BEGG COUSLAND ENVIROTEC LTD.

MIST ELIMINATORS FOR PROCESS & EXHAUST GASES

The conceptual role of demisters or mist eliminators is to remove a liquid from an air or gas flow, using mechanical collection by filaments.
The liquid may a pollutant or, like water, be *per se* benign, but in either case it is contaminating the air or gas. The separation of the liquid from the air or gas within a process may prevent contamination of the subsequent process or prevent damage to or corrosion of downstream equipment; it may recover a useful product, or prevent an atmospheric emission that in some way is undesirable.

One must frequently consider and understand the process in order to design filters or to troubleshoot, if problems occur. Accurate data about the filter's duty is not always available; a visible plume from a chimney stack can be a symptom of a process problem, and not poor filtration or a filter failure.

The range of filter types.

Liquid is entrained in an air or gas flow following either of 2 basic situations.

- The air or gas meeting mechanically generated spray or generating the spray as it passes through a liquid. Such mechanically formed sprays are termed ' droplets ' and are usually always over 5 to 10 microns in size.

- The air or gas reacts chemically or physically resulting in a fume or condensation mist formation. These particles are mainly below 3 microns, frequently sub-micron in size.

Droplet and mist filtration can be achieved using :

- CHEVRONS / VANE PACKS
- DEMISTERS / MESH PADS / KNITTED WIRE BLANKETS
- FIBRE CO-KNITTED COALESCERS
- MIST ELIMINATORS / CANDLE FILTERS / FIBRE BED FILTERS

Vane Packs are the most simple form of gas-liquid separator, using wave or chevron style plates spaced sufficiently apart to allow the gas to enter and to pass a series of changes of direction. The larger liquid droplets are unable to change direction and impact on the surface of the plates, and then drain out by gravity. They operate at relatively high velocities, installed vertically or horizontally, and can be fitted with ‘double pocket’ internal hooks for increased efficiency above 8 microns.

Demisters are made of layers of knitted wire or monofilament to various thicknesses, densities etc. to suit the duty. The demister has always been relatively cheap and easy to install & maintain. The pressure loss is fairly low, while removal of droplets above 5 microns is the basic minimum.

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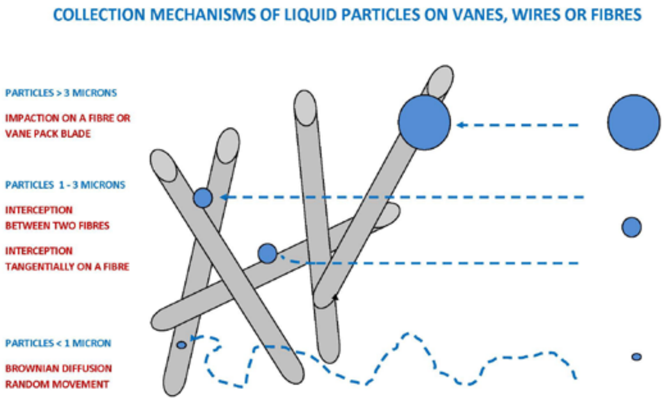
Coalescers were developed to increase the collection of particles finer than 5 microns and achieve this best above 2 microns. Coalescers can operate as a single filter, coalescing the mist and collecting the liquid as it passes (horizontally) through the filter layers; they can also operate as the first of 2 stages, coalescing mist into larger droplets which then either drain or are re-entrained as the gas continues its upward flow, to be collected in a second stage demister. The liquid hold-up is higher than in a demister, the density greater due to the use of finer diameter wires or fibre yarns; one or two stage, the pressure loss will be higher than for a demister.

Mist eliminators or candle filters as we know them are constructed of a bed of fibres (most commonly glass fibres) through which the gas passes horizontally. The small diameter fibres allow much higher densities to be achieved than in coalescers and on an equal velocity basis, the pressure loss would be inordinately high. The actual velocities used in candle filters are, however, lower, partly to keep pressure loss practical, but also in consideration of collection mechanisms other than impingement which can be utilised at lower velocity in conjunction with fine fibres.

Impaction :
The mechanism whereby a droplet cannot avoid hitting one of the fibres or wires of moderate size randomly arrayed in the path of the gas, even though the fast flowing gas 'streamlines' past the wires. There is a relationship between the diameter of wire and the size of droplet collected.
The range of velocities is broad (1-4 m/sec for meshpads, and above 5m/sec for Vane Packs) without affecting efficiency.



Interception :
Collection is achieved by trapping the droplet between two adjacent filaments or fibres. The finer the filaments, the more there can be in a filter with less space between them, which increases the rate of interception of finer mists. At higher velocities interception is a mechanism of coalescence, but at lower velocities it aids collection.
Normal velocity range for Interception is 0.2 to 2.5 m/sec

Brownian Diffusion :
At low velocities (optimally below 0.25 m/sec.), as the gas passes horizontally through a bed of very fine fibres, the fine mist particles are bombarded by the gas molecules surrounding them, causing the particles to move in various directions, both towards and away from the fibres. The multiplicity of fibres means, however, that the mist is virtually certain to contact one or more fibres and be collected.

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The selection criteria.

Selection of the type of filter needed is often a compromise based on practical considerations. One may start from one of the main considerations below, but find that the ultimate is not the optimum.

- **By Efficiency :**

  Legislation may demand a maximum exit level of contaminant or the operator may wish the maximum removal of a contaminant at any stagein a process, or may wish the maximum recovery of a valuable product.
  The operator may not know the size of particles to be removed, and in the absence of measurements assumptions may be made, but guarantees would favour caution on the part of the filter supplier, and the most efficient would be considered.
  The operator may know he has only droplets and so the lower efficiency types will only be considered.

- **By Pressure Loss :**

  The gas flow in a process is generated by a fan or compressor, which generates a vacuum or discharge pressure. The pressure is energy and so is a cost to be carefully considered, how and how much is used. Generally, the lower the pressure loss of a filter the better, except where the operator correctly understands the problems potential lower efficiency may cause, or where the resultant filter space requirement and filter size and ultimately cost are out of proportion to the benefit of pressure loss saving.
  Re-vamp projects often require a maximum pressure loss to be maintained above all else.

- **By Housing Space :**

  Most filters are fitted in a vessel near the exit or on top of a process tower and the filter housing diameter is often smaller than the tower diameter. Minimising the filter diameter and housing height allow cost savings.
  Again re-vamp projects may mainly constrain you by space (or by weight pro-rata space).
  What you can physically fit in a given space must still allow correct operating velocities to be achieved.

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Design considerations.

Beyond the obvious design factors of gas volume, pressure, pressure loss, operating temperature and housing space, there are a range of other considerations that can be very important. 2 of these are :

- Gas flow direction / filter installation type
- Process variations / mist formation

Gas flow direction / filter installation type.
In most applications the gas flow to the filter is vertically upwards. This suits vanes, demisters and coalescers where the liquid can then drain downwards by gravity. Meshpads and Vanes can also handle horizontal gas flows when the filter is installed vertically, and with Double Pocket vane styles, it is done in this way.
Vertical gas flow suits candle filters as, although the gas will pass horizontally through the fibre bed, the fibre bed is vertical, cylindrically formed (or sometimes formed of flat panels in a polygon), with an open end and a closed end. An upward flowing gas can pass from the outside of the cylinder to the inside if the candle filter is hanging from a support plate, or the gas can pass from the inside of the cylinder to the outside if the candle filter is standing on a support plate.
We call the hanging arrangement HT1 and each candle filter has its own drain and liquid seal to prevent by-pass. This design is very stable mechanically and suitable for high efficiency operations.

The standing arrangement we call F and the collected liquid flows onto the support plate to drain from there through tubes down into the lower part of the vessel or directly out of the vessel. Some plants prefer this design and latter drain arrangement as drain tubes add to the height of the vessel.
The standing type F has some other design advantages. With a hanging design, there is a limit to the amount of gas you can pass through the inner open top area of a filter without exceeding the relevant re-entrainment velocity. This applies as the collected liquid flows through the fibre and down the exit face of the cylinder. Too high a velocity caused by the gas volume and some liquid will re-entrain. The F type can therefore be made longer than the HT1 type as the gas is passing from the restricted volume / area of the inside of the cylinder to the more open volume / area around the outside of the filters.
The F type is therefore the only practical design for the higher velocity type fibres and care is always taken to ensure that the actual velocity used is compatible with the liquid loading and achievable drainage rate from the fibre. In some filters there is a lower density material on the exit side to enhance drainage within the fibre or to collect re-entrainment.

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Candle filter development started with the most efficient type developed first, and then development took place to find higher velocity fibres and designs to minimise space. This work still bears fruit sometimes, but with a limited application. More filtration area within a given filter housing volume is theoretically possible with more smaller cylinders or with concentric cylinders with the gas passing from the gap between the cylinders through the inner or outer cylinder, but increased pressure loss and mechanical stress as high volumes of gas enter the inlet orifice of such designs means that the gas volume per filter must be limited, limiting in turn the filter's height. See our Xtra-Flow designs.

Sometimes the gas flow is deliberately arranged vertically downward, to enter a candle filter cylinder and flow through the fibre bed to the outside. In such an arrangement , HT2, there is no need for a drain tube / liquid seal for the filter as the liquid drains from the outside surface to the vessel sump by gravity, while the vessel's gas exit is carefully positioned high up causing the cleaned gas flow to avoid the draining liquid.
This arrangement is most commonly used in 'organic' applications, removing oil mist, even directly after a compressor. For the highest possible efficiency 2 sets of Brownian Diffusion type filters can be installed in series. The same effect can be achieved by passing the gas through both of 2 concentrically arranged fibre beds. See our Xtra-Pure designs.

Process variations / mist formation.
Process variations happen. Planned or otherwise. If you know they will happen you can design-in the flexibility. If you know there might be such upsets, you can build in the contingency.
Plants can be designed to operate at 110% capacity or say 30% at start-up or low season. 110% is usually easier than 30%, as at low velocities Brownian Diffusion is lessened, impacts are avoidable. Equally important, lower flows usually mean lower liquid loads and lower liquid loads mean less saturation / lower pressure losses and for candle filters less saturation / lower pressure losses mean efficiency may drop. In general we recommend a minimum flow % or velocity for high velocity candles. For high efficiency types there is no theoretical minimum, but in practice it depends on maintaining saturation.
Higher velocities may not be the result of increased gas flow. They may be localised, resulting from partial solids blockage on the filter, uneven gas distribution before the filters caused by scrubber packing blocking or being unevenly wetted, or uneven gas distribution after the filters caused by a badly positioned gas exit point from the vessel. The general increased velocity or increased velocity at some of the filter(s) can lead to re-entrainment. Precaution against solids and careful checking of potential gas distribution problems are good practice.
Higher loadings of fine mist can result for various reasons. Shock cooling of the gas by colder liquid spray or incoming gas generates a lot of very fine mist if the rate of cooling is faster than condensable vapour can be removed by mass transfer. Organic contaminants and particulates can act as a nucleus for the formation of fine mists. Unscrubbed or unconverted gas can react in the saturated fibre bed and reappear as extra mist. Gas not properly dried may cause the water vapour to reappear later as extra mist.

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