MIST ELIMINATORS

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Contents

Summary

The right choice and design of a mist eliminator for desalination plant evaporators is of great importance. The separators have the important task of holding back the brine droplets entrained by the soaring vapor, thus guaranteeing a high vapor purity which is essential for both the smooth process and the product purity.

Almost all larger MSF-evaporators include wire mesh mist eliminators. The latter have proved to be worthwhile for years because they are not very prone to accidents and are efficient and comparatively economical. The durability of the separators is several years which is another reason, apart from the lower purchase price, to choose this type of separator.

In contrast, wave-plate separators are mainly used in MED-evaporators. In the past this process was less important for desalination because it was replaced by the MSF-process for cost and efficiency reasons. Recently, however, interest in the MED-process has increased and therefore some plants have been built. Consequently the interest in wave-plate separators has increased.

Apart from higher costs of purchase and lower separation efficiency, they have a number of advantages as well.

Compared with wire mesh mist eliminators, the flow velocity is about 50 per cent

higher in the case of vertical flow stream. The needed surface area of the separator is correspondingly smaller and is why smaller evaporators can be built resulting in a considerably lower investment. As they are less prone to clogging with regard to salt deposits, they do not have to be maintained so often which also reduces costs.

Apart from costs the most important features of the mist eliminator are function and separation efficiency. Both aspects are decisive in which type of mist eliminator to choose.

Therefore it should be considered for future planning and construction of plants whether it would be reasonable to use both wire mesh and wave-plate separators for the evaporator unit of desalination plants which comprises up to 40 stages. This would help to reach the optimum function and economy in each stage.

1. Introduction

Mist eliminators are used in desalination plant evaporators to avoid entrainment of brine droplets. Droplet separation is necessary for both a smooth function of the process and also the high purity water quality requested. The capacity of the plant can be restricted by corrosion resulting in a reduction of the maintenance intervals and salt deposits on the bundles of the pipes which in turn decrease the heat transport and increase the heat demand. Therefore the smooth function of the mist eliminator is of great importance.

Desalination plants which work with evaporators are normally equipped with knitted wire mesh or wave plate eliminators. Whereas in all larger MSF-evaporators knitted wire mesh mist eliminators (demisters) are used, in MED-evaporators wave plate eliminators are mainly installed. Since the flow velocity of the latter is higher, a smaller surface is needed. In contrast, knitted wire mesh mist eliminators have a better separation efficiency.

The efficiency of mist eliminators depends on the following parameters (Babcock, Internal Report 1998):

- Liquid entrainment
- Droplet range
- Flow velocity of the vapor
- Distance between brine level and mist eliminator
- Specification of the mist eliminator (in the case of wire mesh separators includes specific superficial area, pad thickness, wire diameter, porosity)

The separation efficiency can be described either with the total separation efficiency η:

$$\eta = \frac{L_O - L}{L_O}$$

with

L_O as liquid amount at mist eliminator inlet and
L as liquid amount at mist eliminator outlet
or with the fractional separation efficiency $\eta_F(d)$ for a specific droplet size d:

$$\eta_F(d) = \frac{L_{Od} - L_d}{L_{Od}}$$

with

L_{Od} as liquid amount at mist eliminator inlet for a droplet size d and
L_d as liquid amount at mist eliminator outlet for a droplet size d.

In practice the total separation efficiency η is of relevant significance because it can be used to determine the vapor purity or the saline concentration of the condensate in case of a given saline concentration of the brine. The latter is determined by conductivity measurement and at a value of about 50 $\mu S\ cm^{-1}$ or in the case of high purity distillate conductivity at about 5 $\mu S\ cm^{-1}$.

As already mentioned the liquid load of the vapor as well as the characteristic of the liquid droplets are important for an efficient separation. The size of the produced droplets is decisively influenced by the following processes (Babcock, INternal Report 1998):

- Bursting of vapor bubbles at the brine surface
- Splashing brine at the outlet of the brine orifice
- Foaming

The origin of droplet entrainment is a complex process and is determined by the operating conditions as well as the material data of the brine resulting from this and the vapor of each evaporator stage. Semi-empirical models describe the entrainment of droplets in MSF-evaporators sufficiently (See: Entrainment in Evaporators).

2. Knitted Wire Mesh Mist Eliminators

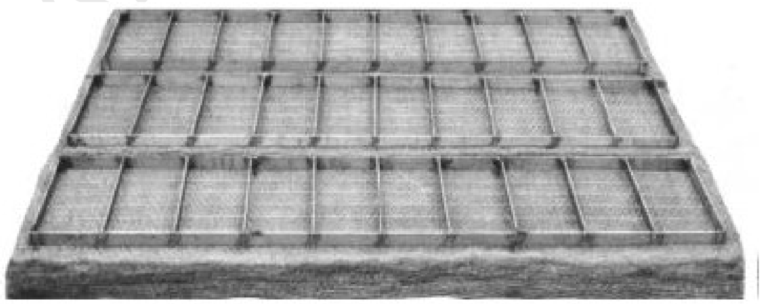

Figure 1. A knitted wire mesh separator for evaporator.

This type of mist eliminator is installed in almost all large MSF-evaporators. Usually there are about 20 to 40 corrugated knitted wire mesh layers, 100 to 200 mm high. According to preference concerning corrosion resistance stainless steel or monel with a wire diameter of 0.28 mm is used for production. As a rule, the pad is fixed between a top and bottom grid. Figure 1 shows the typical design of a knitted wire mesh separator for evaporators:

Table 1 shows a list of some mist eliminators manufactured by Rhodius for installation in evaporators.

Type	**Packing density (kg m^{-3})**	**Specific surface (m^2 m^{-3})**	**Porosity P(%)**	**Material**
RHO-214-Mo-0.28	214	360	97.5	Monel 400
RHO-192-SS-0.28	192	360	97.5	SS AISI 316 L
RHO-145-SS-0.28	145	262	98.2	SS AISI 316 L
RHO-80-SS-0.28	80	145	99.0	SS AISI 316 L

Table 1. Mist eliminators manufactured by Rhodius.

The droplets are separated depending on their size according to the mechanisms of Inertial impact, Direct interception and Diffusion:

Inertial impact

Every single wire in a wire mesh package is an obstacle in the gas flow and therefore a deviation of the streamlines takes place. Due to their sufficient inertia certain droplets can not follow this deviation and impinge in a straight line the obstacle.

Direct interception

Droplets smaller than the droplets mentioned above (inertia impact) have a smaller momentum of inertia which enables them to follow the streamlines. In case the streamline lies close to the target the droplet may touch the surface of the target and can be collected.

Diffusion

For droplets of submicron size, separation by inertial impact and direct interception is not practicable. Droplets smaller than 1 μm in diameter are separated by the Brownian motion. This is a continuous stochastic movement of particles caused by collisions with gas molecules. The probability of the particles colliding with the target and becoming separated rises with increasing Brownian motion.

Droplets are always separated as a total of the separation mechanisms described. The importance of each mechanism depends on the operating conditions, the droplet size and the specification of the mist eliminator.

In principle, the droplet separation only works within a certain velocity range. If the velocity is too low, the droplets follow the streamlines around the target and separation efficiency declines. If, in contrast, the velocity increases, the separation efficiency improves because smaller droplets can be separated as well. Until now the latter have been able to move around the target (wire). The separation efficiency increases only to the point where the liquid cannot drip in the opposite direction of the stream any longer. The consequence is a re-entrainment, which means the liquid passing the mist eliminator and increasing the saline concentration of the distillate.

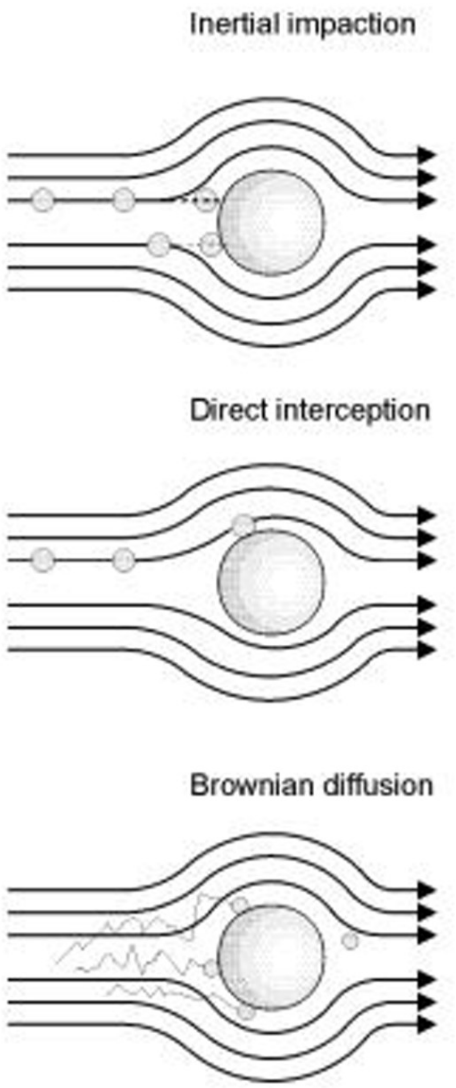

Figure 2. The droplet size and the specification of the mist eliminator.

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Bibliography and Suggestions for further study

Droplet Separation (Technical Literature) (1997), Hambach A., Rhodius GmbH, Weißenburg.

Internal Report (1998) Babcock in cooperation with University Aachen, University Bremen, Todd and Associates and Wangnick Consulting.

OSW Report No. 705: Operation of the Multi-Stage Flash Distillation Plant, San Diego, California Third Report (Semi-Annual) PB 206510.

Saline Water Conversion Engineering Data Book (2nd Edn) (1971) M.W. Kellog Company, Piscataway, N.J. for Office of Saline Water, Nov. 1971. A Team of the Bureau of Reclamation and office of Saline Water.

Sommariva C, Borsani R and Tasca A (1991) Distillate purity from MSF: the theoretical design and a real case behavior. *Desalination* 81, 309-320.

Sounders M and Brown G (1934) Design of fractionating columns. *Ind. Eng. Chem.* 26, 98-103.

York O H and Poppele E W (1963) Wire mesh mist eliminators. *Chemical Engineering Progress* 59(6).