International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V69I9P204

Volume 69 Issue 9, 29-33, September, 2021

Original Article

Monitoring System For A Bucket Milking Machine Based On IoT

Chiraphon Takaeng[1] and Apinan Aurasopon[2]

[1]*Faculty of Engineering, Rajamangala University of Technology Lanna, Lampang, Lampang, Thailand.*
[2]*Faculty of Engineering, Mahasarakham University, Kantharawichai district, MahaSarakham, Thailand*

apinan.a@msu.ac.th

Abstract *- This paper proposes a monitoring system for bucket milking machine operation based on The Internet of Things. The system consists of embedded systems for monitoring 1) the speed of vacuum pump including input power sources such as voltage, current, power, energy, frequency, and power factor and 2) the operation of pulsator such as maximum and minimum vacuum, time period, round per minute, time phase A, B, C, D, milking and rest phases. These data are sent to the cloud system for recoding in Google sheet. From the experiment results at dairy farms, the proposed system can correctly measure the operations of the vacuum pump and the pulsator. Moreover, these data can be used to classify the milking bucket machine correctly.*

Keywords — *Bucket milking machine, vacuum pump, pulsator, embedded system, Google sheet.*

I. INTRODUCTION

The milking machine operates based on pulling a vacuum on the teats of the cow, causing the milk to flow. It is important equipment in the milking process, helping farmers to save time and cost. Milking productivity can be increased, and milking can be performed in conditions that are more hygienic if the milking machine is in good condition. In reference to [1], the milking machine associated with mastitis in cows was studied. The milking machine will not influence mastitis occurrence on-farm if it is installed, operated, maintained, tested, and functions according to international standards. Therefore, its performance should be monitored frequently, such as the vacuum pump, it can remove air from a closed pipe producing a vacuum in standard values 37-42 kPa, and the pulsator, it can control valve operating at 60 cycles per minute and a ratio (open and close) 60:40 [2]-[4].

The mastitis problem results in the quantity and quality of milk reduced. In previous works, a lot of researchers have concentrated on measuring the quality of milk, such as pH, temperature, salinity, gas, and a viscosity [5]-[7]. Some researchers applied The Internet of Things (IoT) for real-time monitoring [8]-[9]. However, there has been no paper focused the monitoring the milking machine, which is an essential tool for milking processing.

Therefore, this paper proposes a monitoring system for milking machine operation. The measured data are sent to record in Google sheet. These data are helpful to farmers for considering the milking machine condition. The paper is organized as follows: Section II gives the basics of the bucket milking machine. Section III gives the detail of the proposed system and the method for measuring the milking machine operation. Section IV shows the experimental results for classifying the milking machine conditions. Finally, Section V concludes the work.

II. BUCKET MILKING MACHINE

Most small dairy farms in Thailand have used the bucket milking machine for yielding cow milk. Because this machine type is cheaper than others, therefore, this paper focuses on improving the efficiency of this machine type.

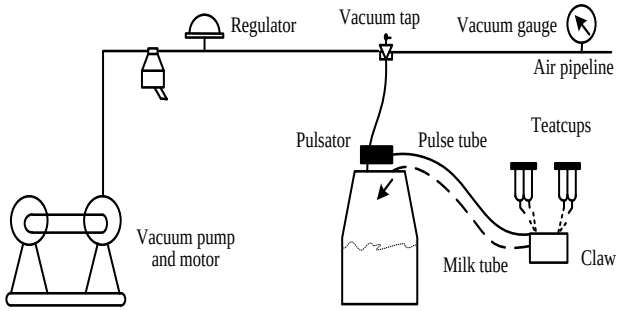


Fig. 1 A bucket milking machine type

Figure 1 shows a bucket milking machine that consists of important parts 1) A vacuum pump removes air from a closed pipe. The result of this removal is to create a pressure lower than the surrounding atmosphere. 2) A vacuum regulator is a type of control valve that decreases the pressure of a fluid to its optimal value at the output stage. This is achieved by opening and closing valves to control airflow, and 3) Pulsators are valves that cause the liners to open and close on the teat once each second (i.e., pulsation) by connecting the pulsation chamber of the teat cup to vacuum or atmosphere.

Milking can be performed in conditions that are more hygienic if the milking machine is in good condition. Therefore, preventative maintenance is so important. However, it has been used for a long time. It may default, resulting in a vacuum, and valves cannot operate under standard values.

III. EMBEDDED SYSTEM FOR MONITORING THE MILKING MACHINE OPERATION

The monitoring system consists of two embedded systems for measuring the milking machine operations: 1) the vacuum pump and 2) the pulsator.

A. Embedded system for monitoring the vacuum pump operation

Figure 2 shows the embedded system for monitoring the vacuum pump operation that consists of 1) a PZEM-004T AC digital power energy meter module (Using UART series communication) for measuring voltage, current, power, energy, frequency, and power factor, 2) a photosensor for measuring vacuum pump speed and 3) NodeMCU for calculating the data and sending them to Google sheet. In contrast, the adapter USB 5V is a power supply.

To find the data of vacuum pump operation, the calculated steps are as follows:

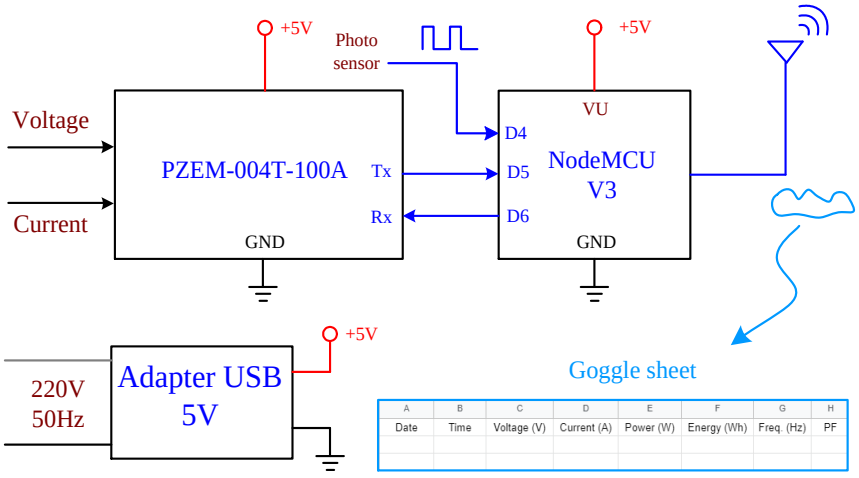


Fig. 2 Block diagram of embedded system for monitoring the vacuum pump operation.

1) Reading and decoding the voltage, current, power, energy, frequency, and power factor from PZEM-004T-100A.
2) Reading the plus number from the photosensor and calculating the round per minute.
3) Sending the data to Google sheet.

B. Embedded system for monitoring the pulsator operation

Figure 3 shows the embedded system for measuring the operation of the pulsator that consists of an analog vacuum sensor, XGZP6847A (Output 0.5 to 4.5V for measuring -100 to 0 kPa) and NodeMCU. The battery 9V is regulated by 7805 as a power supply. This system is installed on the bucket to measure the vacuum output of the pulsator that as shown in Fig. 4. Note that the characteristics of vacuum output signal such as maximum vacuum, milking, and rest time can illustrate the operating condition of the pulsator. To measure the vacuum signal characteristics, we have calculated steps as follows:

1) Sampling the signal 1,500 points at time sampling period, 1 ms, and find the maximum and minimum vacuum.
2) Searching the points A1, B, C, D, and A2.
3) Calculating time period of the cycle, rounds per minute, milking, and rest time.
4) Showing them on LCD and sending them to Google sheet.

These data are recorded in Google sheets each day, which can be used for classifying the operating condition of bucket milking machines.

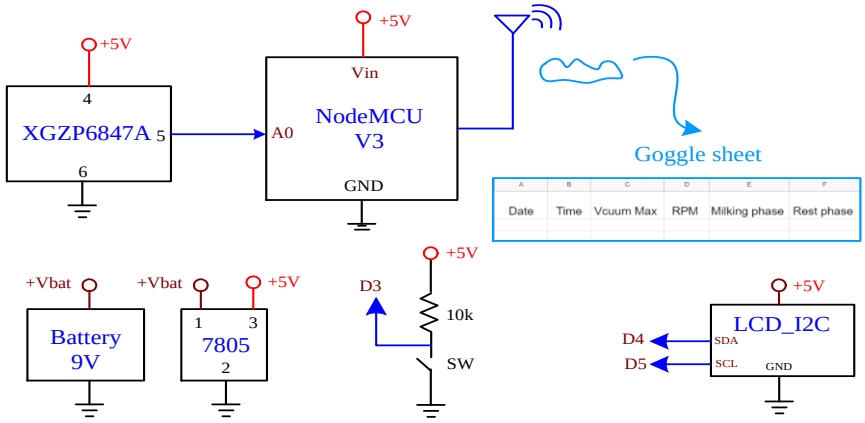


Fig. 3 Block diagram of embedded system for monitoring the pulsator operation

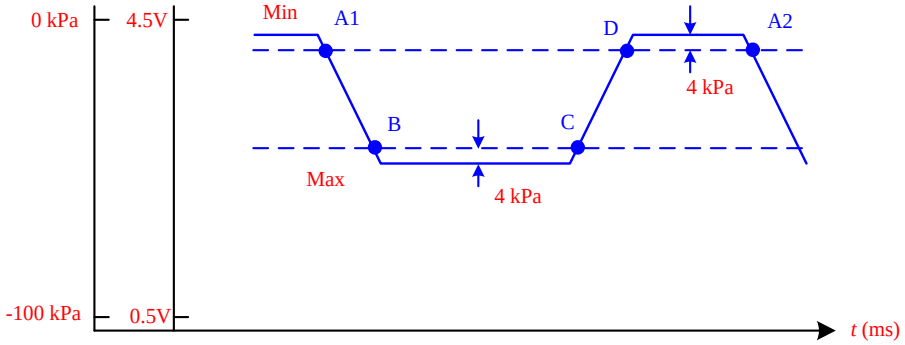


Fig. 4 Vacuum signal of pulsator operation

IV. EXPERIMENTAL RESULTS

In this session, we show the experimental results of the proposed monitoring system. The milking machine system was set up as follows:

- Vacuum pump power: 746 W., suction capacity: 220 l/min., voltage: 220 V, 50 Hz, pump speed: 1,440 rpm
- Maximum vacuum: 40 kPa (Vacuum regulator setup)
- Milking cycle: 60 rpm, milking phase 60, and rest phase 40 (Pulsator setup).

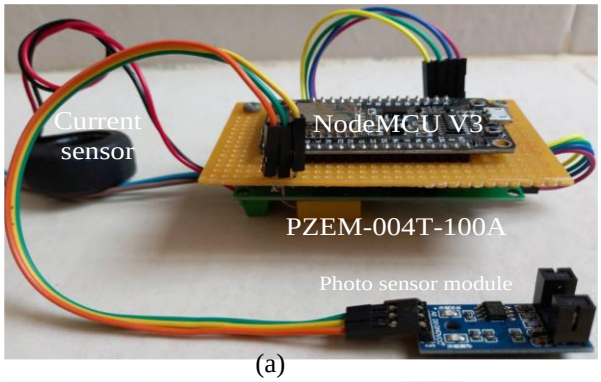
Figure 5 shows the prototypes of the embedded systems that were installed to measure the operation of the vacuum pump and pulsator.

For the first test, we examined the measured data correction of the embedded systems. Therefore, they were compared with the standard multimeter, speed meter and Pulsator tester. We found that their errors are in the range ±1%. The measured results in Fig. 6 show the recoded data in Google sheets. These data show that the milking machine operates in good condition resulting in effective milking processing.

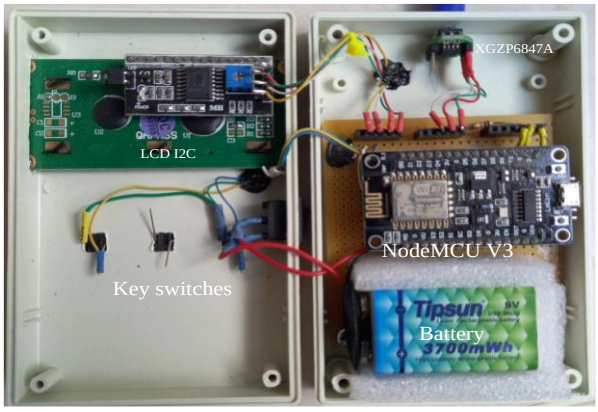
A. Data analysis for vacuum pump operation

Normally, the specifications of the vacuum pump are power 746 W, current 5.2A, and pump speed 1,430 rpm, where it operates under source voltage 220 V, 50 Hz. However, in the test, the results show as Fig. 6, the electric source, 227V, 50Hz, power 852.2W, current 4.75A, energy 63.3Wh, PF. 0.79 and 1,400 rpm. These data can be used as references to analyze the operating condition of the vacuum pump because it is accepted as the normal present condition.

Assuming that the vacuum pump speed is lower than 1,400 rpm or the current is higher than 4.75A. This may cause its machinery to have some problems. Moreover, the data of electric energy can be used to estimate the electric cost [10]-[11], and the information of PF can be used to select a capacitor for improving the electric energy efficiency.



(a)



(b)

Fig. 5 Pototypes of embedded systems for measuring (a) Pump operation and (b) for Pulasator operation

B. Data analysis for pulsator operation

When the vacuum pump operates in normal condition, it produces a vacuum level of more than 42 kPa, which is controlled by a vacuum regulator in the range of 37-42 kPa. While the pulsator controls the milking cycle, 60 rpm, milking phase 60%, and rest phase 40%.

These data are recorded and monitored. From the data, they can be analyzed by case to case as follows

1) In case the maximum vacuum is higher than 42 kPa. But it cannot be adjusted in the range 37-42 kPa. It may be caused by the vacuum regulator.

2) In case the vacuum is in the range 37-42 kPa, if the milking cycle, milking phase, and rest phase cannot be adjusted as under standard value. It is caused by the pulsator.

V. CONCLUSIONS

This paper proposed a system for monitoring the milking bucket machine operation. Two embedded systems were designed and built to measure the data of 1) vacuum pump such as input voltage and current, power, energy, power factor and vacuum pump speed and 2) pulsator such as minimum and maximum vacuum, time period of the cycle, rounds per minute, milking and rest time. These data were sent to record in Google sheet. This system can help the farmers for monitoring the conditions of the bucket milking machine.

From the tests, we showed the measurement results and data sending to Google sheet. The data analysis was discussed in case the vacuum pump and pulsator operated under abnormal conditions.

	A	B	C	D	E	F	G	H	I
1	Date	Time	Voltage (V)	Current (A)	Power (W)	Energy (Wh)	Frequency (Hz)	Power factor	Speed (RPM)
2	1/1/2021	8:54:14	227	4.75	852.2	63.3	50	0.79	1400
3	2/1/2021	9:30:41	226	4.75	850.2	62.3	50	0.8	1439
4	3/1/2021	9:10:29	227	4.76	852.3	63.4	50	0.79	1402
5	4/1/2021	9:05:22	230	4.73	850.3	63.3	50	0.79	1400
6	5/1/2021	9:09:30	225	4.77	851.1	62.6	50	0.8	1395
7									
8									

(a)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	Time	Maximum vacuum (kPa)	Minimum vacuum (kPa)	Time period (ms)	RPM (minute)	Phase A (ms)	Phase B (ms)	Phase C (ms)	Phase D (ms)	Milking phase (%	Rest phase (%)
2	1/1/2021	8:44:14	40	0	998	60.12	140	461	104	293	60.22	39.77
3	2/1/2021	9:20:44	39.5	-1	1001	59.94	140	459	103	299	59.84	40.15
4	3/1/2021	9:00:30	39.8	-0.38	999	60.06	139	460	103	297	59.95	40.04
5	4/1/2021	8:55:22	40.2	-0.45	1000	60	141	459	105	295	60	40
6	5/1/2021	8:59:35	40	0	1001	59.94	143	457	103	297	60	40
7												
8												

(b)

Fig. 6 Data recoded in Google sheet (a) Vacuum pump operation and (b) Pulsator operation

ACKNOWLEDGMENT

This research project is financially supported by Mahasarakham University.

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