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The Mechanical loss and the Temperature Distribution of the bearings of the Centrifugal Pump

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Abstract

The predictive maintenance of the machine performance in any Oil Company is based on the mechanical vibration, different in sounds and different in temperatures on the machine. The machine may crash and stop working at any moment if there is no maintenance schedule. Furthermore, The Mechanical loss or the bearing friction loss produces heat loss. Heat generated has a direct influence on bearings service life. This paper studies and investigates the temperature distributions and heat loss by bearings in the horizontal centrifugal pump located at the desalination unit of the first stage in Azzawiya Oil Refining Company, which is part of the predictive maintenance program subjected to the regular inspections vibrometricas in each year periodically The results illustrated that the temperatures ranged between 27.06 °C and 61.15 ^{o}C and the average temperatures were 55.15 ^{o}C.,

Keywords: mechanical loss, Centrifugal, Temperature, bearing. Pump.

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المفاقيد الحرارية الميكانيكية والتوزيع الحراري للمحملات بمضخة الطرد المركزي

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الملخص

ان مفاقيد القدرة الكهربية من الناحية الميكانيكية معظمها ناتج من الاحتكاك الحاصل في المحملات مع عمود الدوران للمضخة the bearing friction loss هذا الفقد يولد حرارة تؤثر بدورها في العمر الافتراضي للمحمل. في هذا البحث نحاول دراسة ومناقشة المفاقيد الميكانيكية والتوزيع الحراري الناتج من احتكاك المحملات مع عمود الدوران لمضخة الطرد المركزي الافقية والواقعة بوحدة التحلية بشركة مصفاة الزاوية. تشير النتائج الي ان توزيع درجات الحرارة يتراوح بين القيمتين 27.06 °C و 61.15 °C وبمتوسط درجات حرارة مقداره 55.15 °C.

الكلمات المفتاحية: المفاقيد الحرارية الميكانيكية، الطرد المركزي، درجات الحرارة، المحملات، المضخة.

Introduction

Most Oil Companies use centrifugal pumps; these machines need periodic maintenance, the most important of which is predictive maintenance. The predictive maintenance of the machine performance in any Oil Company is based on the mechanical vibration, different in sounds and different in temperatures on the machine. The machine may crash and stop working at any moment if there is no maintenance schedule. Furthermore, the mechanical loss or the bearing friction loss produces heat loss; the heat generated has a direct influence on the bearings service life. Many authors researched and investigated about the mechanical loss and the temperature conditions and diagnostics in this field, thus it was

http://www.doi.org/10.62341/dhmb6678

mentioned in the literature review. This paper studies and investigates the temperature distributions calculations and experimentally then comparing that with the production of the heat loss by bearings in the horizontal centrifugal pump located at the desalination unit of the first stage in Azzawiya Oil Refining Company, which is part of the predictive maintenance program subjected to the regular inspections vibrometricas in each year periodically. Figure (1) shows the photo of the case under study in the Company, the results illustrated that the temperatures ranged between 27.06 °C and 61.15 °C and the average temperature was 55.15 °C.,

Literature review

Many studies investigate and analyze the heat loss or the heat flux dissipated through the equipment of the machine into the environment. KATSUMI YAMAZAKI proposed and investigated the method of calculating the losses of induction motors involving iron mechanical loss [1]. [2]. evaluate the stray load losses in the cores, they found that the calculated no load losses are almost the same as the measured ones. [3]. presents and analyses the dynamic performance of a squirrel cage induction machine integrated to a flywheel storage for two cases in constant power and constant torque, with a developed model in MATLAB. Simulink, the results show that the SCIM FESS has satisfactory characteristics in energy regulation and dynamic response during load torque variations. [4]. The study focuses on the analysis of the damaged rolling element bearing of the pumping system. The measurements were performed on full scale model. [5].The study investigates components of the mechanical loss together with heat transfer effects in an axial flux PM motor. It's found that the theoretical findings show good agreement with experimental data. [6]. The study investigates and focuses on the heat loss analysis of the pump. The heat loss simulation results agreed with the churning loss below 4000rpm.

The Case under Study

The Horizontal Centrifugal Pump is the case study which located at the desalination unit of the first stage in the Azzawiya Oil Refining Company. Figure (1) shows the photo of the case under study. Table

http://www.doi.org/10.62341/dhmb6678

(1): shows the Manufactured and tested according to the rules IEC34-1 of the case study.

Figure (1) shows the photo of the case study, and the points 1,2,3,4 are the measured locations

Table 1. Shows the Manufactured and tested according to the rules IEC34-1 of the case study.

Routine Test Report			/		temperatures ambient 20°C				
Rating	V	Hz	KW	A	r/min	cosΦ			
	380D	50	11	20.69	2930	0.89			
test	Pole	Line		Input		output		cosΦ	η
No load	2	U(v)	f(Hz)	I(A)	P1(kw)	P2(kw)	r/min		
		400	50	6.49	0.56				

The Total Loss of the Pump

The Total Loss of the induction motor Pump comes from the copper losses, iron losses and mechanical losses. The Total power loss can be calculated from the following equation:

$$p_{loss} = p_1 - p_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where: p_1 is the electric input power drawn, and p_2 is the shaft power [7]. According to Figure (2), which illustrates the information of the performance curves of the case under study, which is certified in the laboratories of Azzawiya Oil Refining Company. Figure (2) shows the difference between the shaft power curve and the electric input power drawn curve. The Total power loss is the difference

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between the two curves, and it was compared to the electric input power drawn as shown in Figure (3). The losses are evident between the two curves.

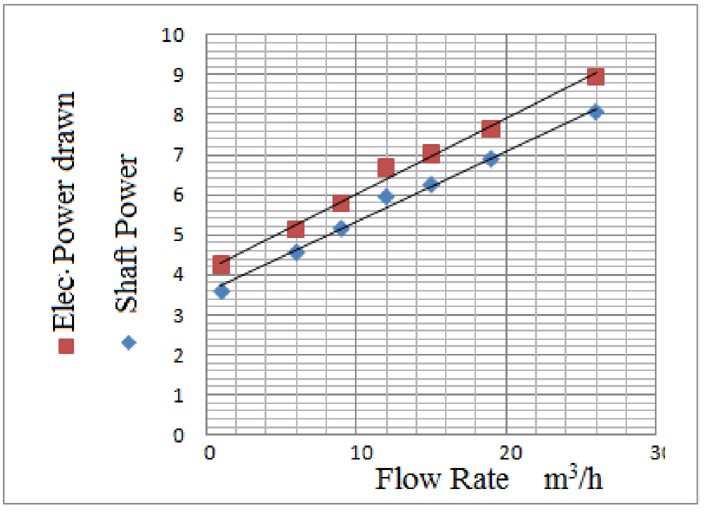

Figure (2) The performance curves of the case under study from the data sheet of the pump of the company.

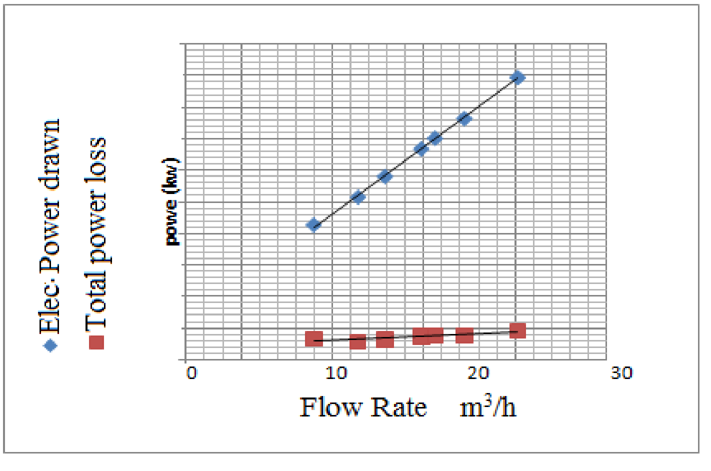

Figure (3) The total power loss compared to the electric input power drawn from the data sheet of the company

Heat Transfer through the equipment's

The heat flux dissipated from the shaft, through the bearing into the frame due to the temperature difference, the process of the heat

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transfer takes place by the conduction method, so that the heat flux Q can be calculated from the following equation:

$$Q = KA\frac{\Delta T}{\Delta x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where: Q = teat of heat transfer (w)
K = heat transfer coefficient (w/m °C)
A = area basis of overall heat transfer (m^2)
$\frac{\Delta T}{\Delta x}$ = the gradient of the temperatures (°C/m) [8]

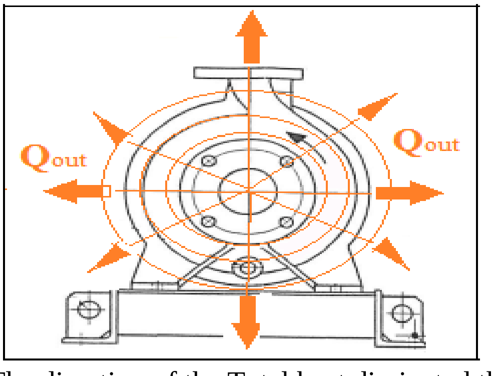

Figure (4) The direction of the Total heat dissipated through the environment. The sketch of the case study of the company

Data collection
Data collected using the portable FALCON analyzer model12481as an instrument, which connects to the PC, Data automatically, collected at PC screen. Using the NESTi4.0 program software includes powerful tools for machine analysis to confirm the automatic diagnosis, and with ACOEM ACCURX analysis method it offers the possibility to get an automatic diagnosis for all bearing defects.

The Mechanical losses or the Total Heat Generation by Bearings
The mechanical losses come from the bearing friction loss which is proportional to the high speed and heavy load mechanism, which can be written as:

$$p_b = \sum_i T_i w_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)\ [9].$$

http://www.doi.org/10.62341/dhmb6678

Where p_b is the total loss of all bearings(w), T_i is the torque of the bearing friction and w_i the angular velocity of the bearing [9]. So that, using equation (2) to calculate the heat generation due to the speed of bearing and its locations, Figure (5) shows the results of that. The difference in the columns of the heat generation is because of the difference in the value of the torque of the bearing friction and its locations.

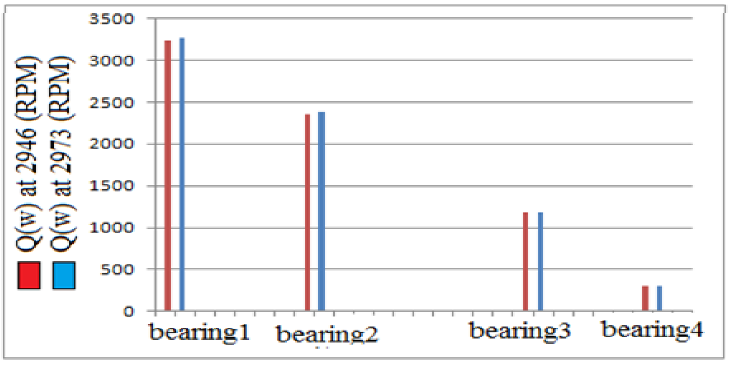

Figure (5) The calculations of the heat generation according to the speed of bearing with its locations

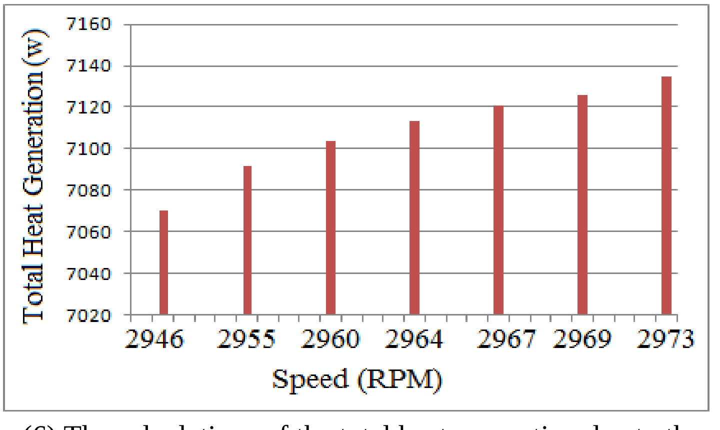

Figure (6) The calculations of the total heat generation due to the speed of all bearings

Different Sources of the Temperatures at the Pump Surface

In addition to the heat generated as a result of the total power loss. There are other external factors that affects on the temperatures surface. The temperatures increase or decrease due to the hot or cold

http://www.doi.org/10.62341/dhmb6678

climates. The direction of sunlight also affects the recorded temperatures of the machine.

Results and discussion

Data is automatically collected at the PC screen. Using the portable FALCON analyzer with the NESTi 4.0 program software includes powerful tools for machine analysis to confirm the automatic diagnosis and record the temperature conditions and diagnostics with ACOEM ACCURX analysis method, which offers the possibility to get automatic diagnosis for all the bearing defects, so that the results was illustrates in figures 7, 8, 9, 10 and 11.

Discussions of the Machine Temperatures

Figures 7, 8, 9 and 10 show the temperature distribution of the pump due to the bearing frictions in the three directions at points 1, 2, 3, and 4, measured and recorded by the portable FALCON analyzer. In figure 7 the temperatures ranged between 27.06 °C and 45.13 °C. At point 2 "Electric Motor –DE" the temperatures were recorded between 39.15 °C and 61.15 °C. In figure 9 "Pump –DE", the minimum temperature was 31.34 °C but the maximum temperature was 60.06 °C. At point 4 "Pump –NDE", the temperatures ranged between 33.97 °C and 46.67 °C. So that the lowest temperatures on the pump surface were 27.06 °C, but the highest temperature was 61.15 °C. These temperatures come from the power losses presented as copper losses, iron losses and mechanical losses.

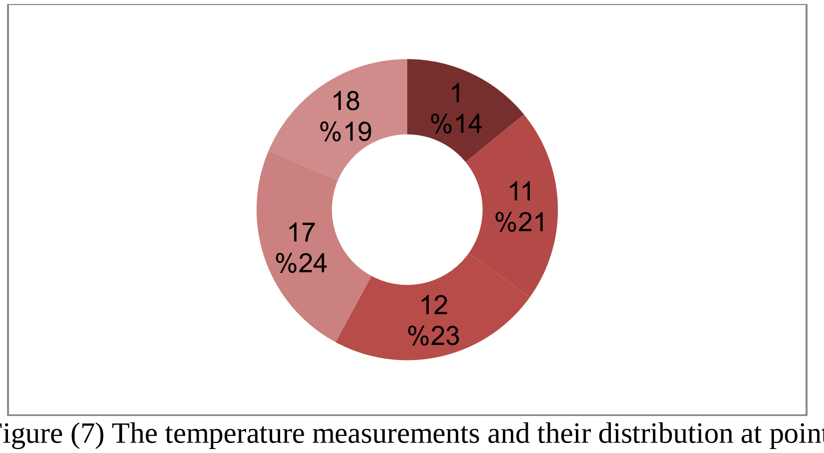

Figure (7) The temperature measurements and their distribution at point 1, Electric Motor-NDE in 3 directions

http://www.doi.org/10.62341/dhmb6678

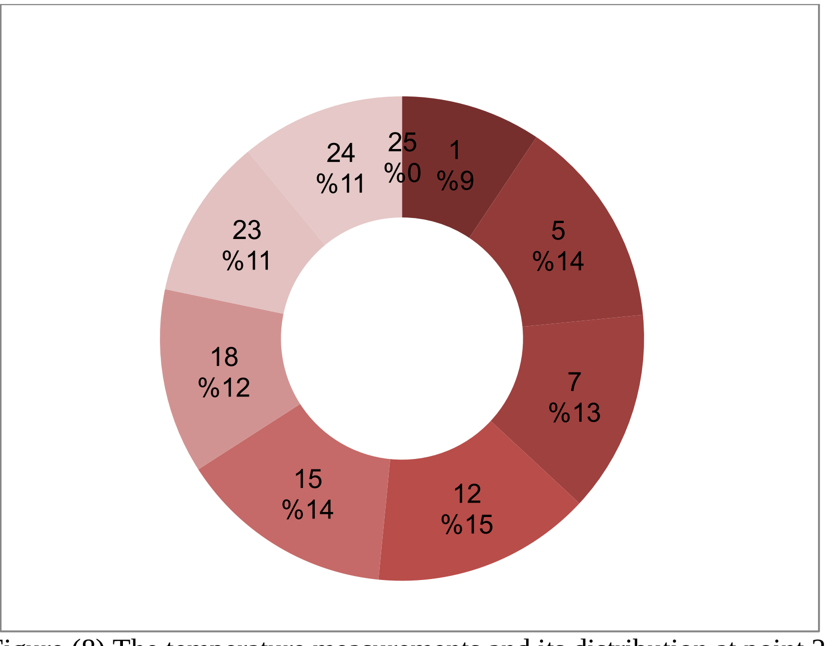

Figure (8) The temperature measurements and its distribution at point 2, Electric Motor-DE in 3 directions

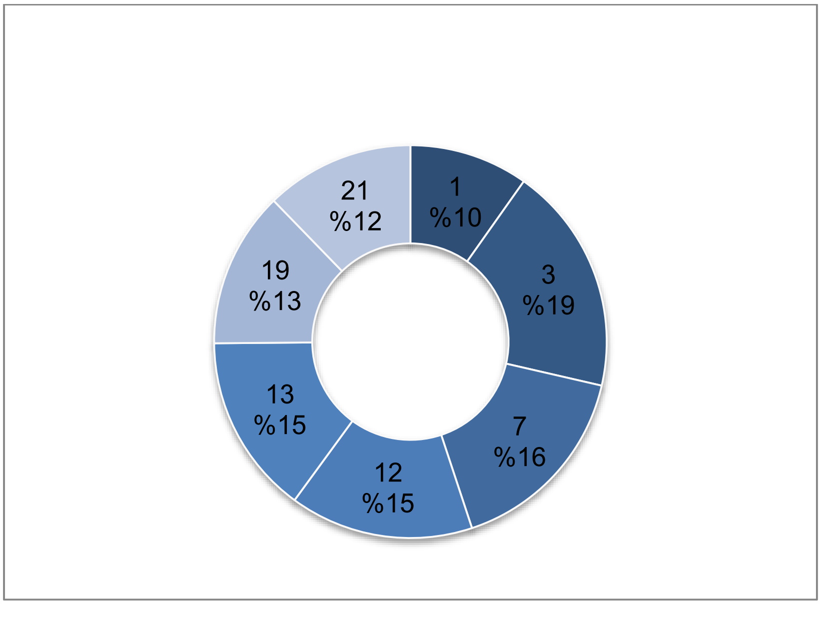

Figure (9) The temperature measurements and their distribution at point 3, Pump-DE in 3 directions

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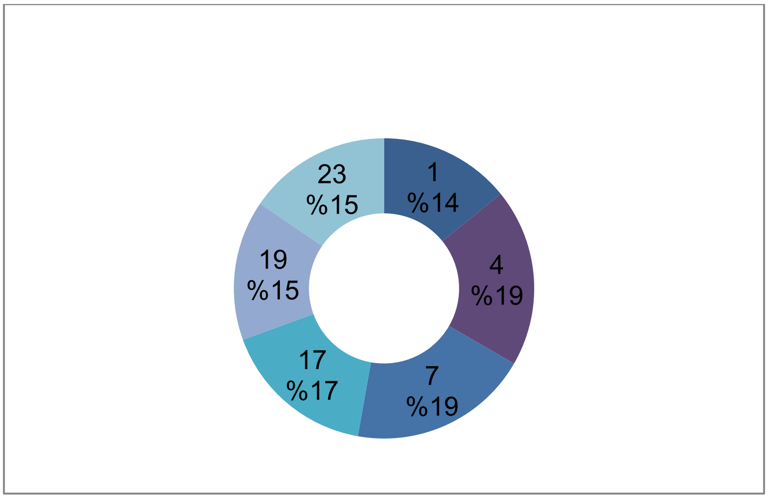

Figure (10) The temperature measurements and its distribution at point 3, Pump-NDE in 3directions

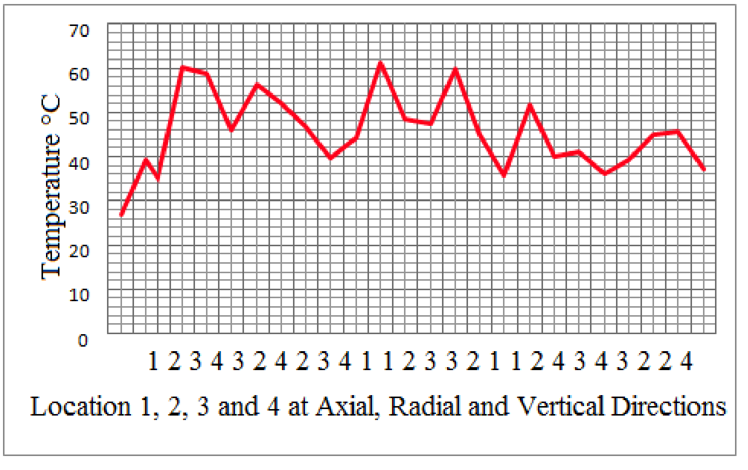

Figure (11) The temperature measurements and its distribution at all point.

Figure (11) shows the temperature difference due to all bearings in three directions at all points, incorporating other sources like the direction of the sunlight. The temperatures ranged between 27.06 °C and 61.15 °C. The average temperatures were 55.15 °C the lowest temperatures on the pump surface were 27.06 °C, but the highest temperature was 61.15 °C. The temperature differences are also due

http://www.doi.org/10.62341/dhmb6678

to the cooling of the external fan, and the passage of water through the pump also causes differences in the temperatures.

Conclusion

The main aim is to determine the heat flux due to the bearing friction loss, then discuss it with the temperature distributions measured by the portable FALCON analyzer. The results illustrate that the temperatures ranged between 27.06 °C and 61.15 °C. The direct of the sunlight influences the recorded temperatures. The average temperatures were 55.15 °C. Therefore, the heat generated by the bearing loss or mechanical loss has a direct effect on the service life of the pump.

Acknowledgement

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