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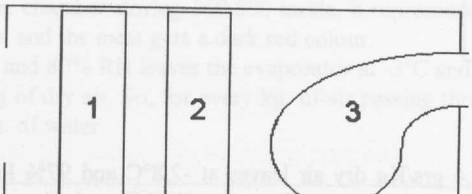
INTRODUCTION

In meat products drying (such as ham, sausage…) a great quantity of energy is required in the refrigerating circuit, so this implicates a high overcost to charge on the product. We have studied and tested the next system purposed, and it can represent savings between 25% and 60% of the actual energetic consumption, depending on the working temperature and humidity (the most working temperature and relative humidity you have, the most you can save). To perform this system, we have worked with the humid air diagram, the psychrometric diagram, and the refrigeration cicles, changing not the desired temperature and humidity for the product.

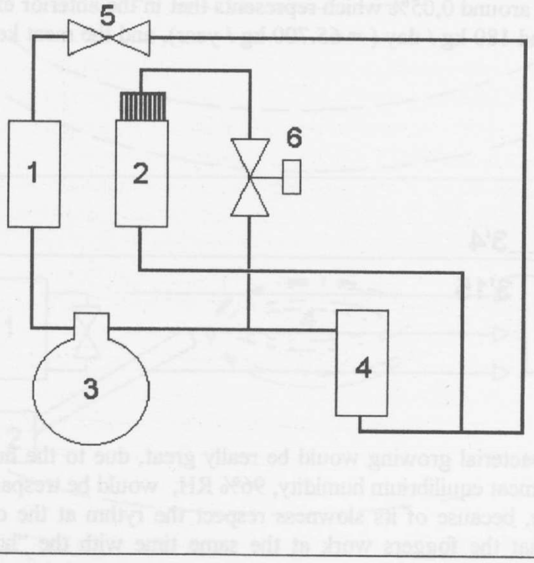
METHODOLOGY

Meat products drying takes place in air flowing chambers, and this air flowing we must move is quite high inside the chamber (to make uniform all the chamber variables and all the products inside).
So it is very usual to use between 60 and 100 recirculations of the chamber volume every hour, with values of the product inside the chamber between 50 and 100 kg / m^3.
This air passes through the drying refrigerating machine, and in the vertical or horizontal air treatment unit receives the following treatment:



1.- EVAPORATOR.
2.- CONDENSER.
3.- VENTILATOR.

And the refrigerating scheme is as follows:



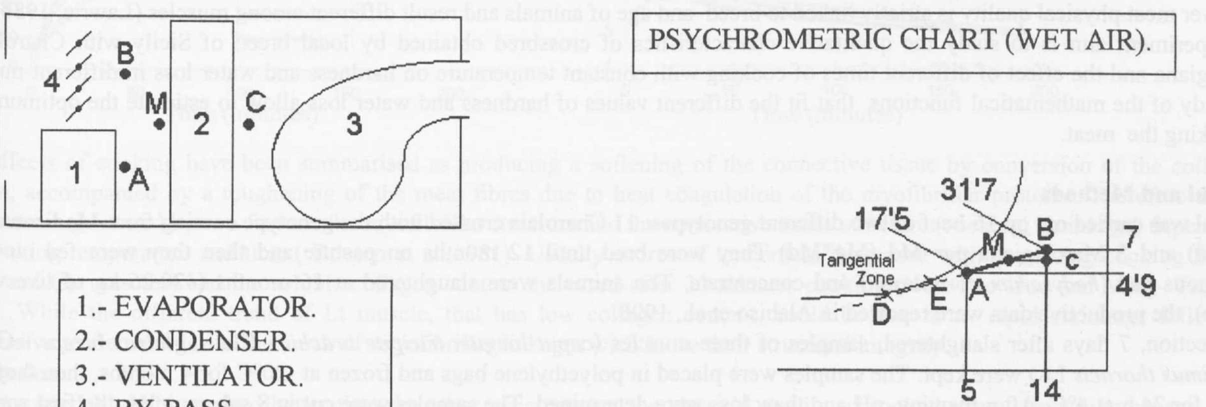
PSYCHROMETRIC CHART (WET AIR)

1.- EVAPORATOR
2.- INTERIOR CONDENSER
3.- COMPRESOR
4.- EXTERIOR CONDENSER
5.- THERMOSTATIC EXPANSION VALVE.
6.- SOLENOID VALVE (HOT GAS).

This implicates that the air entering in the air treatment unit is (for example) at 14ºC and 70% RH (so the enthalpy is 31,7 kJ / kg dry air) and an absolut humidity about 7 gr / kg dry air. This air leaves the unit at 9ºC and 90% RH (this implicates an enthalpy of 24,6 kJ / kg dry air) with an absolut humidity about 6,4 grs / kg dry air. This is what it happens almost in all the meat dryers, and it represents a consumption of 7,1 kJ / kg dry air to eliminate 0,6 gr of water / kg dry air, so we have:

$$\frac{7,1}{0,6} = 11,8 \text{ kJ / gr water.}$$

Our purpose has been tested in various installations, and it consists in including an air by-pass in the evaporator, as in the following scheme:



If we take the same air entering this new air treatment unit (this is: 14ºC, 70% RH, h= 31,7 kJ / kg dry air, and an absolut humidity of 7 grs / kg dry air), it will leave the evaporator at 5ºC and 90% RH (so h= 17,5 kJ /Kg dry air) and an absolut humidity of 4,9grs / kg dry air. On this way, the consumption is 31,7-17,5 = 14,2 kJ / kg dry air, but now it eliminates 7 - 4,9=2,1 grs of water / kg dry air. So, the energetic consumption we will have is:

$$\frac{14,2}{2,1} = 6,76 \text{ kJ / kg water.}$$

So, if we compare the purposed system versus the satndard one, we see that the energy saving is quit e important:

$$\frac{11,8 - 6,76}{11,8} = 42\%$$

The constructive characteristics for this machine are: cooler evaporation temperature must be near the point E temperature (tangential zone in the psychrometric diagram), in our example T_E=-1ºC, but we could get until -4ºC if it was necessary.
In some meat products, when they have a lower evaporation temperature, ice can start appearing in the evaporator, but a simple defrosting done by the air of the drying chamber (it is at a positive temperature) is enough to solve this problem, and it has not any energetic cost.
Hatch control is driven thanks to a temperature sensor placed in the point A of the air treatment unit (5ºC in our example).
A refrigerating machine consumes 1/ 2,2 kJ of electric energy for every kJ given to the air (taking a value of COP=2,2). So in the first case, the electric consumption is $\frac{11,8}{2,2} = 5,36$ kJ / gr of water, so for every kg. of water it eliminates, it consumes 1,49 electric kWh.

Instead of this, in our purposed case the consumption is $\frac{6,76}{2,2} = 3,07$ kJ / gr of water, so for every kg of water it eliminates, it consumes 0,85 electrickWh.

CONCLUSIONS

The air treatment unit of a drying installation must treat the air in the evaporator following a tangent line to the saturation curve. This is implicates that only a correct portion of the air is treated, and the rest must be passed through a by-pass.
The refrigerating scheme of the machine does not experiment any changes, we have just to protect it in front of any problems with ice appearances, with defrosting.