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A Noise Reduction Procedure: A Constructal Approach

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Abstract

This paper reports an experimental procedure based on the Constructal Law to reduce the noise level. The study investigates both the component level and the system level noise reduction. It is shown that at 100% load and at the second construct, a noise of 3dB will be reduced.

Keywords: Constructal; Noise Reduction; Correlations; Second Construct

Introduction

One of the objectives of designers in IT [1] is to reduce the noise level of the systems. In this paper, we show our attempt to lower the noise level by using a Constructal Approach. Constructal Law, as it is commonly known today, has taken 20 years to evolve. To obtain a good and concise idea about this law and its many, ramifications the readers are referred to [2] and the papers cited there. The Constructal Law states that: "For a finite size system to persist in time, it should evolve in a manner to provide an easier access to fluid going through it [3]. In an industrial context, one interpretation of persist in time is that a program which supports a system should not be eliminated. One of the reasons that we made use of Constructal Law, is its power to predict the design3. In some of our past publications in the industrial contexts, we addressed the Refrigeration Condenser, Thermal Management in Microgravity, Stability analysis and finally Charger Thermal design [4-6]. Here, in this paper the Acoustic aspects and Constructal Law are investigated. The system under study is a 2RU server, and the noise generation will be mainly due to four cooling fans which are in the push mode (the fans will direct air to the outside of the system). We made a distinction between Component level and System level acoustic optimization. Our method in this paper is purely experimental. The paper is organized in five sections. In section two, the acoustic set up, the measuring system and the characteristics of the acoustic chamber are explained. The experimental protocol is also explained in that section. Section 3 is devoted to the noise reduction; in 3a the component level noise reduction is explained. While in section 3b, the system level noise reduction is presented. In the same section, some curves and tables are given to characterize the acoustics of the system. Finally, in Section 4 the conclusion and discussions are presented.

Materials and Methods

In this section we will focus on the experimental set up and the Data Acquisition System that we used. We conducted all experiments in an anechoic acoustic chamber with 10 Microphone set-up, see Figure 1. The chamber is maintained at a constant temperature, and constant humidity. The microphones are connected to a DAS System provided by Nelson Company. A software is used particularly for the results of this system. The test results cover component and system levels which will be discussed in Section 3.

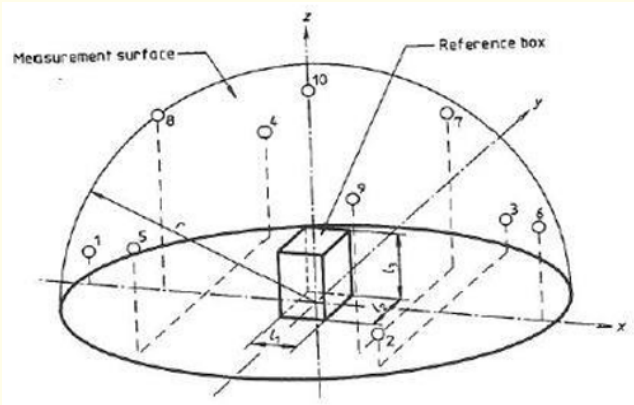

Figure 1: 10 Mics System.

Results

Section 3 are composed of two sub- sections: 3a and 3b. Our objective is to reduce the noise level. Our tools are foam and duct.

Component level

In this section, our experimental protocol will be presented in two parts.

First, we will present the acoustic results of the original system. Then after establishing the base line, we will insert foams in the fans. The result is shown in Table 1. The speed of fans is presented in Appendix A.

The Load	*Noise (Original System)*	*Noise after component level*
40%	72.6	72.1
50%	79	78.5
70%	86.5	86
100%	97.7	96.2

Table 1: Component Noise Level Solution (dB).

System level

In this section, we apply designing the baffle. We mean that we add a duct to the existing server (see figure 2).

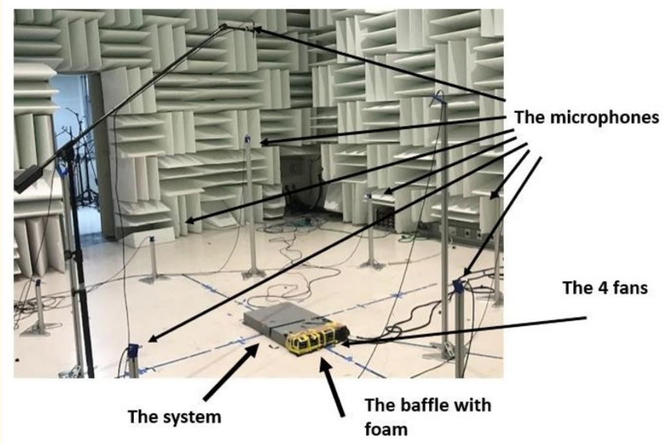

Figure 2: The ducted (baffled) server.

In reaching this design, the first construct was to add the baffle. Then the second Construct was creating a partition for each fan (see figure 2).

The results are presented in Table 2.

The Load	*First Construct*	*Second Construct*
40%	71.9	70.3
50%	77.1	75.7
70%	85.7	85.1
100%	95.1	94.6

Table 2: System Level Noise Solution (duct plus foam).

As can be seen from Table 2, at 100% load the noise level is reduced 3 dB.

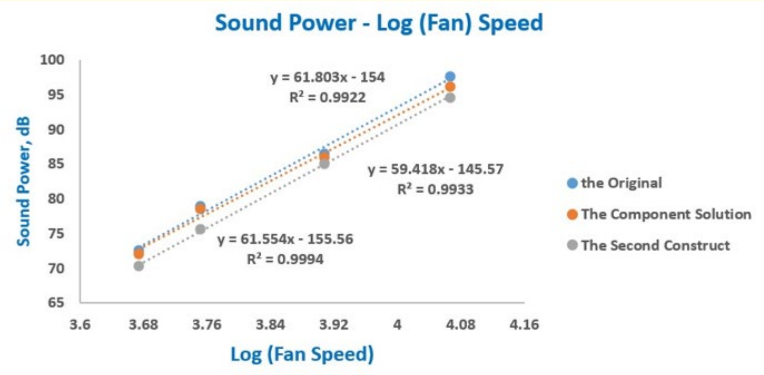

Figure 3

It should be reminded that Figure 3 shows the reduction of the noise level (please note that x is log RPM and y is the Sound Power). One may ask the question why we stopped at the second construct. To answer, we should remind that there is a constraint in the system which is the air flow (See Appendix B).

Discussion and Conclusions

In this paper we proposed a simple method to reduce the noise level in a 2 RU server. The speed of fans is changed from approximately 4000 RPM to 12000 RPM. Our strategy of noise level reduction was based on Constructal Law. We did that in two parts: Component level and System level. It was shown that at 100% load, we can reduce noise level by 3dB.

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References

1. J Killeen., et al. "Fan-noise reduction of data center telecommunication server racks with an acoustic materials broad band, low frequency, sound absorbing liner". Applied Acoustics 203 (2023): 109229.
2. A Bejan and JD Charles. "Animal design advantage from the analogy between friction and body heat loss". BioSystems 235 (2024).
3. A Bejan. "Shapes and Structures, From Engineering to Nature". Cambridge (2000).
4. MS Sadeghipour and Y Pedram Razi. "Natural convection from a horizontal cylinder, the optimum distance between te confining walls". IntHeat Mass Trans (2001).
5. MC Mojtabi., et al. "Heat transfer due to high frequency vibration: a new approach for achieving thermally optimum geometry". ICTAM (International Conference on Theoretical and Applied Mechanics), Warsaw Poland (2004).
6. Bob Roohparvar and YP Razi. "Thermal Management of planar micro-transformer". IMAP, 42nd International Symposium on Microelectronics, San Jose (2009).

Appendix A

Fans Speed Table (RPM).

Loads	***Fan 1***	***Fan 2***	***Fan 3***	***Fan 4***	***Fan 5***	***Fan 6***	***Fan 7***	***Fan 8***
40%	4886	4526	4913	4594	4913	4522	4886	4545
50%	5869	5383	5875	5427	5914	5394	5901	5421
70%	8385	7692	8411	7792	8450	7769	8411	7826
100%	11973	11180	12053	11320	11920	11297	12134	11297

Appendix B

The following figure shows the air flow of the system. Which is virtually the same as when there was no baffle.