Force Controlled Polishing Head

MIE TEAM #12
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Abstract

The Electrochemical Characterization lab at Concordia University, supervised by Dr. Rolf Wüthrich, has requested the design of a force feedback device that will polish electrodes by the means of a semi-automated system. Several design objectives are to be taken into consideration. In order to achieve a clean surface finish on the graphite electrodes, the machine must apply a uniform force on each sample. In addition to being interchangeable, the holding mechanism of the device should be capable of holding multiple electrodes of different shapes and sizes. A concise literature review has revealed that in order to obtain a clean surface finish on the electrodes, the abrasive used to polish should be on the order of a few microns. A comparison was made between the completed Force Feedback Electrode Polishing device and the commercially available Buehler Vector LC 250 Power Head. The specifications sheet revealed that the weight has been reduced from 55 lbs to 30 lbs. In addition, the rotation speed of 60 rpm of the holding device has been replicated. Both machines can apply 0 to 5 lbs of force on the electrodes. The testing phase of the project revealed that the accuracy of the force application of the device is 0.1 lbs, matching the desired design goal. Several improvements can be made to the final product developed for Dr. Wüthrich. It is recommended that the current plastic ball bearing installed should be replaced with a metal linear ball bearing, for improved rotation accuracy of the electrode holder. Finally, the aluminum components of the machine should be anodized in order to prevent corrosion.

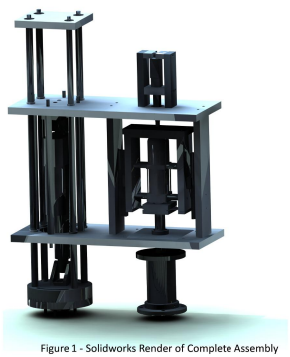

Figure 1 - Solidworks Render of Complete Assembly

Objective

The purpose of this project was to create a force controlled polishing machine for graphite electordes of various dimensions.

This was done by considering certain constriants.

- The rotation speed of the holder with the electrodes is no more than 60 RPM

- The head that holds the electrodes must be interchangeable to allow for various shapes.

- The force applied should be controlable between 0 and 5 lbs

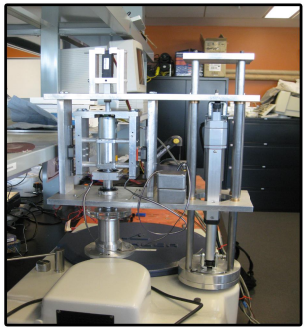

Figure 1 - Assembly of Machine

Design

Design Evolution Through Iterative Process

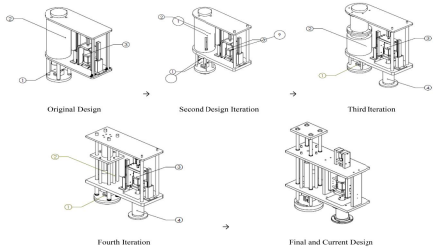

Figure 3 - Iterations of the Design

Holding Head

The Holding head (Figure 4) was designed to hold up to 8 samples of graphite. The pins on each side of the holder allow this assembly to be interchanged in the near future to accomodate for different shaped electrodes.

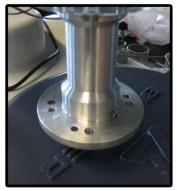

Figure 4- Holding Head

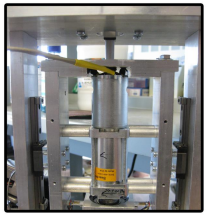

Figure 5 - Fork Assembly

Fork Assembly

The Fork Assembly (Figure 5) is used to apply the force from the fine actuator. The assembly also serves as a supporting armature to the strain gauges which are used to measure the deflection, hence the force applied. Finally the fork serves as the housing mechanism for the geared DC motor.

Coarse Actuator

The Coarse Actuator (Figure 6) is used to adjust the height of the main assembly. The full stroke of the coarse adjustment actuator is 4 inches. It is manually adjustable by the use of a three position switch.

Figure 6 - Coarse Actuator

Controls Box

1: Potentiometer:
Used to adjust the up and down motion of the fine actuator. Turning the knob clockwise/counter-clockwise will adjust the reference voltage in the circuit which allows a different voltage input to the actuator.
2: Three position switch:
Used adjust the up and down motion of the coarse actuator. The up and down position of the switch refers to a positive and negative voltage, respectively, whereas the middle is zero.
3:DC motor on on/off switch:
Motor operated by a toggle switch.
4: LED Display:
Display is used as the force readout indicator
5: Emergency Stop:
Attached directly inline with the kill switch. In case of emergency. The kill switch, when pressed, cuts the main power from the power supply to the machine instantly.

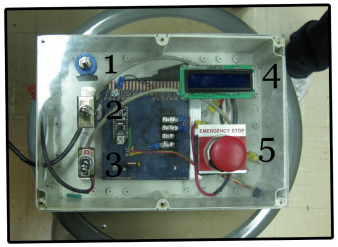

Figure 7 - Controls Box

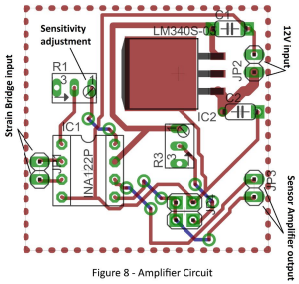

Figure 8 - Amplifier Circuit

Amplifier Circuit

The main electronic components of the amplification system are two INA122P instrumentation amplifiers manufactured by Texas Instruments. This was chosen after sampling and testing several types of differential amplifiers, and showed the greatest overall performance and ease of implementation. These are powered by the regulated voltage coming from one TC780 5V regulator.

Conclusion

In conclusion, a working mechanism was designed and manufactured capable of polishing electrodes in a semi-automated fashion in order to produce more consistent results.This apparatus can hold and polish up to 8 samples simultaneously at a controlled force ranging from 0 to 5 lbs within a precision of 0.1 lbs.

Acknowledgements

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