Time delay based noise control in centrifugal fans

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The most common noise control systems are already based on passive and active techniques. Passive noise control is a typical technique for high frequency noise and active noise control also for low frequency noise. In this paper, a simple and cheap method is proposed to determine the difference between sound waves of two centrifugal fans based on time delay in power starting to control low frequency noise. The highest level in the noise level analysis shown in study fans is at 250 Hz. In the interference stage of study, noise measurements were recorded in the time delay of 3, 6 and 8 ms for power start for one of the fans. Results showed that an 8 ms time delay resulted in 1.3 – 2.3 dB(L) reduction in total sound pressure level of fans. This method is suggested for noise control of low frequency in the same sources.

Key words: noise control, fan, time delay, wave interference

1. INTRODUCTION

Noise pollution is one of the most important environmental problems, which is not only an urban management predicament in the developing countries, but it also a concern of the developed countries [1]. Noise production by mechanical sources is a risk factor for accidents and an indicator of energy waste. The most common noise control systems are already based on passive and active techniques. Passive noise control is a typical technique for high frequency noise and active noise control for low frequency noise. Researches on centrifugal fan noise reduction have primarily focused on the control of blade passing noise. From a subjective point of view, tones are generally the most annoying components and thus need to be reduced. Many techniques, mostly passive means, have been developed for reducing the noise emitted by fans [2]. Many investigators have focused on the active control of low-frequency ducted fan noise. These approaches are based on ANC methods for low frequency noise produced by axial and centrifugal fans. Wu and Bai obtained a 7 dB reduction in 330 Hz using an ANC technique [2]. Also, Gerald et al obtained a 13 dB reduction in 300 Hz for axial fans noise control using ANC technique to lower centrifugal fan noise. Valarde et al performed a study for predictive maintenance procedure using pressure and acceleration signals from a centrifugal fan [3].

Active noise control techniques use either an acoustic reference signal or an optical sensor for periodic sources to eliminate this feedback constraint. In the active method , the system instability, which may occur due to the feedback of the control signal to the reference microphone, is modified by modeling this feedback loop and subtracting it from the measured reference (internal model controller), which is appropriate for active tonal fan noise control. Recent works have also been

conducted using computer simulations on the active control of fan tones radiated from the intake of turbofans using an annular secondary source ring and in-duct error sensors or external error sensors. Thomas et al. applied a method to an operational engine turbofan and obtained attenuations up to 12dBA for the fundamental frequency [1,4,5,6,7]

Wave interference is the phenomenon which occurs when two waves meet each other while traveling along the same medium. The interference of waves causes the medium to take a shape which results from the net effect of the two separate waves upon the particles of the medium. If two crests having the same shape meet one another while traveling in the opposite directions along a medium, the medium will take on the shape of a crest with the amplitude twice the size of the two interfering crests. This type of interference is known as constructive interference. In the maximum constructive interference for the waves with the same phase, there was a 3 dB increase in total sound pressure level of sources in the receiver point. If a crest and a trough having the same shape meet up with one another while traveling in the opposite directions along a medium, the two pulses will cancel each other's effect upon the displacement of the medium and the medium will assume the equilibrium position. This type of interference is known as destructive interference. Figure 1 shows three wave shapes produced by the same two sound sources which produce a resultant shape in the receiver point. The resultant is shown on the right hand figure; in two cases (on the left and in the middle), constructive interference occurs and in the third case constructive or destructive interference occurs. In this phenomenon wave phase of two sources is very important.

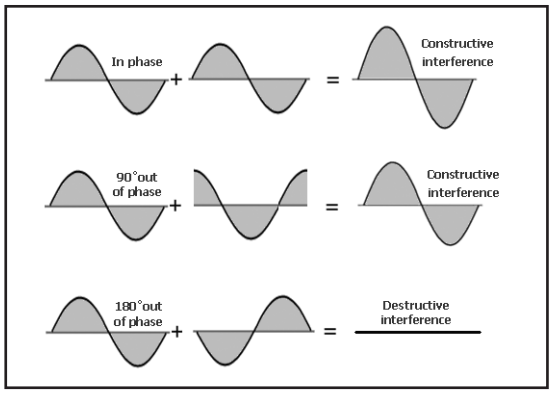

Figure1. Constructive and destructive interferences occurring in the third case in the wave phases of two sources

In this study, a methodology has been developed in order to create deference in generated sound wave in one of two same centrifugal fans by time delay method in power starting. This study can be applied in an extensive domain of great practical applications.

2. METHOD

In this paper, a simple and cheap method of difference between waves of two centrifugal fans based on time delay of power starting was proposed to control low frequency noise.

The highest level in the noise level analysis in the studied fans was at 250 Hz. In the interference stage of the study, noise measurements were recorded in the time delay of 3, 6 and 8 ms for power starting for one of the fans. Noise measurement was

based on frequency weighing of dB(A) and dB(L) and slow mode condition by TES type 1358 sound level meter in an acoustic room where R_t=0.17s and NRC=0.7. Two centrifugal fans had consecutive serial numbers and were installed on a heavy structure and a rubber pad vibration isolator.

In this study, the first stage noise measurements were based on dB(A) for single and double fans in 346, 693, 1039 and 1385 rpm. In the second stage of study, interferences were conducted by using an electronic time delay controller. There was performed a comparison of 1/1 octave band frequency analysis of sound pressure level of two fans by interferences in any speed and time delay interferences in fan B based on leader frequency (250 Hz) consisting of 3,6 and 8 seconds. Figure 2 shows the microphone situation in the measuring room and figure 3 also shows the measuring diagram of power switch, electronic time delay controller, study fans and sound level meter position. Figure 4 shows the 1/1 octave band analysis of sound pressure level for study fans.

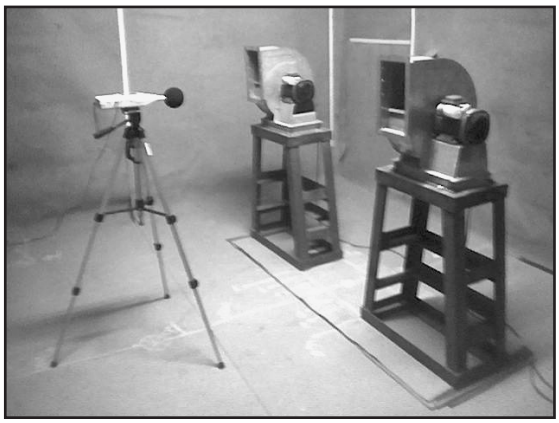

Figure 2. Microphone situation in the measuring room

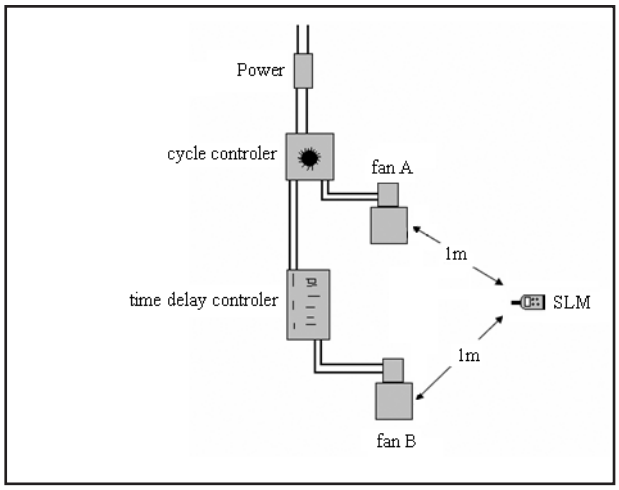

Figure 3. The measuring diagram

3. RESULTS

In the first stage of the study, the noise of fans was measured. Results of measurements in figure 4 showed that the highest level in the noise level analysis was at 250 Hz. In the second stage of the study, by using an electronic time delay controller based on the temperature of air and wavelength of sound, optimum interferences of power starting of fan B were calculated about 2 ms. In this stage, the time delay of 3, 6 and 8 ms was performed. In this assumption, the maximum

constructive interference was obtained on 8 ms and 6 ms equalling 4 ms and 2 ms, respectively. This limitation is caused by electronic effects. In the third stage of the study, interference noise was measured in rpms. Table 1 compares the total sound pressure level of two study fans in any speed. Table 2 compares the 1/1 octave band analysis of sound pressure level of two fans in any speed at 250 Hz. Table 3 compares 1/1 octave band analysis of sound pressure level of two fans by interferences at 1385 rpm.

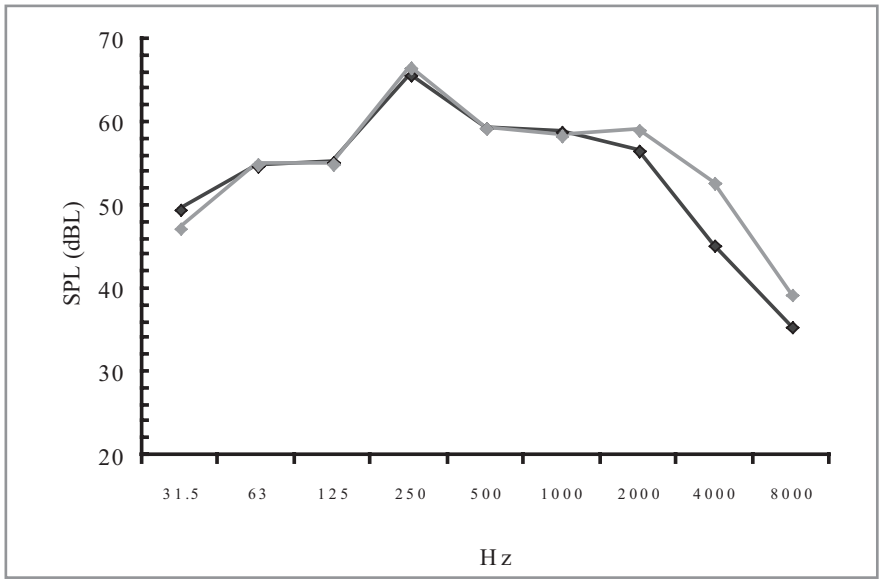

Figure 4. 1/1 octave band analysi of sound pressure level for study fans

Table 1- Comparison of total sound pressure level of two study fans in any speed

Total SPL dB(A)				
1385 rpm	**1039 rpm**	**693 rpm**	**346 rpm**	
73.4	72.5	70.8	70.2	0 (no effect)
73.1	71.8	70.5	70.4	3 (alert)
74	67.7	72.2	70.5	6 (constructive)
72.1	71.4	69.2	68.8	8 (destructive)

Table 2. Comparison of 1/1 octave band analysis of sound pressure level of two fans in any speeds at 250 Hz.

	SPL in 250 Hz dB(A)			
Time delay (ms)	**1385 rpm**	**1039 rpm**	**693 rpm**	**346 rpm**
71.4	70.1	67.4	68.1	0 (no effect)
70.9	68.8	66.9	67.9	3 (alert)
72.1	72.6	69.6	68.5	6 (constructive)
70.1	69.1	66.0	65.8	8 (destructive)

Table 3. Comparison of 1/1 octave band analysis of sound pressure level of two fans by interferences at 1385 rpm.

SPL dB(L)										
total	**8000Hz**		**4000**	**2000**	**1000**	**500**	**250**	**125**	**63**	**31.5**
73.4	40.7	53.8	61.4	61.2	62.7	71.4	59.2	59.7	50.4	0 (no effect)
73.1	43.4	55.9	61.7	62.4	63.2	70.9	59.2	59.5	50.1	3 (alert)
74	43.6	54.9	61.7	62.6	63.2	72.1	59.3	59.7	50.2	6 (constructive)
72.1	41.0	53.6	61.5	61.7	62.8	70.1	59.0	59.4	50.3	8 (destructive)

4. CONCLUSIONS

The most common noise control systems are already based on passive and active techniques. Passive noise control is a typical technique for high frequency noise and active noise control also for low frequency noise [8,9,10]. In this study, a simple and cheap method of difference between sound waves of two same centrifugal fans based on time delay of power starting was proposed for the control of low frequency noise. The highest level in the noise level analysis in study fans is shown at 250 Hz. Results of this study showed that time delay of 8 ms for fan B was the best destructive interference equal in 1.3 dB in total sound pressure level of the same two fans in receiver point. Also, in the leader frequency of noise (250 Hz), this noise reduction for time delay of 8 ms was 2.3 dB at 346 rpm and 1.3 dB at 1385 rpm. This interference method for 3 ms had a Alert effect while it had a constructive effect for 6 ms. Results of this study were confirmed with wave interference theory because in the maximum constructive interference for the waves with the same phase, there was a 3 dB increase. In this study by time delay of 8 ms that resulted in 180° out of phase, there was obtained a maximum of 2.3 dB reduction in fan noise levels. On the other hand, time delay of 6 ms for fan B had a constructive effect equaling 0.6 dB. Results also showed a maximum reduction of noise at 250 Hz by time delay of 8 ms. This study presented an effective method of the electrical noise control for low frequency noise. Time delay noise control method reported in this paper can be applied in an extensive range of great practical applications of industrial noise sources such as fans. Calculation showed if the same sources increase to 8, by time delay method, noise reduction could be up to 5.5 dB. Time delay method for large scale uses will need an electronic controller so that there will be obtained optimization of noise reduction. Although, in comparison with passive and active methods of noise control, this method had weak results of noise reduction, but simplicity of method and cost benefit make it effective for noise control.

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LOVELY LEGISLATION

South Ajax (Canada) residents ask: why can't the Town's noise bylaw be used to deal with a motorist riding a motorcycle at 4 a.m. Answer: the statute can't be used on a vehicle licenced by the Province.

BRANDS HATCH

Brands Hatch has signed a deal to reduce noise and disturbance at its events. Owners of the race track in Longfield, Kent, drew up the deal with Sevenoaks District Council, after listening to proposals form residents groups. The voluntary agreement sets out days and times of operation, noise limits, as well as a code of practice for tannoy use and aircraft flight paths. A special phone line and email address has been set up for complaints. Jonathan Palmer, chief executive of Motorsport Vision Ltd., which owns the track, said the firm was eater to create the minimum disturbance necessary. "Whilst motor racing will inevitably create some noise, we have now finalised a very detailed management plan that will ensure noise from Brands Hatch progressively decreases in future," he said. Robin Hales, chief executive of Sevenoaks District Council said: "By working closely with the owners of the circuit to develop its first ever noise action plan, local people will receive greater protection from noise disturbance."

EU ORDERS QUIET IN CZECH REPUBLIC

For some time, environmental experts have been concerned that as many as half a million Czechs are exposed to night-time noises exceeding 60 decibels mainly caused by car traffic. Meanwhile, a recently issued Health Ministry map illustrates that all across the country Czechs are exposed to dangerously high levels of noise both day and night, with the municipalities of Ostrovacice, Polom and Slavnic officially designated the noisiest in the Czech Republic. The EU believes that high noise levels are causing thousands of heart-related deaths around Europe each year, with sleep deprivation leading to stress and high blood pressure. The Czech Republic has been issued with a deadline - by June 18, it must present a concrete plan of action to the EU detailing how it will deal with the problem. The plans must be formulated on a regional basis, with, for example, the city of Brno coming under the purview of the south Moravia region. The only exception is Prague, whose city government must formulate its own strategy. Encouraging more people to abandon their cars and use public transport is viewed as one crucial solution, while technology also has a role to play, with noise-reducing surfaces on roads, as well as insulating walls also playing a key role. However, concerns have already been voiced that the Czech authorities will simply not be able to formulate these plans in time. In that case, the European Commission has the power to take legal action against the country and ultimately impose fines totalling millions of Euros. Prague authorities have already announced that they will be unable to meet the deadline in time. Other regions are also facing a series of technical and logistical difficulties, in fact, only one region - Moravia-Silesi – says that it should meet the deadline.

THE LETTER OF THE LAW

A Mooloolaba man (Australia) who has fought Main Roads for 12 years to get noise and pollution barriers erected has been forced to abandon his backyard because of traffic noise. Michael Weston, said the continual racket from the Sunshine Motorway, about 50 metres from his back fence, was unbearable. While Main Roads constructed soundproof barriers for his neighbours, Mr Weston's property is in what the neighbourhood calls the "missing link" – a 200-metre gap between Emerald Springs and Palmview. "It's the same as sitting under a flight path where the planes are landing continuously," Mr Weston said. "We've got to do all the entertaining inside, we don't use the backyard, plus it's always filthy from the pollution. We can't keep it clean." The Westons built their home, which backs on to a part-rainforest nature strip, in 1988 when the road behind then was an eight metre-wide single lane bypass. The section of the Sunshine Motorway behind the property was built six years later in 1994. In 1999, Mr Weston headed up a petition for more noise protection. Hundreds of residents signed. In 2006 Main Roads conducted sound tests in Mr Weston's backyard. They found the level was 64 decibels, averaged over 18 hours. The level at which Main Roads is required to take noise-reduction measures on new roads is 63 decibels. However, under the department's 1992 noise policy, the intervention criteria is 68 decibels for "old roads", which includes the Sunshine Motorway because, even though it was built in the early '90s, it was gazetted well before then. "Now, it's a six-lane highway and they're saying it's not a new road," Mr Weston said.

NEIGHBOURS

Tracey Kirby, 33, of Hyndburn (near Blackburn) has been upsetting her neighbours by playing music very loudly at all times of day and night. The neighbours complained to the Council and, in October 2006, Miss Kirby was served with a noise abatement notice. Which she ignored. And it was not until September 2007 that she was convicted at the Magistrates Court of breaking the noise abatement notice: fined £100 and ordered to surrender her music equipment. Except it took another six months – during which the music played on – for the Council to obtain warrants and a forfeiture order, to enter her home and seize the equipment. Whereupon she went out and got replacements. The music plays on.

* * *

A recent survey conducted by Mori has shown that nearly half of the UK's population feels their life suffers due to noise when they are at home. This figure has risen 35 % since 2006, and 2% of people surveyed say they had moved house to escape noisy neighbours.

ZURICH AIRPORT

Switzerland and Germany have agreed to a fresh start in efforts to solve a long-standing dispute over flight noise from Zurich aiport. A working grpoup, which has been inactive for two years, is to meet again to try to work out an accord on noise levels caused by flights into and out of the airport passing over nearby German territory. The group, which includes representatives of the Swiss Federal Civil Aviation Office and the German transport ministry, is to prepare a study on the noise pollution problems on each side of the border. In 2003 the Swiss parliament rejected an agreement aimed at satisfying both countries, a move that prompted Berlin to impose restrictions on inbound flights to Zurich, Switzerland's busiest airport.

FIRST AMENDMENT RIGHT TO MAKE A RACKET

The Washington D.C. Council has narrowly backed an effort to limit daytime noise levels on city streets, a measure heralded by community leaders but condemned by local unions as a crushing blow to their First Amendment rights. The measure, approved by an 8-5 vote, would limit non-commercial amplified speech between 7 a.m. and 9 p.m. to 70 decibels in residential areas and 80 decibels downtown and in certain mixed zones – or 10 decibels louder than the surrounding noise. "We're the nation's capital," said Ward 2 Councilman Jack Evans, whose proposed amendment to limit the restrictions to residential areas was rejected. "We're supposed to be on the cutting edge. Now that we're restricting a certain freedom, in an environment in the last eight years where we've restricted a lot of freedoms, this gets a little scary." John Boardman, executive secretary of Local 25, called the bill "particularly onerous." Local 25 represents food and beverage workers who often picket outside hotels. "You have the right to say what you want but you won't be heard," Boardman said. Evans, whose opposition to the bill drew protesters with bullhorns to his Georgetown home, said 70 decibels would eviscerate lawful demonstrations.

CANBERRA POWER STATION

A proposed Canberra "technology city" power station and data centre development has struck a hurdle with the news that the noise it makes will exceed current environmental protection regulations. Two sites were found to be above the current ACT zone criteria in the acoustic report supplied by Bassett Consulting Engineers. The report was submitted to the ACT Planning and Land Authority. Macarthur residents worry about the effect of noise on their homes. One, Peter Moore, said a power station in the Tuggeranong district was not the problem. "No one disagrees that's it's a good idea for Canberra. It's just what we are after. But the fact that you are putting it in a suburb is the problem," Mr Moore said. The Bassett assessment found that, "Noise levels at the site boundary immediately to the west and north of the full capacity gas fired plant machinery slightly exceeds the night time industrial zone criteria." The proposed gas power station is currently designated as broadacre land subject to zone E noise standards. The Bassett acoustics team believed the area would be rezoned to allow for a higher level of noise. "It is expected that the entire area will be rezoned as industrial and therefore designated as Zone A, with emission criteria of 65 dB during the day and 55dB at night."

DEEPING ST. NICHOLAS WINDFARM

Jane and Julian Davis left their Deeping St Nicholas, Lincolnshire, home at Christmas 2006 after months of sleepless nights due to noise and vibration from wind turbines, which are less than 1km from their house. After complaints to the Local Government Ombudsman over the handling of their issue by South Holland District Council, monitoring of noise levels will now take place once more to establish the extent of the issue. Mr and Mrs Davis believe the council has refused to take enforcement action relating to a planning condition which should limit the noise from the Deeping St Nicholas windfarm, and claim monitoring by the council in October 2007, which concluded there was no problem, is invalid because the turbines were only operating at a third of their capacity. The condition was imposed by a planning inspector, and now must be investigated by the Parliamentary Ombudsman. But Mr and Mrs Davis believe the basis of measurement for wind turbine noise against background noise, guidance known as ETSU-97, is flawed, and the ombudsman agreed it was open to interpretation. Mrs Davis said: "What councils are finding is that it is very difficult to measure wind turbine noise using ETSU-97.