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Performance of Air Compressor with respect to Loading & Unloading cycle: A Case Study

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Abstract - *Energy audits don't save money & energy for companies unless the recommendations are implemented which are carried out after the Audit. For the Efficient Work of the Compressor it is necessary to improve efficiency by changing the pressure ratio, determining the FAD (Free air Delivery) and comparing it with its standards. A detailed study to establish and investigate, energy balances for the industrial plant has been carried out for the compressor working on full load operation. In present paper work the energy audit of power compressor has been successfully completed and it is concluded that the total energy saving is possible by implementing the recommended actions. Moreover some energy conservation tips are also provided for the better performance of an air compressor.*

Key Words: **Audit, Compressor Audit, Energy Management, Financial Analysis, Energy Conservation**

1. INTRODUCTION

A great thought says that the net energy saved is the energy generated. It is such that if some amount of energy is saved it will be directly used in other purpose so it is termed as the energy generated. "Energy can neither be created nor be destroyed it can be just transformed from one form to another. The total energy in the universe is constant." This law of energy conservation is very important in the terms of economic savings of an industry. This is because the other operating factors i.e. the labour and the material remains almost constant to a value for any industry. The only varying parameter is the energy in which there is the highest scope of saving of the energy. In this industrial era of 21st century, the continuously energy demand increasing in the world, has made necessary to take an important step towards the conservation of the energy and make it fulfil by implementing proper energy management plans. Not only the demand is increasing rapidly but also the operating cost of energy is also increasing drastically. So it becomes necessary to highlight the areas of the energy wastage and implement an energy conservation action plan on it to save the energy.

Implementing energy audit determines the use of energy or consumption and identification methods for energy savings. Air compressors account for significant amount of electricity used in Indian industries. Air compressors are used in a variety of industries to supply process requirements, to operate pneumatic tools and equipment, and to meet instrumentation needs. Only 10 – 30% of energy reaches the point of end-use, and balance 70 – 90% of energy of the power of the prime mover being converted to unusable heat energy and to a lesser extent lost in form of friction, misuse and noise.

1.1 ENERGY AUDIT

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme. [1]

Energy Audit includes the following main parameters to be performed:

- Material Balance and Energy Balance
- Energy Monitoring and Targeting
- Energy Action Planning
- Financial Analysis and Management
- Cost effective measures

Energy Audit focuses upon the following objectives to be accomplished while conducting the audit:

- Relating Energy inputs and product outputs
- Highlighting wastages in major areas
- Implementation of energy conservation
- Realisation of savings
- Waste minimisation & recovery
- Resource conservation

Energy Audit is user friendly and is a helpful tool as environment friendly as it focuses upon the energy conservation application. Thus it is very necessary for any organisation or industry to follow up the energy audit in order to suppress the increase cost in the demand of energy.

Types of Energy Audits

The energy audit orientation would provide positive results in reduction energy billing for which suitable preventive and cost effective maintenance and quality control programmes are essential leading to enhanced production and economic utility activities. The type of energy audit to be performed depends upon the function or type of industry. There can be two types of energy audit.

- Preliminary audit (walk-through audit)
- Detailed audit (diagnostic audit). [2]

(a) Preliminary audit (Walk-through audit)

In a preliminary energy audit, readily-available data are mostly used for a simple analysis of energy use and performance of the plant. This type of audit does not require a lot of measurement and data collection. These audits take a relatively short time and the results are more general, providing common opportunities for energy efficiency. The economic analysis is typically limited to calculation of the simple payback period, or the time required paying back the initial capital investment through realized energy savings. [2]

(b) Detailed audit (Diagnostic audit)

For detailed (or diagnostic) energy audits, more detailed data and information are required. Measurements and a data inventory are usually conducted and different energy systems (pump, fan, compressed air, steam, process heating, etc.) are assessed in detail. Hence, the time required for this type of audit is longer than that of preliminary audits. The results of these audits are more comprehensive and useful since they give a more accurate picture of the energy performance of the plant and more specific recommendation for improvements. The economic analysis conducted for the efficiency measures recommended typically go beyond 3 the simple payback period and usually include the calculation of an internal rate of return (IRR), net present value (NPV), and often also life cycle cost (LCC).[2]

2. COMPRESSOR

The Compressed air system is not only an energy intensive utility but also one of the least energy efficient. Over a period of time, both performance of compressors and compressed air system reduces drastically. The causes are many such as poor maintenance, wear and tear etc. All these lead to additional compressors installations leading to more inefficiency. A periodic performance assessment is essential to minimize the cost of compressed air.[3]

Purpose of the Performance Test to find out:

- Actual Free Air Delivery (FAD) of the compressor
- Isothermal power required
- Volumetric efficiency
- Specific power requirement

The actual performance of the plant is to be compared with design/standard values for assessing the plant energy efficiency. [3]

How can potential energy savings be identified?

There are various measures for realising potential savings in compressed air systems; these have different effects depending on the particular part of the compressed air system. First of all, performing a **compressed air audit**, i.e. a precise analysis of the existing system with a focus on energy efficiency (effective and efficient use of energy), is recommended. In order to develop recommendations for actions that are well thought out, economically speaking, and are designed to exploit potential savings to their fullest, a good audit will examine four different areas: the complete system, compressed air generation, air preparation and actual usage of the air.[4]

Depending on the applicability of the energy-saving measure, how cost-effective it is and the savings produced, the average potential savings in the individual areas of the system vary:

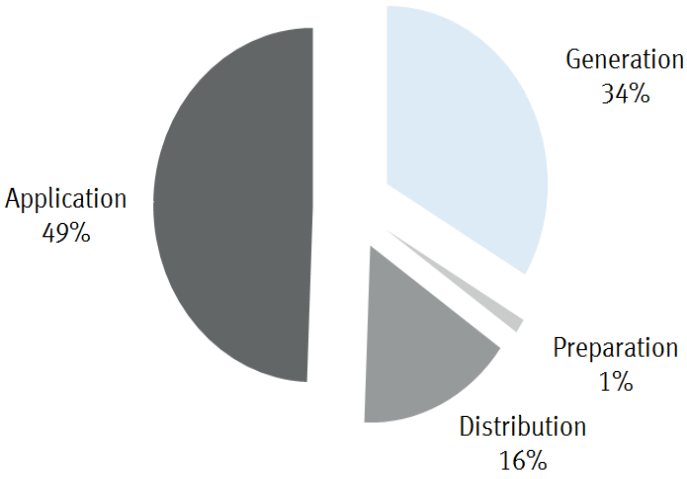

Chart -1: Cost-effectiveness of measures in the individual areas of the compressed air system [4]

2.1 CASE STUDY: COMPRESSOR AUDIT PERFORMANCE IN AN INDUSTRY

The performance of Air Compressor installed in the industry with respect to loading-unloading cycle, electrical parameters and efficient usage were checked during energy audit study. The installed compressors are as listed:

Table -1: Installed Compressor List

Sr. No.	1	2
Plant Name	Producer Plant	Producer Plant
Rated CFM	100	100
Type	Reciprocating	Reciprocating
Motor HP/RPM	30/1440	30/1440
Air Compressor	IR Compressor A	IR Compressor A

Following is the details of installed compressor:

Table 2(a): Details of Installed Compressor (A)

AIR COMPRESSOR NAME	New I.R. Compressor No. A
MAKE	INGERSOLL RAND A
TYPE	Reciprocating
RATED CFM	100
AIR RECIEVING TANK VOLUME M^3	0.54
SERVICE AREA(where it is sent)	Common Head
SET PRESSURE KG/CM^2 (ON/OFF)	6.2-6.8
MOTOR HP	30
MOTOR RPM	1440

Table 2(b): Details of Installed Compressor (B)

AIR COMPRESSOR NAME	New I.R. Compressor No. B
MAKE	INGERSOLL RAND B
TYPE	Reciprocating
RATED CFM	100
AIR RECIEVING TANK VOLUME M^3	0.8
SERVICE AREA(where it is sent)	Common Head
SET PRESSURE KG/CM^2 (ON/OFF)	6.2-6.8
MOTOR HP	30
MOTOR RPM	1440

The Loading and unloading cycle with respect with respect to timing durations was observed and were as follows:
The readings taken are load and unload pressure with respect to their interval of time operation.

Table 3(a): Details of Load & Unload Cycle of New I.R. Compressor no. A

LOAD SECONDS	LOAD PRESSURE	UNLOAD SECONDS	UNLOAD PRESSURE
40	6.1	8	6.4
41	6.1	11	6.4
42	6	14	6.4
43	6.1	13	6.3
44	6.1	12	6.4
43	6.1	13	6.4
42	6.1	10	6.4
43	6.1	8	6.4
42	6.1	10	6.4
43	6.1	11	6.4

Table 3(b): Details of Load & Unload Cycle of New I.R. Compressor no. B

LOAD SECONDS	LOAD PRESSURE	UNLOAD SECONDS	UNLOAD PRESSURE
9	6.2	32	6.4
11	6.2	28	6.4
12	6.2	71	6.4
11	6.2	65	6.3
10	6.2	67	6.4
10	6.2	69	6.4
10	6.2	78	6.4
11	6.2	83	6.4
11	6.2	124	6.4
12	6.2	95	6.4
11	6.2	91	6.4
10	6.2	108	6.4
14	6.2	111	6.4
13	6.2	119	6.4
14	6.2	106	6.4
12	6.2	115	6.4

Table 4(a): Summary: New I.R. Compressor No. A

TOTAL LOAD SECONDS	380
TOTAL UNLOAD SECONDS	98
TOTAL SECONDS	470
%LOADING	80
%UNLOADING	20
MEASURED ON/OFF PRESSURE	6.1-6.4

Table 4(b): Summary: New I.R. Compressor No. B

TOTAL LOAD SECONDS	189
TOTAL UNLOAD SECONDS	333
TOTAL SECONDS	522
%LOADING	36.2
%UNLOADING	63.8
MEASURED ON/OFF PRESSURE	6.2-7.1

ENERGY CONSERVATION PROPOSAL:
Stop Identified air compressor and switch load to another related compressor of the same plant.

Savings		Investment	Payback Period
13212 KWH	Rs 95,216	NIL	IMMEDIATE

Background:
It was observed that the following compressor was found running at very low loading and has lesser load and more unload in the ratio. It is operated additionally along with other compressor of the same plant in case of higher demand of compressed air.

Sr. No.	1
Plant Name	Producer Plant
Rated CFM	100
Air Compressor	IR COMPRESSOR B
Duration LOAD:UNLOAD Ratio	11:89
On/Off set Pressure Kg/cm^2	6.2:6.8
KW Load: Unload	22.3:4.12
Annual Consumption KWH	52848

Suggestion:
Looking into application and operating parameters required, we suggest to stop above air compressors and switch load to another related compressor of the same plant for such that the IR Compressor B of Producer plant can be switch over to IR Compressor A of the same plant.

Savings:
Due to such switch over annual power consumption of identified air compressors can be saved and also maintenance cost shall reduce.
Due to switching over of load to other identified compressors; exact savings cannot be identified. However considering loading approx 25% of the total consumption can be saved per year.

Savings Anticipated:

Calculations:
It shall be 0.25*52848= 13212 KWH per year
Now per unit charge is Rs 7.2/unit
So, 7.2*13212= Rs 95,216 per year.

Investment Required:
Nil

Payback Period:
It shall be immediate

3. ENERGY CONSERVATION TIPS

1. Consider variable speed drive for variable load positive displacement compressors.
2. Use a synthetic lubricant if the compressor manufacturer permits.
3. Be sure lubricating oil temperature is not too high (oil degradation and viscosity) and not too low (condensation contamination).
4. Change the oil filter regularly.
5. Periodically inspect compressor intercoolers for proper functioning.
6. Use waste heat from a very large compressor to power absorption chillers or preheat process or utility feeds.
7. Establish compressor efficiency-maintenance program. Start with an energy audit and follow up, then make a compressor efficiency- maintenance program as a part of your continuous energy management program.
8. Avoid over sizing- match the load.
9. Install a control system to coordinate air compressors.
10. Minimize purges, leaks, excessive pressure drops and condensation accumulation.
11. Use small air compressors when production loads is less or is off.
12. be sure that air/oil separators are not fouled.
13. Establish compressed air efficiency maintenance programme. Start with an energy audit and follow up, then make a compressed air efficiency maintenance program a part of your continuous energy management program.

4. CONCLUSIONS

Energy Audit is the perfect tool that can give the idea about the usage of energy and further more details can be obtained by the further analysis. A careful audit can give the idea to the organization or the industry for the energy management programmes and the major affected areas of the energy waste to which action plan can be made and implemented. A Compressor audit has the potential to provide immediate action savings.

In this paper a detailed study has been made to reduce the energy consumption of the compressor. Moreover the payback period and recommendation is provided for ensuring the conservation of energy and the action plan.

To save energy the following practices is to be made:

- Stop the air compressor IR COMPRESSOR B and switch its load to another compressor of the same plant.
- Reducing Heat loads
- Efficient maintenance practices
- Proper Insulation

This will surely make power saving about approximately 15-17% of the energy consumption in the producer plant of the industry. The data provided in the paper also shows how we can save the electrical energy by just incorporating some installations and making the operation/machine energy efficient. Some conservation tips are also provided which are in general to be incorporated to save the energy.

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