SECS Senior Design
Available Projects – Summer 2024

Development of a small engine/motor dynamometer

Sponsor: Michael Latcha, PhD, ME (latcha@oakland.edu)

In developing electromechanical systems, it would save considerable time and effort to verify the actual performance of a motor that has been purchased (or found as surplus), instead of relying on the specifications that are reported in the data sheet (if a data sheet is available). The use of a small (<100 W?) dynamometer that would quickly, conveniently, and accurately produce the torque vs rpm curve would greatly enhance the efficient and accurate development of such systems.

The design and construction of small engines (powered by steam or compressed air, internal combustion, or Stirling engines, and more), is an ongoing source of industrial research and a popular hobby world-wide. However, there does not exist a commercial device that can be used to quickly, conveniently, reliably, and repeatedly produce the torque vs rpm curve that would allow these researchers and hobbyists to objectively measure the performance of such systems.

This project will address both needs by developing, constructing, and demonstrating a small dynamometer with the following characteristics:

- Quickly measure the power (torque x angular speed) curve of a small motor or engine, ideally with a single sweep from stall through its top speed.
- Able to attach quickly and securely to common small engine and motor shafts.
- Able to be quickly and accurately calibrated.
- Top speed 20,000 rpm, max power 1/8 hp (100 W)
- Parts to be either 3D printed or readily obtained with minimal machining.
- Choice of microprocessor is determined by the measurement techniques selected by the design group.
- Optional but desirable – the device is scalable and can accommodate engines and motors up to 1/2 hp (400 W).
- Budget - $300

In the Winter 2024 semester, four design groups took on this task and successfully developed dynamometers that can accurately measure the performance of small electric motors. In the Summer 2024 semester these devices will be extended to small engines:

- Review the designs developed in the Winter 2024 semester, test them, revise as necessary to improve the performance and accuracy for use with several types of electric motors.

- Design and build, or obtain and build from a kit, a small, simple compressed-air engine (budget of $300)
- Model and predict the performance of the small engine.
- Develop a test plan to measure the performance of the small engine.
- Use the revised dynamometer to measure the performance of the small engine, compare it to the predicted performance.

NOTE: Confidentiality and assignment agreements are required before students can begin work on this project. This project will be part of a series of projects submitted by OU to the State of Michigan to encourage entrepreneurial activity in MI college graduates, so if you wish to go into business for yourself, this may be the project for you.

Design of a Sensor Testing and Demonstration Device

Sponsor: Brian Dean, PhD, ECE (bkdean@oakland.edu)

The project requires the design of single or multi-chambered device(s) with device testing port(s).

A user will be able to place a sensor into the testing port and then command the chamber to run through predetermined testing and/or demonstration procedures. At a minimum, the chamber should be designed to complete static calibration and dynamic characteristic procedures.

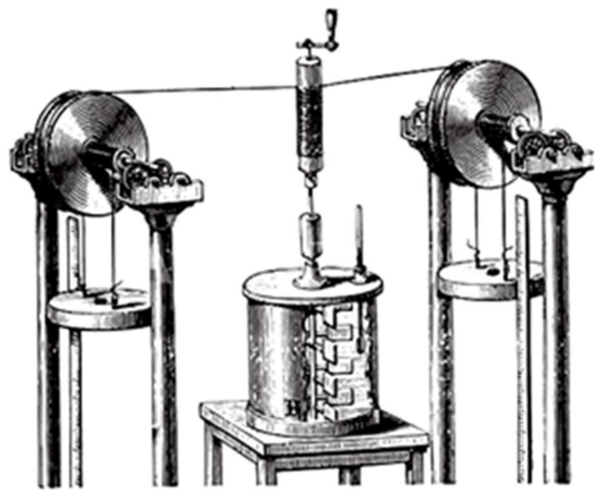
For the static calibration procedure, the chamber should be able to reach specific set points and report its own uncertainty range. For the dynamic characteristic procedure, the chamber should be able to produce a step, ramp, and/or sinusoidal signal where appropriate. Devices to be tested in the chamber(s) are pressure sensors, temperature sensors, and flow/velocity sensors.

The device is intended to be used in sensor design and analysis classes. As such, the device needs to be easily set up and easily stowed after use.

Design and Construction of a Joule Apparatus

Sponsor: Thomas Raffel, PhD, OU Department of Biological Sciences (raffel@oakland.edu)

James Joule (1818-1889) is one of history's most famous experimental physicists, because he obtained the first accurate measurements equating mechanical energy with heat energy. In his experiment, he converted nearly all a weight's gravitational potential energy into measurable heat energy, by connecting the weight to a paddle inside an insulated container of water. Normally a dropped weight would release all its kinetic energy at once, by crashing into the ground. In Joule's setup, however, a gear system makes the paddle spin very fast while the heavy weights lower at a constant slow speed, so nearly all its energy goes into heating the water.



Dr. Raffel created a homemade version of Joule's apparatus from an old-fashioned ice cream maker. In this version, each 9 kg weight drops ~1 meter at a time and there is 3 kg (3 L) water inside the chamber.

The purpose of this project would be to redesign and build an updated Joule Apparatus:

- Efficiently convert a falling weight's potential energy to heat energy
- Incorporate a digital temperature sensor and display
- Design should be robust, appropriate for demonstration and student use
- Design should allow quick set up and take down, and convenient storage
- Take advantage of 3D printed parts where available
- Produce a complete set of 3D files and drawings to allow the design to be shared
- Budget – TBD

Design of an Electrical Data Acquisition System

Sponsor: Derek Smith, OU FSAE, (smith41@oakland.edu)

The Formula SAE team has a D100 dynamometer and a DC 200 controller for the dynamometer. The unit is a water brake system that is basic in its functionality. The main unit is constructed with a housing with a bladed impeller inside. The housing is bolted into a fixture so that the housing can pivot slightly. This pivoting action is registered by a strain gage load sensor. The unit also contains a 60x Hall effect sensor, and both of these sensors are outputted to the control unit.

For the unit to operate properly a steady flow of water in plumbed into the impeller housing, the engine to be tested is then coupled to the unit and operated. As the engine is run, the water flowing through the housing resists the rotation of the engine at a pre calibrated value depending on the flow of the water. The water flow is controlled by 2 gate valves, one is a large bore gate valve which is used to control the coarse volume of water flow. The second valve is a smaller gate valve that will fine-tune the water flow to a specific value. The electronic signals from the load cell and speed sensor are fed into the controller, there the value for rotational speed is displayed on 1 of 3, 4 position 7 segment displays. The second display provides the calculated value of torque, the final display provides a calculated value of power.

The project will focus on a complete redesign of the DC 200 controller. The sensor data will be collected via analog input into a microcontroller board (Arduino Uno). The board will process the load cell and speed sensor data to calculate power and torque values. It will then output these values along with values to be graphs to a 10” HMI (Human Machine Interface). The HMI can be used as a control panel and will be used to communicate with the Arduino to change the values for gear ratio as well as other parameters that will affect the calculated values. Device control with the use of the HMI in conjunction with the Arduino will also be used to control a redesigned water flow control system. This system will use DC motors to adjust the water flow remotely along with water pressure help of a water inlet pressure sensor.