Friction measurement system using load cell for Tribotronic system on Pin-On-Disc (POD) tribometer

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Abstract. This paper discusses part of Tribotronic system on Pin-On-Disc (POD) Tribometer focusing on friction measurement using load cell. The analysis conducted using MATLAB software to measure Coefficient of Friction (CoF) of 2 sample types in order to prove the validity of the measurement. The 2 samples are lubricant (Shell Helix Fully synthetic oil) and lubricant (Shell Helix Fully synthetic oil) with additive. It is revealed that the measurement of the lubricant with additive shows better CoF (0.006) than lubricant without additive, CoF of 0.02.

1. Introduction
Tribology plays a key role in implementation in reduction of emission in modern-day machine design. Tribology based machine design caused major contribution in development of compact and low weight machinery [1-4]. Tribotronics, applies to the integration of tribology and electronics. Tribotronics or active tribology based on adaptive performance is thought of as being critical in the implementation of smart machine concepts.

The conditions of a tribological system are monitored by sensors that provide information on i.e. temperature, pressure, friction, vibration, oil properties such as total acid number or additive depletion and other parameters of interest. The signals from these sensors are processes and transmitted to the control unit. In the computational or decision making part, real-time software based on tribological algorithms calculates the required action which is then implemented by actuators. Such a system is thus autonomous and self-adjusting. This allows for on-line tuning of the tribological system for the best performance. The key principle of tribology is the practice of additional so-called loss outputs such as friction, wear and vibration [5]. This paper is focus on developing simple method of measuring friction using load cell and analysis on the friction pattern using MATLAB software.

1.1 Coefficient of Friction
The ratio between the this frictional force (F) and normal load (W) is known as Coefficient of Friction (CoF), denoted with symbol ‘µ’ [6]. This relation led to the formulation of First Law of Friction which is expressed by (1):

\[ F = \mu W \] (1)
1.2 Load Cell
This project utilizes strain gauge type single point load cell that consist of four strain gauges. It has capacity to up to 100 kg of load and output voltage up to 10 V with of sensitivity of 2.0 mV/V [7].

2. Methodology

2.1 Electrical system
Electrical components involve for the experiment including the load cell itself is as shown in Figure 1. The cell is fixed to an aluminium arm that is elastically swingable. The cable attach on the load cell is connected to the signal conditioner. The signal conditioner will normalize the voltage output from the load cell between 0 to 2.5 V. Normalization is important in order to comply data logger input specification that can only capture signal between specified voltage [8].

![Figure 1. Electrical component involved](image)

2.2 Mechanical arrangement
Arrangement of the load cell on top of the POD is shown in Figure 2. Basically a stationary contact pin hold by an elastic type arm that can be extended to almost half diameter of a disc underneath it. The arm is also connected by high tension string wire attached with a weight holder. The disc is rotated electrically and controlled by motor drive. The disc rotation is measured in RPM. The contact pin is hold into a holder that is attached to an arm that can be slide the arm is fixed with a load cell to detect the sliding force. When the disc is rotating and with a load applied on the pin, the contact between the pin bottoms with the disc surface will cause a sliding force that is detected by the load cell and read by data logger.

![Figure 2. Load cell arrangement on top of POD system](image)
2.3 Control system and software

![Block Diagram](image)

**Figure 3.** Friction measurement system block diagram

Initially the load cell is calibrated for 20 N/V then the output signal from the load cell in term of voltage variation is captured by the data logger and transmitted to personal computer (PC). This output signal is translated into friction force using equation (1) with W (N) is pre input as 20 kg. The experiment runs on 2 types of samples.

3. Results and discussion

Figure 4 shows the tribological behaviour of Coefficient of Friction (CoF) with respect to the Time (s) in lubricant and lubricant with additive. As a comparison we choose the value of CoF from the range of 200 s to 1200 s. The average value of CoF for the lubricant and without lubricant are 0.02 and 0.006 respectively. That means the CoF can be reduced significantly, i.e. about 70 %.

![Graph](image)

**Figure 4.** Coefficient of Friction (CoF) versus Time (sec) for the lubricant and lubricant with additive
4. Conclusion
The load cell arrangement and analysis with MATLAB has succeeded measuring CoF for both samples. Results show that with the addition of additive, the CoF reduced remarkably.

Acknowledgments
The author would like to thank Ministry of Higher Education (MOHE) for funding this research (MOHE grant no: 20110105 FRGS) and UNITEN seed fund (grant no:JS10050449)

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