HOW TO DO SELF ASSESSMENT ON COMPRESSORS?

PERMAWELD PVT LTD

Vol. 1 Compressors

Introduction

Have you ever tried to perform shop floor self-assessment on the performance of compressors? If not, then this article helps you to do the self-assessment on your own with relatively less instruments which are mostly readily available in any industry.

This article covers Free Air Delivery test for compressor, Isothermal and volumetric efficiency tests, and overall leak quantification tests.

Compressor Capacity Assessment

Due to ageing of the compressors and inherent inefficiencies in the internal components, the free air delivered may be less than the design value, despite good maintenance practices. Sometimes, other factors such as poor maintenance, fouled heat exchanger and effects of altitude also tend to reduce free air delivery. In order to meet the air demand, the inefficient compressor may have to run for more time, thus consuming more power than actually required.

The power wastage depends on the percentage deviation of FAD capacity. For example, a worn-out compressor valve can reduce the compressor capacity by as much as 20%.

A periodic assessment of the FAD capacity of each compressor has to be carried out to check its actual capacity. If the deviations are more than 10% corrective measures should be taken.

The ideal method of compressor capacity assessment is through a nozzle test wherein a calibrated nozzle is used as a load, to vent out the generated compressed air. Flow is assessed, based on the air temperature, stabilization pressure, orifice constant. etc.

Since this article is all about performing assessment in simpler way, lets discard nozzle test method.

Simple method of Capacity Assessment in Shop floor

Isolate the compressor along with its individual receiver being taken for test from main compressed air system by tightly closing the isolation valve or blanking it, thus closing the receiver outlet.

Open water drain valve and drain out water fully and empty the receiver and the pipeline. Make sure that water trap line is tightly closed once again to start the test. Start the compressor and activate the stopwatch. Note the time taken to attain the normal operational pressure P2 (in the receiver) from initial pressure P1.

Calculate the capacity as per the formulae given below:

Actual Free Air Discharge

$$\boldsymbol{Q = \frac{P_2 - P_1}{P_0} \times \frac{V}{T} \times k \quad Nm^3/minute}$$

Where,

P_2 -Final pressure after filling (bar abs)
P_1 -Initial pressure after bleeding (bar abs)
P_0 -Atmospheric pressure (bar abs)
V -Storage volume in m^3 which includes receiver, after cooler and delivery piping
T -Time taken to build up pressure to P_2 (minutes)

The above equation is relevant where the compressed air temperature is same as the ambient air temperature, i.e., perfect isothermal compression. In case the actual compressed air temperature at discharge, say $T_2{}^0C$ is higher than ambient air temperature say $T_1{}^0C$ (as is usual case),the FAD is to be corrected by a factor **k = (273 + T1) / (273 + T2).**

Suction Velocity Method

This method of capacity assessment helps when isolation of compressor is not possible, like industries which runs all 365 days in a year. This method requires an anemometer to measure the incoming air velocity to the compressor.

To start the test, the air inlet area, where the air filter is fixed has to be measured, eliminating surface area of obstacles like grill, mesh etc. Using an anemometer measure the velocity of incoming air at various points in front of the suction area. Take as many samples as possible and average it out. Follow the below equation to calculate the FAD.

$$\boldsymbol{Q = A \times V \times 3600\, m^3/h}$$

Where,

A - Suction Area, m^2
V - Average Air Velocity, m/s

Specific Power Consumption

This parameter is an important factor to judge how well the compressor is performing with respect to its design. Specific power consumption is the amount of power required to generate one unit of compressed air i.e. kW/CFM or kW/Nm^3/h.

A power analyzer can be used to record the incoming power to the compressor. The measured power value can be used to calculate the specific power consumption since the FAD has been already calculated from previous exercise. The derived value can be compared against the design value of the compressor. The increased value of specific power consumption means that the compressor is under performing.

Efficiency Evaluation

Several different measures of compressor efficiency are commonly used: volumetric efficiency, adiabatic efficiency, isothermal efficiency, and mechanical efficiency. Adiabatic and isothermal efficiencies are computed as the isothermal or adiabatic power divided by the actual power consumption. The figure obtained indicates the overall efficiency of compressor and drive motor.

Isothermal Efficiency

$$\textbf{Isothermal Eff.} = \frac{\textbf{Isothermal Power}}{\textbf{Actual measured input Power}}$$

Where,

Isothermal power (kW) = P_1 x Q_1 x $\log_e r$/36.7
P_1 = Absolute intake pressure (barG)
P_2 = Absolute delivery pressure (barG)
Q_1 = Free air delivered (m^3/hr)
r = Pressure ratio P_2/P_1

The calculation of isothermal power does not include power needed to overcome friction and generally gives an efficiency that is lower than adiabatic efficiency. The reported value of efficiency is normally the isothermal efficiency. This is an important consideration when selecting compressors based on reported values of efficiency.

Volumetric Efficiency

$$Vol.Eff. = \frac{FAD\ m^3/min}{Compressor\ Displacement}$$

Where,
For Reciprocating Compressor,
Compressor displacement = $\frac{\pi}{4} \times D^2 \times L \times S \times \chi \times n$

D	= Cylinder bore, m
L	= Cylinder stroke, m
S	= Compressor Speed, rpm
X	= 1 for single acting & 2 for double acting cylinders
n	= No. of cylinders

Leak Quantification

One can perform shop floor leak quantification by following the simple steps.

- Shut off compressed air operated equipment (or conduct test when no equipment is using compressed air).
- Run the compressor to charge the system to set pressure of operation.
- Note the sub-sequent time taken for 'load' and 'unload' cycles of the compressors. For accuracy, take ON & OFF times for 8 – 10 cycles continuously. Then calculate total 'ON' Time (T) and Total 'OFF' time (t).

$$\textbf{\% Leakage} = \frac{\mathbf{T}}{\mathbf{(T+t)}} \times \mathbf{100}$$

or

$$\textbf{System Leakage Quantity (m}^3\textbf{/min)} = \frac{\mathbf{T}}{\mathbf{(T+t)}} \times \mathbf{Q}$$

Where,

Q	= Compressor capacity (m^3/min)
T	= Time on load in minutes
T	= Time on unload in minutes

However, performing this experiment in a full-time running plant is close to impossible. So, conducting a leak survey audit will be the best choice.

Leak detection by Ultrasound Leak Detector

Leakage tests are conducted by a Leak Detector having a sensing probe, which senses when there is leakage in compressed air systems at high temperatures-beneath insulated coverings, pipelines, manifolds etc.

The leak is detected by ultrasonic vibration. Leak testing is done by observing and locating sources of ultrasonic vibrations created by turbulent flow of gases passing through leaks in pressurized or evacuated systems.

If you are interested in performing a complete compressed air leak detection services at your plant, visit this link: Permaweld's Compressed Air Leak Service

Permaweld has 14+ years of experience in compressed air leak audit over various types of industries. More than 3,90,000 points surveyed speaks the volume of the experience.

Conclusion

Performance measurement of air compressors is important. By having permanent monitoring on the compressed-air system, you will realize even more benefits. The key is to perform predictive maintenance so that components are serviced before they fail. Also, keep track of the energy consumption to ensure the investment will pay off in a short time. Combined with regular leak surveys, these factors will allow you to enjoy a healthy and efficient compressed air system.

- ***Maxwell Dennis***
Energy Auditor, BEE

References

- "Energy Efficiency in Electrical Utilities", Fourth Edition, 2015, by Bureau of Energy Efficiency.