Never be operated at speeds faster than the manufacturers recommendation.

© IJERGS, All Rights Reserved.

4. Equipment should not become overheated.

Moving parts, such as compressor flywheels, pulleys, and belts that could be hazardous should be effectively guarded.

Compressed Air Equipment Maintenance

1. Only authorized and trained personnel should service and maintain air compressor equipment.
2. Exposed, non current-carrying, metal parts of compressor should be effectively grounded.
3. Low flash point lubricants should not be used on compressors because of its high operating temperatures that could cause a fire or explosion.
4. Equipment should not be over lubricated.
5. Gasoline or diesel fuel powered compressors shall not be used indoors.
6. Equipment placed outside but near buildings should have the exhausts directed away from doors, windows and fresh air intakes.
7. Soapy water of lye solutions can be used to clean compressor parts of carbon deposits, but kerosene or other flammable substances should not be used. Frequent cleaning is necessary to keep compressors in good working condition.
8. The air systems should be completely purged after each cleaning.
9. During maintenance work, the switches of electrically operated compressors should be locked open and tagged to prevent accidental starting.
10. Portable electric compressors should be disconnected from the power supply before performing maintenance.

Air Compressor Applications

Laboratory Air Compressors

- Gas Chromatography
- High performance liquid chromatography
- ION Chromatography
- Rheometers, Viscometers
- Particle Size analyzers

Medical, Healthcare

- Autoclaves, Sterilizing
- Dental milling machines
- Patient Simulators
- Hospital Headwalls
- Medical gas booms
- Blood-analyzers

Electronics

- Antenna(telescopic)
- de-icing(mobile transmitters)

© IJERGS, All Rights Reserved.

- Pick and place machine
- 3D Printers
- Computer graphics
- Computer disc robot-automat

Food, Beverage, Water

- Bakeries(spraying of vegetable oil)
- Coffee automats
- French fried vending machines
- Ozone generators(water treatment)

Miscellaneous

- Screen printing equipment
- Digital printing equipment
- Watch testing equipment
- Weapons simulations
- Mobile Phone repair equipment
- Machine shop equipment
- Dry sprinklers
- Air-brushing
- Air vending for gas stations
- Coin counting machines
- Door/window opening
- Gas compression

Conclusion

Air compressors are used as versatile tool throughout the industries for a variety of purposes. At Malabar cements, air compressors are used for various applications. Air compressors are one of the major sources of energy consumption in the industry. In the present scenario, the importance of energy conservation is increasing day by day. So it is important to improve the efficiency of air compressors in the industry. As a result, I carried out the performance test of compressors at Malabar cements. It was found that majority of compressors at the plant are running at efficiencies less than 70%. Due to cost problem we cannot replace all the compressors with energy efficient ones. The compressor having an efficiency of 30.7% is replaced with screw compressors which has better performance and efficiency. The annual cost savings by installing the new compressor was also calculated. For other compressors preventive measures taken to improve efficiency were suggested. From the analysis of compressors, faults were detected and suitable remedial measures were suggested. Since the compressors are working at corrosive and high temperature conditions, design modifications are suggested in order to increase the efficiency of the compressors.

© IJERGS, All Rights Reserved.

References

1. "Energy Efficiency in Air Compressors", N.C.Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance, January 2004.
2. Eric C Harding, "Energy Saving Potential by Optimising the Process of Air Generation and Consumption", Air Technology Ltd, England, vol.6, pp.72-93, June 2007.
3. "Compressor and Compressed Air System", Energy Efficiency Guide for Industries, Chapter 3, pp. 55-71,2009.
4. "Performance Assessment Of Compressors", Bureau Of Energy Efficiency, chapter 8, pp. 107-114, 2006.
5. R Virendra, "Detailed Energy Audit and Conservation in a Cement Plant", vol.2, pp.248-257, June 2015.
6. "Energy Efficiency and Resource Saving Technology in Cement Industries", Asia Pacific Partnership on clean Development and Climate, May 2000.

© IJERGS, All Rights Reserved.