WATER CONDENSATION IN AIR COMPRESSION

Statement

Evaluate the amount of condensate produced in the compression group of an air-liquefying plant were ambient air at 25 ºC, 100 kPa and 50%RH is compressed up to 10 MPa and left to cool.

En la etapa previa de una planta de licuación de aire, se comprime aire ambiente a 25 °C, 100 kPa y 50% de humedad hasta 10 MPa, y se deja enfriar. Calcular la cantidad de agua que condensa.

Solution. The humidity ratio (absolute humidity) of ambient air is:

$$w = \frac{M_{va}}{\frac{p}{\phi\, p^*(T)} - 1} = \frac{0.622}{\frac{100\ \text{kPa}}{0.5 \cdot (3.17\ \text{kPa})} - 1} = 0.010\ (10\ \text{g/kg})$$

but the maximum water content after compression is (saturated air):

$$w = \frac{M_{va}}{\frac{p}{\phi\, p^*(T)} - 1} = \frac{0.622}{\frac{10\ \text{MPa}}{1 \cdot (3.17\ \text{kPa})} - 1} = 0.2 \cdot 10^{-3}$$

and the rest of incoming water exits as condensate: Δw=9.8 g of water per kg of dry air. More properly, the amount of condensate should refer to the intake, i.e. $\Delta \dot{m}_w / (\dot{m}_a + \dot{m}_{w1})$ instead of $\Delta \dot{m}_w / \dot{m}_a$, but the relative difference is just w_1 (1%); that is why one often says loosely ‘per kg of air' instead of 'per kg of dry air'.

Comments. Drying compressed air is achieved by means of after coolers, separators and condensate drains.

Compressor capacity is usually given in standard volumetric rate of air delivered; e.g. a small air compressor for painting may yield 150 L/min of standard air, at 800 kPa, consuming 1 kW, running at 3000 rpm, with only one piston of 40 mm in diameter and 40 mm displacement.

Notice that some additional cooling or air drying is needed if the delivery must be supplied non-saturated to avoid possible condensations downstream.

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