THERMOELECTRIC INTEGRATED NUMERICAL MODELING PROCESS OF A TEMPERATURE AND HUMIDITY CONTROL DEVICE APPLY TO VEHICLES FOR FOGGING PREVENTING

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Abstract

Comfort and security for automobile drivers strongly depends on the environmental conditions inside the vehicle. Temperature and humidity are crucial parameters which have great influence in the comfort of the passengers inside the vehicle.

Besides, the water vapor concentration together with the temperature can lead to a condensation problem on top of the windows, which reduces the view and adds a dangerous moment to the driver and passengers.

The effect of the cold wall can produce as consequence the saturation of the water vapor and condensation on the windows This has been solved with different solutions physically and chemically. In this work we propose a practical solution to control the temperature and humidity in the vehicle cabin focus from a Mathematical model which allowed us to know the hygrometric stage and how to control with a chemical solution and thermoelectric control of the relative humidity.

Introduction

The process to control the hygrometric stage and the temperature of the enclosure inside the vehicle will be determined by the knowledge of the properties of the humid air inside of a fix volume. When the water partial pressure (p_v) in a determine volume is lower than the saturated pressure at the air temperature T (p_s) , $p_v < p_s$, then the humid air will not be saturate. If the water partial pressure agrees with the saturation pressure, $p_v = p_s$, then the air is saturated with humidity. The relative humidity (r) is the relation between p_v and p_s :

$$r = \frac{p_v}{p_s} \qquad \text{eq.1}$$

To get to know the humidity composition of the air, this variable is enough as it is know the temperature, humidity and the pressure could allowe us to obtain a partial pressure of the water vapor and the molar fraction. As the dry air composition will not change it will be a better option to work with another property of the humid air which is the specific humidity (e) and this is coefficient between the water mass (m_g) and the dry air (m_a):

$$e = \frac{m_g}{m_a} \qquad \text{eq.2}$$

For the humid air not saturate (r < 100%) the water mass will be in the stage of vapor phase, then we can obtain the following figure:

$$m_g = m_v = \frac{M_g p_v V}{R_0 T} \qquad \text{eq.3}$$

where

m_v is the water vapor mass
M_g is the water molar weight
V is the control volume
R_0 is the gas constant
T is the temperature

and for the dry air:

$$m_a = \frac{M_a p_a V}{R_0 T} \qquad \text{eq.4}$$

where

M_a is the dry air molar weight
P_a is the partial pressure of the dry air

If eq.3 and eq.4 is replaced in eq. 2 we will obtain,

$$e = \frac{M_g}{M_a} \cdot \frac{p_v}{p_a} \qquad \text{eq.5}$$

As the atmospheric pressure (in general p) is the addition of p_v and p_a

$$p = p_v + p_a \qquad \text{eq.6}$$

and the division of the molar weights Mg/Ma is 0,622, then eq.5 as a function of the relative humidity (r) could be expressed as:

$$e = 0{,}622 \cdot \frac{p_s}{\frac{p}{r} - p_s} \qquad \text{eq.7}$$

The saturate vapor pressure (p_s) is a temperature function , the specific humidity (e) is a function of the temperature (T), the relative humidity (r) and the atmospheric pressure (p) and will be expressed as:

$$e = f(T , r , p) \qquad \text{eq.8}$$

When the humid air is saturated the relative humidity is 100% and the eq.7 will lead to:

$$e\Big|_{r=100\%} = e_s = 0{,}622 \cdot \frac{p_s}{p - p_s} \qquad \text{eq.9}$$

And as p_s is a function of the temperature (T) then the specific humidity when saturate is function of the temperature and the pressure (p). When the amount of water is higher than that the air can support in vapor shape, this will condensate in a liquid form (or solid) and this happens when it meets the relation:

$$e > e_s \qquad \text{eq.10}$$

The dew point is a characteristic parameter of the humidity in air and the temperature.

The inner part of the car is much warmer as the ambient outside after it was use or the sun was focusing on the top. Thus the air inside can contain much more water than outside at the same relative humidity. The inner part of windshield temperature will cool down with the time first and drops will be formed by condensation of the water vapor. Lowering the temperature to the saturation e_s, the temperature corresponding to this point is the dew point. If the air is at the temperature T_1, relative humidity r_1 and pressure p, the vapor pressure p_v is:

$$p_v = r_1 \cdot p_s(T_1) \qquad \text{eq.11}$$

And for the dew point (at temperature T_R):

$$p_s(T_R) = p_v \qquad \text{eq.12}$$

Then:

$$p_s(T_R) = r_1 \cdot p_s(T_1) \qquad \text{eq.13}$$

Knowing the temperature and the relative humidity inside the enclosure of the car, it could be solve with the use of thermoelectric cooling devices to maintain the temperature and humidity and avoid the typical points in the humid air which are not desire and are written in the equations 9 and 13.

Temperature and humidity control

The humidity is controlled with a combined system, using thermoelectric cooling devices and a absorbent polymer, this has the properties to absorb or dispense the water vapor retain as a temperature function. The diagram of the polymer control is shown in the next figure:

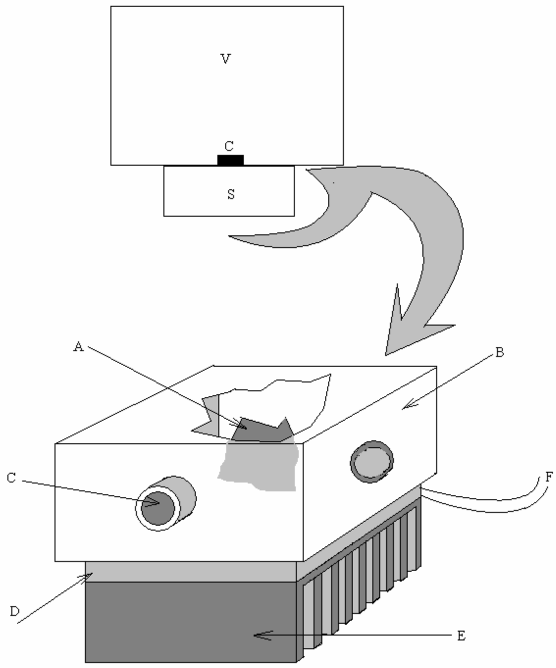

fig. 1 Humidity control device

where,

V is the volume to be control

S is the system to control de humidity

A are the polymer grains

B is the mass support block

C is the outlet measure disposal

D is the thermoelectric device

E is the heat sink

F thermoelectric connections.

Its working functioning is quite simple: when the relative humidity in volume to be controlled is higher than the desired humidity then thermoelectric device must cool the polymer, this way the polymer will absorb the water vapor from the air, by doing this the relative humidity will decrease in the volume to be controlled. If the relative humidity in the volume is lower than the desired relative humidity the thermoelectric device will start heating. This way the relative humidity will be increase inside the volume. This action could be express as:

$$r = f(T_p) \qquad \text{eq.14}$$

$$T_p = f(V_p) \qquad \text{eq.15}$$

where,

r is the relative humidity

T_p is the polymer temperature

V_p is the voltage apply to the thermoelectric device

It could be said that if the voltage V_p is positive the relative humidity (r) will decrease and if V_p is negative will go higher. Starting from equation 7 the specific humidity (e) can be obtained that supplies enough information for the characteristic point of the wet air as the dew point that could be avoid by lowering the humidity in volume to be control instead of the temperature that could remain constant. The following drawing shows the mechanism.

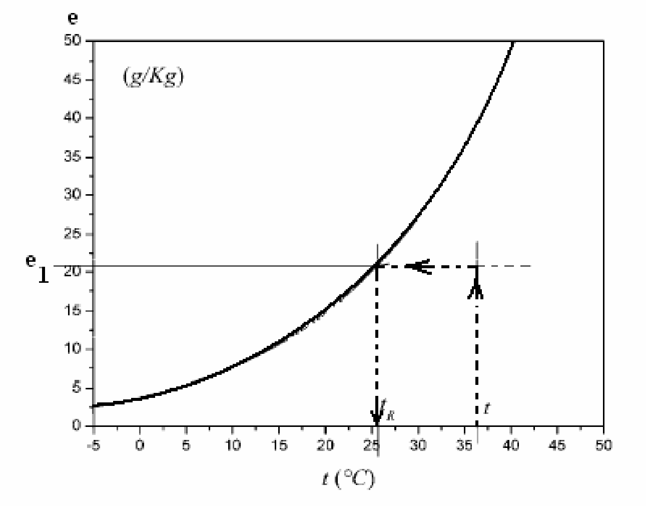

fig.2 Specific humidity vs. temperature

An example: In a volume where there is a temperature of 36.5C, a relative humidity of 54% and atmospheric pressure of 1013 mb , using the equation 13 and the figure 2 we can know the dew point will be given at 26C and a specific humidity of 21 g/Kg. This information will be helpful for a control system with a micro-processor to forecast the conditions of the dry air and make a psychrometric analysis.

In practice the cabin air is led via a ventilation system through the humidity actuator which is controlled by the electronic system.

Electronic control system

In fig. 3 it could be observe a description of a functional system.

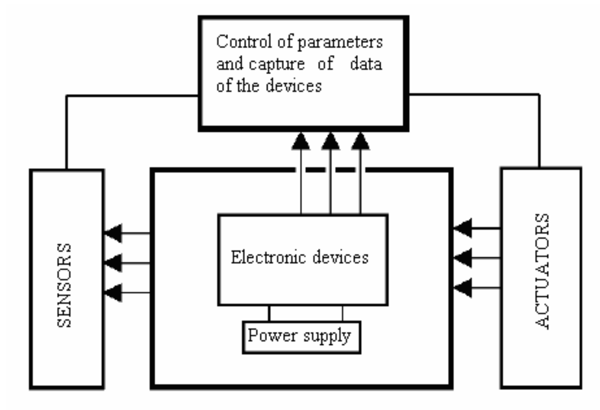

fig.3 Functional Description of the electronics

The system will analyze a data acquisition of the parameters that are inside the vehicle environment. To obtain the temperature and humidity values several sensors are located in suitable positions. The information that is required by the micro-controller must be in a digital format, for such it has been use an analogical-digital converter already include in the sensors. On the windshield a humidity and temperature sensor was placed to obtain the effect of the cold wall and be able to detect the dew point. Another two sensors are located inside the vehicle environment. The micro-controller receives the temperature and humidity values and also the state specifications pre-establish. From this information, the micro-controller will do the task of this parameters actuation in the controlled volume of the environment of the vehicle by the use of actuator series based in a Peltier device for the temperature and with the use of some polymers which temperature is also controlled by a Peltier device for the humidity.

The micro-controller use is PIC 16F84 that has 1K of memory to be program for this application is plenty space, the use of an analog-digital converter can be avoided as the humidity and temperature sensor has it already incorporated.

With a PC board and a display the humidity and temperature desire can be set. There are two zones complete different: the general environment inside the vehicle and the cold wall zone. The micro-processor will respond in a different way in the zones where it should maintain the humidity and temperature values.

In the zone of the cold wall it should be taken into account the dew point temperature in such way if the windshield temperature gets closer to the dew point, it should be a lower relative humidity by means of the use of the humidity actuator and this way there will not be condensation.

The following figure (fig.4) shows the sensor distribution and actuators inside the environment, as well as the control system.

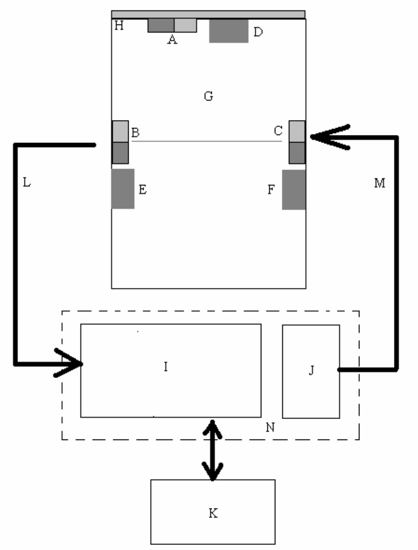

fig.4 Location of the sensors and actuators

were:

A,B,C are humidity and temperature sensors

D,E,F are humidity and temperature sensors

N is the control system

I is the micro-processor

H is the windshield

J is the current amplifier

K is the board and display for the user

L,M are the connection buses

The program of the micro-controller PIC to execute all the previous mentioned functions should be done in language C and with an assembly done for such purpose of this micro-controller. The humidity and temperature sensors are together in one pack. One detail of the sensor pack is shown below, in the next figure.

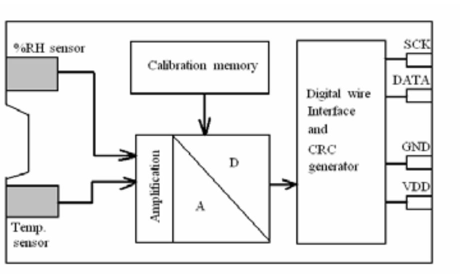

fig.5 Temperature and humidity sensor.

In the following figure (fig.6) it could be observe the humidity actuator base in the use of a polymer.

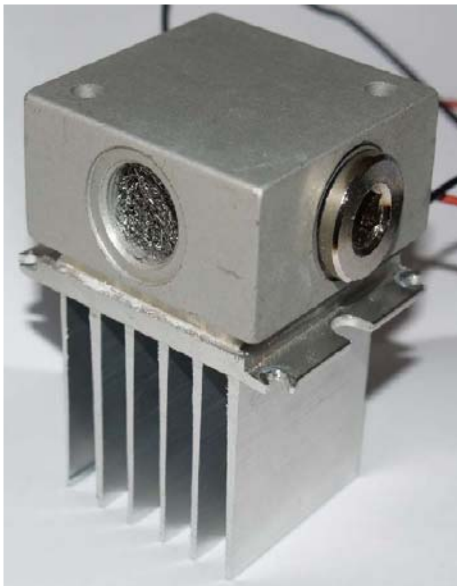

fig.6 Humidity actuator system including polymer.

Conclusions

It was developed a humidity and temperature control for the environment of the vehicle with the final target of improving the comfort and security of the driver and passengers and to avoid the condensation problems on the windshield through the previous detection of the dew point at the cold wall.

It has been used a polymer combined with the actuator design for the humidity obtaining absorption or dispensing of the water of or into the environment.

References

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