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OPTIMUM CONDITION SEARCH FOR TANGENTIAL FLOW FAN INTEGRATED TO AN AIR CONDITIONING SYSTEM WITH A DIFFUSING CEILING

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1. INTRODUCTION

An original air-conditioning system is being developed by the Air Conditioning and Building Systems department, based on a special air diffusing technique: The air is processed by a convector-fan located in the door impost, then flows through a very thin plenum chamber (7cm) situated above a suspended ceiling of stretched fabric. It is filtered through a non-woven fabric placed inside the plenum, then diffused through a permeable material into the usable space of the room near the heat losing walls. This process presented more in detail in [1],[2] does not use inlet grilles or related ductwork. The thermal performance in terms of temperature gradients, air speed and temperature asymetry conforms entirely with the ISO7330 standards.

The aim of the research work presented here is to minimize the size of the convector fan so that it can be integrated into the door impost, while meeting the acoustical and air-flow constraints.

2.DESCRIPTION OF THE CONVECTOR-FAN

As far as bulk is concerned, the convector-fan placed in the door impost was defined according to standard data: 0,81m in length, 0,25m in height and 0,15m in thickness. The choice of a tangential flow fan, equipped with an impeller of 0,65m in length and 0,06m in diameter, was therefore a necessity.

However, with a standard design, such a fan generates a noise power level which is too high at the speeds utilized. Consequently its performance had to be improved.

3. TEST PROCEDURE AND NOISE TRACING

The first trials were conducted whis a standard tangential flow fan integrated whith its driving motor and its casing into the upper part of a box 0,41m long, 0,35m wide and 0,12m deep. This box, open at the front, allows the simulation of the fan position inside the transfer module. Acoustic level measurements were conducted with the help of the intensimetric technique at 120 points spread out across the front part of the box.

Preliminary measurements carried out on the standard fan permitted to determine the origin of the dominant noise: the acoustic level measured at the front of the box is 23 dBA when only the motor suspended within the box rotates; it is 26dBA when the motor is fixed on to the casing, 32 dBA when the motor drives the impeller fixed to the casing, and it reaches 37 dBA when the tongue is put into place, with the motor still turning at the same speed of 900 rpm in the four cases considered.

The noise is therefore caused by air-flow; it results from the coupling of tongue-impeller-volute, and the findings are confirmed by the noise-chart.

4. SUCCESSIVE MODIFICATIONS BROUGHT TO THE FAN

The modifications brought to the system mainly concern the material used for the volute and the tongue,but the profile shapes and the positions of both in relation to the impeller have also been altered

Melamin foam of 3 cm average thickness used to make the volute and tongue offered the double advantage of acting as a good sound absorbing material and of being sufficiently rigid to permit precision moulding.

Its absorption coefficients measured with a standing wave method on a 2,5 and 5cm thick sample are respectively as follows: 200 Hz (0,05; 0,15); 500 Hz(0,2; 0,5); 1000 Hz (0,4; 0,85); 2000 Hz (0,7; 0,95).

Eight different configurations were the object of a comparative study:

Version 0: mass-produced standard form with steel volute and tongue

Version 1: The volute has been replaced by a foam one with the same profile

Version 2,3,4: The volute is the same as in the version 1, and the tongue made of foam; These 3 versions differ from one another by a variable distance between impeller and tongue, respectively 7, 11, and 2mm

Version 5: Volute and tongue made of foam are 2mm distant from the impeller

Version 6 and 7: The volute and tongue are modified

5. RESULT ANALYSIS

The acoustic power level varies uniformly and in a practically linear way with the rotation speed of the rotor for all the configurations considered: within the 700 to 1200 rpm range, it rises by 3 dB when the rotation speed of the motor increases by 100 rpm.

Only delivery flows for a rotation speed of 950 rpm and zero static pressure available are presented here

In versions 2, 3 and 4 where the volute and the tongue are made of melamin foam, greater distance between the tongue and the impeller brings about a reduction of the global acoustic power level, as well as a reduction of the delivery flow.

In the next versions, the distance between the tongue and impeller was set to 2mm as in version 4.

In comparison with the latter, an improvement of the delivery flow and a reduction of the sound power level of 2 dB can be observed. However, the comparison between the last versions and Version 0 show that the acoustic power level and the delivery flow are close to each other.

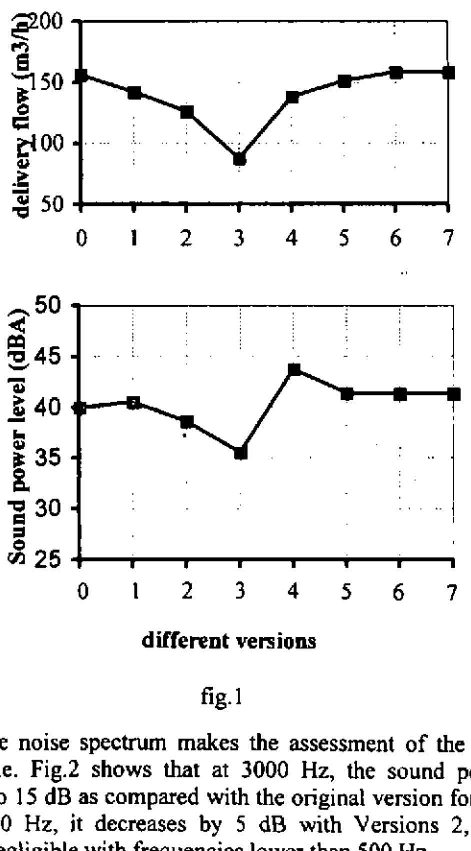

fig.1

Analysis of the noise spectrum makes the assessment of the melamin foam efficiency possible. Fig.2 shows that at 3000 Hz, the sound power level has decreased by 10 to 15 dB as compared with the original version for Versions 2, 3, 6 and 7; At 1000 Hz, it decreases by 5 dB with Versions 2, 3 and 7. The improvement is negligible with frequencies lower than 500 Hz.

The gain is therefore directly related to the absorption coefficient of melamin foam.

The narrow band spectrum of the noise radiated by the tangential flow fan reaches a peak which can be observed in all the versions whatever the rotational

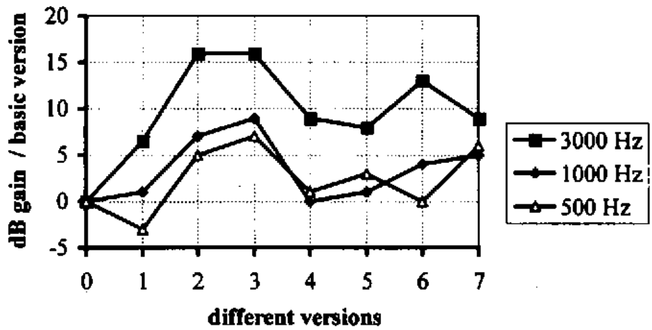

Fig.2

speed of the impeller may be. This peak occurs exactly at the fan blade rotation frequency. The absorbing material does not affect this peak, but its emergence in relation to the sound power level at 5000 Hz is not constant: for an impeller rotation frequency of 950 rpm, this peak appears at 380 Hz and rises by 20 dB in Version 7.

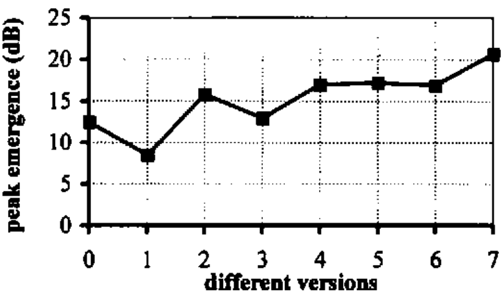

Fig.3

In these tests, no dephasing was attempted by inclining the fan-blades in relation to the tongue. By streamlining the spectrum and bringing out the emergence of the peak corresponding to the passage of the fan blades past the tongue, we can hope to improve the noise levels on the 0,63m long prototype under study.

References

[1]Y.Lenat-A.Triboix-O.Funfschilling, « Plafond diffusant en tissu tendu » Chauffage Ventilation Conditionnement d'air n°4-94, Avril 1994

[2]O.Funfschilling-Y.Lenat « Acoustic performance of an air conditioning system with a diffusing ceiling » p.655 Noise-con 94