
بسم الله الرحمن الرحيم

DESIGN, DEVELOPMENT OF OIL MIST ELIMINATOR FOR ROTARY VACUUM PUMP AND ITS EFFECTIVENESS FOR CLEAN ENVIRONMENT

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INTERNATIONAL SCIENTIFIC SPRING -2010 (ISS-2010)
NATIONAL CENTRE FOR PHYSICS
01- 06 MARCH, 2010

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Introduction

- Vacuum pumps are used in a variety of scientific systems for production of vacuum in industrial process and sophisticated research work.

- Keeping in view, the increasing demand for clean environmental conditions as imposed by the legislation of air quality standards induced by Pakistan Environmental Protection Agency (PEPA) and US EPA [1-2], an oil mist eliminator **(OME)** for rotary vacuum pump was designed and developed.

- The mechanical actions of oil lubrication, oil sealed vacuum pumps often generate large concentrations of micron size visible oil mist, or smoke in their exhaust stream.

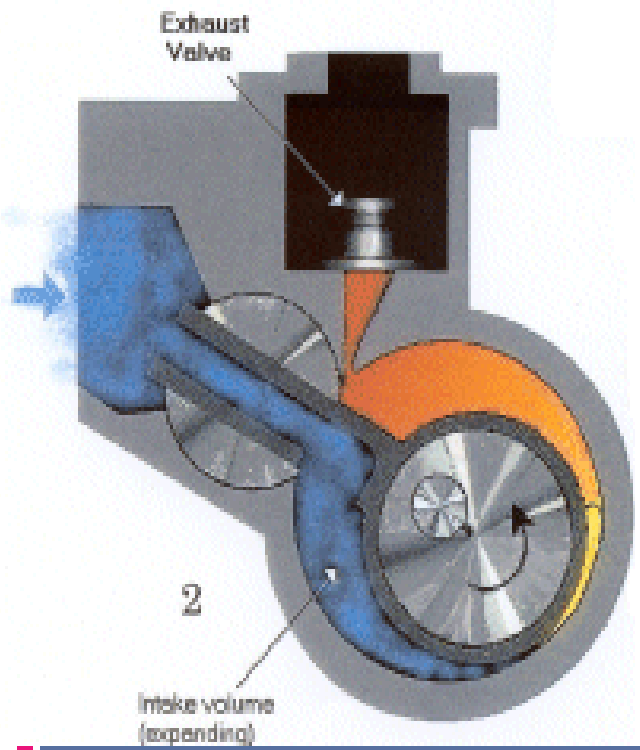
- This can lead to contamination of the surrounding air and invisible oil plumes in working atmosphere.

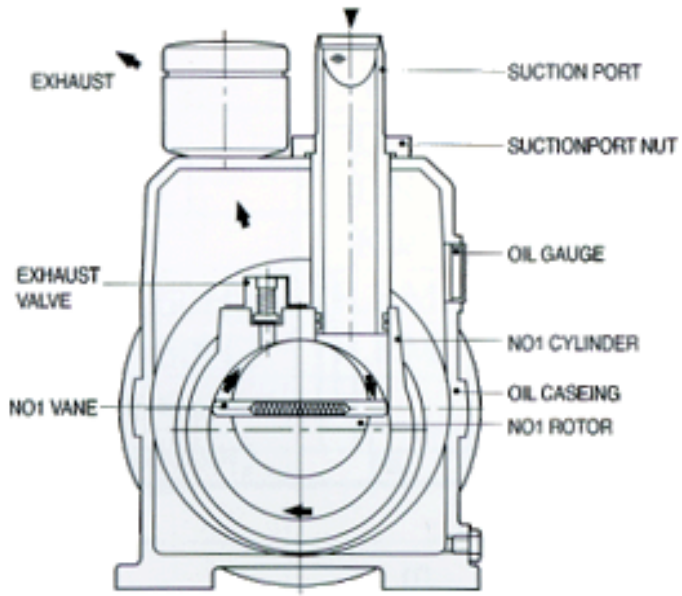
Introduction (contd...)

- An OME is recommended to trap these airborne contaminants, conserve expensive pump oil by collecting in the filter lower part.
- During rotary vacuum pump operation oil mist escapes from the exhaust port, mainly when pumping between atmospheric pressure and one mbar [4-5].
- These oil mist eliminators are essential part of every mechanical rotary vacuum pump keeping laboratory environment clean and safe for the workers.

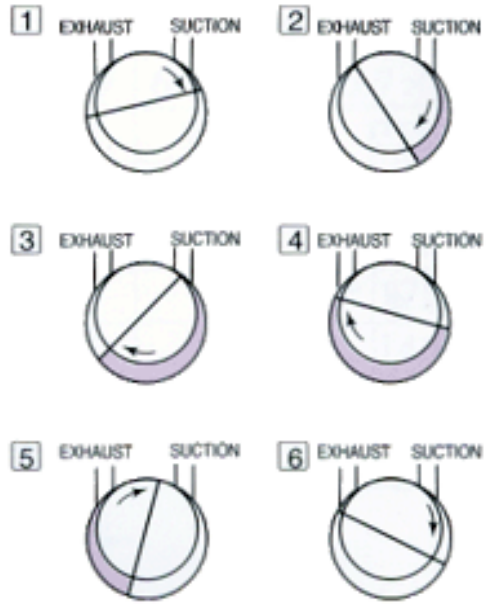
Rotary pump

Rotary vacuum pump can be a major source of laboratory air contamination. When turned ON a large volume of air is pumped through the pump oil.





(A)Structure



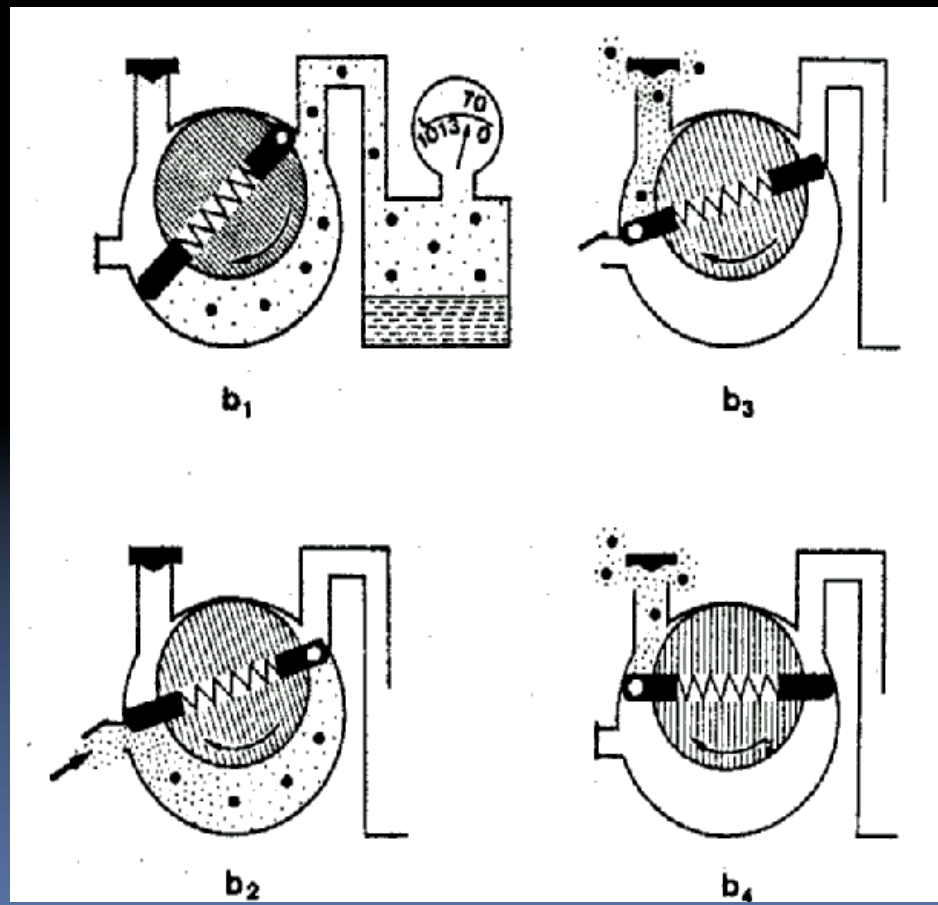
(B) Movement theory

Rotary pump with gas ballast

Gas blast results fine oil mist through pump exhaust port into the laboratory air. These mists contains not only oil, but also contains other organic chemicals that are dissolved in the pump oil.

When vacuum pumps are used with the instruments such as mass spectrometers, residual organics analyzed by the mass spectrometer may trap in the vacuum pump oil.

These organics are purged out of the oil and enter the laboratory air via the pump exhaust port are toxic, carcinogenic and harmful to the working environment .



Environmental and health problems

- These Oil mists can produce serious environmental and health problems in the laboratories, Where vacuum pumps are used for production of vacuum.

- For this reason, it is normally recommended that vacuum pumps be vented out side or in a laboratory exhaust hood [8-9].

Oil Mist Eliminator (OME)

- An OME for vacuum pump has been designed to solve the above-mentioned problems and is a useful tool to keep environment clean.
- This OME was not designed and fabricated for the trapping of volatile organics exhausted by the vacuum pump.
- A charcoal trap can be used to trap a wide range of the volatile and semi-volatile organics in the vacuum pump exhaust [10].
- However our designed OME can be used in conjunction with a charcoal trap to provide more efficient and safe trapping of emissions from laboratory coming out from the exhaust of vacuum pumps.
- In this way, we can improve the quality of air in the laboratory where vacuum pumps are used for evacuating various types of vacuum chambers, large volumes and other related systems.

Types of oil mist eliminators

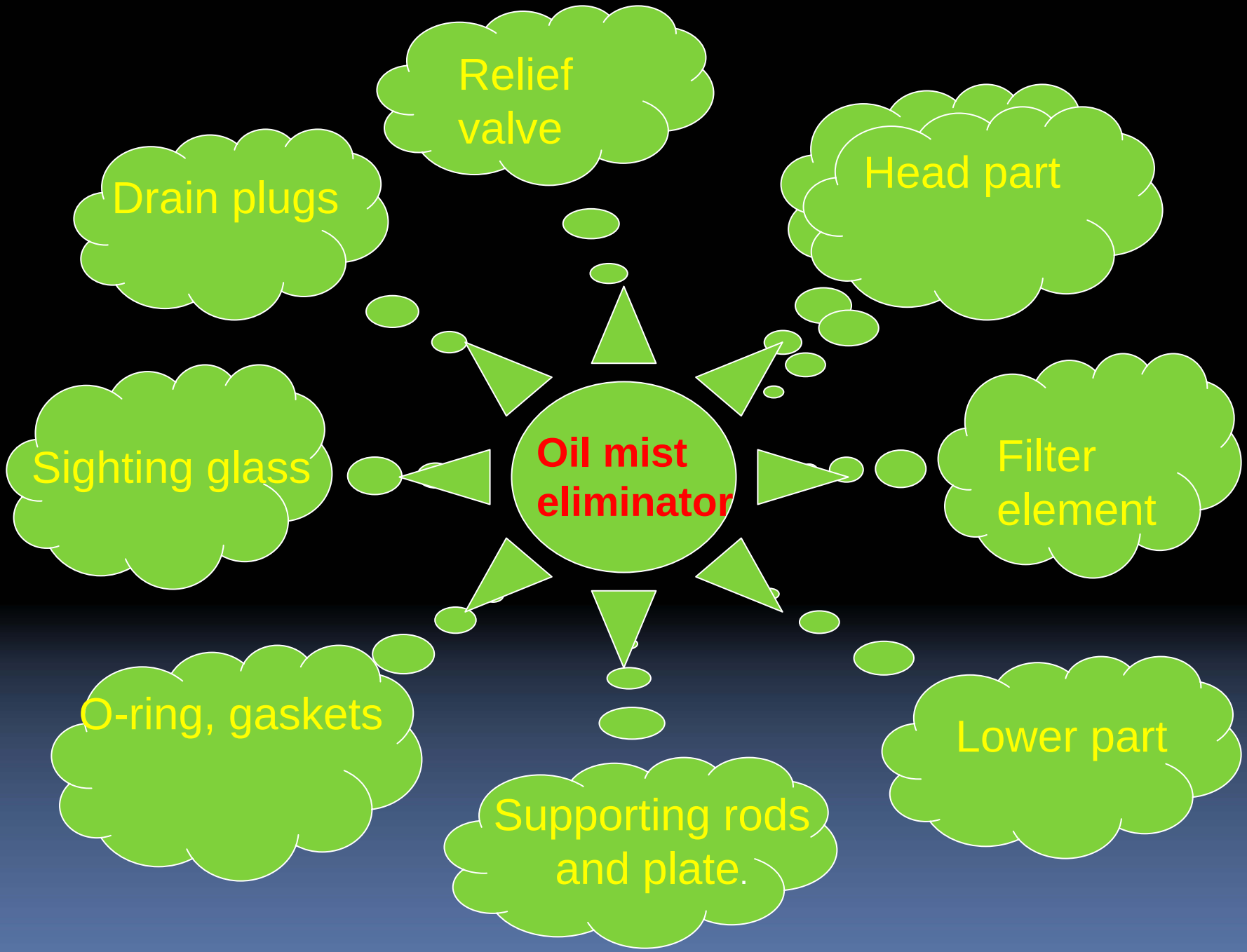
Two types of OME are commonly used.

1. OME with paper filter element

2. OME with micro fiberglass element

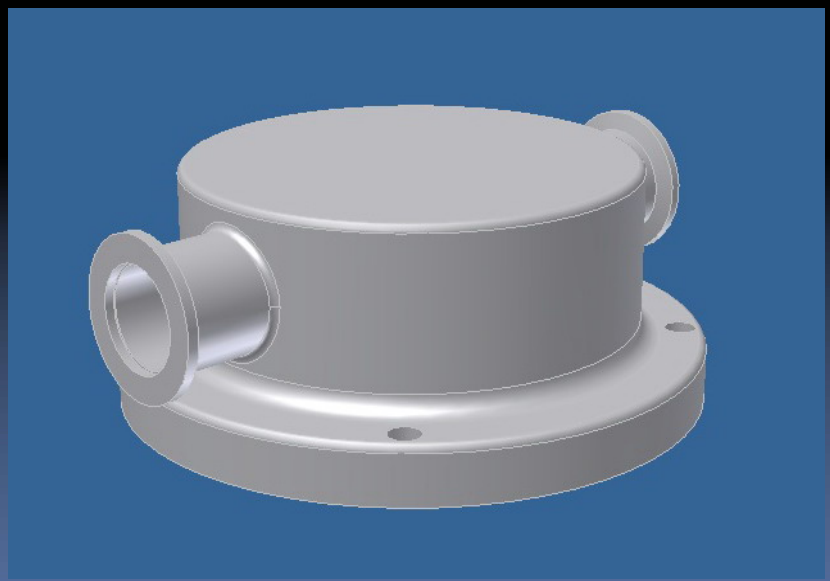
Design and development

- Our design is a micro fiberglass type filter element supported by polyester media on the up and downstream sides which provide extremely fine mechanical filtration as compared with filter elements made of paper filter [11].
- These types of filter elements do not absorb oil; they just only separate the oil from air passing through the filter. The separated oil is accumulated in lower part of body, which can be retrieved back into the pump.`
- Since these filters do not absorb oil, they only need changing if the pump exhaust contains particulate contamination. If pump oil is particulate free, we may only have to change the filter once a year.
- Materials of construction are the key consideration for maximizing the service life of the mist eliminator.
- Whereas OME filter designed with paper filter element need frequent replacements of filter elements due to absorption of oil.

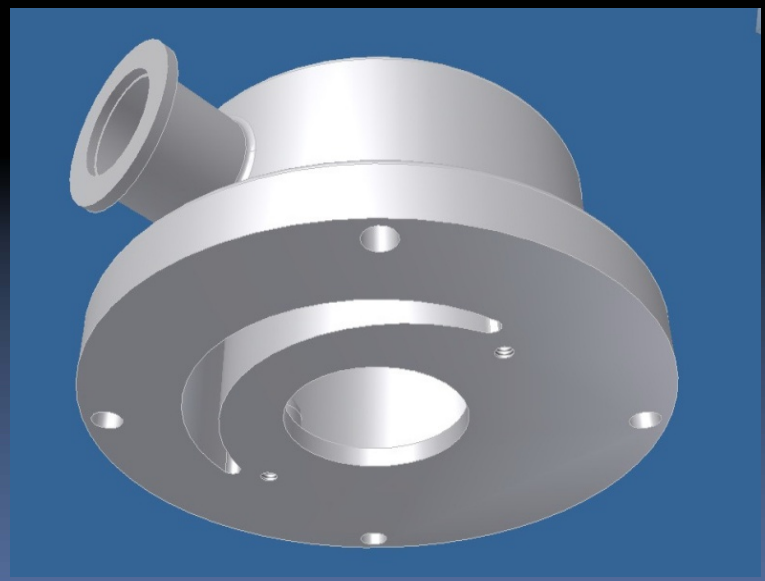

Relief valve
Drain plugs
Head part
Sighting glass
Oil mist eliminator
Filter element
O-ring, gaskets
Supporting rods and plate.
Lower part

Head part

- Head part of designed OME has inlet port and exhaust port
- Designed in such a way that contaminated air entering from inlet port can only pass through the cylindrical filter element and filtered air pass through the exhaust port.
- Head part is aluminum casted , machined and finished



Head part



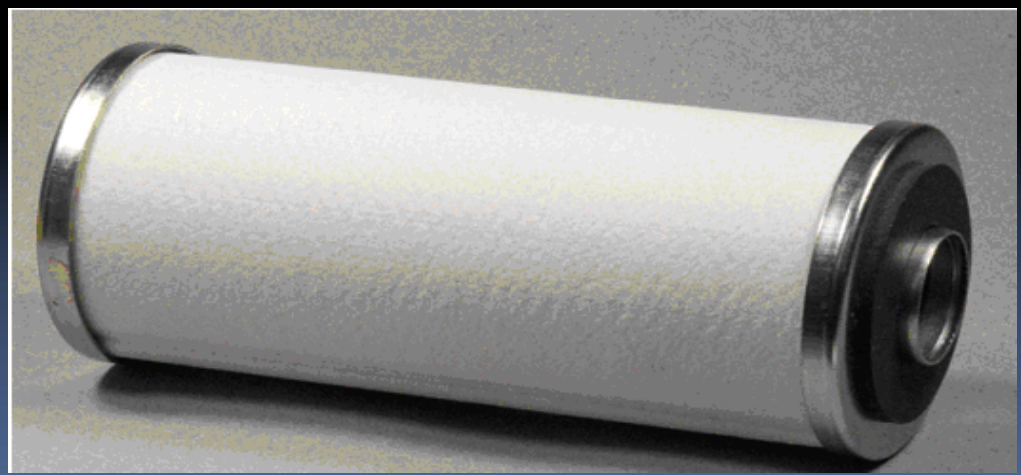
Internal structure

Filter element

- A filter element consists of a mass of fibers, oriented across the direction of flow and originates from paper making technique.
- In some hand-made filters, used in research, there may be a series of parallel elements, each element consist of a layer of parallel fibers.
- Filter manufacturing skill lies in ensuring that the fibers are separated.
- Frame work referred as "grid".
- Material for frame work low-carbon alloy steel (type304L).

Filter element (contd…)

- Our designed filter element is cylindrical type as shown.
- The cartridge in cylindrical filter element is made of micro-fiber glass, which separates the air pollutants. Filter element may get clogged in the long term due to cracking products in the oil, and this may cause over pressure to build up in the pump. In order to make sure that the over pressure will not exceed an admissible value and cause damage to the pump or the motor, a pressure relief valve is provided in the filter element.

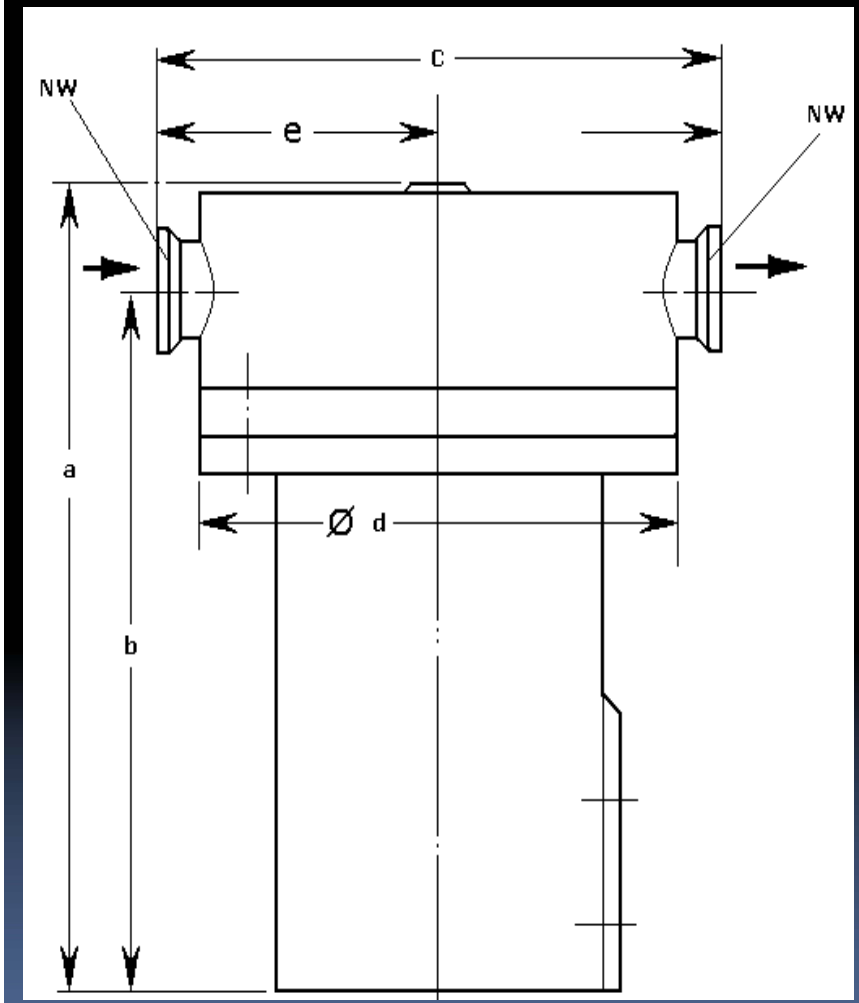


Designed filter element

Lower part

- The Lower Part is a cylindrical hollow body made of aluminum casting. It has an inspection window and oil drain plug.
- The oil separated by filter element is accumulated in lower part of the body. The lower part is designed in such a way that, it has an oil inspection window.
- If the oil rises above the center of the inspection window, it can be drained just, by opening the drain plug.
- The construction of the OME casing allows replacements of the filter element if necessary.

Designed and developed OME



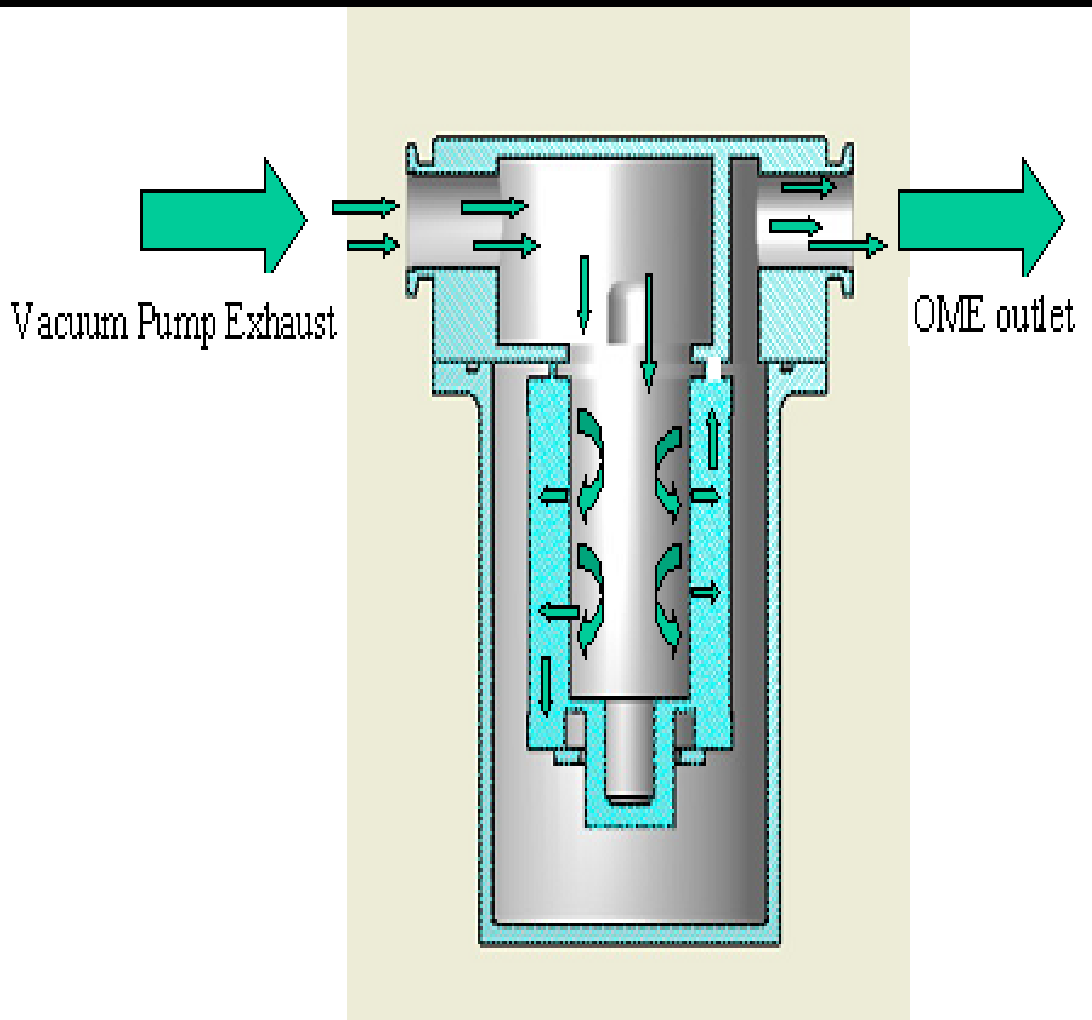
Block diagram

NW	a (mm)	b (mm)	c (mm)	θ (mm)	e (mm)
40 KF	370	340	180	160	90

Dimensions

Design and Working of OME

Designed OME



Internal design and working of OME

Specifications

Trapping efficiency 0.2 to 0.3 micron size particles.

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Exchangeable filter element.

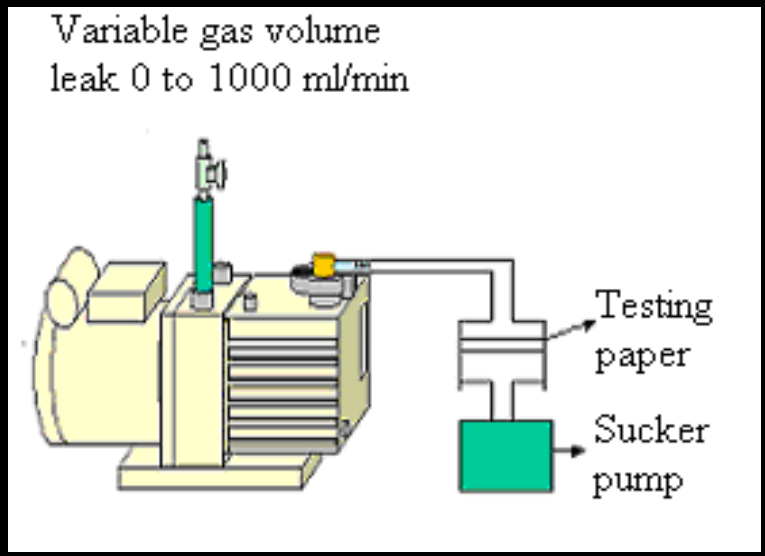
Built-in pressure-relief valve.

Sight glass to check the amount of oil collected.

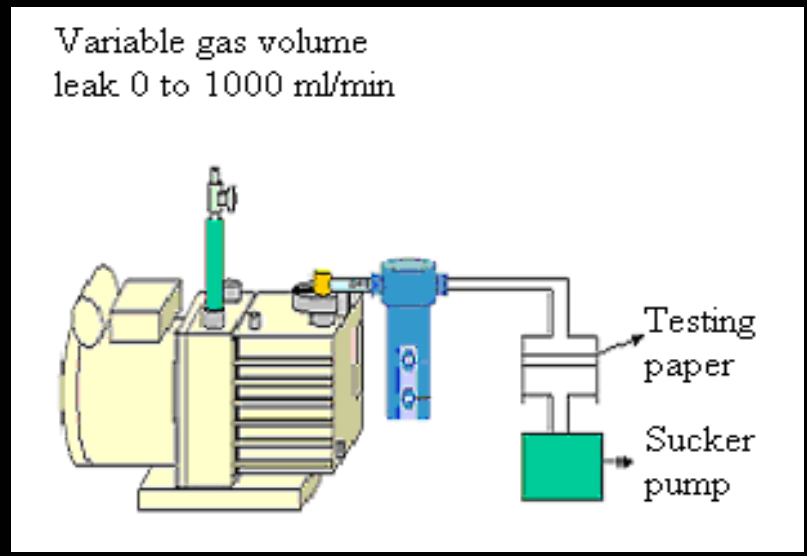
Helium leak tight. ,Drain plug for easy recovery of pump fluids.

Resistant to solvents., Prevent loss of pump oil.

Experimental setup and procedure



Vacuum pump exhaust sample collection without OME.



Vacuum pump exhaust sample collection with OME.

Initially pump was run for four hours before taking any sample, drained the pump oil. The pump was again filled with Canopus oil and run for four hours before any sample was collected. The same process was repeated with M100V oil in the pump.

Experimental setup and procedure **(Contd...)**

- This cleaning and flushing procedure assured that the pump was free of contaminants from the previous use of vacuum pump.
- In this study, a micro needle valve was attached to the intake port of vacuum pump to permit a calibrated flow of air into the vacuum pump.
- The flow through the needle valve was adjusted to 100 ml/min.
- Samples were collected both with and with out the OME.

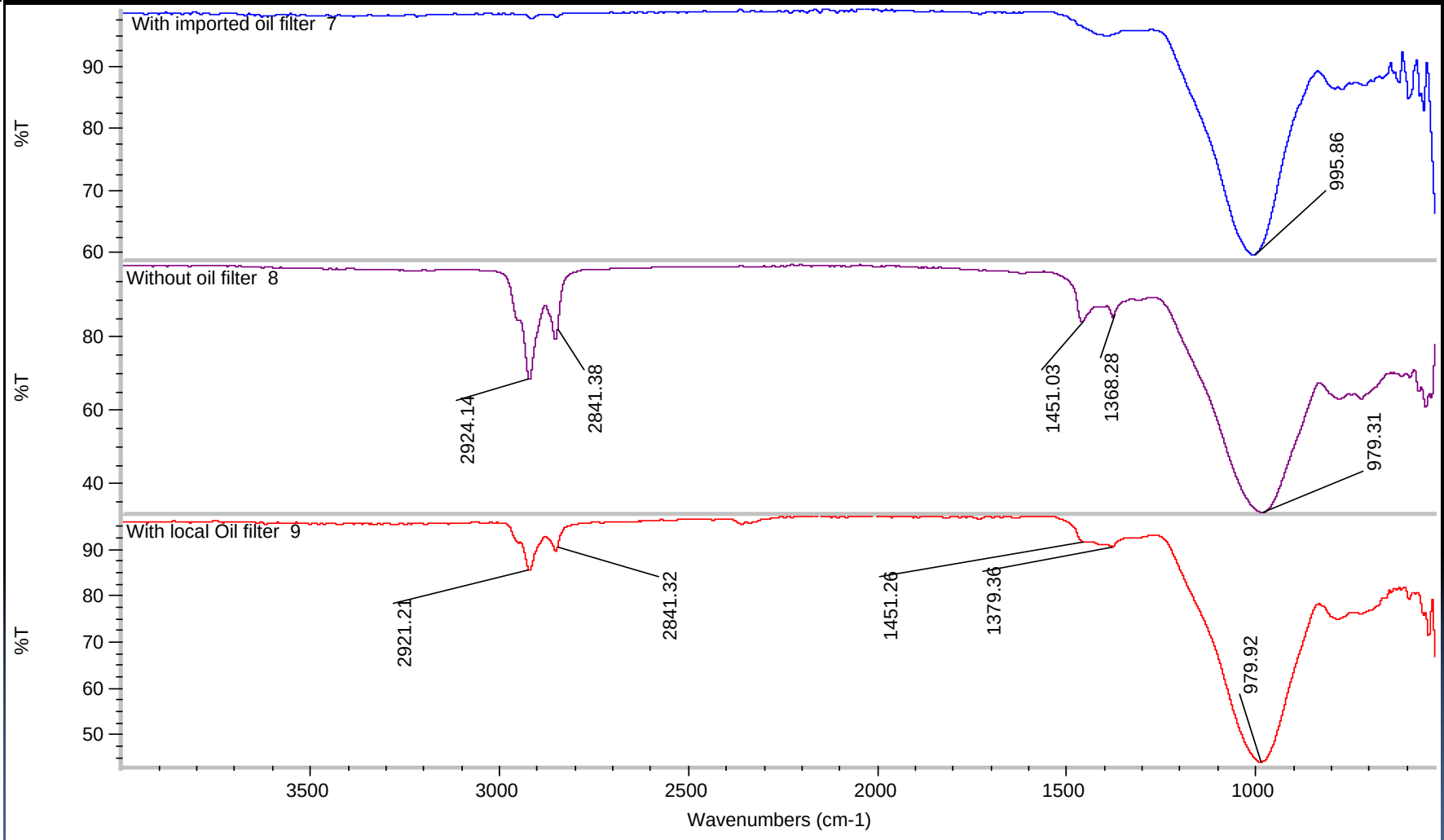
Experimental setup and procedure (contd...)

- In both cases of taking air samples with out OME and with OME, the pump was run for four hours continuously with 15 minutes gas ballast intervals.
- The air ejected from the pump before and after OME were allowed to pass through the test paper filter with the help of sucker pump.

Results and discussion

- All samples were analyzed with the help of Fourier Transform Infrared spectroscopy (FTIR Model Nexus 470)
- The results obtained for local made OME were compared with imported one.

Results and discussion (contd...)

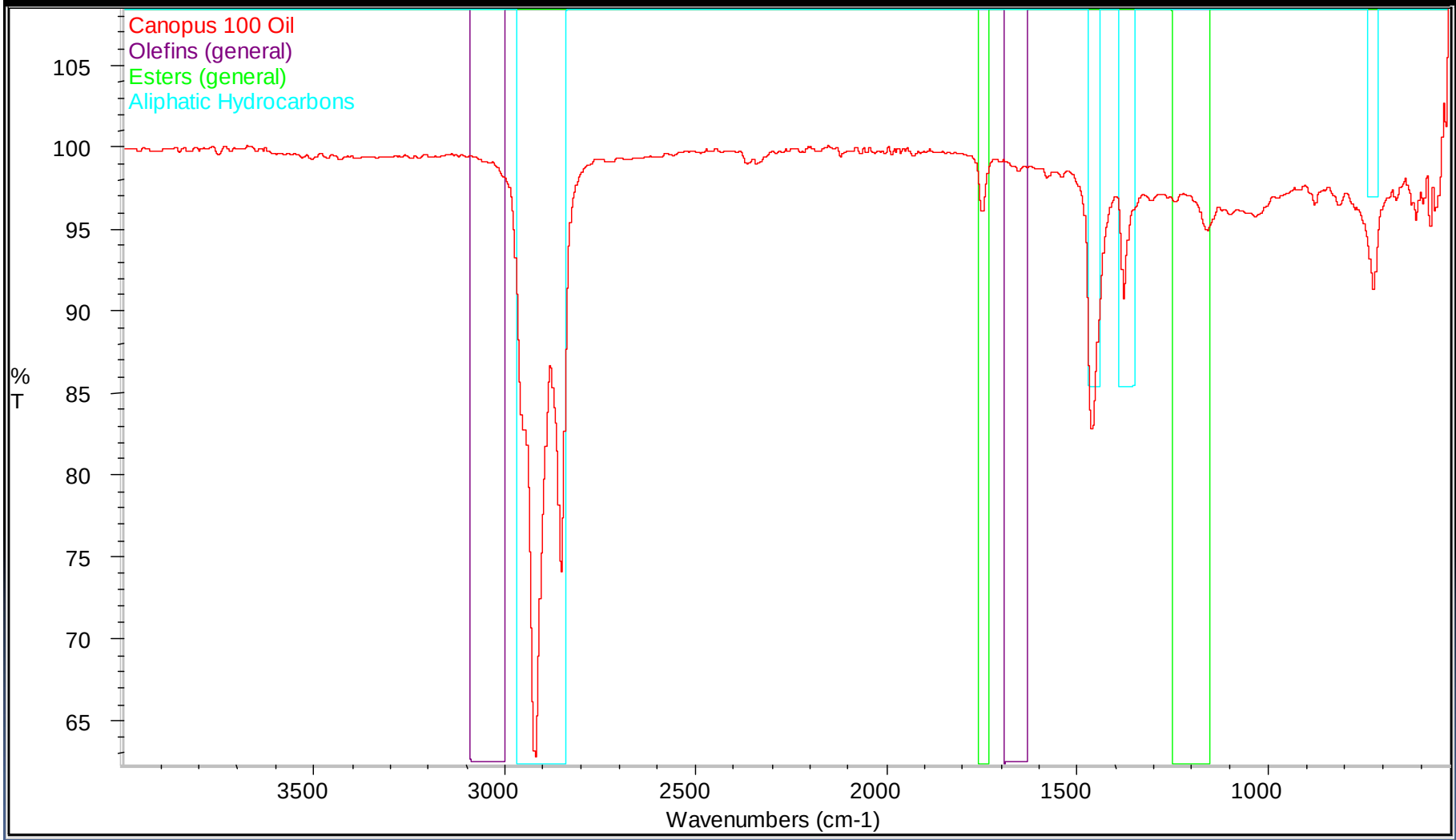


The FTIR spectra of samples with imported, local made and with out OME using Canopus oil in vacuum pump.

Results and discussion (contd...)

From the above mentioned spectra for testing the effectiveness of OME with imported, local made and with out OME using Canopus oil clearly shows that designed and developed oil mist eliminator was effective for controlling the unwanted pollution of oil mist in the laboratory however the imported OME performance was slightly better than our local made OME.

Results and discussion (contd...)

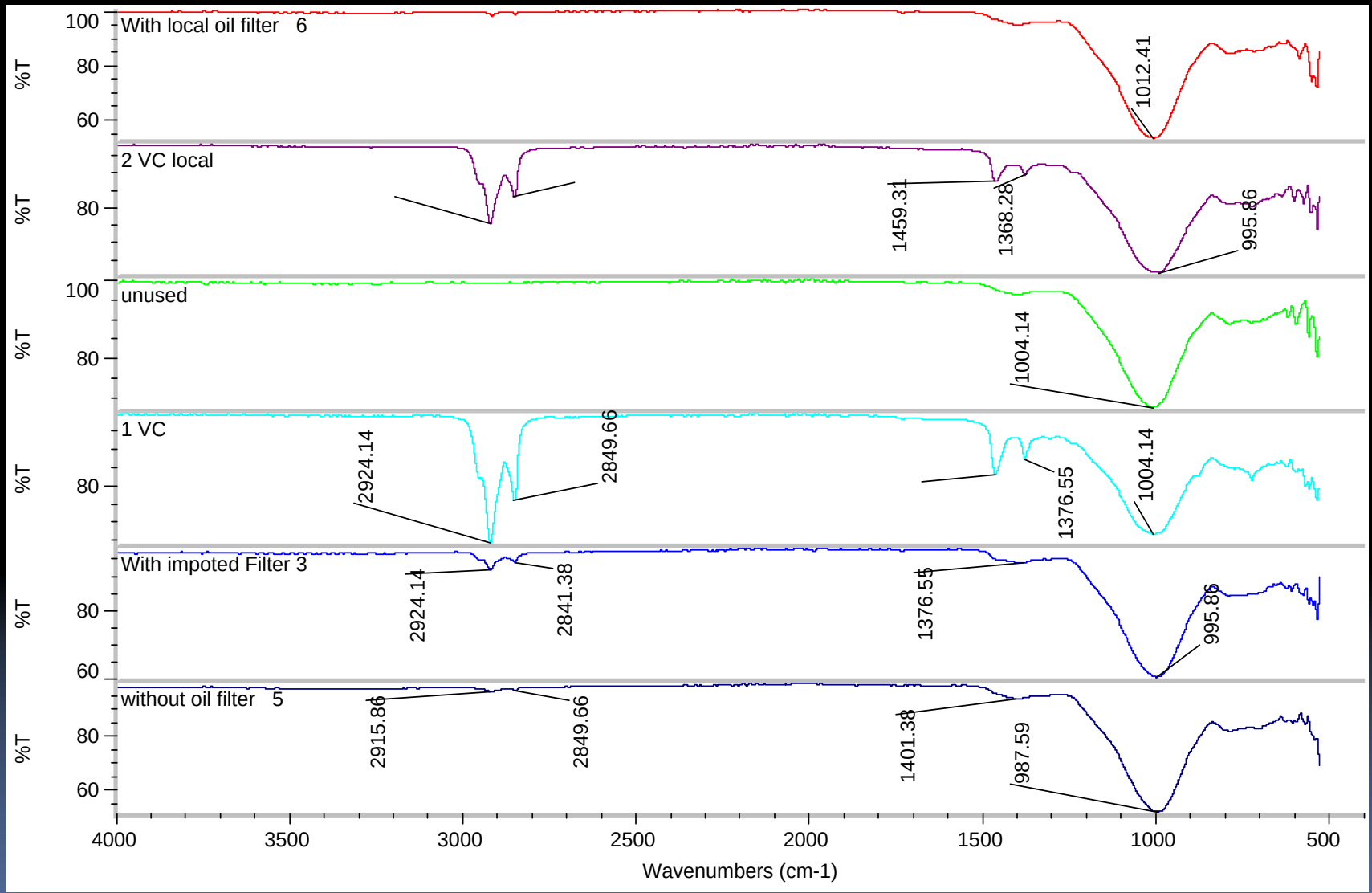


The FTIR spectra of Canopus oil .

Results and discussion (contd…)

- The FTIR spectra of Canopus oil sample used in the D-60 vacuum pump showed the presence of hydrocarbon.
- Also the group CH=CH-, CH_2 is present in the range of 2900-3000 cm^{-1} .
- Spectrum for test paper with out OME showed the same functional group - CH=CH-, CH_2 in the range of 2841.38-2924.14 cm^{-1} which verify the existence of oil mist presence in the exhaust air from rotary vacuum pump.
- Samples taken after the local made OME showed the functional group - CH=CH-, CH_2 in the range of 2841.32-2921.2 cm^{-1} with low peak.
- This means that local made OME is effective in controlling the pollution of oil mist.
- Filter element of local made OME require a little improvement. Whereas no functional group found in the range of Canopus oil in FTIR spectra of imported OME.

Results and discussion (contd...)



Comparative FTIR spectra of samples without, with imported, with local made OME and of unused test paper using M 100V oil in the vacuum pump.

Results and discussion (contd…)

- For M 100V oil in pump the spectra obtained are presented in above slide for testing the effectiveness of designed and developed OME.

- Spectra of samples without, with imported, with local made OME and of unused test paper clearly shows that the developed local made OME effectively reduces the unwanted pollution of the laboratory.

Results and discussion (contd...)

- Spectrum 1VC with gas ballast and without OME of the sampled air from exhaust port of rotary pump, clearly shows the presence of functional group CH=CH- , CH_2 in the range of 2849.66-2924.14 $cm^{-1.}$

- Spectrum (2VC local) showing the FTIR results of sampled air with gas ballast and with local OME. The spectrum is showing the presence of same functional group CH=CH-, CH_2 in the range 2849.66-2924.14 cm^{-1} with low peaks.

- This indicates that local made OME is effective in controlling the oil mist from exhaust port of D-60 rotary vacuum pump even with gas blast.

Results and discussion (contd...)

- Spectrum marked as no-3 shows results with gas ballast and with imported OME. The graph reveals that same functional group is present with much lower peak.
- Thus imported OME is effective in stopping of oil mist from rotary pump.
- Spectrum marked as (unused) indicates the FTIR of test paper.
- Spectrum no. 5 shows the results without gas ballast and with out OME The spectrum is showing that with out gas ballast the oil mist from exhaust port comes out in reduced quantity.
- Spectrum no. 6 is presenting the FTIR of sampled air without gas ballast and local OME is used. The spectrum is revealing that no functional group is present in the range of M 100V oil.
- Thus local made OME is much effective in stopping the oil mist from exhaust port of rotary pump in case of M 100V oil.

Conclusions

- Designed and developed oil mist eliminator is proved to be effective in preventing oil mists and the heavy vacuum pump oils exhausted into the working atmosphere.
- The OME is effective in trapping these high-density components and collecting these in the lower part. However the OME is not effective in trapping the lighter hydrocarbons and other volatile organics, which can contaminate the pump oil.
- To trap these materials, another filter called a charcoal trap is used in conjunction with this OME. Volatile and semi volatile organics are trapped in the vacuum pump oils from the operation of various instruments, and are slowly exhausted from the vacuum pump oil.
- When the OME is used with different oils in the vacuum rotary pump the local made OME was effective in trapping these heavy oils mists, prevents them from contaminating and saturating the laboratory environment.

References

1. Pakistan Environmental Protection Agency, National Environmental Policy (2005) Air Quality and Noise Standards.
2. USEPA (1994) Indoor Pollution: An Introduction for Health Professionals EPA-402-R-94-007
3. Leybold-Heraeus (2000) Vacuum components and standard system manual
4. G.T. Harland, (1997), The Fundamentals of Vacuum Technology, AVS monograph Series M-6, The Education Committee- American Vacuum Society.
5. F.O. John Hanlon, (1989) A Users Guide to Vacuum Technology, 2nd Edition, John Wiley& Sons, New York.
6. J.P. Hospon, (1984). The future of vacuum technology. J. Vac. Sci. Technol. A 2(2).
7. B.E. Davies, (1997). Water, Air, Soil Pollut. 94 (85).
8. E.A. Mackey, P.R Becker, R. Demiralaph, P.R. Greenberg, B.J. Koster, S.A Wise, Arch, (1996). Environ. Contam. Toxical. 30 (503).
9. P.N. Lee, D.M. 1993. Experimental Toxicology, Corning (Eds.), Cambridge.
10. J. John Manura, (April 2000). Vacuum pump exhaust filters, Scientific Instrument. Services.
11. J .A. Harrop, (1969). The effect of fiber configuration on the efficiency of aerosol filtration.
12. G. L. Faris, (1958). High efficiency fiber filters for the treatment of fine mists.
13. C.N. Davies (1973) air filtration. Academic press. London. New York


Thank You