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Measurements of Vibration and Noise Level at Different Cement Companies

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ABSTRACT

The aim of this article is to compare Vibration and Noise measurements caused by different types of Machines at cement factories with the standard evaluation criteria of Vibration ISO 2631 – 4 EVS – EN 5349 – 2 and Noise following the standard ISO 9612 – 2009. Two cement companies were chosen, the first is located at Baddish district, 30km west of Mosul city (Iraq), which is called Baddish general cement company, while the other is located south of Mosul, and is called Hammam Al-Alil general cement company. Three stations were chosen for each company (raw materials grinding mills, cement grinding mills and exhaust fan stations) having different electrical motor capacities. Noise level meter and vibration level meter manufactured by B & K (DENEMARK) were used for measurement. The location of bearing were chosen for vibration measurement, while the location of the operator ears for noise measurement, where chosen. It was found that most of the readings in vibration levels were unacceptable according to the evaluation criterion of vibration magnitude and noise level higher than 85dBA due to rotating unbalance misalignment and faulty gear matching (ISO 1940/1, 1990).

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قياسات الاهتزاز ومستوى الضوضاء في شركات الأسمنت المختلفة

صباح محمد جميل علي / كلية الهندسة , جامعة الكتاب , كركوك , العراق
هبة حسين علوان / كلية الهندسة , جامعة نولج , اربيل , العراق

الخلاصة

الهدف من هذه الدراسة هو مقارنة قياسات الاهتزازات والضوضاء الناتجة عن أنواع مختلفة من المكائن في مصانع الأسمنت بمعايير التقييم القياسية للاهتزازات (Vibration ISO 2631 - 4 EVS - EN 5349 - 2 لـ) والضوضاء باتباع ISO 9612 - 2009 القياسية. تم اختيار شركتين للأسمنت، الأولى تقع في منطقة بادوش، على بعد 30 كم غرب مدينة الموصل (العراق)، والتي تسمى شركة الأسمنت العامة بادوش، بينما تقع الأخرى جنوب الموصل، وتسمى شركة حمام العليل للأسمنت العامة. تم اختيار ثلاث محطات انتاجية لكل شركة (طواحين طحن المواد الخام ، وطواحين طحن الأسمنت ومحطات العادم) لديها قدرات محركات قدرات كهربائية مختلفة. استخدام مقاييس مستوى الضوضاء ومقاييس مستوى الاهتزاز بواسطة جهازين مصنوعين من قبل شركة B & K (Denmark)للقياس حيث تم اختيار مواقع المحامل لقياس الاهتزاز ، في حين أن موقع آذان المشغل لقياس الضوضاء. وقد وجد ان مديات مستويات الاهتزازات والضوضاء دون المستوى المقبول وفقا لمعايير تقييم حجم الاهتزاز وأعلى من 85 dBA لمستوى الضوضاء بسبب عدم الاتزان في مكائن الدوران ، وعدم الاستقامة في المحاور الدوارة هما الاسباب الرئيسية (ISO 1940/1) ، (1990).

الكلمات الدالة: الاهتزازات ، الضوضاء ، مراقبة الأداء ، الأسمنت, مقاييس مديات الاهتزازات

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1. INTRODUCTION

Measurement of vibration and noise level of varies machines at any cement company helps the Engineering maintenance officials of the company to observe the variation of vibration and noise level for each machine during the operation period. It helps for the indication and monitoring of the machines performance and gives immediate warning whenever the vibration level increasing above the recommended level of that machine. This will give a warning before the failure occurs [1].

Cement plants are one of the major areas that play a significant role in the economy of countries. The cement product is a significant input for numbers of civil and minatory industries all over the world. It has a large function in many industries, the line of cement production is important for continuous production, and

any stoppages for any part of production processing, will causes damage of production and ultimately a loss of money to the company. Most of the causes of stoppages are due to a high vibration and noise level (unacceptable); these are due to rotating unbalance, gear misalignment and bearing failures [2].

Thus, continuous monitoring the station of machines are important in any cement companies, the monitoring can be consider as vibration measurement at different working times for each machine and recording the continuity of line production as shown in Fig. 1 before failure occurs.

The high level of vibration will create rapping between the rotating shafts and bearing causing Noise arising bearing Temperature.

Noise in work environment is the major cause of concern for safety and health of the factory workers [3].

Regulations limiting the Noise exposure of industrial workers have been instituted in different countries because they have a high acoustics power.

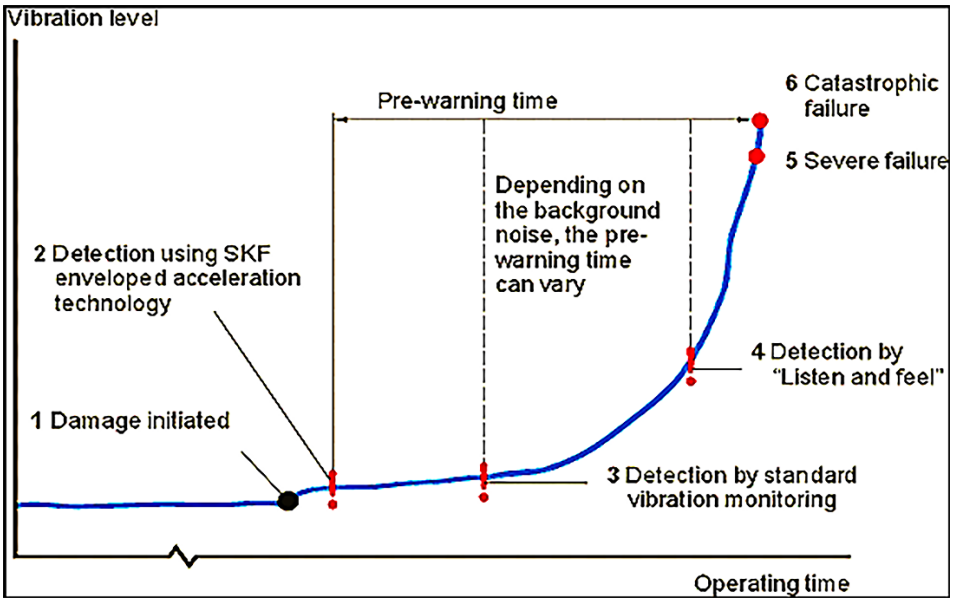

Fig .1 The relation between the Vibration of Machine with time [2]

2. EXPERMENTS AND PROCEDURE

In general, there are several types of vibrations including natural vibration, transient vibration, and forced vibration [4]. To recognize the type of vibration, a series of measurements were conducted at each station for vibration measurement using Bruel and Kajer vibration equipment with its accelerometer's shown in Fig. 2. (a), together with noise emission using noise level meter as shown in Fig.2 (b)

Fig .2. (a) Vibration Measurement Instrument

Three machine stations were chosen for each company, raw materials crusher Mills, cement grinding mills and exhaust fan for the kiln. The accelerometer was mounted on the bearing of each unit at X-Y axis individually as shown in Fig.3.

Fig .2. (b) Noise level meter

Each mill consists of electrical motor with (1000 *R.P.M*) fed into a reduction gear having five stages to reduce the speed to (15 *R.P.M*) to rotate the drum of the mill that contains balls made from steel inside it to crush the raw materials or the cement production line. Fig.4 shows general layout of the mills unit and points of accelerometer locations for measurements.

Where points (1-8) show the location of the accelerometer attached point. Three points were selected for noise pressure measurements using portable noise level meter mounted at the level of the operator's ear, 1,2 at Front ,3, 4 at the Back.

The readings were repeated at point (1- 6) for vibration measurement of the exhaust-fan shown in Fig. 5 and the points (1, 2) and (3, 4) below for noise pressure measurements.

The measured vibration and the noise level of raw materials mills, grinding mills and exhortation for both companies are listed in Tables (1 – 4).

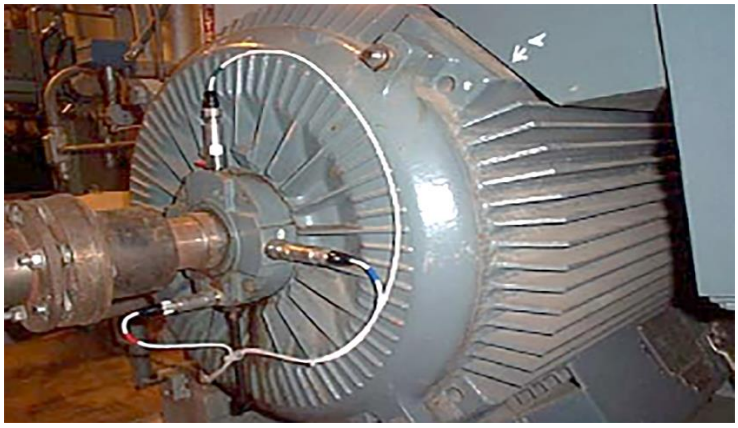

Fig .3. location of Measuring Bearing Vibration

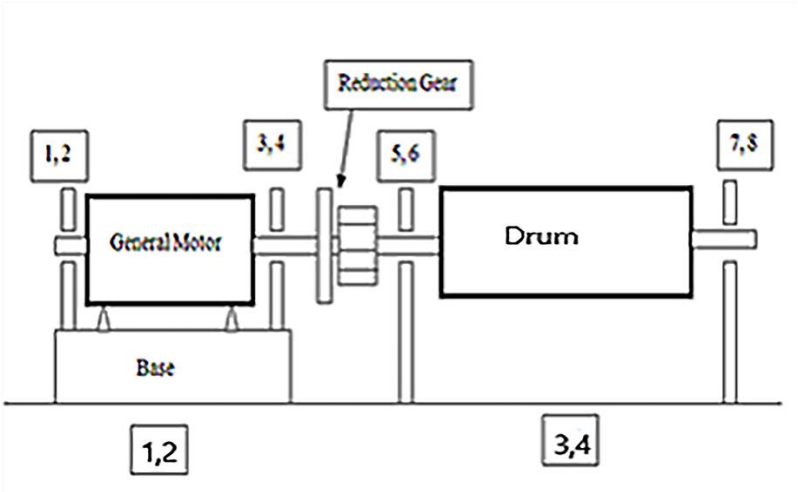

Fig .4. general layout of the mills unit and points of accelerometer locations.

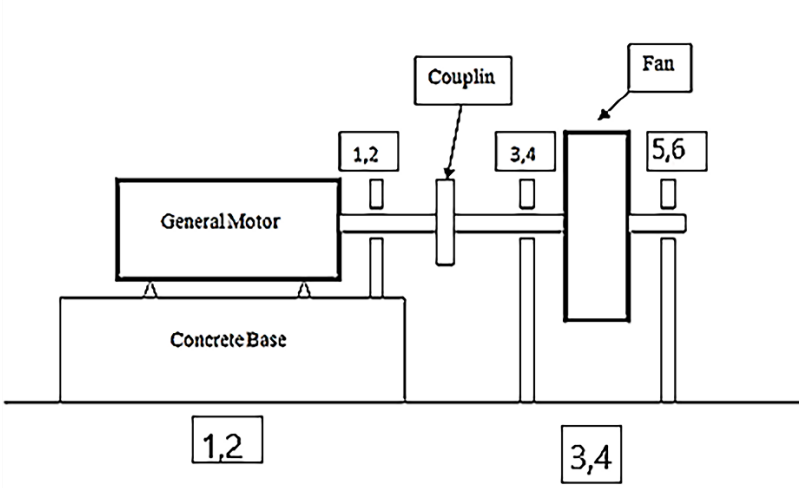

Fig .5. the station of vibration measurement

3. SOFTWARE FOR NOISE ANALYSIS

In order to analyze the noise signals and to find the causes, the signal fed from sound level meter into Frequency analyzer, then to the computer using the MATLAB program. The computer program prepared for the results simulators can be used to understand the performance of the system [5] and the most important functions used is the function that can feed the noise signal to the program so that we can later analyze the signal and obtain the variables obtained compared to the normal state of the system. It also includes the introduction of some special variables (such as Sampling Frequency) and Number of Samples. Through the program was as following:

1. Calculate the value of the RMS and the Max value of the segmented signals by analyzing the signal depend on the Time Domain.
2. Frequency analysis in frequency domain using Fourier analysis technique (FFT) [6].

Figure (6 a & b) show the wave of the sound when there is not any irregular sound in the system.

In our article, the result of the sound wave for the system is calculated by using Fast Fourier Technique shown in Figure (7), irregular shape of the sound wave of stable system of the wave.

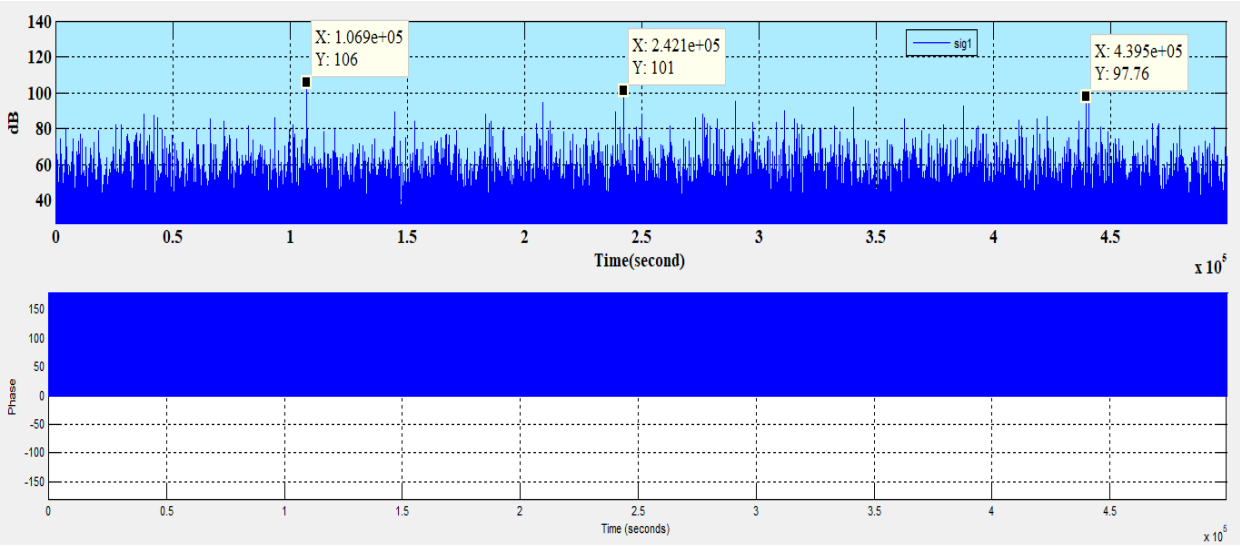

Fig. 6. (a) The regular wave sound of the system

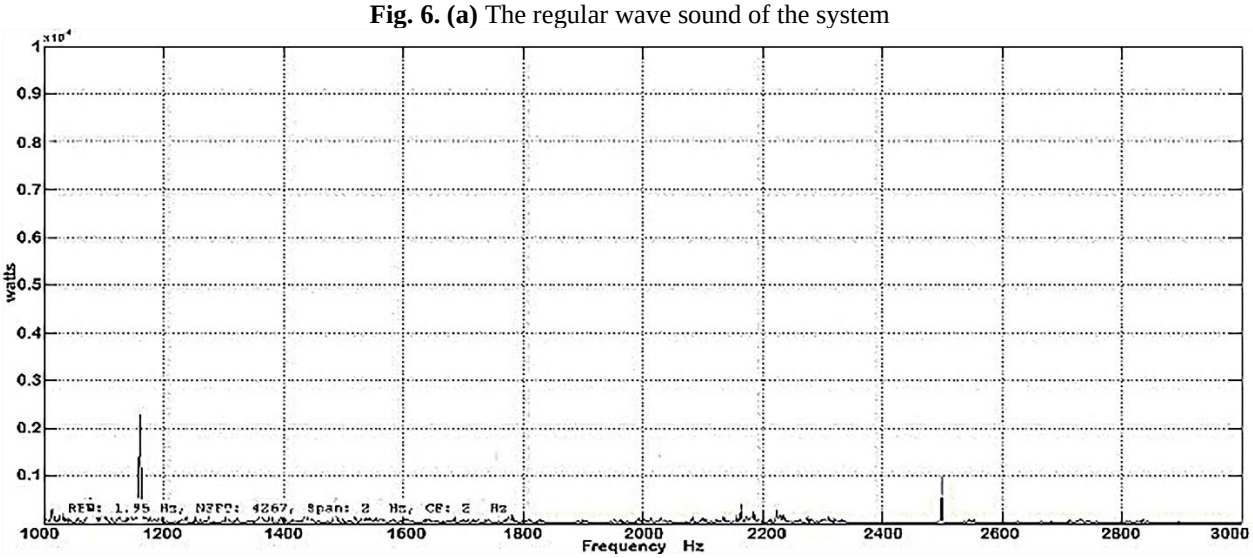

Fig. 6. (b) The regular sound wave of the system separated from other surrounding sounds.

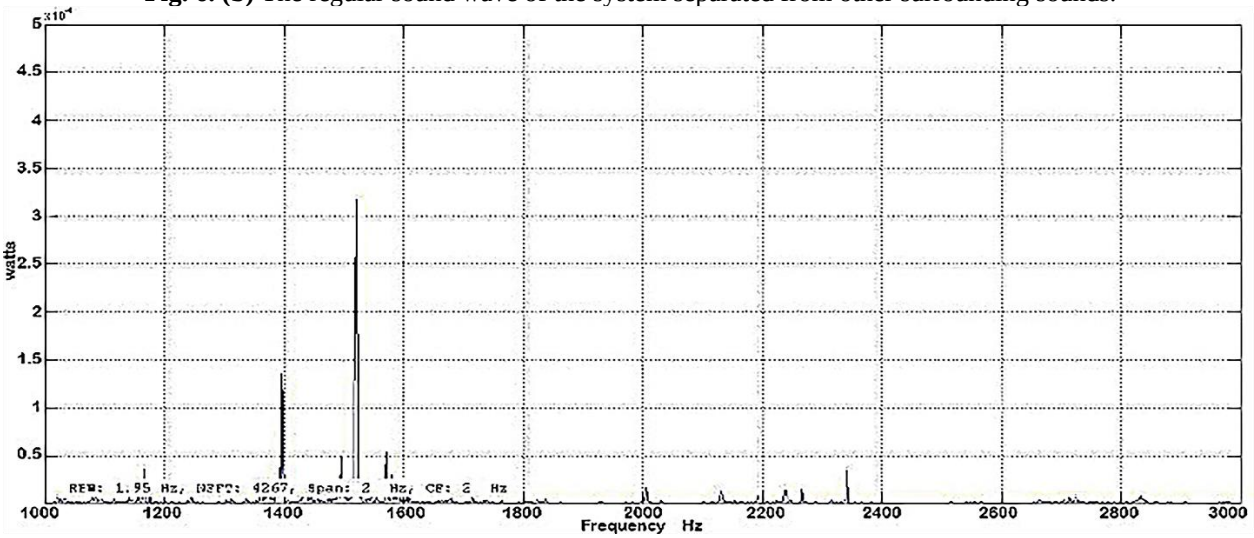

Fig. 7. Irregular shape of the sound wave of the system.

4. DISSCUSSION

Before rushing into discussion of our results, it is important to look at the cement process, as shown in Fig. 8.

Cement plants have hundreds of rotating parts [7], typical machinery unit consists of many equipment; fan, pumps, compressor, motor and drum. In addition, the rotary kiln. Each equipment has several bearings, reduction gears, which has many degrees of freedom of vibration level. The combined effects of all units make noise and rise of bearing temperature [8].

Most of the research were concentrated on machinery vibration and noise, which are available in, many books of vibration. Some work was done on the reaction phenomenon [9], which creates vibration due to a lack of imperfect matching. The work done on noise pollution and the effects on human health by many researchers due to the fact that industrial laws in many countries provide protection to workers from noise pollution exceeds the (85 *dBA*) [10].

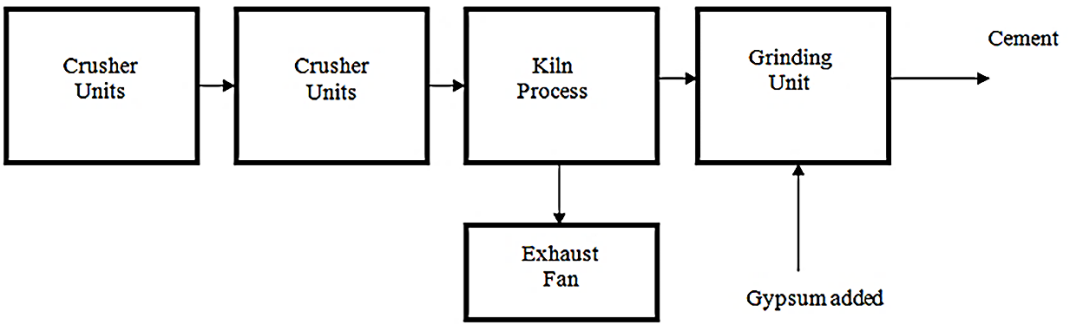

Fig. 8. Stages of Cement Processes

4.1 HAMAM AL-ALIL COMPANY

Back to Table 5, for Hamam Al-Alil Company (see Tables 1, 2), which represent typical evaluation criteria of vibration magnitude, since the mills unit can be assumed to be (≥ 75 *KW* class IV (large soft foundation)). Thus, most of the readings at different locations can be assumed within satisfactory except location 7, 8 at zone Unsatisfactory, (high level of vibration).

Table 1
Vibration Measurement

Raw material mills stations (*mm/s*)

Location 1	**1**	**3**	**5**	**7**
Vertical	4.5	7.1	6	11.2
Location 2	2	4	6	8
Radial	5.5	6.8	5.9	8.3

Cement grinding mills station (*mm/s*)

Location 1	**1**	**3**	**5**	**7**
Vertical	5.5	6.8	9.5	10.5
Location 2	2	4	6	8
Radial	6.2	7	6.5	8.1

Exhaust fan station (*mm/s*)

Location 1	**1**	**3**	**5**
Vertical	2.8	3.5	4.1
Location 2	2	4	6
Radial	3.1	3.4	3.9

Raw materials mill and cement grinding mills readings are existing in zone Unsatisfactory which is in high vibration level, due to unbalance because the steel balls inside the mills - crush of the raw materials, or the cement located inside the Drum causing unbalance of the Mills.

The measurements of these locations should be repeated in varies periods time and careful observation to the bearing should be paid in order to avoid high level of vibration, ultimately causing damages to those parts.

In order to know, causes of high-level vibration readings, the vibration meter is to be connected to frequency analyzers, recorder, and computer. This will give different frequency levels, each type of frequency will show certain reasons such as unbalance of rotating masses, misalignment, imperfect matching.

For exhaust fan vibration level, most of the reading is existing within zone Good and Satisfactory, which are acceptable Table 5. For noise measurements most of the readings are (> 85 *dBA*). These are due to the rotation of the mills at (15 *R.P.M*) causing an aerodynamic noise, and also due to the noise generated by steel balls smashing the raw materials for the Raw-Materials mills. This due to aerodynamic noise and the cement clinkers for the cement grinding mills. The housing walls of the gearbox oscillate with natural frequencies and emit sound waves to the surrounding [11].

Table 2
dBA

Location 1	**1**	**2**	**3**	**4**
Raw-Material Mills Station	99	105	105	100
Cement grinding mills station	105	106	106	104
Exhaust fan station	90	95	95	90

4.2 BADDISH COMPANY

Again, location 7, 8 for both raw materials mills and cement grinding mills Table 3 show high level of vibration located on zone Unsatisfactory, and the reason mentioned for Hamam Al-Alil Machines is the same for

Baddish Machines. Again attention should be paid for further measurements and vibration analysis is required. For the exhaust fan most of the reading is located at zone Good, and Satisfactory which is within the limits Table 5. For noise measurement Table 4 most of the readings were (> 85 *dBA*), due to rotating unbalance which causes the shaft to bend slightly and rub the main bearing, breaking the oil film as shown in Fig.9 also, aerodynamic noise generated by the drum rotation [13].

Table 3
Vibration measurements

Raw-material mills stations

Location 1	**1**	**3**	**5**	**7**
Vertical	6.5	7.5	6.5	12.2
Location 2	2	4	6	8
Radial	6.4	6.9	7.1	9.5

Cement grinding mills station (*mm/s*)

Location 1	**1**	**3**	**5**	**7**
Vertical	6.4	7.1	10	11
Location 2	2	4	6	8
Radial	7.1	7.5	7.8	9.5

Exhaust fan station (mm/s)

Location 1	**1**	**3**	**5**
Vertical	3.5	4.5	4.9
Location 2	2	4	6
Radial	3.4	3.9	4.2

Table 4
Noise pressure level measurement (*dBA*)

Location 1	**1**	**2**	**3**	**4**
Raw-material, Mills station	110	105	109	100
Cement grinding mills station	110	103	110	105
Exhaust fan station	90	92	92	95

For Noise measurements, most of the readings (> 85*dBA)* due to the same reasons mentioned for Hamam Al-Alil machines: cement grinding mills, raw materials mills, and for exhaust fans.

5. CONCLUSIONS

From the result of this work, we conclude:

1- From the noise power level and vibration velocity of Cement Machines at different periods of times through their work can be measured periodically in order to predict the Performance of machines.
2- In order to keep all rotating Performance of cement factories in satisfactory level condition of noise power level and vibration levels, should be taken in consideration the weekly testing of vibration and noise level as an important maintenance program of the company. It includes balancing of rotating parts and alignment of the machines.

6. RECOMMENDATION FOR THE FUTURE WORK

Fixed accelerometers can be built on each bearing of rotating machine for vibration monitory and alarms generated when vibration levels skip the limits and fixed by the evaluation criteria zone vibration magnitude. Further investigation could be done by connecting the vibration meter to frequency analyzer using Frequency Analysis Technique in order to known the causes of high vibration level. In addition, air muffles should be supplied to all operators in order to avoid damages to their ears. Noise berries should be built between machines to avoid vibration and noise transmission [14].

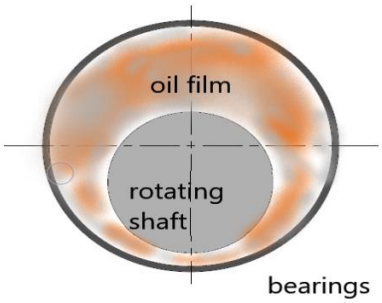

Fig .9. Unbalance rotation of the shaft inside the bearing

Table 7
Typical evaluation criteria zone vibration magnitude (*mm/s*) [12]

VIBRATION SEVERITY PER ISO 10816						
	Machine		Class I small machines	Class II medium machines	Class III large rigid foundation	Class IV large soft foundation
	in/s	mm/s				
Vibration Velocity Vrms	0.01	0.28				
	0.02	0.45				
	0.03	0.71		good		
	0.04	1.12				
	0.07	1.80				
	0.11	2.80		satisfactory		
	0.18	4.50				
	0.28	7.10		unsatisfactory		
	0.44	11.2				
	0.70	18.0				
	0.71	28.0		unacceptable		
	1.10	45.0				

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