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FUNCTIONAL ANALYSIS OF AIR CONDITIONING SYSTEMS

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1. CONTEXT AND ISSUES

The various issues presented in the following paragraphs, can under certain aspects appear divergent in their objectives and the means to implement them (the improvement of comfort is generally more expensive in energy terms).
In fact, they are complementary and take part in the vision that the individuals of our modern society have more comfortable world.

1.1 CONTEXT

At the beginning of the sixties, the aircraft industry changed to a significant degree its method of design of the aircraft and among them mainly the planes of air supremacy.

The old approach vas to conceive the planes only on aerodynamic and resistance of materials bases and then to adapt an autopilot. The new approach was to conceive the plane and its controller at the same time. To conceive these new planes naturally unstable and to stabilize them artificially brought a notable benefit to the level of the performance of the engine

Concorde was the first designed plane thus, but partially with this new method, whereas General Dynamics F16 was completely. It was step known as C.C.V. (Control Configurated Vehicule), concerned with the technique Integrated Design.

The consequences were large and exceeded the framework of aeronautic, mecatronic, instrumentation

There is thus Generalized Conception if the physical design of the material structure of the process is changed upon the departure of the project by possible contribution of the advanced control techniques. We used this approach for the control of the climate of the space greenhouses.

The traditional field of terrestrial heat exchange is for various reasons (dichotomy of the education system, little need and thus little optimisation, purely static design for dimensioning. etc) far from this integrated step.

The space constraints impose here mass and energy optimisation, which are different from the traditional terrestrial industrial needs. On the contrary, if the space technique were accessible to traditional air-conditioning industry, interesting economic repercussions could be hoped.

1.2 ENERGETIC AND ENVIRONMENTAL ISSUES

In the current energy context, there exist a keen demand for a reasoned use of energy (discharges of greenhouses gas, treaty of Kyoto -, pollution by waste associated with the energy production and transportation).

Significant efforts are thus carried out to respect objectives of reduction in the energy consumption by the air-conditioning systems.

Indeed a significant share of the total energy (45% of the total European consumption) is consumed by the residential and tertiary building.

The modern buildings, more comfortable, compensate for a potential increase in their energy cost of operation by a better total output (design, insulation, better dimensioning of the various installations of comfort, use more effective of the air conditioning systems).

The installations of modern air-conditioning take part in this total effort of reduction in energy consumption.

1.3 CONVENIENCE ISSUES

The concept of comfort is a difficult concept to apprehend. Indeed, this concept is subjective and there are a great number of parameters that are generally difficult to characterize.

The whole of the five senses is brought into play in our perception physical and physiological of comfort and the relationships between them contribute to a total evaluation of this comfort.

Thus, a system of air-conditioning which controls the parameters temperature or humidity satisfactorily may carry out these objectives uses in an inadequate way the actuators at its disposal (ventilators, registers of mixture) by repeated cycles lighting – extinction.
Doing this, it can create, in particular, a hearing embarrassment that harms the global evaluation that we have of comfort.

A modern air conditioning conception needs to take care of all theses aspects.

1.4 GLOBAL ISSUES

Accordingly, the global and integrated design complete system of air-conditioning with its control device brings unquestionable advantages on a system of air-conditioning studied in a traditional way.

Indeed, a powerful process control design allows using the totality of the potential of the system of air-conditioning. One can thus dimension this one in an optimal way.

We can identify a certain number of profits that can be gathered according to their principal recipient.

1st of the benefits: for the manufacturer

Taking into account the whole dynamic characteristics of the system to be controlled, during the phase of design, allows adapting the characteristics of the control units in an optimal way.

According to the specifications of the air conditioning system, the phase design for advanced control design taking into account the control, proposes an optimal dimensioning of the actuators.

The profits on these active bodies are primarily due to shorter dimensioning:

- a less working installed capacity of the active bodies
- a cheaper cost of construction

2nd of the benefits: for the owner

For the owner, a significant criterion of choice for an air-conditioning system, in addition to respecting the technical schedule of conditions, is its cost of annual operation and its facility of use and maintenance by personnel, which is non-specialist of the process control.

We find here the same elements that come from the method of systems design integrated of air-conditioning.
Taking into account (in the process control design) of the dynamic characteristics of the system to be air-conditioned allows to only carry out the actions which guarantee an optimal operation of the system (in particular at the energy consumption level).

Some of the profits for the owner are then:

- a cheaper energy cost use
- a less frequent maintenance (due to less use of the actuators)

2nd of the benefits: for the end-user

It is sometimes difficult to differentiate the owner from the end-user. Intrinsic quality of the air-conditioning system is however judged by the last.

Thus the economic profits due to the better use system of air-conditioning are sometimes difficult to evaluate because they often form part of the economic profits related to the quality improvement of the products manufactured/stored in the air-conditioned room. The increased comfort of the personnel allows profits of productivity in the same way.

The profits for the end- user are thus:

- an increased thermal comfort thanks to the respect strict of the instructions
- an improvement of the quality of the products manufactured

2. PRINCIPLE OF OPERATION

As we consider in the previous chapter, the air-conditioning of interior environments arouses many interests: technological and economic.

According to the air-conditioning application that we wish to realize, the number of parameters to be controlled is variable. In the same way, the material and technics of control process to implement to answer the schedule of conditions are becoming more and more complex.

A basic air conditioning system is the heating of housing. The interior temperature is maintained in a zone of comfort by a single actuator. The heat losses towards the outside are compensated by the energy of radiator. The quality of the regulation is then really low.

Low quality of air-conditioning personal housing does not make it possible to answer in a correct way at the request of the customers (in particular of the tertiary buildings).

Thus the most complex systems of air-conditioning must control a number significant of the room parameters, sometimes with high specifications. One can have the traditional parameters, which are the temperature and the humidity but also the pressure, the dust level, the composition in various gases contained in the room.

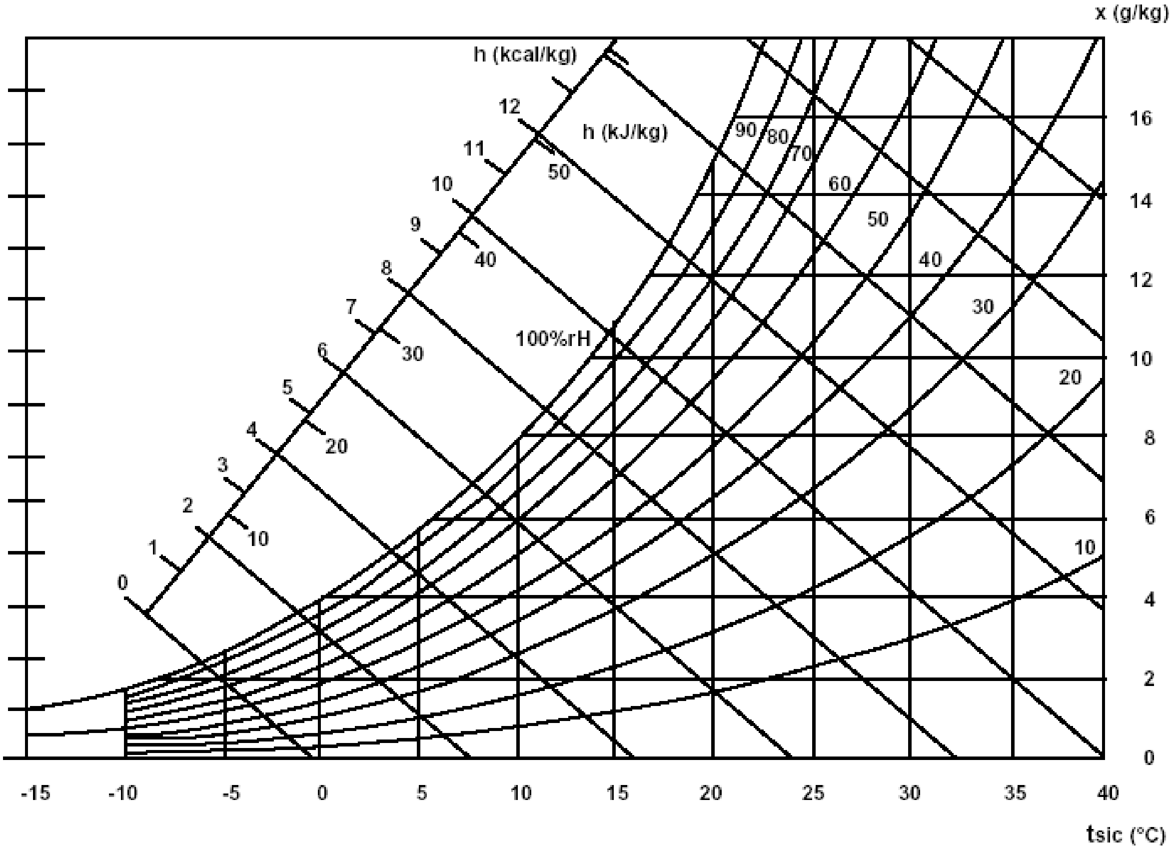
2.1 THE DIAGRAM OF WET AIR OR PSYCHOMETRIC DIAGRAM

The psychometric diagram is largely used in the technique of air-conditioning. It gathers the whole information necessary to the calculation of the thermodynamic properties of wet air.

From this graph, we can quantify all the modifications that the wet air can undergo in a room.

This diagram is set for a specific pressure (atmospheric pressure). To consider elevation problems, we require taking into account the modification of this diagram with the altitude.

The psychometric diagram



From the psychometric diagram, the thermodynamic properties of wet air are quickly calculated.

Many charts exist on the wet air properties among which the diagram of Mollier, the diagram h, X (enthalpy, water mass), the diagram T, X (temperature, water mass). Those diagrams don't present great differences between them.

The representation presented here is that in T, X On the X-coordinates, we find the temperature in °C. On the Y-coordinates, we find the water mass in the air in g/kg (water mass /dry air mass).

The diagram is limited by the curve of saturation (curve of dew) of water in the air. The curves with relative iso-humidity in % (line with constant relative moisture) have a form similar to the curve of dew.

The isenthalpic curves are parallel lines (on this diagram the values are available in kcal/kg and kJ/kg)

Interest of such a diagram is that the whole physical processes of transformation of quality of the wet air can be represented in a simple way by portions of curves

2.2 PROCESSES FOR AIR QUALITY TRANSFORMATION

A system of air-conditioning is made up of various elements, which according to their fitting make it possible to obtain the results wished by transformation of the thermodynamic properties of air.

The standard elements are as follows:

- - the mixture box
- - the filter
- - the cold battery
- - the hot battery
- - the humidifier
- - the fan
- - the air duct

It is necessary to add the control system architecture that includes the strategy of regulation used as well as systems of safety.

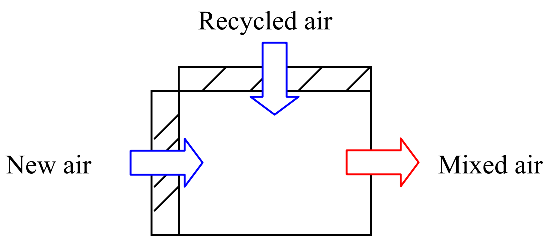
2.2.1 MIXTURE BOX

The mixture box makes it possible to carry out the mixture and the evacuation of various flows of air.

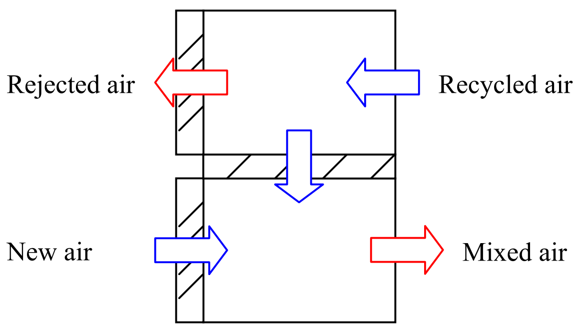
- New air
- Recycled air
- Rejected air

They are provided with shutters (independent or not), which make it possible to proportion the various flows in entry and exit.

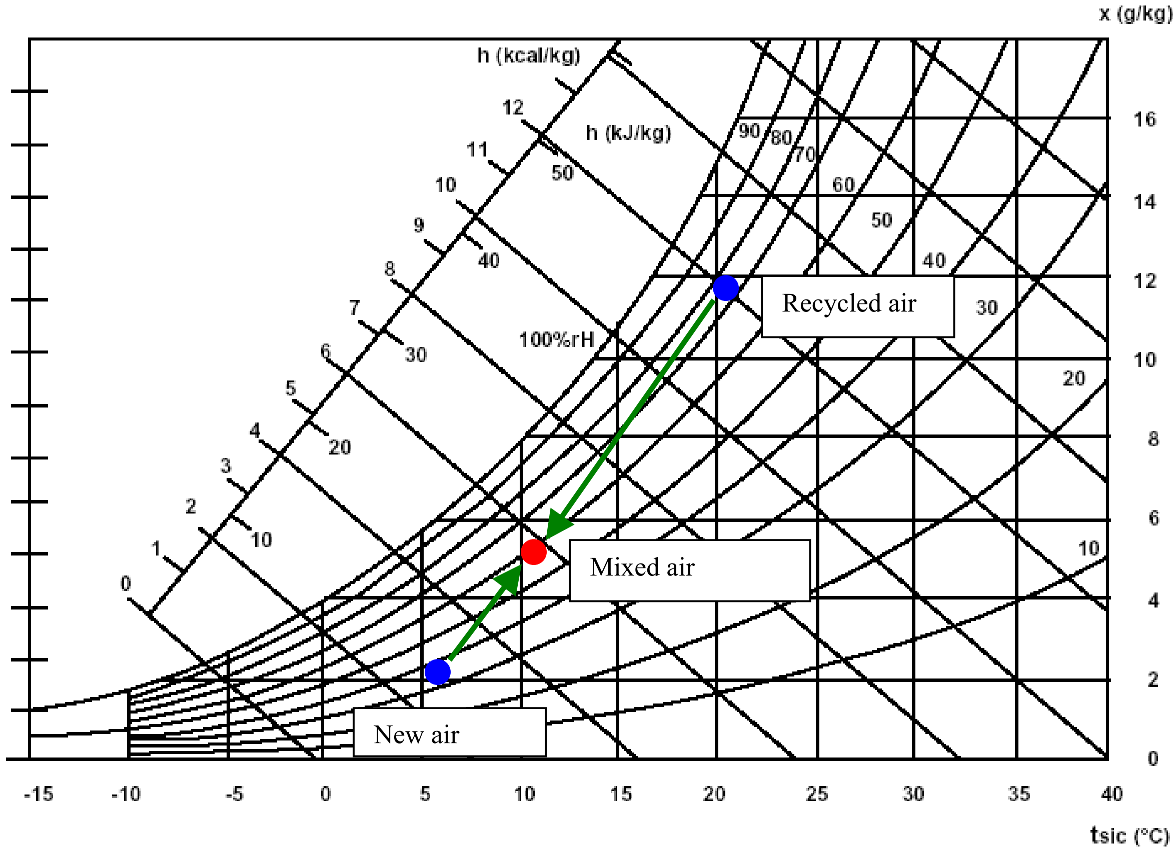
2 ways mixture box



3 ways mixture box



Representation of the mixture of 2 air entries on the psychometric diagram



The mixed air composition is a function of the compositions of the new air and recycled air . By choosing the rate of air recycling, we choose the composition of the mixed air.

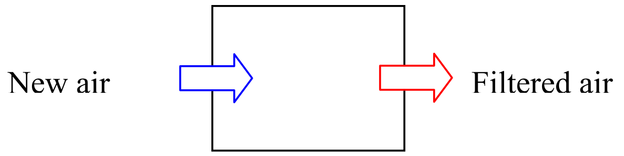
For a 100% rate of new air, the mixed air has the composition of the outside air.
For a 0% rate of new air, the mixed air has the composition of the room air.
For a intermediate rate, the composition of the mixed air is a barycentre of the composition of the new air and the recycled air (according to the flows).

Note: the legislation imposes for the systems used in the air-conditioning where are alive beings (men, cattle) a minimum rate of new air guaranteeing the non-accumulation of pollutant gases in the room (in particular carbon dioxide rate).

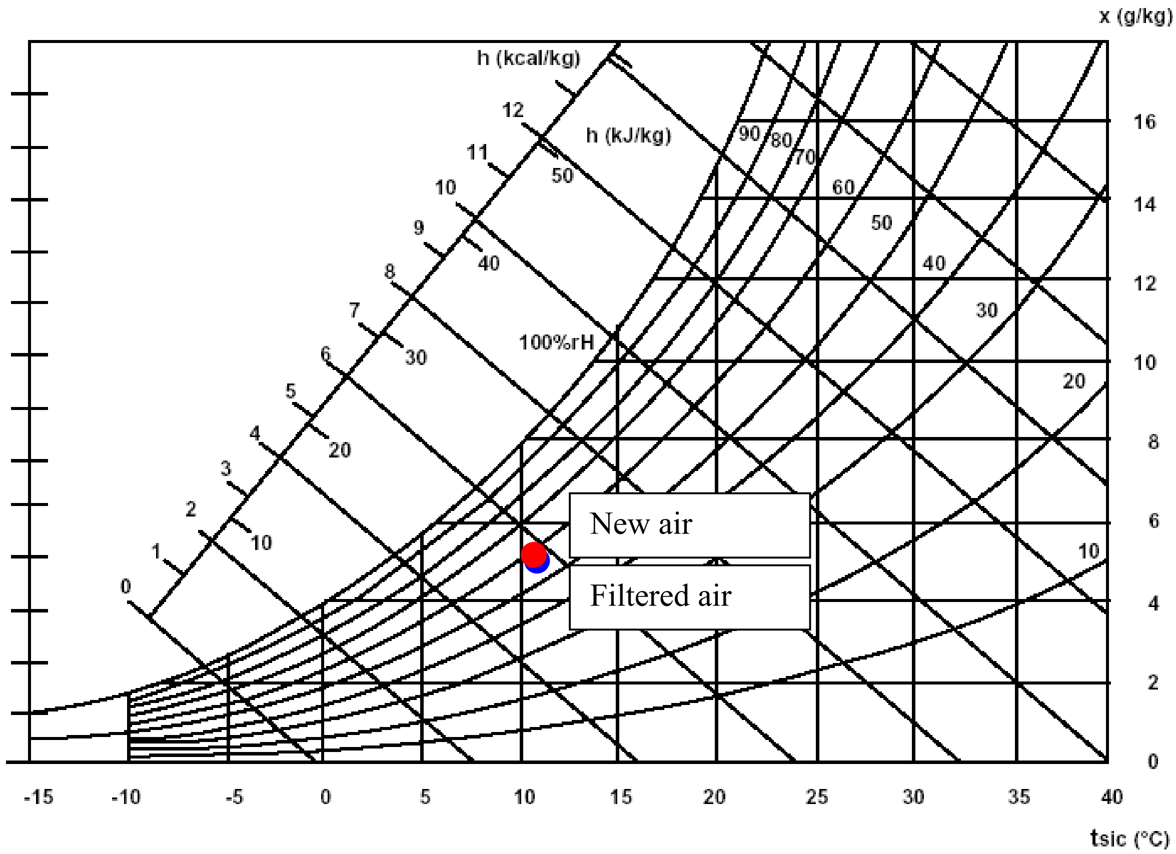
2.2.2 FILTER

The filter does not modify the thermodynamic properties of air. It however involves a pressure loss on the circuit. Its role is eliminating the particles and aerosols contained in the air.

To obtain a good quality of air, we can be to bring to use several types of filters. Each type of box filters more or less well a type of products.



Representation of filtration on the psychometric diagram

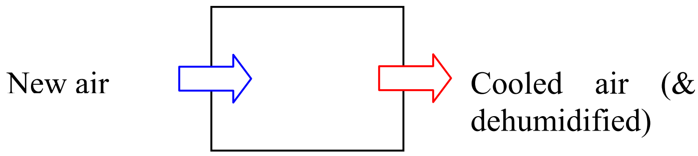


2.2.3 AIR COOLER AND CONDENSER

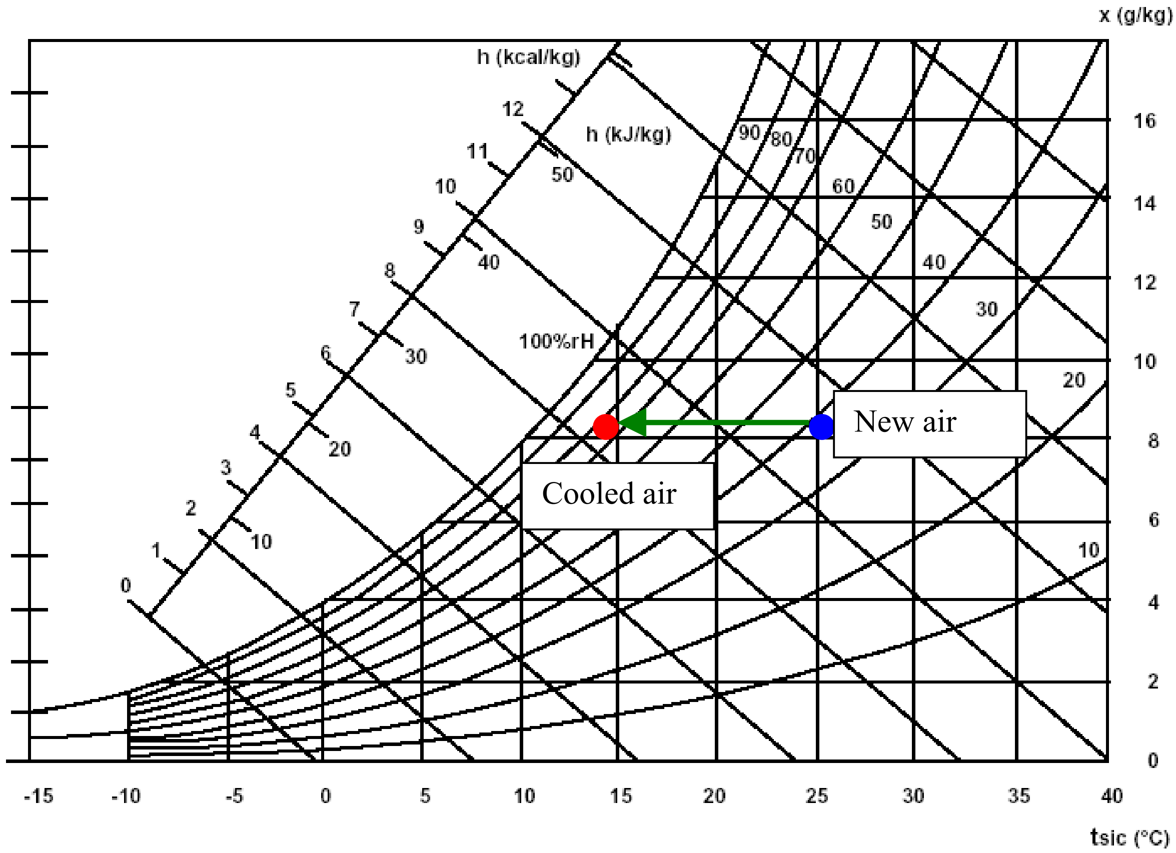
The air cooler is designed for the cooling without dehumidification.
The condenser is designed for the dehumidification of air. The drop of the air temperature is a side effect.

The cold fluid can be:

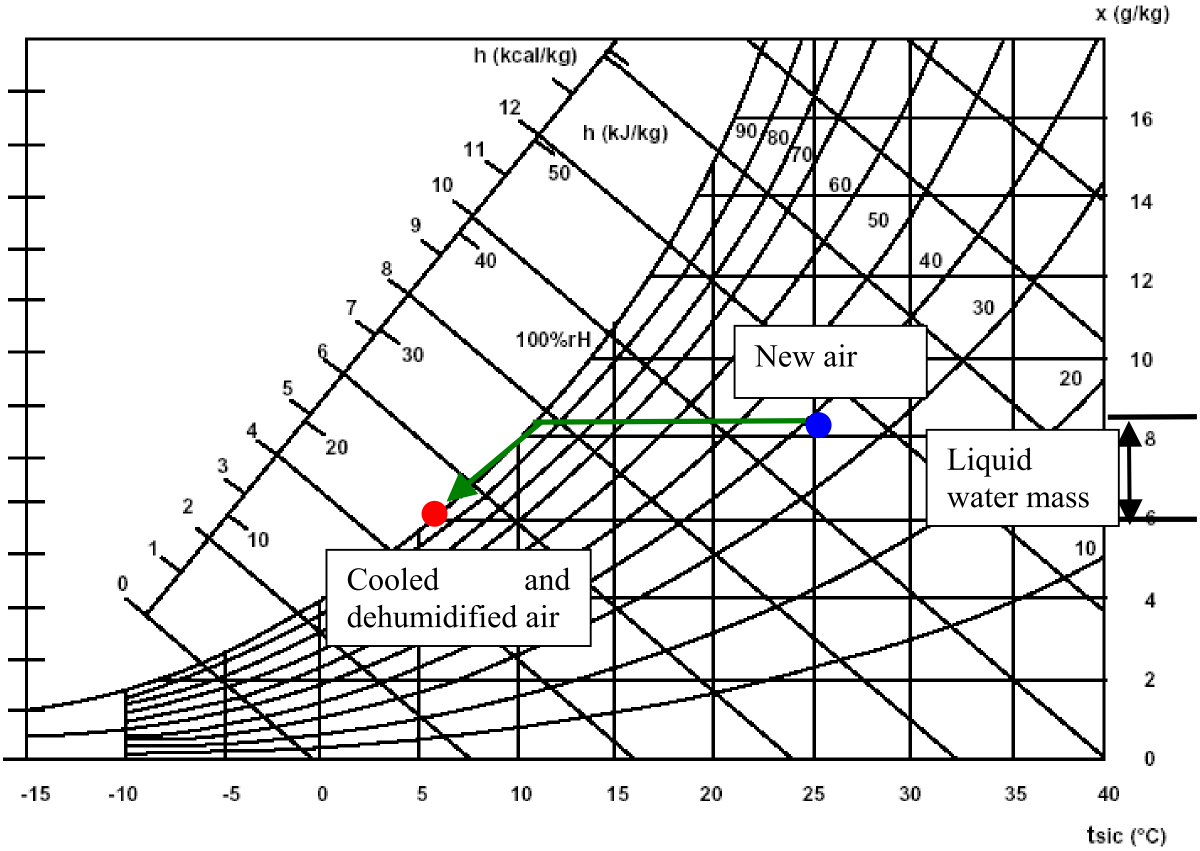
- Frozen water or glycol water. In this case, an auxiliary refrigerating unit is used to maintain at temperature a capacity of liquid which is used in the heat exchanger
- a refrigerating fluid. In this case, the battery is said “direct expansion” .The expansion of the fluid and its liquefaction in the battery creates the negative kilocalories necessary to the cooling operation.



Representation of cooling without dehumidification on the psychometric diagram



Representation of cooling with dehumidification on the psychometric diagram

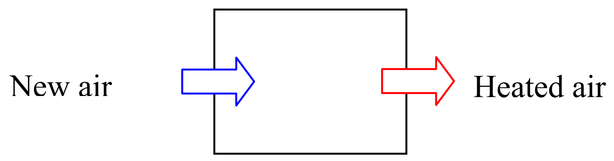


2.2.4 HOT BATTERY

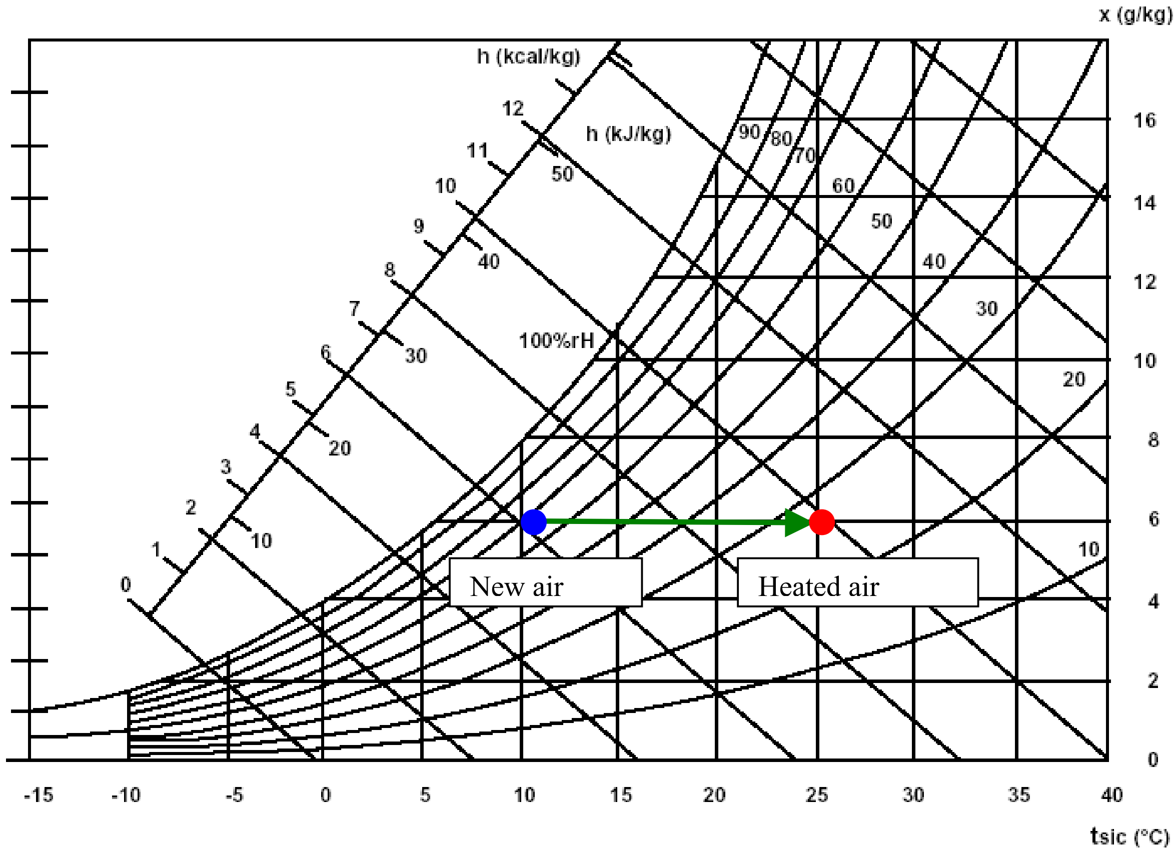
The hot battery brings the calories necessary to the rise of temperature. It can be used for pre-heating or the heating of the air.

The heat addition is done in a heat exchanger by hot water, by overheated water, by vapor, by the refrigerant condensation or by electric resistances.

During the passage in the hot battery, the temperature of the treated air increases. Its absolute humidity is constant, but its relative humidity decreases.



Representation of the air heating on the psychometric diagram

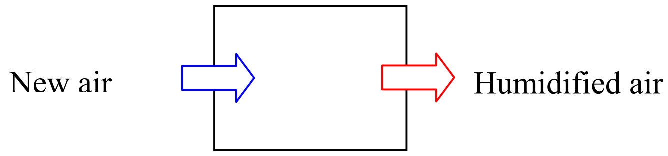


2.2.5 HUMIDIFIER

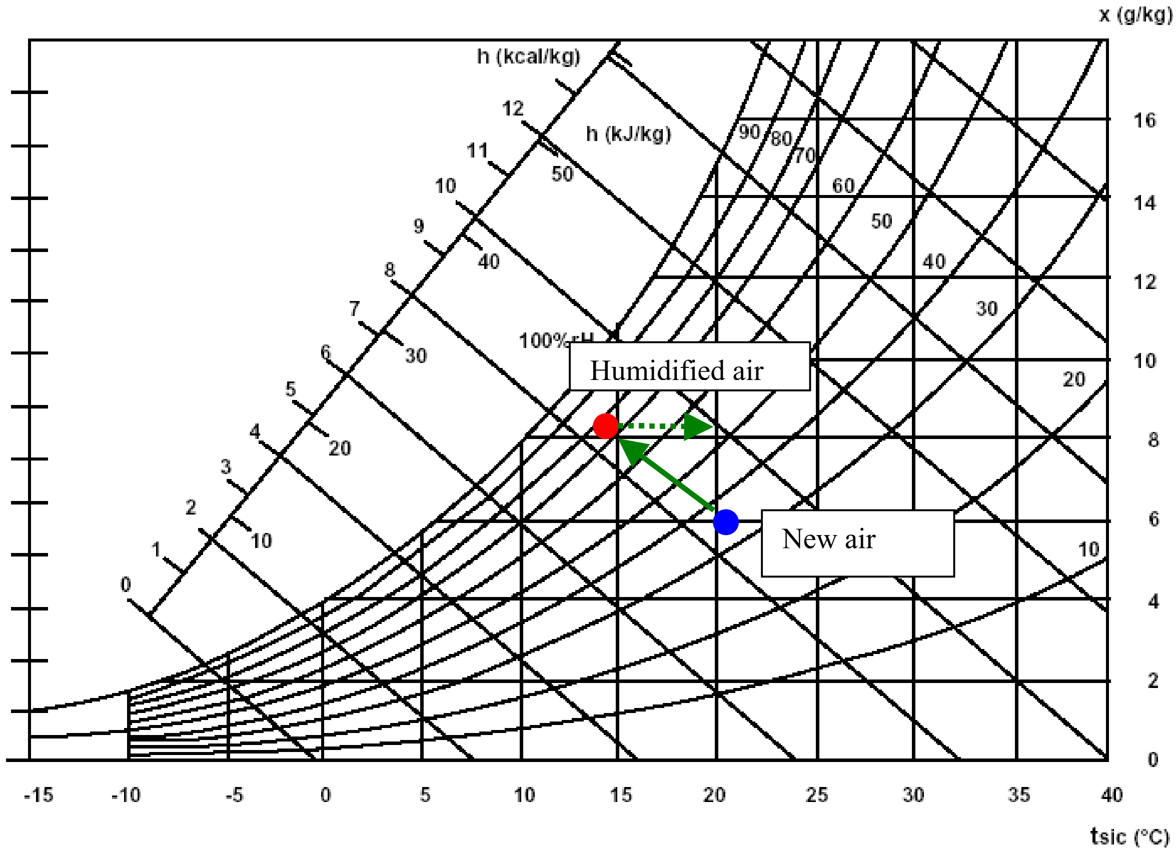
Humidifier is used to increase the water content (absolute humidity) in the treated air.

The water source can be:

- Liquid water: the water is finely pulverized and the treated air brings the latent heat of vaporization. This process is adiabatic.
- Vapor water: the vapor is produced by an independent unit and directly injected into the flow of treated air.

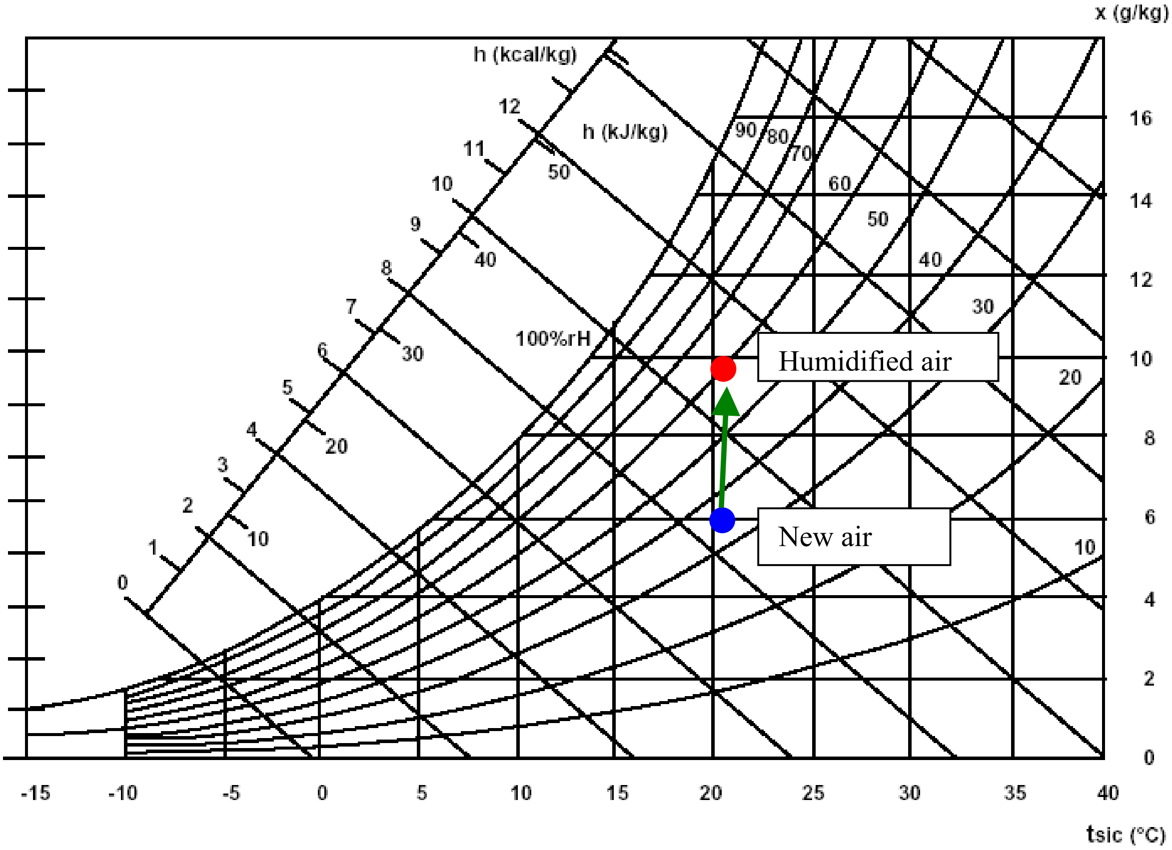


Representation of adiabatic humidification on the psychometric diagram



We notice that with such a humidifier, if the temperature of the treated air were appropriate, it is necessary to add an operation of heating after the humidification operation.

Representation of a humidification with vapor on the psychometric diagram



Here the vapor addition is done almost at constant temperature. We obtain in only one operation the desired temperature and humidity.

2.2.6 Fan

The ventilator allows the transportation of the air in the various parts of air conditioning system.

- In the air conditioning system
- In the air duct intakes
- In the air duct exhausts
- In the room

It compensates the pressure losses due to air frictions and allows the transportation of air. This organ does not modify the air characteristics, the pressure downstream is however higher than the pressure upstream of the ventilator.

There is a lot of fans, which answer each one for a given type of schedule of conditions (pressure of work, flow, output).

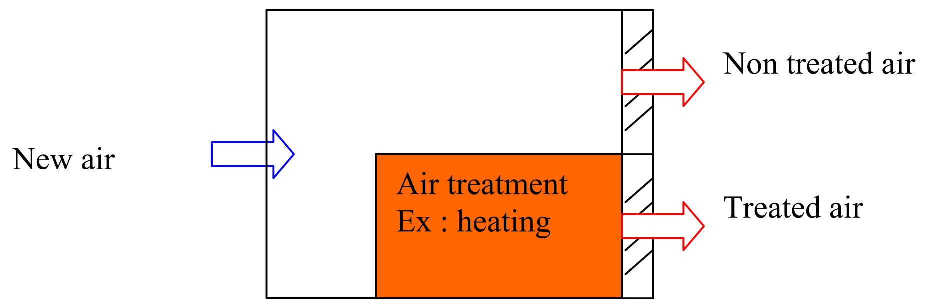
2.2.7 Air ducts

The air ducts have as a role to transport the air from HVAC systems to the air-conditioned room.

They do not modify the air characteristics, except possibly the temperature. One however observes a pressure loss, which is a function length and form of selected sheath.

2.2.8 Bypass box

The bypass box split in two parts the air flow.
The first part of the flow passes through this treatment organ (cold battery, hot battery, humidifier). The second part is not treated.
The control of the shutters of bypass allows modifying the air mass, which crosses it and is often used for energy economy purposes.



2.2.9 AIR CONDITIONED ROOM

The air-conditioned room isn't strictly an element of the system of air-conditioning. However, the physical phenomena are similar to those, which are described above.

The room is subjected to various phenomena which lead to modifications of the characteristics of the air which cross it:

Temperature aspect:

- Heat losses (sensible losses)
- Heat contributions (sensible heat)

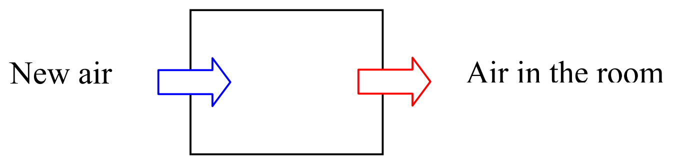
Humidity aspect:

- Latent losses (latent losses)
- Latent contributions (latent heat)

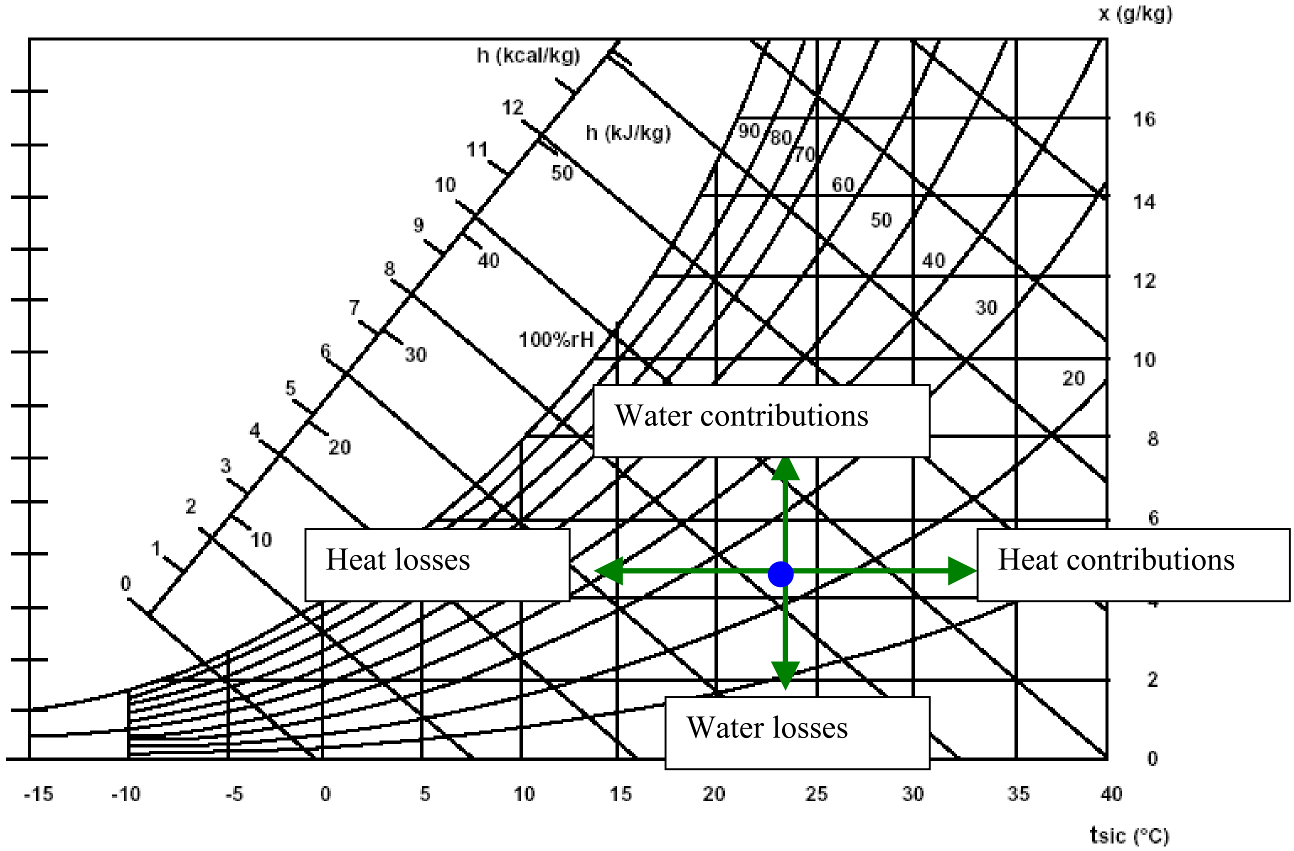
Pressure aspect:

- Losses due to air frictions (pressure loss)

These phenomena are due to the effects of external environment (thermal losses of the building, sunning) and to activities inside the room (human presence, lighting, machines producing heat and vapor)



Representation of the influences of environment and activity on the psychometric diagram



2.3 SOME STANDARD ARCHITECTURES

In this chapter, we will present some architecture of systems of air-conditioning used in particular in the tertiary sector.

2.3.1 AIR CONDITIONING BY TEMPERATURE AND AIR QUALITY CONTROL

2.3.1.1 BOX WITH HOT BATTERY AND COLD BATTERY

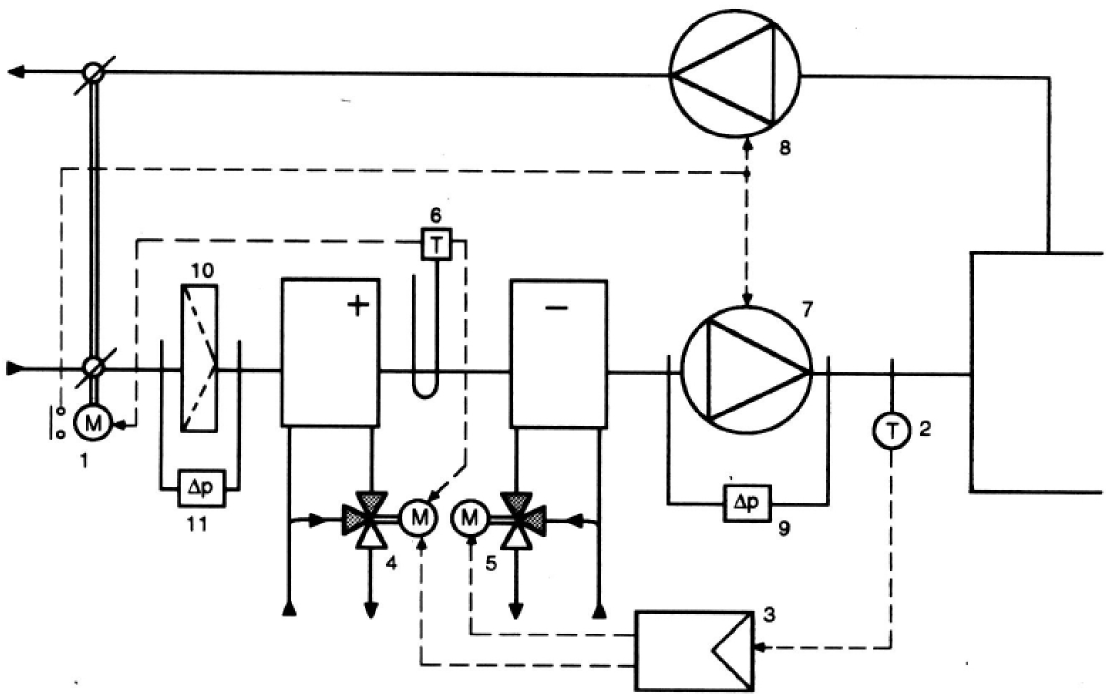
This type of box is used for the temperature control of a room only . The humidity and the pressure remain uncontrolled variables.

It is composed by an inlet of new air (it is then possible to guarantee a minimum rate), by a filter or series of filters (to purify the air from its impurities), by a hot battery, by a cold battery and by a fan.
Two different modes are available:

- heating
- cooling

The control humidity is not done (no humidity sensor).

Organic diagram of the air-conditioning system



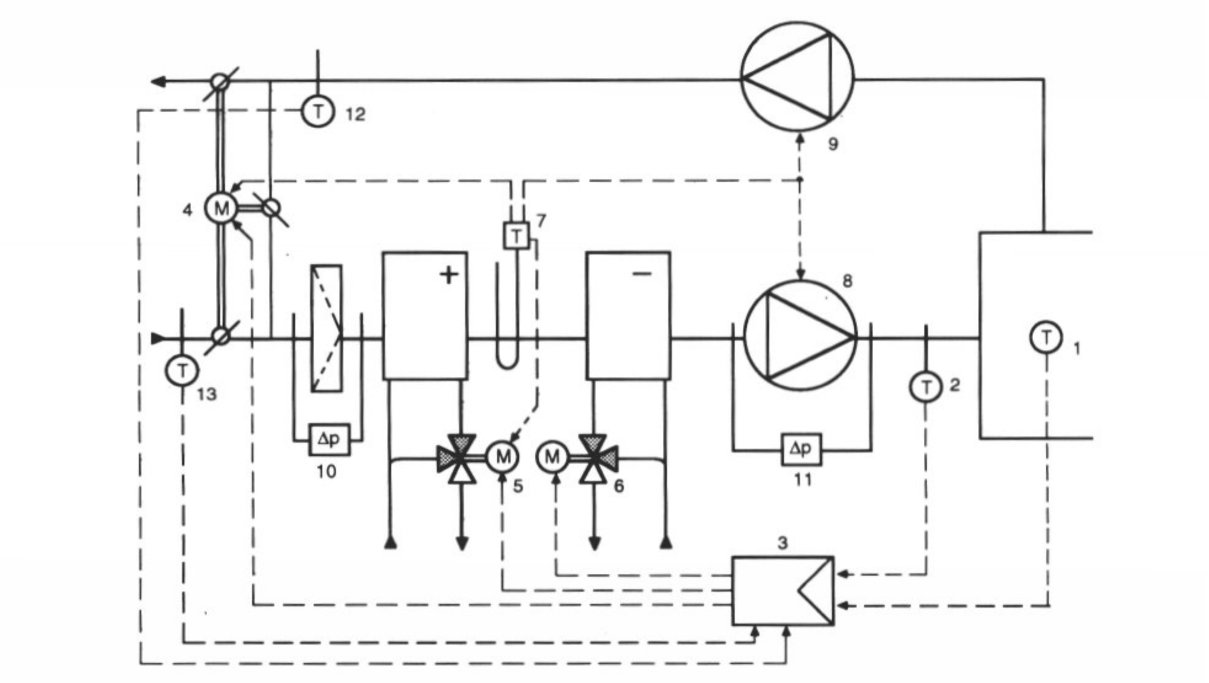
2.3.1.2 BOX WITH A HOT BATTERY, A COLD BATTERY AND SHUTTERS

This type of box is used for the temperature control of a room. The humidity and the pressure remain uncontrolled variables.
The shutter in the case of mixture makes it possible to make a energy economy.
Indeed, the shutters make it possible to control the rate of mixture of the re-circulating air in the air-conditioning system.

Ex: Outside air is colder than the inside temperature. The system of air-conditioning works overall in heating mode. Rather than to take the outside air (too cold), we use the air that has been heated in the room to preheat the new air injected in the air-conditioning system.

It is composed by mixture box having several shutters which make it possible to modulate the rate of new air, the rate of recycled air and the rate of rejected air, by a filter or a series of filters to purify the air from its impurities, by a hot battery, by a cold battery and by a fan.

Organic diagram of the air-conditioning system



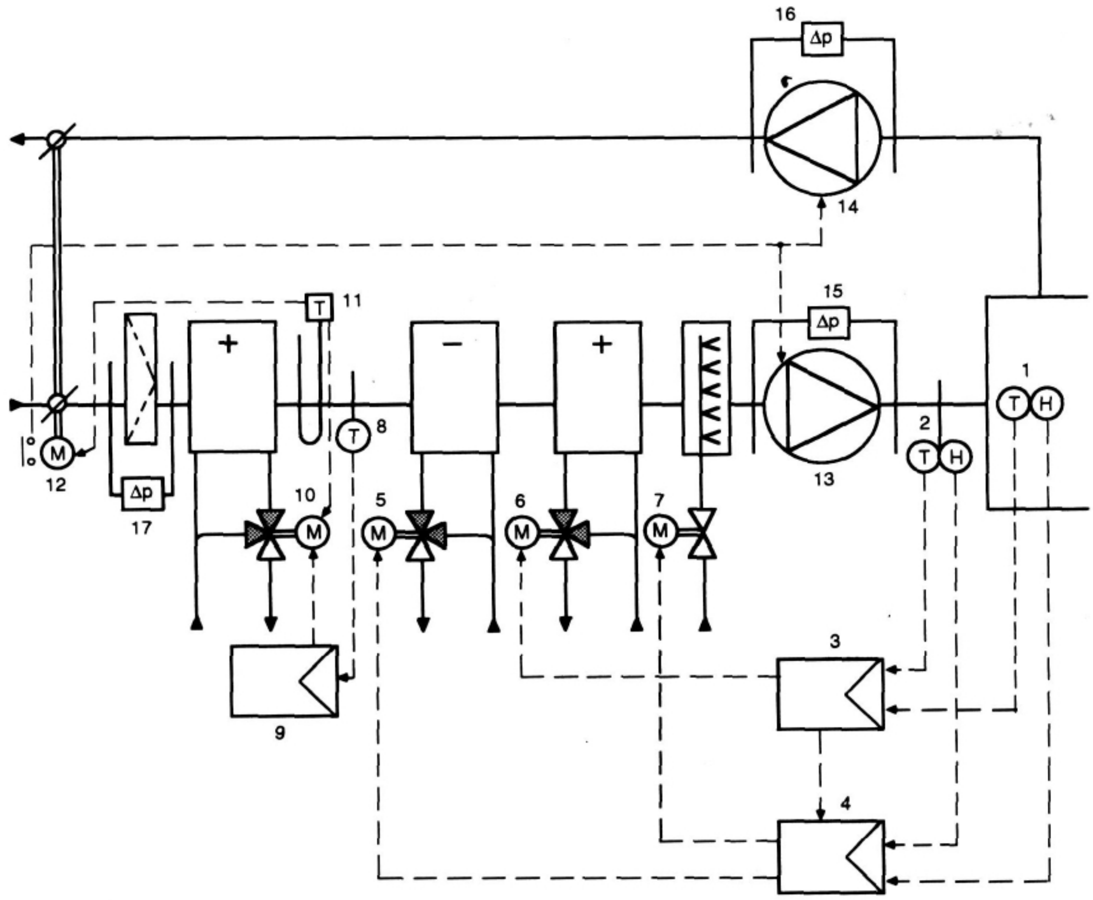
2.3.2 AIR CONDITIONING BY TEMPERATURE, HUMIDITY AND AIR QUALITY CONTROL

2.3.2.1 BOX WITH HOT BATTERY, COLD BATTERY, HUMIDIFIER AND SHUTTERS

This type of box is used for the temperature and humidity control of a room. The pressure remains an uncontrolled variable.

It is composed by mixture box having several shutters which make it possible to modulate the rate of new air, the rate of recycled air and the rate of rejected air, by a filter or a series of filters to purify the air from its impurities, by a hot battery, by a cold battery, by a humidifier (water or vapor) and by a fan.

Organic diagram of the air-conditioning system



2.3.2.2 BOX WITH HOT BATTERY, COLD BATTERY, HUMIDIFIER AND ENERGY RECOVERY

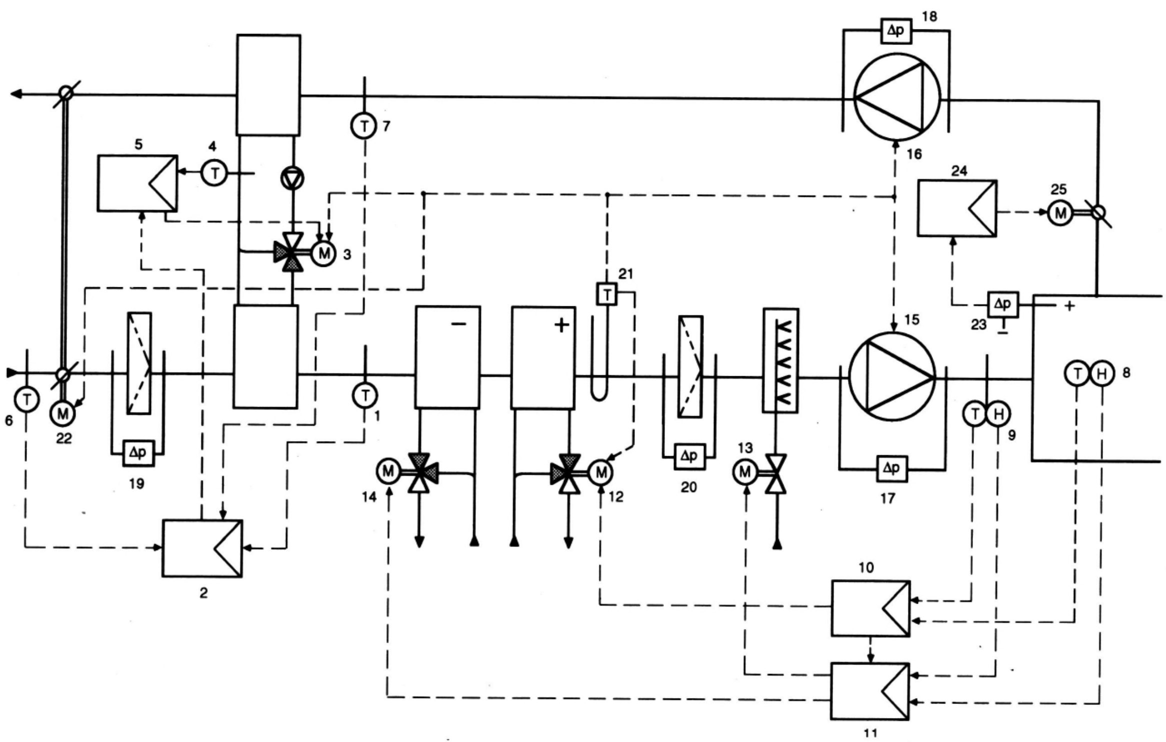
This type of box is used for the control of temperature and humidity, and takes advantage of the previous use of energy.

It is composed of a flexible air inlet flow which makes it possible to guarantee a rate of new air, of a filter or of series of filters to purify the new air from its impurities, of a hot battery, of a cold battery and of a fan which to compensate for the pressure losses due to the air circulation.

The energy system of recovery makes it possible to modulate the quantity of calories or negative calories included in the air. These calories will be added to the air coming from the outside to preheat or pre-cool it.

Different technologies are available to obtain this result (exchanging heat with plates, energy recovery with glycol water.)

Organic diagram of the air-conditioning system



3. CONTROL STRATEGIES

In a first part, we will introduce the principles of the control strategy that are commonly used in the modern air conditioning systems.

In a second part, we will emphasise on the advanced control strategies. Such control strategies are essential when the process becomes more complex (lot of actuators, time delay, multivariable processes) or when the specifications are strict.

3.1 COMMON CONTROL STRATEGIES

3.1.1 BASIC CONTROL

A lot of air conditioning processes are controlled basically with contactors and switches.

These regulators use the principle of on-off control. Depending on the available technology, the regulator may have several acting zones.
For a 2 zones regulator, the actuator may be ON or OFF.
For a 3 zones regulator, the actuator may be ON, half powered or OFF.
When adding zones to a regulator, a pseudo continuous control is obtained.

However, these classic control strategies have a lot of drawbacks and they do not fulfil the objectives of a robust and accurate control strategy:

- Contactor sticking
- A hysteresis is necessary to avoid that the manipulated variable oscillate from on to off.
- The hysteresis on the manipulated variable creates a permanent oscillation on the process measure around the setpoint value. The oscillation period and amplitude depend on the hysteresis setting and on the thermal inertia of the room.
-

3.1.2 P.I.D. CONTROLLER

To achieve better performance in the precision of thermal process, it's necessary to use controller with advanced features.

Desk contactors include mere algorithms (mainly PID type regulators).
Use of microprocessors in these regulators allows additional functions (automatic regulating, auto-adaptive, auto-calibration, auto-test?).

The cost and relative easy use and implementation of these regulators authorise non-experts people to implement the control process of air-conditioning systems.

3.2 ADVANCED CONTROL STRATEGY

Advanced control technologies have been studied since the 80's and 90's. A lot of work and development were done on these years.
In the air conditioning fields, advanced control developments have little results in the industry because of the difficulties to set such a control to work at low cost.

The miniaturization, the costs of the current microprocessors, their use facility and a better knowledge of the techniques of advanced control makes it possible to reconsider their integration in the systems of regulation in the modern air-conditioning systems.

In some applications, the process to be controlled has properties (significant idle period, time-constants and profits static variable according to the point of operation, significant correlation between the actions in the proceeded multivariable case) that require the use of advanced control techniques.

All these advanced control technologies are model based. Some are based on physic equations and identification of the associated parameters; others are based on knowledge models.

The following chapter is about theses advanced technologies and their applications in air conditioning problems.

3.2.1 FUZZY LOGIC CONTROL

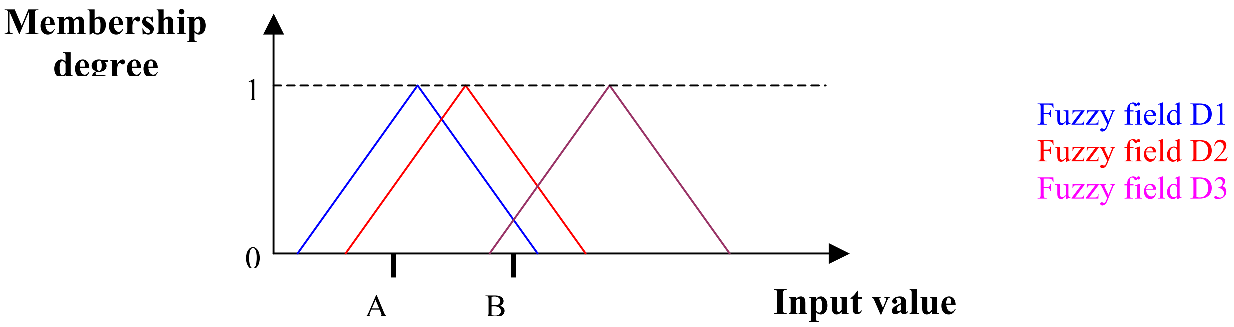
The regulation by fuzzy logic control architecture is based on membership degrees variables of the system to be controlled at certain zones of operation.

For each one of these zones of operation, we identify a regulation that seems to be appropriate. This choice is often done thanks to the operator know-how and practice on the process. This stage thus requires a good qualitative knowledge of the system to be controlled.

Each operation point belongs to one or more of the zones defined before. These zones may overlap. The order applied is then a barycentre of the orders defined in each zone with a weight function of the membership degree of the point of operation to each zone.

The traditional installation process of a fuzzy logic control:

- Fuzzyfication : the physical values are transformed into fuzzy values
- Inference: we calculate the membership degree of each value to every fuzzy fields
- Composition: For each zone, we calculate the outputs of every basic control architectures associated with a fuzzy field.
- Defuzzyfication : we calculate the barycentre of fuzzy control outputs, and then we set it as the applied value of the actuator



Ex: point A is 70 % in the D1 field and 30 % in D2. The order applied will be a barycentre (in the same proportions) of the orders calculated for each one of these fields.

Ex: point B is 20 % in the field D1, 60 % in D2 and 20 % in field D. The command applied will be a barycentre (in the same proportions) of the orders calculated for each one of these fields.

Advantages:

- No need for advanced process control knowledge
- System may contain strong non linearity
- No need for physical modelling

Drawbacks:
- The optimality of fuzzy logic is unproven
- it is necessary to carry out a heavy qualitative analysis of the system to establish a system of valid zones and their associated regulator

Implantations:
Mitsubitshi conceived systems of air-conditioning for both home and industrial users, based on fifty rules. Compared with the old systems, this controller obtains the temperature five times more quickly, reduced the consumption of 24%, and multiplies by two the stability of the temperature while using less sensors. [9]

3.2.2 OPTIMAL CONTROL

The technics of optimal control of the energetic systems were studied since the Eighties, in particular in France by IRCOSE (Institute of Research for the Optimal Control of the Energy Systems).

Like all the techniques of advanced control process, the optimal order is based on the integration of a model of the system to control, into the controller.
The guiding principle of the optimal control is to calculate the optimal value of a specific criterion at every moment (adjustment value) by minimization of an index performance.

It is then necessary to define which type of criterion it is necessary to minimize (ex: energy cost) as well as the associated function. One can modify this performance index by adding terms to him that evaluate for example the thermal cost of comfort, etc. The final function is composed by a sum of the different objectives functions that are balanced by coefficients (weights). These coefficients take value following the interest of the associated function.

Example of performance index to be minimized

$$J=\int_0^t F(t).(y(t)-y_0)^2\,dt+P.\int_0^t G(t)\,dt+Q.\int_0^t H(t).dt$$

With	J	: criterion value
	F, G, H,	: minimisation functions (ex : energy, comfort)
	P, Q	: coefficients weighting associated with the various functions

Advantages
- Optimality of the control is proven
- Taking into account of several factors

Drawbacks
- Need to model the process
- Load of calculation may be important (use of optimisation algorithms)
- Difficulty of evaluating the weight of each term of the function

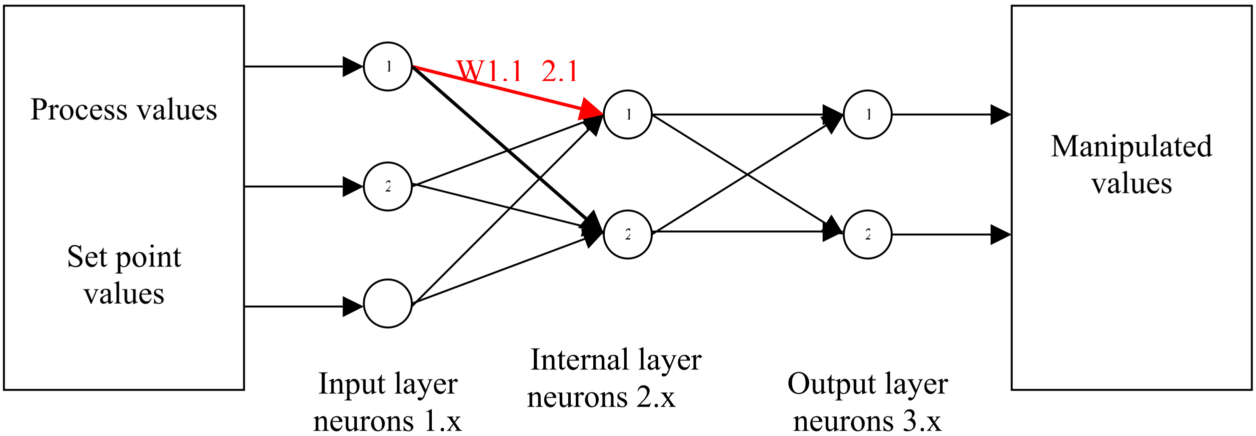
3.2.3 Neural network control

Born in the 80's, the neural network control is based on the principle of the human brain functioning.

The neural network system is made of several layers connected by synapses. The synapse connection is weight by a value from 0 to 1.
The output value of a neuron is computed from the upper neurons output values weighted with the corresponding weight of the connection.

The input layer neurons are selected from a set of values (process values, setpoints, manipulated values, internal neural network values). It's useful to normalise the inputs to help the training of the network and avoid the potential overweight of an input. This normalisation is done with centred values and adjusted standard deviation.
Then, the neural network is designed with layers. Each internal layer has several neurons and each connection is weighted with a function (sigmoid, relay…).
The output layer computes the manipulated values.

To train the neural, it's necessary to use at least 2 sets of data. The first set is used to estimate all the weights between the neural connections. The second set is used to test the training of the neural network. This is done to avoid over training or under training.



This training is done offline. Some process controllers need to adapt their parameters (the connection weights), then an auto adaptation of the weights is made online (the initial values of the weights are computed offline).

The principles of neural network controller are based on the training of the network from the past data of the process. There is no valuable guaranty that the neural controller will be optimal or will have a correct behaviour in the unexplored zones of the training data sets.

Advantages

- No control background needed
- Neural network may handle heavy non linearity of the process
- No physical model needed (statistical model extracted from the data sets)

Drawbacks

- The training phase needs data sets that explore the whole potential process values
- The optimality of neural control is unproven
- It's difficult to understand the computed neural network structure (the parameters have no physical meaning)

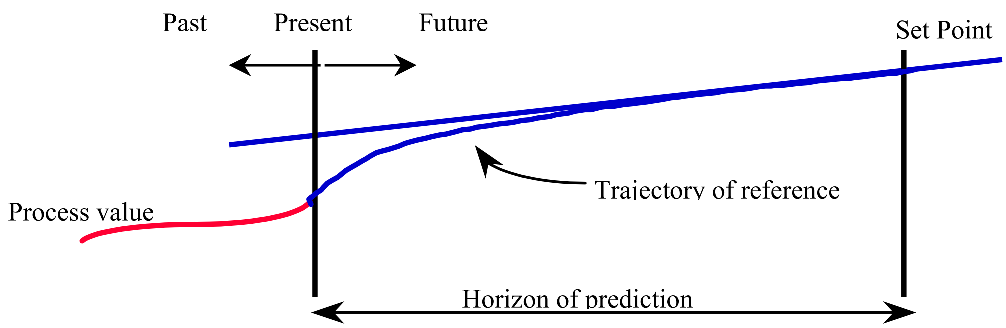
3.2.4 PREDICTIVE CONTROL

The predictive control is based on the dynamic models of the system organs to be controlled. This modelling must take into account the dynamic character of the physical process.
The core of the control architecture is then based on the models

These dynamic models can be:

- of behavior (black box systems): the dynamic responses of the system to a specific request are known and the process of modelling is satisfied to reproduce these types of answers without having the knowledge of the physical parameters.
- of knowledge: the physical equations governing the system are known and used to model the organs.

Predictive control algorithm uses this modelling to predict the response of the system to a request and, as well as possible, to adjust its control action on the actuator.
We can then follow a trajectory of reference for each set point, while respecting the constraints imposed by the various components are not reached (ex: maximum speed of the actuators, minimum flow to respect).



The controller design with a representative model of the system allows leading the process along an optimal trajectory.
For example, the actuators are requested in an optimal way, which makes it possible to minimize the energy used to respect its objectives, to limit their utilization number (less maintenance). This type of control technique makes it possible not to make contrary actions successively to arrive at the final goal (ex: to heat too much for then cooling to obtain the point of instruction).

Advantages

- Proven optimality of the control structure
- Easy evaluation of the robustness
- Easy constraints handling
- Easy tendency addition for measured disturbances in the control architecture
- Diagnostic capabilities of the internal models

Drawbacks

- Model of the process is needed
- Time calculation and memory size possible needs

Implantations

Since many years, Adersa establishes the predictive control for the air-conditioning of the greenhouses. The tropical greenhouse of the Markets in Paris and that of the oceanic museum Océanopolis in Brest uses this type of control architecture. [10]

Adersa is 30 years old of experiments in the field of the advanced control of industrial process based in predictive control and in particular in the control of climate of the greenhouses.

Work on these bases was undertaken for the regulation of CO2 in the tunnels to mushrooms, in particular in Ireland.

Using the technology transfer by Adersa, the industrial company Faiveley (specialist out of railway equipment) developed a system of air-conditioning containing predictive control for theirs TGV 2N (2 levels high speed train), including a cold battery, a hot battery and a guaranteed rate of new air.

4. CONCLUSION

Air conditioning systems show different structures of thermal elements following the needs (cooling, heating, dehumidification) and different regulations answering both the air quality and energy consumption cost.

The analysis of these systems put forward the case of dehumidification like the worst phase in regard of the average consumption due to the fact of the uncontrolled humidity set point after the cooling exchanger. Humidity control is not easy by PID technics generally used because of the non-linearity behaviour of the exchangers. Thus the humidity is managed by addition of water.

Today, automats and informatics' computation allow the use of mathematical models at low costs. Then the predictive control based on process model becomes an economic reality. This technic proves its efficiency when modelling the process is able to recur phenomena.

Then, our objective is to demonstrate the possibility (technical and economic) of a new control system based on modelling. The strong idea is to manage the humidity directly by the cooling exchanger and also the air temperature. The hoped consequence is to avoid or to limit the opposite actions during the air conditioning process and thus to save energy and cost.

In order to valid and to weight the interest of the new control management, a process simulator and the associated predictive controller will be built. Thus, evaluation of the energy recovery can be simulated during different working conditions. After this demonstrating step, it will be necessary to pursue to an implementation on an industrial pilot.

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