Centralized PV Oil Free vs Oil Lubricated System

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Shrinking Geometries; Technology Changes & Environmental Friendly compliance require company like Electronic manufacturing plants, etc to continuously evaluate their process & facility to stay relevant in today fast changing world.

Adopting a system approach in Facility System Design has therefore become a norm. Vendors are now required to warrant the performance at the Point-of-Use instead of supplying only pumps for the system.

Shrinking Geometries

- Every reduction in sizes of a product increases susceptibility to contamination.
- Conventional Lubricated Vacuum pumps poses a risk to contamination.
  - Because when a vacuum pump stops, exhaust of the pump being closer to ambient condition reaches atmospheric pressure much faster than the suction piping system of the pump.
  - Hence, there is a high risk of oil migration in the direction of the process/product.
- This will be worst when the point of use for the vacuum is very near to the product.

Technology

- Facilities Vacuum system play an important part in the final product.
- Changing technology or Trend of a Final product causes changes in the vacuum requirement at the Point-of-Use during production.
- A good understanding of the overall system capability ensure that appropriate solutions can be quickly found when such production requirement change.
- Therefore, a Single Source responsibility for System performance give Value added convenience.
- Hence, purchase is make for an Entire Vacuum System inclusive of Design, Installation and Supply not only for the vacuum pumps alone.

Environmental Friendly

- Environmental Friendliness' production processes have taken centre stage in many companies like Seagate, etc.
- Conventional Oil lubricated vacuum pump's discharge air contaminated with Oil mist during operation. Although, the use of exhaust filter helps but it is not a total solution.
- Oil Free Liquid Ring vacuum pump do not discharge oil mist during operation.
- In actual fact, Oil Free Liquid Ring vacuum pump clean the incoming air suck from the production before it discharge it to the surrounding environment.
- Oil Free Liquid Vacuum pump is therefore a more environmental friendly approach to provide vacuum for production.

Tolerance to contamination

- Contaminant from production are usually pick up by the vacuum system and transport or suck into the vacuum pump.
- Such contaminant cause more wear & tear within a Conventional Oil lubricated pump because of its close tolerance between the operating sliding vane of the pump and its rotor.
- Inlet filters installed before the vacuum pump usually stop most of the bigger contaminant (up to 10 microns).
- But as geometries of the Final product shrink, such contaminant also gets much smaller. Hence the installed inlet filter may not be much help.
- PV Oil Free Liquid Ring vacuum pump rely on a water ring created due to the rotation of the impeller to create vacuum. Most contaminant up to millimeter will pass through the pump without causing any damage or wear & tear to it as compared to Oil lubricated vacuum pump.

Maintenance

- For Conventional Oil lubricated vacuum pump, maintenance is required for the Oil filter, lubrication, Inlet filter, Exhaust filter, etc.
- Depending on the capacity of the pump, up to 30 liters of synthetic oil is required for every oil change.
- Spares such as filters, new synthetic oil, exhaust filter, etc is required on top of the labor required to do the work.
- The only maintenance that is required for PV Oil Free Liquid Ring vacuum pump is the occasional cleaning of its heat exchanger. No other spares are required, only labor to do the maintenance work.

Case Study :

Pump Inlet Vacuum Level

- Case study parameters
  - Specified Vacuum level @ Point-of-Use = 25” Hg V
  - Specified Vacuum level @ Pump inlet = 27” Hg V
  - Specified System flow rate = 22,500 Acmh @ 27” Hg V
- It is important to note that for a System flow of 22,500 Acmh @ 27” Hg V and to accommodate 2” Hg V or 0.067 bar of Total Static losses, the piping network will require pipe of relatively big in size.
- It is usually a norm to have piping network that produce a total Static losses of between 3” Hg to 5” Hg. This is because this will strike the best balance between cost, pump size and allowable static losses.
- For Oil lubricated Vacuum pump, the use of Inlet filters to protect the pump & Oil mist separator to trap Oil mist at the exhaust will add additional Static loss to the entire system.
- Use of Exhaust Mist eliminator will be necessary to ensure compliance to NEA (Singapore) requirement on PM 10 Standard if the pump exhaust is directed out of the building. The other use of Exhaust Mist Eliminator is to prevent excessive oil loss during operation that might warrant frequent top up.
- Most market available Oil Mist eliminator and Inlet filter stated Static loss of less than 1PSI or 68.9 mbar or 2” Hg. Assuming the worst case scenario of 1 PSI/68.9 mbar/2” Hg, the total Static losses across these 2 accessories will be 2 PSI/137.8 mbar/4” Hg.
- Basing on the above, the allowable total piping static losses have to be limited to 0.9” Hg or 30.471 mbar after considering the additional losses from these accessories. These will mean that very big pipe will be required.
- PV Oil Free Liquid Ring vacuum pump does not have this issue. The vacuum level at the Pump inlet can be at 27” Hg V since we do not require the use of Inlet or Exhaust filters.

Performance

- In line with the above and using one of the biggest commercially available Oil lubricated Vacuum pump Brand B, the vacuum level at the pump inlet will be 29.8" Hg V because;
  - Static losses of the Inlet filter : < 2" Hg
  - Static losses of the Exhaust filter : < 2" Hg
  - Assumed total static losses across these filters : < 4" Hg
- The maximum allowable Total System Static losses must be kept at 0.9" hg assuming the Point-of-Use requirement of 25" Hg V.
- The actual system volume at 29.8" Hg V will be 547,000 Acmh @ 29.8" Hg V using Ideal Gas Law ; PV=C.
- Basing on the published Performance Curve of the pump, the capacity of each Brand B at 29.8" Hg V is 680 Acmh @ 4 mbar or 29.8" Hg V.
- Hence a total of 805 nos. of Brand B Vacuum pumps will be required to achieve the requirement.
- Using PV PVLR2S21850 Oil Free Liquid Ring vacuum pump :
  - The operating point at Pump inlet will be 25.9" Hg V assuming that bigger pipe will be used to achieved the 0.9" Hg value for Total system Static losses.
  - Actual pump inlet capacity will be 16,343.3 Acmh @ 25.9" Hg V using Ideal Gas Law : PV=C.
  - A total of only 5 nos. will be required to achieve the requirement.

Machine Room Size

- Based on Brand B published information, the dimension of Brand B Vacuum pump is
  - Length : 87.75"
  - Width : 45.75"
  - Height : 36.75" or 57" with Exhaust filter
- With 805 nos. of the Vacuum pump the estimated minimum machine room size will be
  - 4,014.1 square meter area
- Dimension of each PVLR2S21850 is
  - Length : 4.5m
  - Width : 1.8m
  - Height : 2.7m
- With a calculation of 5 nos. as mentioned above, the estimated minimum machine room size will be
  - 85.5 square meter area
  - The above mentioned space requirement is EXCLUSIVE of the need of Vacuum Buffer Tank, Control & Starter panels for the system.

Power Consumption

- Each of the Brand B requires a 30 kW motor
- The total power requirement for 805 nos. will then be
  - 805 nos. x 30 kW = 24,150 kW
- Each of PVLR2S21850 requires a 90 kW motor
- The total power requirement for 5 nos. will then be
  - 5 nos. x 90 kW = 450 kW
- Hence, the difference in operating cost per year based on S$ 0.2164 per kilowatt hour will be - (24,150 – 450 = 23,700 kW x 365 x 24 hrs x S$ 0.2164) = S$ 44.93 millions

Established International Standard

- Established International Standard give users the confidence that their vacuum pump package is constructed in accordance to the best practice in the Industry for Safety & Reliability.
- Established International Standard for Performance Testing also ensure that a Common platform is used to compare the performance of different made of vacuum pumps.
- This ensure that the user get "what they pay for"!
- PV Oil Free Liquid Ring vacuum pump package can be configured to meet EEMUA 151 or API 681 Standard & tested in accordance to HEI with BEEMA nozzle. This International Standard mentioned are the standards which many MNC manufacturers adopted in the specification.
- Such compliance to Established International Standard provide the user or purchaser the assurance of a package which is constructed with safety & reliability in mind.
- It also ensures that users get the vacuum pump performance which they want. The Tested Performance curve can be used without any reservation for any design consideration of its production process.

A different Perspective

- Assuming that the exhaust of the Brand B vacuum pump can be directed to the Acid Exhaust system leading to the;
  - Omission of Exhaust Mist Eliminator.
  - The client willingness to do more frequent synthetic oil top up of the pumps.
  - The system total static losses will then be possible to be maintained at 2" Hg with the Point-of-Use vacuum level of 25" Hg V.
  - Operating point for Brand B will be at 27" Hg V + 2" Hg (Static loss of Inlet filter) = 29"Hg V.
  - Hence the inlet capacity will be 71,413 Acmh @ 29" Hg V using Ideal Gas Law basing on 22,500 Acmh @ 27" Hg V requirement.
  - A minimum of 60 nos. of Brand B will be required based on the client specification
  - Total Power requirement = 60 nos. x 30 kW = 1800 kW.
  - Minimum machine room size = 299.188 square meter(exclusive of space requirement for Vacuum Buffer tank & Control/starter panels).
- If PV Oil Free model PVLR2S21850 pump is used, the operating vacuum level at the pump will be 27" Hg V since there is no requirement for inlet filter.
  - For system capacity of 22,500 Acmh @ 27" Hg V, a total of 7 pumps will be required.
  - Total Power requirement = 7 nos. x 90 kW = 630 kW.
  - Minimum machine room size = 145.18 square meter(exclusive of space requirement for Vacuum Buffer tank & Control/Starter panels).
- Difference between PV PVLR2S21850 and Brand B
  - Operating Cost on Electrical consumption = (1800-630) x 365 x 24 hr x S$ 0.2164 = S$ 2.218 million per year.
  - Space requirement = 299.188 – 145.18 = 154 square meter.
  - Maintenance Cost – Consumable spares = 60 sets of Inlet filter + Oil filter + Synthetic Oil + misc + labor to change Per Year.