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Design of gas extraction systems for modyfing comfort in closed spaces

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***Abstract*— The quality of the habitat applies various terms among which are comfort with contibutive factors such as temperature, humidity, air purity, among others. In the present work, a design of a forced extraction system was carried out for an area that requires air renewal for academic use and rapid calculation. The model was corroborated with an experimental system finding that there is a similarity of 95.5%.**

***Index Terms*— air flow, environmental comfort, habitat quality**

I. INTRODUCTION

Studies of the effects of comfort on air renewal in closed rooms have been conducted (Wells, EM et al. 2015) that are closely related to the change of the contaminants present or the emitted components that can be dislodged by a process of ventilation (Broderick, Á., et al. 2017). In general, comfort increases with the reduction of suspended particles and the CO2 concentration of the spaces occupied by adults and children (Stamatelopoulou, A., et al. 2019). Indoor air renewal with mechanical equipment can help to change humidity values that also strongly impact comfort parameters due to temperature (Mahar, WA, & Attia, S. 2018) and which has been preferred to automate (Schieweck, A et al. 2018).
Gas extraction systems are based on the use of a fan in which the power supplied is converted into energy to generate the flow of gas or air that needs to be extracted. Because it usually works with low or moderate pressures, it is possible to consider gas as an incompressible fluid of constant density and equal to the average value between the inlet and outlet.
In the present work, a system for determining forced air flow is combined from the set of equations of transport phenomena. This set of equations is useful for people who quickly want to know the effects of forced ventilation and to determine changes in indoor air quantities in housing areas.

II. METHOD

To design these systems, the following steps are applied first, the flow of gas or air that must be extracted according to the characteristics of the system is determined. The Bernoulli equation is then applied to determine the load Φ (m) required to achieve the mass flow w (kg / m2.s) of gas to be extracted, which is determined as:

$$\Phi = \frac{P_B - P_A}{\rho} + g(Z_B - Z_A) + \frac{v_B^2 - v_A^2}{2} + h$$

where P is the pressure (Pa), ρ is the average density of the gas (kg / m3), Z is the height (m), g is the acceleration of gravity (9.8 m / s2), v is the volumetric velocity of the gas flow (m / s), h represents the load associated with friction (m), subscript A represents the entry point and subscript B the exit point. Because the gases are fluids of very low viscosity it is possible to consider that the pressure losses are negligible, so that the load is practically used in the generation of the flow and in overcoming the gravitational effects.

Determine the power Ψ (kW-h) required according to the efficiency η of the fan:

$$\Psi = \frac{w \times \Phi}{\eta}$$

This methodology was applied to solve a triplicate experimental case that consists of the design of an extractor to purify the air in a room.

Figure 1 shows the room from which it is required to perform the gas extraction with the corresponding tube through which the exit of this occurs.

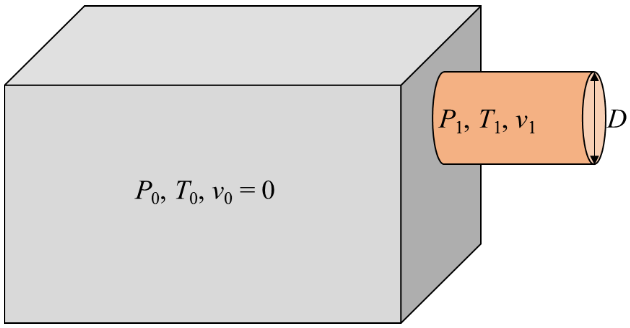

Figure 1. System for the extraction of air from a room. P is the pressure, T the temperature, v the gas velocity and D is the diameter of the extraction tube

III. RESULTS AND DISCUSSION

The density of the air can be estimated through the equation for gases, and is calculated through the relationship:

$$\rho = \frac{PM \times P}{RT}$$

where R = 8.31 J mol-1 K-1. The average gas density is determined as:

$$\bar{\rho} = \frac{PM}{R} \times \left(\frac{P_0}{T_0} + \frac{P_1}{T_1}\right)$$

The next step is to determine the flow of gas to be extracted, which is calculated by multiplying the volume V (m3) of the room by the number n of extractions required per hour, so that:

$$Q = n \times V m^3 d^{-1}$$

$$= 1.1574 \times 10^{-5} n \times V \frac{m^3}{s}$$

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For gas flows in tubes it is recommended that the speed be between 6 and 24 m / s. Selecting a velocity value v1 in the tube according to this criterion calculates its diameter:

$$D = 2\sqrt{\frac{Q}{\pi v_1}}$$

Disregarding the gravitational effects, and considering that the air velocity in the room is equal to 0, you get:

$$\Phi = \frac{P_1 - P_0}{\rho} + \frac{v_1^2}{2}$$

donde la potencia requerida se determina como:

$$\Psi = \frac{\bar{\rho} \times Q \times \Phi}{\eta}$$

In this way, for a room 10 m long, 5 m wide and 2.5 m high, at a pressure and temperature equal to that outside (P = 1 atm and T = 300C), where 5 air extractions per day, there is a flow of $7.2338 \times 10^{-3} \frac{m^3}{s}$ that with a real average density of $1.1664 \frac{\text{kg}}{m^3}$ you can select a speed in the extraction tube equal to 6 m / s having as extractor diameter $3.9180 \times 10^{-2} m$ and $\Phi = 18.0 \frac{m^2}{s^2}$ the required power assuming an efficiency of 60% is:

$$\Psi = \frac{1.1664 \frac{\text{kg}}{m^3} \times 7.2338 \times 10^{-3} \frac{m^3}{s} \times 18.0 \frac{m^2}{s^2}}{0.6} \times 1d$$
$$= 6.075 \times 10^{-3} \text{kWh}$$

The process was evaluated on a pilot scale in a closed area of 3mx3mx2.20m with an analog electric extractor. The enclosed space evaluated the air quality with equipment that connected to a Purikor brand analog air flow meter. The area was kept at a constant temperature at 25 ° C.

The measurements gave deviations of up to 95.5% with respect to the calculated air and the proposed design system.

The process can also work to remove air from the space that changes the suspended particles and which, obviously, by evacuating the space reduces the concentrations of unwanted components. The system is applicable to homes and enclosed spaces occupied by living beings. Likewise, the movement of the air can cause changes in humidity in the indoor environment, which in turn modifies its comfort due to the thermal sensation it can produce.

IV. Conclusion

A System of equations was obtained as a model that considers the extraction of air from enclosed spaces where deviations of up to 95.5% are observed with respect to the theoretically calculated. In a future work the calculation will be made for the system with change of humidity and temperature and the effects in the same space.

Acknowledgment

The preferred spelling of the word “acknowledgment” in American English is without an “e” after the “g.” Use the singular heading even if you have many acknowledgments. Avoid expressions such as “One of us (S.B.A.) would like to thank ... .” Instead, write “F. A. Author thanks ... .” **Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page**.

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