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Analysis of Split Air Conditioner Noise using Sound Intensity Mapping

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Abstract – *This paper describes the noise generation and noise source identification for air conditioner noise using sound intensity method. Split unit air conditioners have an indoor unit and an outdoor unit connected by communication pipes. Noise can be reduced the efficiency and performance of the air conditioner. In order to identify and analysis of noise at air conditioner system, experiment has been conducted using sound intensity mapping method. The investigation is carried out by varying the parameters which are the fan speed and temperature. A grid rig was developed to set noise location and rating by locating the microphone at rig point. The noise mapping is presented in contour form to indicate the different level of noises from different location. The highest noise sound levels occur at the front side of air conditioner which is about 74.78 dB at the fan. The second highest noise sound level is occur at the right side of the compressor is 72.11dB. Sound power level is proportional to fan speed at the lowest temperature of the air conditioner. This method can be applied on-site rather than in an anechoic chamber as long as the background noises are stationary.*

Keywords: Noise Mapping, Sound Intensity, Noise Source, Air Conditioner

1.0 INTRODUCTION

Air conditioners are typically categorized into split-type and multi-type air conditioners. Split-type air conditioners have an indoor unit and an outdoor unit connected by communication pipes. Multi-type air conditioners have plural indoor units connected to an outdoor unit. Air conditioners may also be categorized into ones that air conditioners operate a refrigerant cycle in one direction to only supply a room with cool air, and ones that selectively operate a refrigerant cycle in two directions to supply a room with hot or cool air. Now days, mostly every home has their own air conditioner system is to provide comfort during hot days and nights. A frequent problem for the air conditioner manufacture is the noise comes from the air conditioner. Noise is considered undesirable and the cause of the noise may in some cases even limit the heating or cooling efficiency of the air conditioner. In this research, noise source identification of split unit air-conditioner system was determined by experimental approach.

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The noise produced by air conditioning unit probably caused by several mechanical and aerodynamics sources such vibration of the compressor shell, electric motor vibration and fan noise [1]. Any mechanical coupling of such source as the fans, the compressor or the electric motor will cause the cabinet panel to vibrate and radiate acoustics energy. The most annoying source of noise at some air-conditioning units appears to be due to the vibration of the electric motors at 120 Hz and harmonics [1,2]. Actually this vibration is due to fluctuations in the magnetic forces [2]. There are some studies on the fan noise have found that it is involved experiment with minor geometry changes of fan to reduce noise. Morinushi [3] have reported that minor changes in the location can have minimal effects on fan performance. This is parallel with Graham [4] stated that fan performance and efficiency are normally negatively affected by such changes. Field survey of the disturbance caused by the noise of outdoors residential air conditioner units [5]. Leventhall and Wise [6] reviewed the design specifications especially for low frequency noise and discussed the dominants factors in noise complaints. Noise mapping from air conditioned noise in classroom have been discussed by Lilly [7]. Research on the basic acoustical measurement methods based on sound pressure measurement to determine the sound power radiated from fans [8]. Basically, prediction of dominant noise source is very important in machinery noise control problem [9]. There are several standards for sound intensity measurements completed or under progress. ISO 9614 governs sound power determinations based on sound intensity [10-12]. This standard divided into two parts, one use for point measurements (ISO 9614-1) and another one makes use for scanned measurements (ISO 9614-2). However ISO 9614-2 is the most popular method and can be used for engineering and survey grade determination of sound power. Furthermore, ISO 9614 has been extended to allow scanned measurements to be for precision grade determination of sound power (ISO 9614-3).

2.0 TEST RIG

Simple test rig have been fabricated to locate the microphone in order to measure noise at particular location. . The measurement will focus on the cross section in z-direction. The rig is design by using Solidwork and the dimension of the rig is 90 cm x 70 cm as shown in Fig. 1 (CAD) and fabricated test rig in Fig. 2. Each section of the cross section for the mapping is 10 cm x 10 cm and it was follow the International Standard ISO/DIS 9614-1.

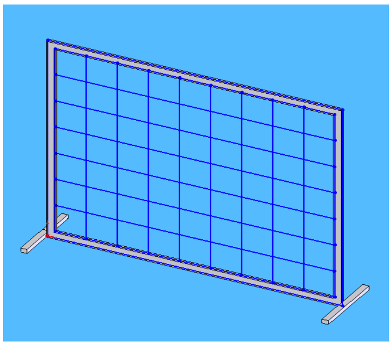

Figure 1: CAD of Test Rig

Figure 2: Fabricated of Test Rig

3.0 RESULT AND DISCUSSION

Noise generated from air conditioner systems was measured from different view to find out the noise contribution. Sound power is a measure of the amount of sound energy a sound source produces per unit time, independent of its surroundings. Sound power has a number of useful applications. It can be used to calculate the approximate sound pressure level at a given distance from a machine operating in a specified environment. It can be compare the noise radiated by machine of the same or different type. In this section, different temperature and fan speed were used to identify where the noise source of the air conditioner system always occurs. It easy to determine the source depends on the colour that obtain from the mapping process. The noise level indicator will present the value depends on the colour of the measurements. Table 1 shows that for high 20 ^{o}C give the highest value of sound power level at critical point foremost at all sides compare to the other different temperature. An even show that at the front side shows the increments of sound power level but for the other side it present that the highest value still at high 20 ^{o}C. The a-weighted one-third band sound power levels radiated by different parts of the units were determined from sound intensity measurements made on different parts of the air conditioner and for different temperatures and different speed of fan.

Table 1: Sound Power Level at critical point for different temperature

Sides\Parameter	Sound Power Level (dB)		
	High at 20 ^{o}C	High at 22 ^{o}C	High at 24 ^{o}C
Front	74.7	75.7	75.7
Back	66.3	64.3	65.9
Right	72.1	67.6	70.3
Left	59.4	56.9	58.3

Table 2 shows the details value of noise level at different location to determine where the highest sound signal radiated from the front side of air conditioner. The sound power radiated of about 74.8 dB. Table 3 shows the details value of noise level at different location to determine where the highest sound signal radiated from back side of the air conditioner. The sound power level obtain is about 66.3 dB at the highest peak of frequency is 630 Hz. From the observation, the noise come forms the vibration of the housing of the air conditioner with the floor.

Table 2: Sound power level at the critical point at the front side for 20^{o}C

Location	Noise level, dB	Location	Noise level, dB
1	71.2	6	71.5
2	74.7	7	74.8
3	71.8	8	71.1
4	71.6	9	67.8
5	68.7	10	69.2

Table 3: Sound power level at the critical point at the back side 20^{o}C

Location	Noise level, dB	Location	Noise level, dB
1	62.5	5	62.9
2	64.9	6	62.4
3	66.3	7	62.3
4	64.4	8	62.2

Figure 3 shown a-weighted one-third band sound power levels for the sound radiated form high speed of fan and temperature 20^{o}C at a front side. Fig. 4 shows a-weighted one-third band sound power levels result for the back side of the air conditioning unit.

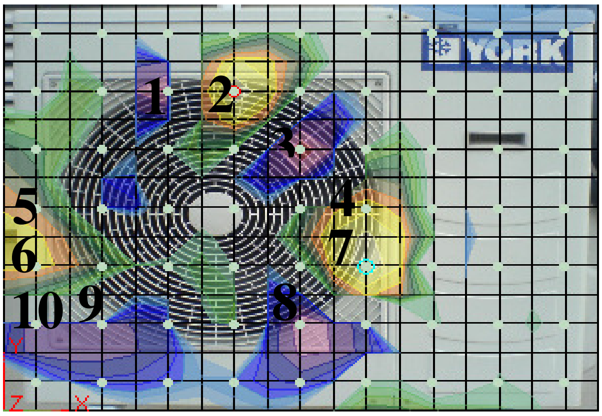

Figure 3: Noise sources for high speed fan at 20^{o}C the front side

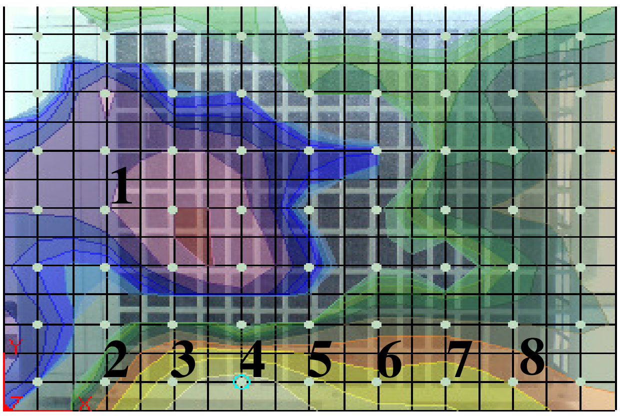

Figure 4: Noise sources for high speed fan at 20^{o}C at the back side

Table 4 shows the details value of noise level at different location to determine where the highest sound signal radiated from the right side of air conditioner. The total sound power levels is increased is about 5dB from the back side. This shows that the noise at the compressor radiated more at the right side. Table 5 shows the details value of noise level at different location to determine where the highest sound signal radiated from the air conditioner. Form the noise mapping it gives 59.409dB at 160Hz for the total sound power levels. The sound power levels are low compare to the front side because the noise from the fan radiated more from the front side.

Table 4: Sound power level at the critical point at the right side for 20^{o}C

Location	Noise level, dB	Location	Noise level, dB	Location	Noise level, dB
1	69.226	5	69.817	9	70.284
2	68.448	6	72.115	10	71.048
3	69.198	7	68.741	11	69.698
4	70.876	8	71.448	12	70.385

Table 5: Sound power level at the critical point at the left side for 20^{o}C

Location	Noise level, dB	Location	Noise level, dB	Location	Noise level, dB
1	57.902	5	59.409	9	57.051
2	55.204	6	57.848	10	57.24
3	58.341	7	57.193	11	57.178
4	58.28	8	56.762	12	57.075

4.0 SUMMARY

The result obtained from the sound intensity mapping process shows that for different temperature and different fan speed gives different effect on the noise signal as had been proved in this project. Sound power level will increase as higher fan speed and the lowest temperature of the air conditioner. From the analysis of the data it can be concluded that the highest noise sound levels occur at the front side which is at the fan that is about 74.8 dB. The second highest noise sound level is occur at the right side which is at the compressor is about 72.1 dB. The results that get from the analysis give the similar result with two papers that shows the noise generated from the air conditioner systems always occurred at the fan and compressor.

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