VACUUM BOOSTERS FOR DRYING APPLICATIONS

Drying is a process of removal of a liquid from a solid mixture by thermal means. Under this article, we shall not consider mechanical methods, such as filtration, centrifuging, pressing, etc. of liquid removal from solids. Various drying process & techniques are extensively used in the various Process industry, Pharmaceutical industry, Food processing industry, Dye & Chemical industry, Perfumes & Permitted Food additive industry etc primarily to achieve one or more of the following,

- Product concentration.
- Purification by removal of unwanted volatile elements.
- Solvent recovery.
- To increase shelf life and to facilitate further processing and permit proper utilization of the final product.
- To reduce shipping costs by reducing weight of the product.
- To reduce the rate of biological decay.
- To enhance the value of by products of a process.

Drying is an important and widely used process in the industry. Often it is a major cost center in process operations. The reason for this is the high-energy requirement for the removal of water. Typically, to remove 1 kg of water, we require 540 kcals of energy *[latent heat of vaporization of water*] plus at least another 60 kcals to take care of sensible heat requirements. Hence, regardless of the nature of process, we must supply at least 600 kcals for every kg of water removed from the material. This, therefore, demands high-energy inputs and for this reason the process efficiency must be maintained as high as possible.

The cheapest energy source is the sun. That is why many industries take recourse to sun drying. For example, in small food industry, chillies, ginger, etc., are all sun-dried; in the textile industry, fabrics and yarn are often sun-dried; in the ceramic industry, freshly moulded bricks and blocks are sun dried. Very often, most process requirements demand continuous working, independent to the weather conditions or time of the day. So there is a vast body of ovens, dryers, drying tunnels, dehydrators, etc., to take care of industrial drying processes. While these techniques are well known, their use is now being replaced by **Low-pressure, Low temperature drying techniques**, which have the advantage of enabling the drying process to be carried out at low temperatures. This process results in optimum energy utilization, lesser thermal exposure & damage to the product and very often, improved quality. In fact, it is possible to dry a product at sub-zero temperatures (Freeze drying) by simply reducing the pressure to an appropriate value for carrying out the process. Freeze Drying, most widely adopted process today in food processing industry is based on the same principle. Amongst the many advantages of low pressure drying techniques over oven-techniques, some are: -

- Drying time is accelerated drastically.
- Solvent recoveries are possible, resulting in substantial savings.
- Reduces pollution.
- Minimizes oxidation losses and product degradation due to reduced Thermal exposure.
- Wide range of operating temperatures can be selected to suit the product/process requirements.

For example, conventionally **Katha** (*an essential ingredient of paan masala and paan*), is dried by traditional cold room drying process. It is kept in cold rooms for over a period of about 24 days, with cold dry air blowing over it. The moisture levels are reduced from typically 50% + to about 12-15%. The temperature in the cold room is maintained at slightly above 0 degrees C, throughout the process time. However, by adopting low pressure drying techniques, this period can be reduced substantially. This would not only save energy requirements but also reduce the huge inventory hold-ups. Katha is a high-priced product and shortening of the process time would result in substantial savings otherwise involved. Shorter process times also reduce possibility of fungus/moulds/bacteria attacks. Similarly Drying of various other products, such as Gelatin, Meat, Milk products, Green bodies etc, can also benefit by this fast process.

During the selection & designing of any Drying process the fact is that basic energy requirements are proportional to the mass of water/solvent evaporated and no process can alter it. The additional /Auxiliary energy, which is relatively a large percentage of the total energy, can be minimized which would be the savings. Low pressure Low temperature drying offers energy efficient alternatives to the conventional drying methods. The additional capital cost of the equipment is easily offset by the gains in productivity and quality improvements. The diagram below shows typical low temperature drying installation. Conventionally, Water Ring Vacuum pump/ Water Ejector/Steam ejector or Piston Pumps are used to create vacuum. They have limitations to the Ultimate Vacuums achieved, pumping speeds, pump fluid contamination and consume relatively high energy.

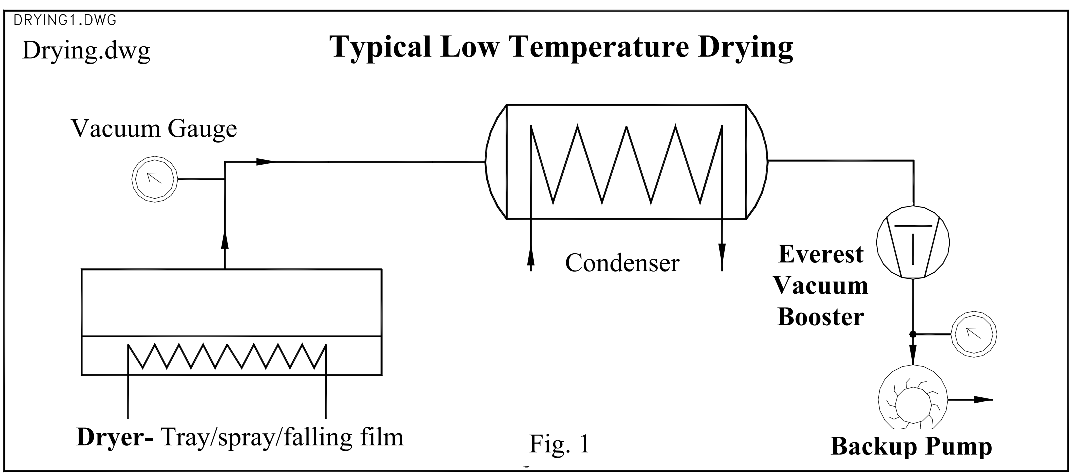
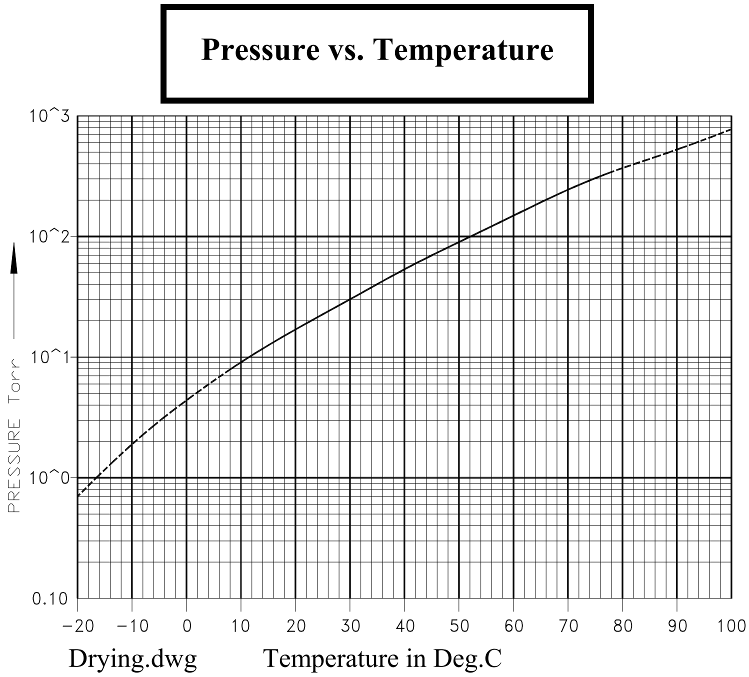


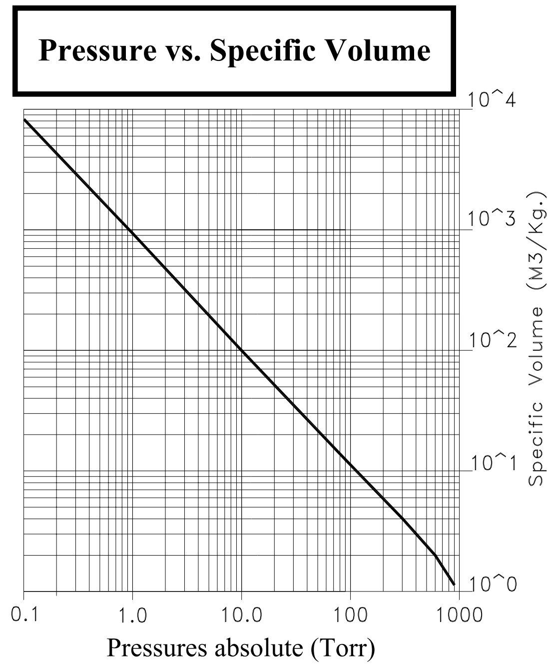
Fig. 1

A vacuum Booster, when used in conjunction with any of the above, over comes all the associated limitations and increases the overall process efficiency by increasing the vacuum and pumping speeds with relatively very little extra energy.

Role of Boosters in the Drying Process

The diagram of a typical low-pressure drying installation is shown in **fig. 1,** above. The low-pressure drying process works on the fact that the boiling point of water decreases with drop in pressure. A look at the graph below shows the relationship.





From the above graph we see that at about 4 Torr, it is possible to "boil the water" at 0 degrees C. Accordingly Drying can take place at low temperatures, to meet the process requirements, provided the corresponding suitable pressures are maintained.

The "Booster" Advantage: However, things are not as simple as they look. The advantage of drying at a low temperature has a penalty, that the volume of water vapor per kg mass [*specific volume*] increases with fall in pressure. A look at **graph above** shows this effect, in which, 1kg of water occupies a volume of 1.67 m^3 at 100 degrees C, but at a pressure of 10 Torr it occupies 106 m^3. In other words, the volumetric capacity required from the pump must be increased by about 60 times. The **Vacuum Booster** is the ideal choice to overcome this problem as they give very high pumping speeds with relatively low energy consumption.

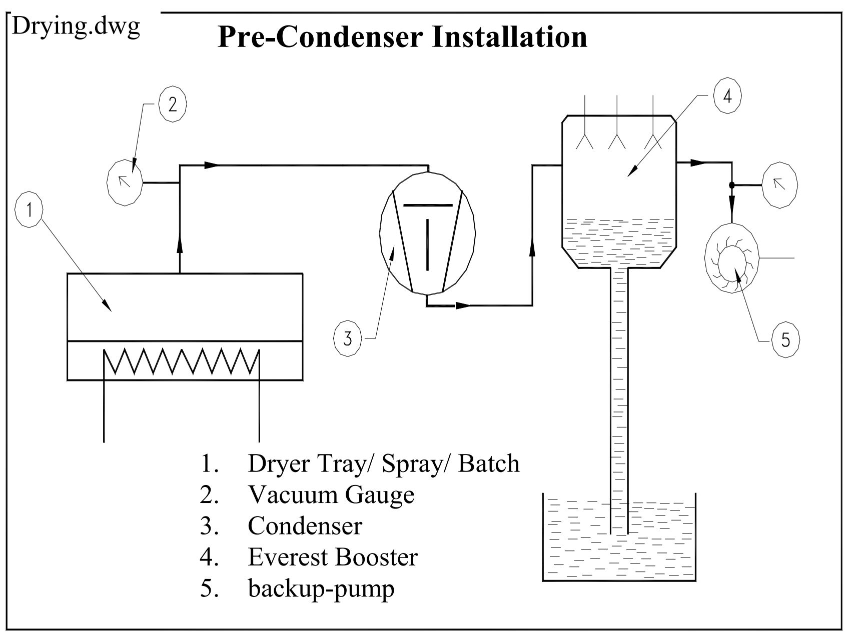
Principle of the Vacuum Booster : The Vacuum Booster works on the Positive Displacement principle and comprises of two eight shaped lobes, rotating at high speed vacuum in a vacuum tight casing. Since there are no sliding parts, require no internal lubrication and offer **dry pumping**. As internal friction losses are practically nil, the machine rotates at high speeds giving high volumetric efficiency, high pumping speeds and yet consume little power.

Booster Installation:-

Vacuum Booster can be installed before the condenser or after the condenser, depending on the process requirements. Both Installations have their merits and depending on the process can be selected to optimize.

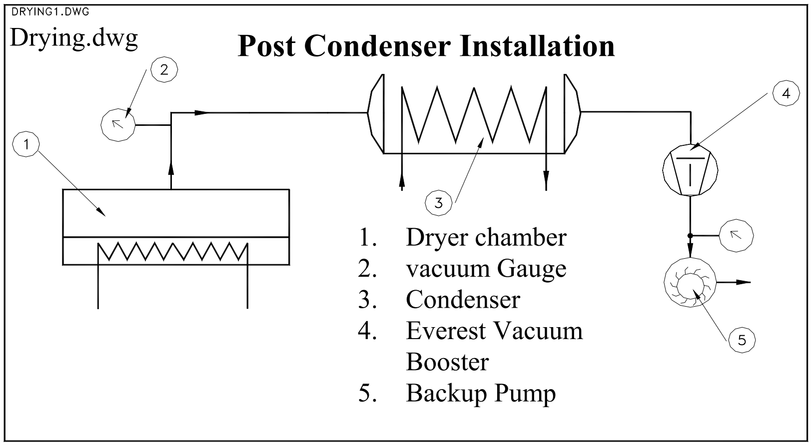
Pre-Condenser Installation:-

Booster is installed as shown in figure below. In this installation the vacuum attained in the chamber is high and due to the vapor compression at the discharge end, the condenser temperatures can be relatively higher. For applications using Barometric Condensers this would be an ideal choice since the vapor pressure of water at 30ºC (*taking the condenser water temperature*) is about 30 Torr, which would otherwise restrict ultimate vacuum levels. The booster, in this arrangement has to handle both condensable & non-condensable loads and therefore, should be of high volumetric displacement whereas the backup pump can be relatively small as it to handle only the non-condensable loads. A right selection of pumps can dramatically increase process efficiency, reduce process time & reduce energy requirements.



Post-Condenser Installation:-

Here the booster is installed after the condenser, which is generally surface/shell & tube type. The size of the booster is relatively small as compared to Pre-Condenser Installation. An additional Secondary condenser between the Booster & Backup pump would enable to trap residual vapors, reducing the contamination of the backup pump fluid. This is very useful for Solvent recovery processes or applications requiring elaborate Effluent treatment Processes to clean the pump fluid before it is re-used /discharged.



Whatever the installation may be, the advantages associated with the installation of Boosters are great and offset the capital costs giving low payback period. The boosters have very little maintenance and long service life. The operating costs are low since no auxiliary energy or utilities are needed. The can be easily integrated into any conventional system as they require practically no additional auxiliary support.

Industries that can benefit from low pressure drying:

- Food processing
- Freeze Drying of drugs and medical items
- Textiles: Rapid drying of thread and fabrics.
- Ceramics : Rapid drying of large ceramic bodies
- Drying of transformer oil
- Drying of bulk materials such as katha, gelatin, etc.
- Spray drying of milk products.

(Article written by technical team of Everest Transmission – The only successful manufacturer of Mechanical Vacuum Boosters in India)

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