

ANALYSIS ON EFFECT OF TEMPERATURE ON MOISTURE SEPARATION IN AIR COMPRESSOR

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ABSTRACT

Compressed air is widely used in variety of industrial application. The air used for various application must be free from the various impurities such as oil, moisture and dust particle. Filters are often used to remove the contamination of compressed air. This works explore the effect of temperature on the filter performance i.e. filter efficiency and the pressure drop across it. Both experimental analysis as well as CFD analysis has been carried out to study the performance of filter at various temperature in the range of 10 °C to 35 °C. Results shows that performance of filter were better in the temperature range of 15 to 20 °C. Both experimental and CFD results were matching.

Keywords: Filter, coalescing, moisture, CFD

INTRODUCTION

A ready supply of clean compressed air is important to many industries. Acceptable contaminant levels vary depending upon application. Aerosol contaminants may be mono- or poly- dispersed [1]. Clean and dry compressed air plays an essential role in industry with many applications and is often considered a "fourth utility" at most facilities. It is used to move conveyors, transport products, power pneumatic

tools, automate equipment, operate critical instrumentation, packaging, and for process operations [2]. A major problem in compressed air systems is the presence of water, oil, and solid contaminants which can adversely affect air quality and lead to rust, scaling, instruments clogging, valves sticking, frozen lines, and process contamination. Water vapour is naturally present in air and condenses as it is compressed and cooled. Oils are introduced by lubricated air compressors. Solid particles can be in the form of scale, rust, desiccant from a dryer, and atmospheric dust from a compressor intake [2].

The increased use of compressed air and the development of many new and more sophisticated devices and controls have accelerated the need for clean dry air. Hence, drying technology advanced, and dryers came into general use [3]. Prefilters are typically used to remove solid contaminants and to reduce the loads on coalescing filters. Water and some condensable vapours are removed using inline air dryers. For oil removal, mechanical separators are effective with large oil drops. For small drops, especially in the submicron size range, coalescing filters are used.

NEED FOR FILTRATION

Atmospheric Air entered the compressor consist of moisture, oil and other contamination. High pressure and temperature compressed air

discharge and cooled in chilled water cooled aftercooler, condensation took place and liquid collected in condensate separator which is water and oil. Still air consist of some percentage of moisture after separator, Which need to be remove for better efficiency of further process. Thus prefilter is used just after the condensate separator to remove the remaining moisture and oil contamination. Air is then passed through the desiccant bed dryer where Dryness is achieved by dew point suppression. After-filter which is a particulate filter used after the dryer to remove the dust that may be carryover from dryer.

TYPICAL COMPRESSED AIR DRYING PROCESS

The compressed air drying process includes many equipment components including filters. Their performance has an effect on the degree of dryness and cleanliness of the compressed air. Figure 1 below shows the typical air drying process.

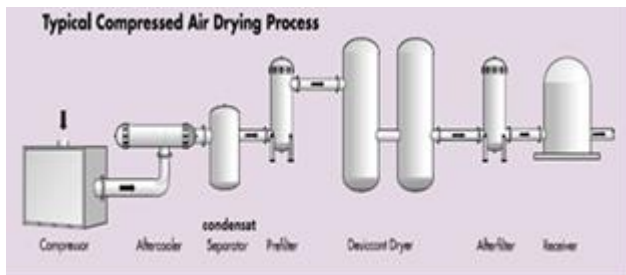


Figure 1 Typical compressed air drying process

COALESCER FILTER MEDIA

M.G. Hajra et al. (2002) [4] Coalescer filter media are specifically designed to remove submicron droplets from compressed air. Coalescence occurs when two drops merge into one droplet. Droplets carried by the air are captured or their velocities are slowed by the fibres within the filter medium. Trailing droplets collide with the leading droplets. When two colliding drops stay in contact long enough, and

the collision has sufficient energy, the two drops merge into one drop. This may occur whether the drops are physically attached to fibres or not. Drops that are attached to fibres may also merge due to a thin liquid film spreading between the drops on a fibre.

The Coalescence filtration occurs in 3 steps [5]

1. Droplets are captured on the fibers.
2. Captured droplets coalesce into larger drops.
3. The enlarged drops migrate through the medium.

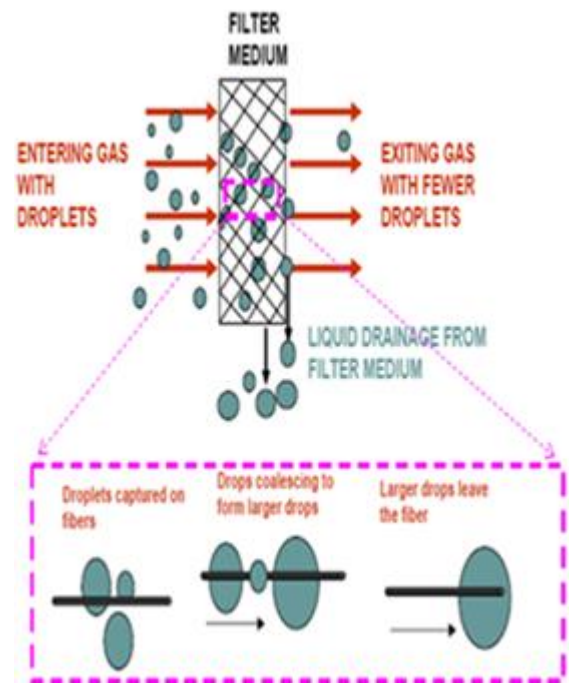


Figure 2 Coalescing Filtration

The overall filter performance depends upon the combination of particle capture, droplet coalescence, and liquid drainage. Initially the filter medium is liquid free. At the start of the filtration, drops collect but little or no drainage occurs. As the liquid concentration in the filter increases the liquid will start to drain from the filter. The filter continues to accumulate oil until the collection rate is balanced by the drainage

rate at which point the filter operates at steady state [4].

EXPERIMENTAL RESULTS AND DISCUSSION

The experimental analysis were done on the existing set up at Low Temperature Facility of TIFR, which is shown in figure 3.

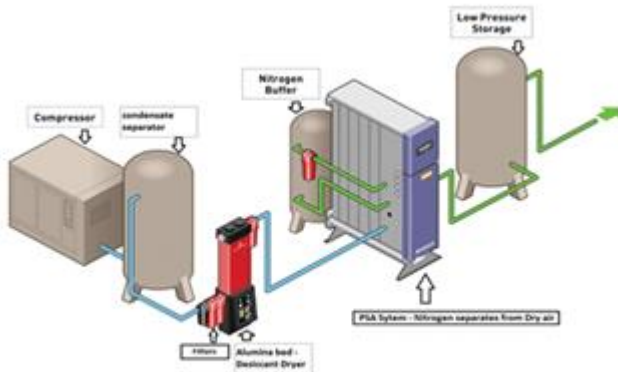


Figure 3 Experimental Setup

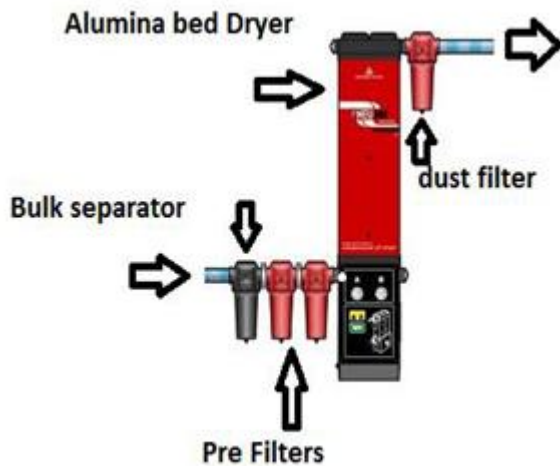


Figure 4 Filters Arrangement

Table 1 Summary of operating conditions and the parameters varied during testing of filter media

Parameter	Condition
Compressor free air delivery (FAD)	5.6 m ³ /min at 9.1 or 9.2 bar pressure
Compressor outlet temperature	80 °C to 83 °C
Atmospheric Air flow condition to compressor	At 1 atm pressure and 20 °C to 30 °C temperature.
Inlet stream mass concentration (to filter)	0.5 litter
Temperature of air after the condenser	Varied from 10 °C to 35 °C
Humidity	55% to 65 % RH

The compressed air coming out of compressor which is usually at a temperature of 80 to 83 °C, pass through the condenser which uses chilled water. The high pressure, hot air is cooled in the condenser to a temperature range of 13 to 25 °C (as with the existing setup at TIFR) before gets into the receiver tank. Most of the moisture and oil get condensed and collected within the receiver tank. The air is then allowed to pass through the Prefilters. Wherein it passes through bulk water separator and then High efficiency coalescing and dust removal filters. Wherein remaining traces of moisture is removed. The air after condenser contains about 0.5 liters of oil and moisture passed through Prefilters. Of that 0.5 liter most of moisture removed in bulk water separator and collected by receiver tank and remaining traces of moisture removed in filter. It was found that about 99.925 % moisture removed by filter and remaining traces removed by desiccant dryer.

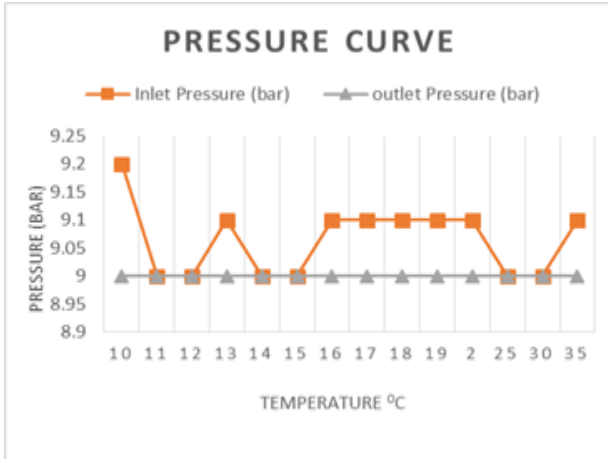


Figure 5 Pressure variation Curve



Figure 6 Actual Filter Element

CFD RESULTS AND DISCUSSION

For CFD analysis model of the existing filter were made by using software SOLID WORKS and then it was imported to the ANSYS 14.5 for further simulation work. The filter model were designed was simplified in order to perform the simulation. For Simulation FLUENT is used in ANSYS 14.5 as a solver.

Table 2 Technical Specification of Filter

Filter Grade	AA
Model	030AA
Filter Type	Coalescing
Porosity	1 to 0.01 micron
Pipe size	1 ^{1/4} "

Following figures shows the different form of filter element. Viz. actual filter element, simplified filter element, sectional view of filter element.

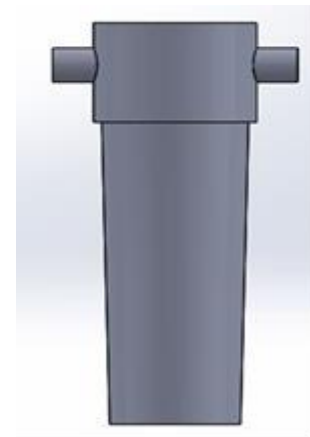


Figure 7 Simplified Filter Model

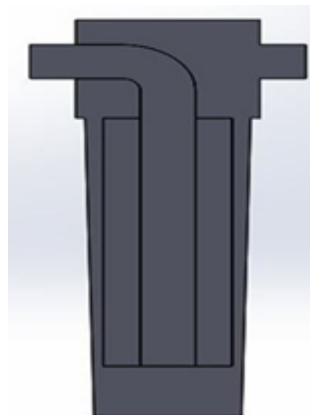


Figure 8 Sectional Symmetrical Model



Figure 9 Meshed View

To carry out the simulation of any system that system has to convert into grid structure so that the simulation will be done for every element for better results. This grid structure or meshed structure is created by different mode, here Meshing of the model for the simulation were done in ANSYS 14.5. The number of element form were 36000. The performance of filter in terms of pressure drop and filter efficiency were analyzed by using FLUENT as solver in ANSYS 14.5. Following section shows the CFD results.

FILTER EFFICIENCY

In order to find out the efficiency of filter, contours of volume fraction at various temperature has been plotted. For this condition Eulerian multiphase model has been used. Following figures shows the contours of volume fraction at various temperature.

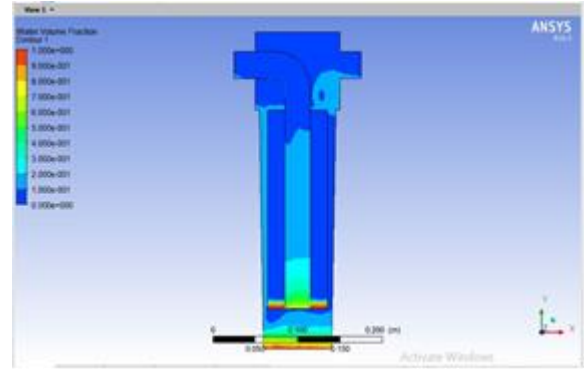


Figure 10 Volume Fraction (Water) at 15 °C

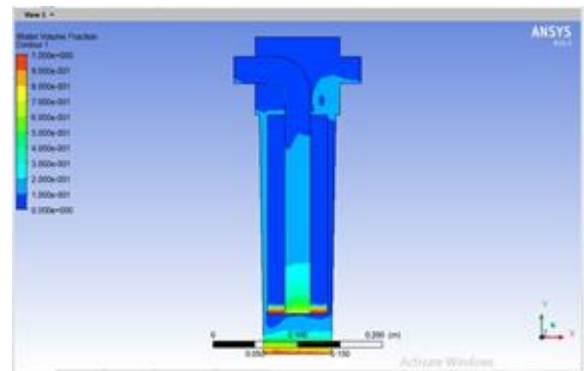


Figure 11 Volume Fraction (Water) at 25 °C

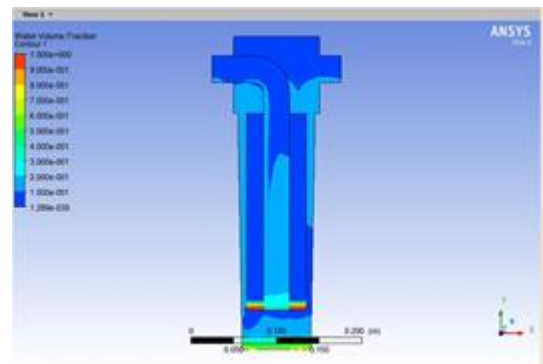


Figure 12 Volume Fraction (Water) at 35 °C

EFFICIENCY CURVE

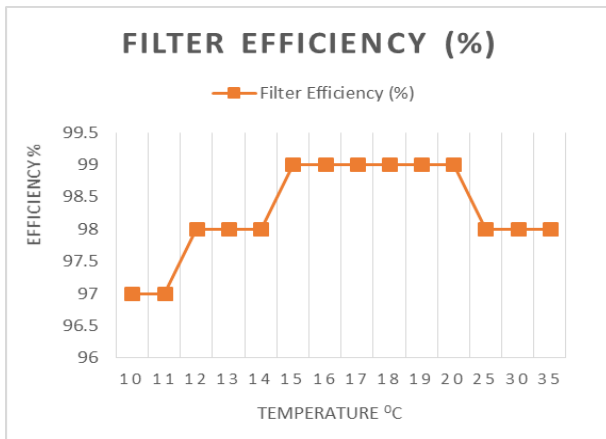


Figure 13 Efficiency vs Temperature Curve

From the above analysis it has been found that the efficiency of filter were maximum in the range of temperature from 15 0C to 20 0C. Thus it would produce more dry and pure air in this range as compare other temperature.

CONCLUSION

In this paper effect of temperature on the filtration of compressed air through coalescing filter were analyzed, both experimental analysis as well as CFD analysis were done to find out effect of temperature on pressure drop and the filter efficiency. Experimental results shows that the efficiency of filter were maximum in the range of 15 0C to 20 0C. CFD results shows that pressure drop is 0.2 bar across the filter and the efficiency of filter is maximum i.e. 99% in the range of 15 0C to 20 0C. It shows that the maximum of the moisture removed in the filter and hence desiccant chamber is protected against the contamination. Hence life of system components increases.

REFERENCE

- [1] P.C. Reist, Aerosol Science and Technology, second ed., McGraw Hill, New York, 1993.
- [2] Application profile Of Graver Technologies “Filters for Compressed Air Dryer”.
- [3] Compressed air Gas Institute “Compressed air and gas drying” guide book.
- [4] M.G. Hajra, K. Mehta, G.G. Chase “Effects of humidity, temperature, and nanofibers on drop coalescence in glass fiber media” Separation and Purification Technology 30 (2003) 79-88, Elsevier,2002.
- [5] N. Azhaguvel, P. Bharathidasan, P. Rajesh “Separation and Analysis of Oil Based Aerosols from Compressed Air” N. Azhaguvel et al. / International Journal of Engineering Science and Technology (IJEST) Vol. 3 No. 4 April 2011