Diagnosis of Faulty Induction Motor using different sensor

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Abstract—

Single phase induction motor is being the most widely used in different devices at the recent years, which make it a subject to a different failure. This paper presents a measured data calculations and analyzed using different sensors for detecting the single phase induction motor failure. The acoustic wave is currently being used in a wide range of sensing fields including physical sensing, chemical sensing and bio-sensing. One of the most important acoustic sensor is piezoelectric, Piezoelectric was used to detect the acoustic wave generated from these motors, any changes in these acoustic it will be detect to indicate for some occurred failure with in these motors. Another alternative sensor has been used is the modified optical fiber. The modified optical fiber sensor is constructed in a short segment of unshielded the outer sheath and replaced with a cd disk. This fiber was worked as an acoustic sensor by moving the acoustic signal across the fiber tube due to the difference in the refractive index in the 1mm unshielded area. In this study different experiment have been a accomplished and analyzed for detecting the induction motor failure which provided an information that will enable for future modification of sensors.

الخلاصة:

تعد المحركات الحثية ذات الطور الواحد هي الأكثر استخداما على نطاق واسع في الأجهزة المختلفة للسنوات الاخيرة، مما يجعلها عرضة لأنواع مختلفة من الاعطال. تقدم هذه الورقة حسابات بيانية وتحليلات مقاسة باستخدام أجهزة استشعار مختلفة للكشف عن فشل في محرك الحث ذات الطور الواحد. تستخدم حاليا الموجات الصوتية في مجموعة واسعة من أجهزة الاستشعار بما في ذاك الاستشعار المادي والاستشعار الكيميائي والتنشيط البيولوجي. واحدة من أهم أجهزة الاستشعار الصوتية هو الكهربيضغطي ، حيث يتم استخدام كهربيضغطية للكشف عن الموجة الصوتية المتولدة من هذه المحركات، ان أي تغير في الصوت النتائج عن المحرك سيتم الكشف عنه والتنبيه لوجود عطل ما في هذه المحركات. وقد تم استخدام جهاز استشعار آخر هو الألياف البصرية المعدلة. حيث تم انشاء هذه المستشعرات البصرية المعدلة من خلال قشط جزء قصير من الغلاف الخارجي واستبدالها بالقرص المضغوط. تعمل هذه الالياف كمستشعر صوتي من خلال التغير الحاصل في معامل الانكسار في 1 ملم الغير مغلف، ويتم نقل هذه الإشارة في داخل الليف البصري. في هذه الدراسة تم إجراء تجارب مختلفة وتحليلها للكشف عن الفشل في محرك الحث الذي يوفر معلومات من شأنها تمكن من تطوير المستشعرات في المستقبل.

Key words— Single phase induction motors, piezoelectric sensor, modified optical fiber sensor, laser, photodiode, Acoustic wave.

1. Introduction:

Induction motors are essential components in the vast majority of industrial processes. There are many factors affect the operation of induction motors such as : dust, temperature variations, humidity, continuous operation, and heavy loads . They cause fault on the induction motor[1].

The main reason behind the motor faults is mechanical and electrical stresses. Mechanical faults are caused by over-burdens and unexpected load changes, which may cause bearing faults and rotor bar breakage. The electrical stresses may create stator winding short circuits and result in an entire engine disappointment.

there are different type of faults that occur in the induction motor which can be classified as shown in figure (1).

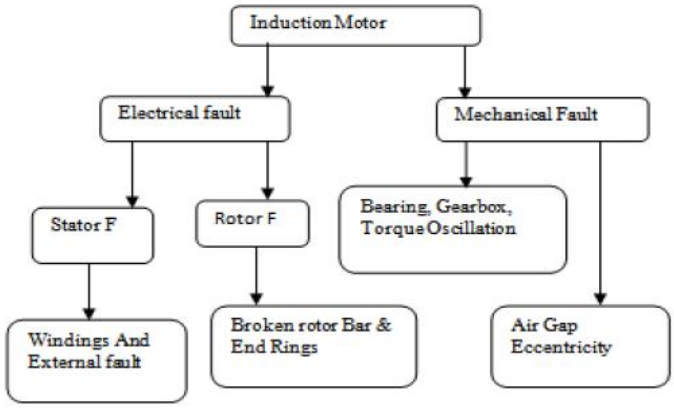


Figure 1: Types of Fault

the most frequent faults in electrical machine are bearing fault. according to IEEE motor reliably study, the percentage of bearing faults are 41%, followed by stator winding faults 38% and rotor faults 10%[2].

In the proposed method, vibration signals are obtained using piezo-electric sensor and motor current. Due to piezoelectric properties of this sensor it is used as actuators. It is also possible to use piezoceramics for both sensing and actuation.

Optical fiber-based sensors have been shown to be attractive to measure a wide range of physical and chemical parameters because of a number of inherent advantages, including small size, light weight, high sensitivity, high frequency response, and immunity to electromagnetic interference. Fiber optical acoustic sensors have shown useful in many applications, such as under water hydrophones , material property analysis, and civil structure non-destructive diagnosis , vehicle detection and traffic monitoring[3].

2. Methodology

The induction motor failure can be detected using an acoustic sensor devices. In the recent years these devices have increasing interest due to its wide range of application like utilized as a filters, resonators, actuators and sensor[4]. In this paper two types of sensors have been used; piezoelectric and modified optical fiber sensors:

2.1 piezoelectric sensor

At the resent year piezoelectric has been increasingly utilized as an acoustic sensor due to its low cost, simple signal conditioning, compact in size[5]. However the most important feature in piezoelectric sensor that its material have the ability to convert energy from mechanical to electrical domain by introducing or appling any stress on its surface due to the accumulation of charge in its material. These charges will be released from piezo material ,proportional to the amount of the applied force due to piezoelectric

effect, forming an output voltage as shown in figure(2) [6]. When piezoelectric utilized as a sensor its material linked to a rigid post at the sensor base, and a seismic mass is connected to the other side of the material.

When the acoustic vibration is enforced to its material an electric charge will be generated, this applied force should be equivalent to the product of the seismic mass by the acceleration to generate a voltage out from the sensor. The signal charge output from the seismic mass is proportional to the increasing in the mass acceleration, therefore over a wide frequency range both seismic mass and sensor base have the same acceleration amount hence the sensor will measure the acceleration of the object under test [7].

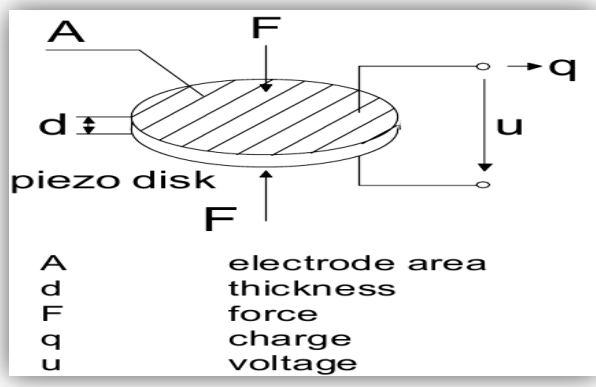


Figure2: Piezoelectric effect [6

2.2 Modified Optical Fiber Acoustic Sensor

Fiber optic acoustic sensor has been increasingly utilized in the recent years with some modification because it provide a level of protection with a valuable physical to the test object by monitoring and distinguish any anomaly or faults by detecting the changed in the vibrations or sounds coming out from the object[8]. Also it can be assumed as a secure tool for transmitting the detected data for final monitoring and diagnostic. The optical fiber used as sensor due to the changes happening with the refractive index because of the vibrations of acoustic wave[9]. When this changes increased the detected signal will increase, this increase can be measured by making some modification in the optical fiber by unshielded the link for a sort segment of the outer sheath and replaced with a cd disk to increase the reflections of signals.

At the end of the optical fiber a photodiode used to detect and measure this changes in acoustic vibration of the measured motor [9].

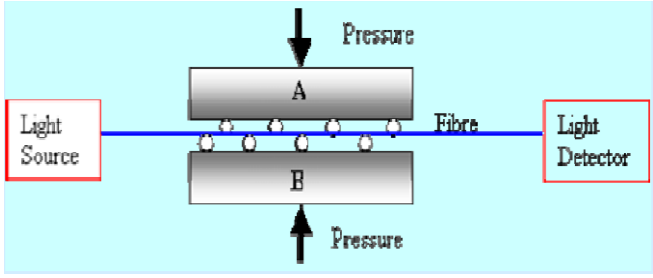


Figure3: optical fiber sensor system

3. Design and Consideration

3.1 Experimental design

The experimental setup used in this project is as shown in figure(4). Two induction motors have been used one with mechanical failure and the other works normally the key parameter of the motor are 0.5 hp, 50Hz & 220v. The two motors are installed on the same bench to measure the difference between the signals detected. A digital oscilloscope is used to store and analyze the capture resulting signals.

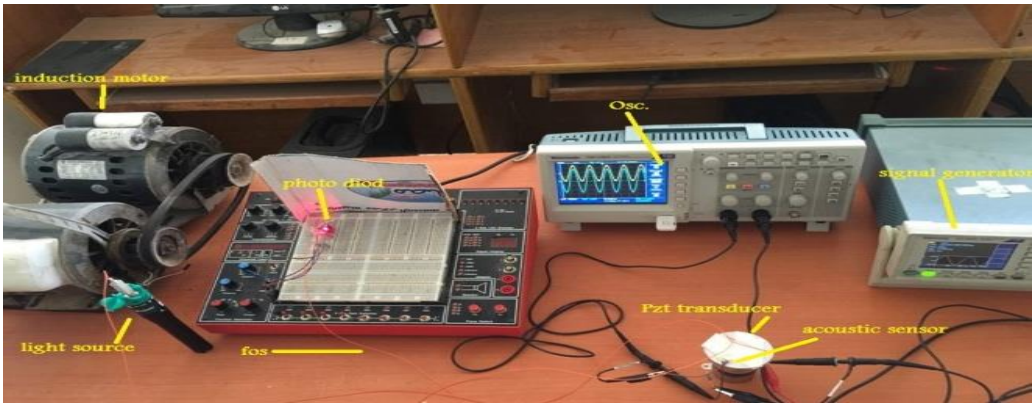


Figure 4: System used to measure vibrations of induction motor using piezoelectric sensor

A 102-1128-ND Piezoelectric sensor shown in figure (5) used as a first sensor to detect the failure with the amplified circuit shown in figure(6) which is consist of three resistances of 1KΩ and amplifier. The amplifying circuit was connect on ETS-7000 A breadboard with an input connect to the Piezoelectric sensor and the output fed to the oscilloscope in order to visualize the detected signals as shown in figure 12.

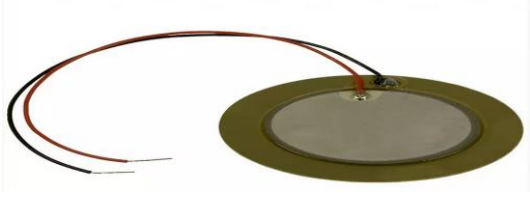


Figure5 : A 102-1128-ND Piezoelectric sensor

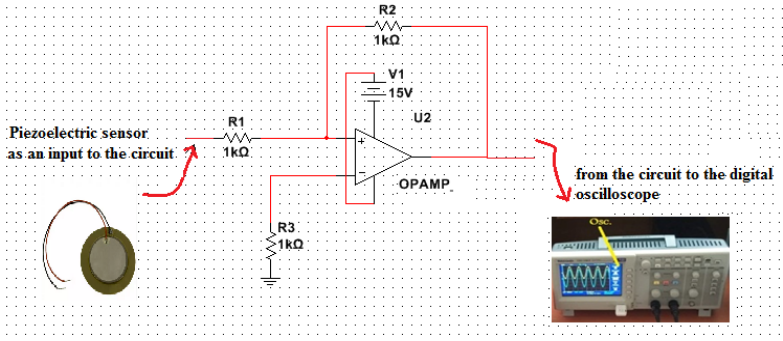


Figure 6: Piezoelectric sensor amplifying circuit

Figure7: Piezoelectric connected to the amplifying circuit

For testing the induction motor operation the Piezoelectric is connected first to the operating motor then it is connected to the defected motor and finally connected to the defected motor with load the three signals are measured and compared as will be shown in the next section.

The Induction motors operation is the measured with a modified optical fiber, which it constructed in a short segment of unshielded the outer sheath and replaced with a cd disk as shown in figure8. This fiber was work as an acoustic sensor by moving the acoustic signal across the fiber tube due to the difference in the refractive index in the 1mm unshielded area. This short segment is connect (touched) to the induction motors , a photodiode laser of 650nm wavelength is used in the transmitter side and an Si photodiode sensor used in the received side. The senor is connect to a bias circuit as shown in figure 9. The bias circuit increase the depletion layer which leads to increase the photosensitive area, that make is the sensor with higher sensitivity by making it easier to collect more light[10].

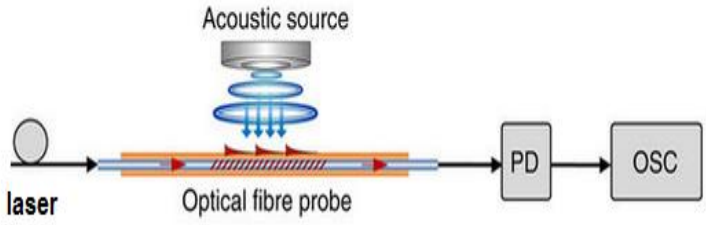


Figure 8: Sensor system

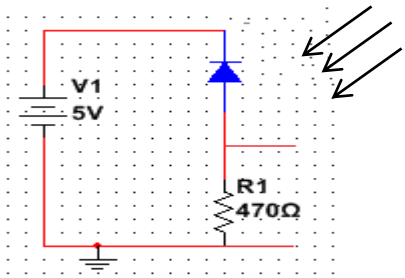


Figure 9: bias circuit

3.2 Calibration of sensor

To measure the sensors performance a calibration have been done by having an acoustic transducers ,shown in figure(10), with a piezoelectric and the modified optical fiber sensors. The sensor calibration can be assume as a method to improve the sensor performance by removing the other structural errors, for exact testing to the sensor performance. When the acoustic waves applied to the sensors two signals has been detect ,as shown in figure(11), one signal for the modified optical fiber sensor and the other for the piezoelectric sensor.

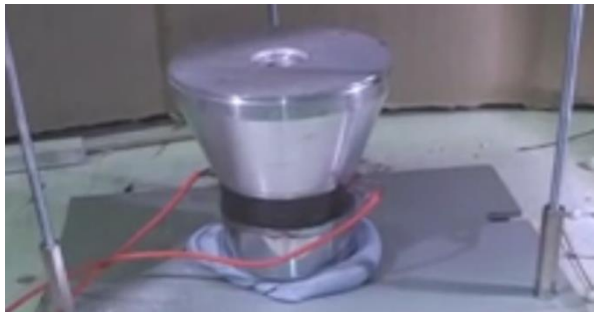


Figure10 : Acoustic transducers

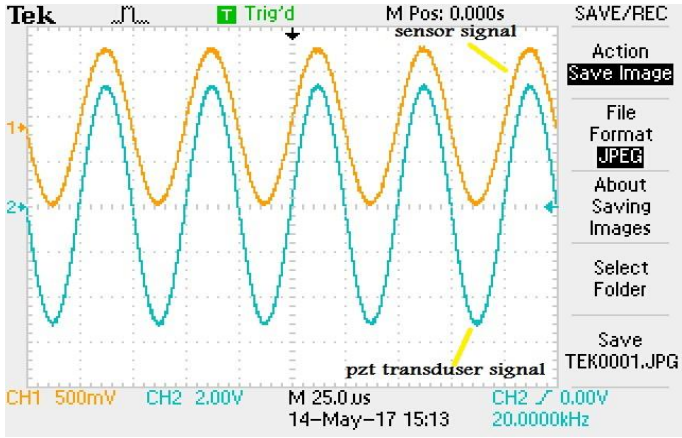
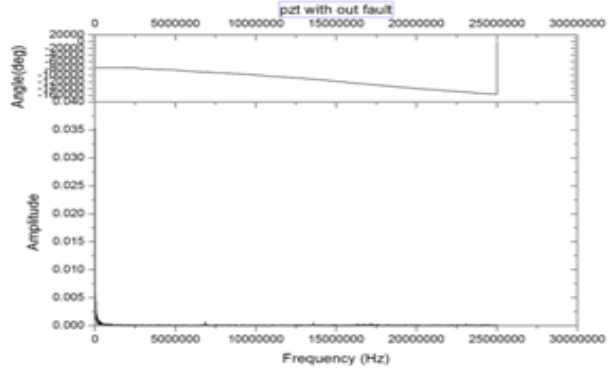


Figure 11: signals results from sensors calibration

As shown in figure 9 the piezoelectric sensor has better performance or more sensitivity to the acoustic wave. However if the fiber used without any modification its sensitivity will be very low for detecting.

4. Results and Discussions

The Design shown in figure 2 is used for online detection to the faults with the single phase induction motors using different sensors. In figure 10, illustrated the results by using piezoelectric sensor when first the motor operating then with defected motor and finally the defected motor with load.



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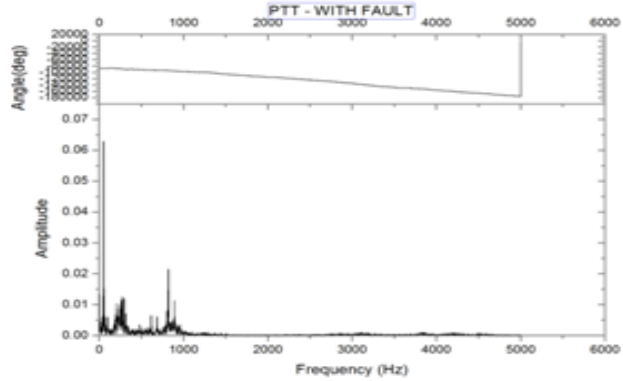
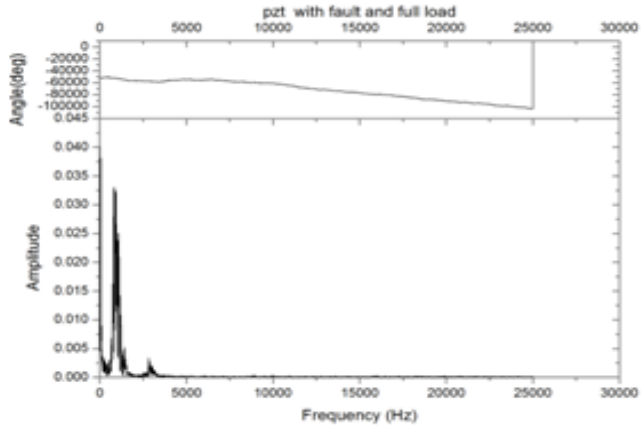


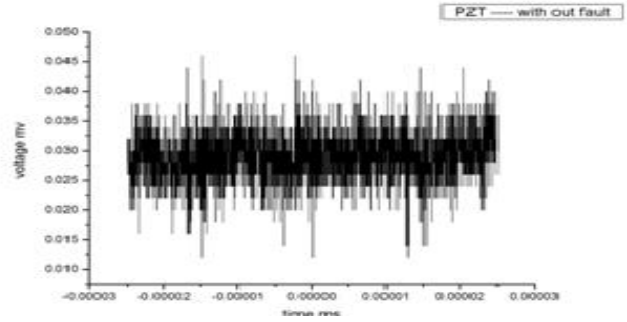
(b)



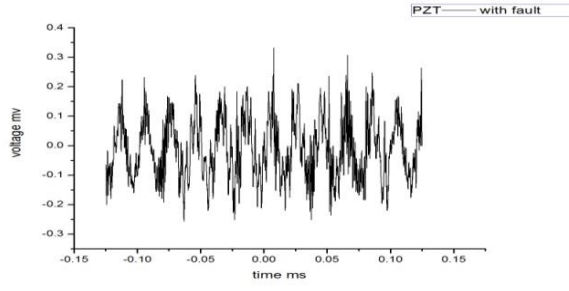
(c)

Figure12: the detected signal with piezoelectric sensor in frequency domain (a): The operated motor, (b) The defected motor and (c) The defected motor with load

Figure 12 shows the detected signal in frequency domain, or spectral analysis, which is considered as the most popular approach to detect the fault of the signal. Fast Fourier Transform (FFT) have been used to compute the feature which is sensitive to presence of fault. in this experiment, the FFT is utilized to analyze the signal of induction motor without fault (operated motor), with fault or defected motor and finally the defected motor with load. The same motors are detected again with the piezoelectric sensor in the time domain as shown in figure(13).



(a)

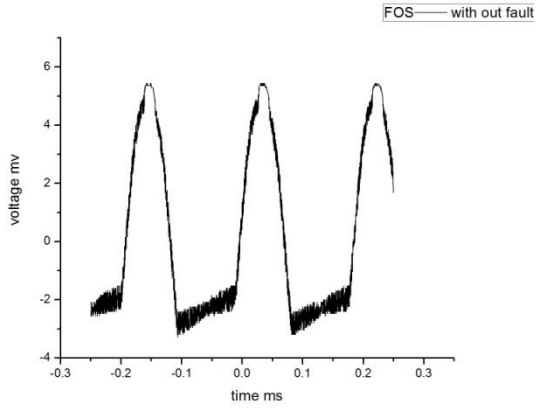


(b)

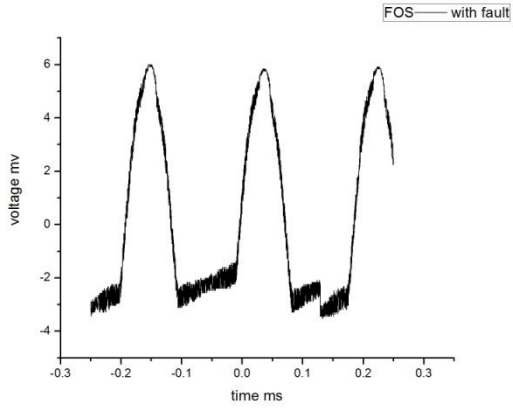
Figure 13: : The detected signal with piezoelectric sensor in Time domain (a): The operated motor, (b) The defected motor

Figure (13) represent the piezoelectric sensor signals in time domain of the operated and defected motors. Time domain analysis, due to its simplicity, has always been an attractive approach for induction motor diagnosis. The simplest method is, to measure the overall RMS level of the induction motor vibration.

Another Sensor has been used , modified optical fiber, to detect the signal of the defected and the operated motor as shown in figure (14).



(a)



(b)

Figure14: The detected signal with modified optical fiber sensor in Time domain (a): The operated motor, (b) The defected motor.

Figure (14), illustrate the operations of the motors that detected with the modified optical fiber, the defect motor has a defect signal. The modified fiber can detect an acoustic wave by moving it across the fiber tube due to the difference in the refractive index in the unshielded area.

5. Conclusion

From the experiments that have been accomplished and analyzed, the following conclusions have been deduced:

1. The piezoelectric sensor show a better detected signal ,than the modified optical fiber, to detected the acoustic waves due to its high ability to convert any pressure wave to a voltage signals.
2. The optical fiber can be used as acoustic sensor by unshielded the outer sheath and replace it with a cd disk, it work as an acoustic sensor by moving the acoustic signal across the fiber tube due to the difference in the refractive index in the 1mm unshielded area.

3. The piezoelectric sensor was measured in time and frequency domain, the frequency domain
shows a more visualized different between the detected signals of the operating and defected motors because it work with Fast Fourier Transform (FFT) which it is used to compute the feature make it more sensitive to presence of fault.

6. References:

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