

Automatic Control of Temperature in a Shaft Bearing

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Abstract There is a continuous need to keep the bearing temperature under a certain critical value. This can be achieved through lubrication. A continuous supply of lubricant is not a cost-effective solution. The aim of this work is to automatically control the temperature a shaft bearing. This is achieved by controlling the supply of the lubricant. The temperature is also sensed and sent to a monitoring terminal using wireless technology.

Keywords Temperature Control, Microcontroller, Shaft Bearing, Lubrication, Wireless Technology

1. Introduction

Shaft bearing get hot during operation and this will affect the life cycle of the bearing[1,2]. Temperature is considered as one important indicator about bearing life. Friction is one causes of temperature rise[3]. Rise in temperature can cause fatigue damage as well[4,5]. There are different products available in the market to lubricate shaft bearing[4,5]. A system proposed in[3] operates when bearing temperature varies more than 15°C, an alarm is activated and an LED indicator will light. There is also a need to monitor the temperature of the bearing and the operation can be restricted to certain temperature (e.g. 150 C)[6,7]. Lubrication must take place before shaft bearing reach its limiting temperature [6,8,9]. The sensor can be placed close to the bearing surface[6]. Different products incorporate automatic lubrication by controlling the amount of lubricant as well as the frequency[10-12]. Most of the proposed automatic lubrication control focuses on the amount of the required volume of lubricant besides the frequency at which the lubricant must be supplied. In this work, a different approach is adopted where the control action is based on the measured bearing temperature. In other words, the lubricant will only be applied when the bearing temperature reaches a pre-set value. The control mode is programmed on-off type.

2. Description of the Mechanical System

The layout of the mechanical system is shown in Figure.1. The mechanical system consists of a motor, shaft, bearing, oil tank, pump, and belt drive. The shaft is fitted into the bearing and it is made to rotate. The shaft is driven by the

motor through a belt. The rotation of the shaft causes a friction between the shaft and its bearing. The resulting friction increases the temperature at the contact region. This temperature is to be measured by an appropriate sensor. The output signal of the sensor is connected to a control circuit. When the temperature reaches 58°C, the oil valve opens automatically to lubricate the frictional area so as to cool it down. The lubrication shall stop as soon as the temperature drops to a certain level (below 42°C)

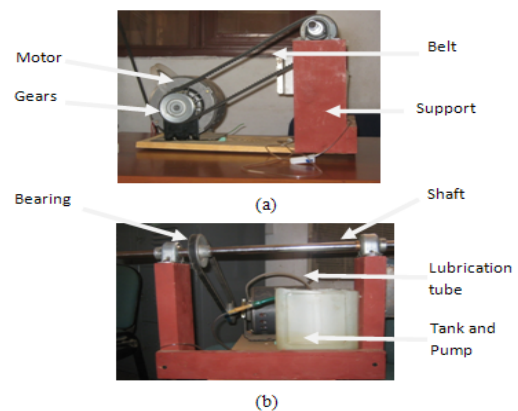


Figure 1. Picture of the mechanical system: (a) front view (b) side view

3. Electronic Design of the System

The block diagram of the electronic design is shown in Figure.2. The temperature sensor (LM35) reads the temperature close to the frictional area and transfers the readings to the microcontroller (Atmega32). The signal received by the microcontroller is analogue so it will be converted to digital format through the ADC (Analogue Digital Converter) which is built in the microcontroller. The output of the first microcontroller is sent through two ports. The first port passes the temperature readings to the encoder (HT12E) and then to the transmitter (ASK module). The transmitter will send the signals wirelessly to the receiver (ASK module).

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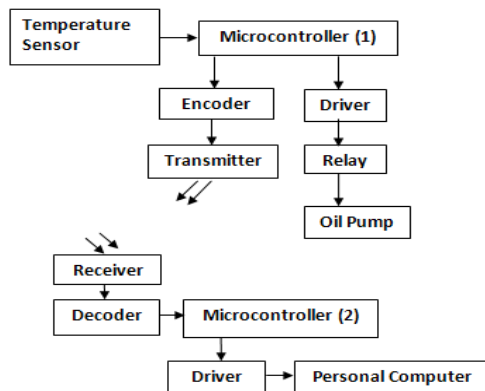


Figure 2. The sequence of the electronic design

The driver (MAX232) will send the temperature reading to the PC in order to be monitored. The second microcontroller only acts as signal converter. While the temperature is being monitored the first microcontroller sends a command to the lubrication process to start if the temperature reaches certain level. Therefore, the microcontroller is programmed to open the oil valve when the temperature reaches 58°C and close the oil valve when the temperature cools down to 42°C. The programmed signal will be transferred to the driver (ULN2003) which amplifies the current to suit the relay. The relay will act as a switch to control the valve. The microcontroller also outputs a signal to an alarm when the temperature reaches the critical degree ($\geq 72^\circ\text{C}$). The layout of the electronic connections is shown in Figure.3.

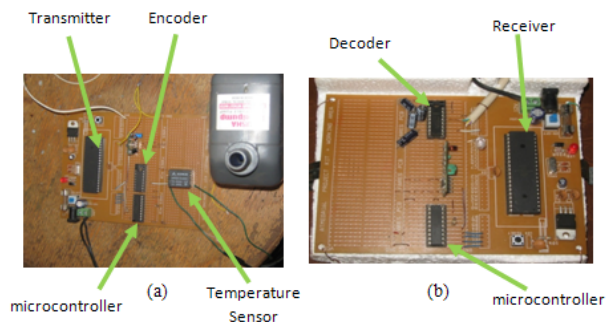


Figure 3. A picture of the electronic boards: (a) transmitter board (b) receiver board

4. Result & Discussion

The shaft was made to rotate by operating the motor and the temperature was monitored on a personal computer. Meanwhile the temperature was measured manually using a thermometer and it was compared with the displayed temperature as shown in Table.1.

The displayed temperature was found to be in good agreement with the manually measured temperature. There is small difference between measured and displayed which could be attributed to the accuracy of the measuring instrument as well as to the time delay.

Meanwhile the temperature was monitored on a personal PC using Hyper Terminal Software. The alarm was set successfully to operate when the temperature reaches 72°C. The

experiment was run again after filling the tank with oil. It was noticed that when the temperature reaches 54 to 58°C the pump operates and it the process of the lubrication starts.

Table 1. Comparison between the displayed and measured temperature

| Temperature (displayed range) | Reference Temperature (Thermometer) |
|-------------------------------|-------------------------------------|
| <30 | 25 |
| 30-34 | 29 |
| 34-38 | 36 |
| 38-42 | 38 |
| 42-46 | 43 |
| 46-50 | 46 |
| 50-54 | 50 |
| 54-58 | 55 |
| 58-62 | 59 |
| 62-66 | 62 |
| 66-70 | 67 |
| 70-74 | 70 |
| 74-78 | 74 |
| 78-82 | 79 |
| >85 | 86 |

5. Conclusions

The temperature of a shaft bearing was controlled and monitored successfully. The temperature was sensed and sent wirelessly to a personal computer to be monitored. A good agreement was found between the displayed temperature and the manually measured temperature. The control of the lubrication process operated successfully as it was made to operate when the temperature reaches approximately 54°C. An alarm system was set to operate when the temperature reaches 72°C. The accuracy and simplicity of the proposed system makes it useful in many similar application.

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