LAB 6: INDUCTION

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Abstract: *This lab report focuses on the relationship between EMF, fluxes, and magnetic velocity. A copper wire coil and magnet are attached to a CNC are the equipment utilized, and the EMFs are repeatedly induced a different magnetic velocities. The EMF is recorded and measured by the DAQ. the resulting measurements that are collected are used to create three plots which include EMF vs. time, flux vs. time, and Max EMF vs. Magnetic Velocity. In order to find the flux a Riemann's is used by utilizing numerical integration. The max EMF is generated at every magnetic velocity showing the relationship between EMF and the velocity. as a whole the goal of this lab is to gain an understanding for a relationship between EMF, fluxes, and magnetic velocity.*

Keywords: *EMF, Riemann sum, magnetic velocity, flux*

1. Introduction

The goal of this lab is just a bizarre relationship between the flux magnetic velocity and EMF. An electromotive force (EMF) is essentially when the electrical action is created from a non-electrical source. For this lab the non-electrical source is the magnet and it is key to note that the EMFs can get their source from chemical or mechanical energy such as batteries or generators. An EMF is measured in volts however not in voltage and is the negative derivative of a flux *(EMF = -dϕB/dt).* The magnetic flux is a measurement of the total magnetic field in a given area which is related to EMF by this given equation: $\phi = -\int \varepsilon \, dt$. It is key to understand these relationships as it helps create these equations, that are listed toward the end of the lab, and will allow for calculations throughout the entire lab. The EMF is measured by the DAQ in volts, which leaves the flux being the only factor that must be calculated.

2. Experimental Procedure

For the setup of this lab the coil is attached to the railing which hovers over the lab table and the magnet is attached to a CNC machine which is used to create an induced magnetic field. for the connection of the DAQ the positive and negative connections are made through Channel 0. the positive charge is on the right and the negative is on the left. to collect data points and measurements the shooting is required to run a python script (run_induction_sweep.py) to ease the data collection process. The center which is position X is set to 270 mm and for the why it is said to 530 mm and for the Z direction it is set to 90 mm. the data points begin to collect when the baguette moves across the front of the coil at a specific velocity which is 52700 millimeters/second per increment of 50.

Equation 1: $\phi_B = -(\Delta t \cdot \overline{V})$ - Magnetic flux equation where ϕ_B is the magnetic flux, t is time and V is voltage.

Equation 2: $\Delta t = t_2 - t_1$ - This equation is the change in time.

Equation 3: $\overline{V} = 1/2(v_1 + v_2)$ -used to find the average volt (plugged into equation 1).

Equation 4: $\phi t = \phi_1 + \phi_2 + \phi 3_3 + \cdots + \phi_t$ -numerically calculates the actual flux values from equation 1 and sums it using Riemann's sum.

Equation 5: $Max\ EMF = |Max\ EMF| + |Min\ EMF|/2$ - This calculates the Max EMF that generates Max EMF vs Magnetic velocity, hence finding the maximum magnitude of the EMF.

3. Results and Analysis

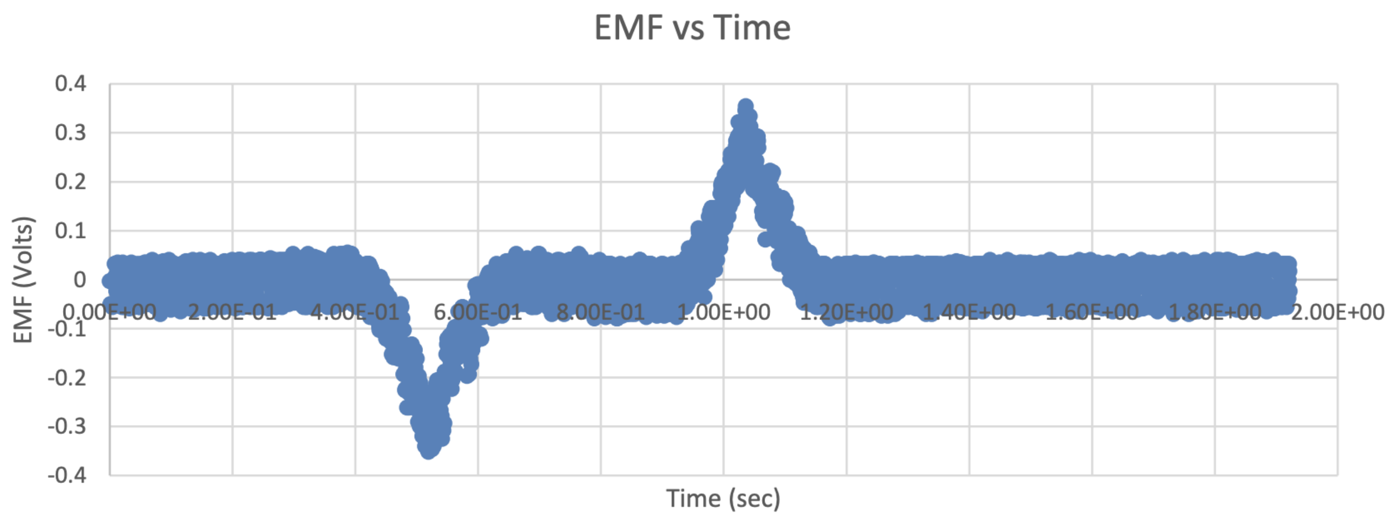

Figure 1- EMF vs Time (400 mm/s magnetic velocities)

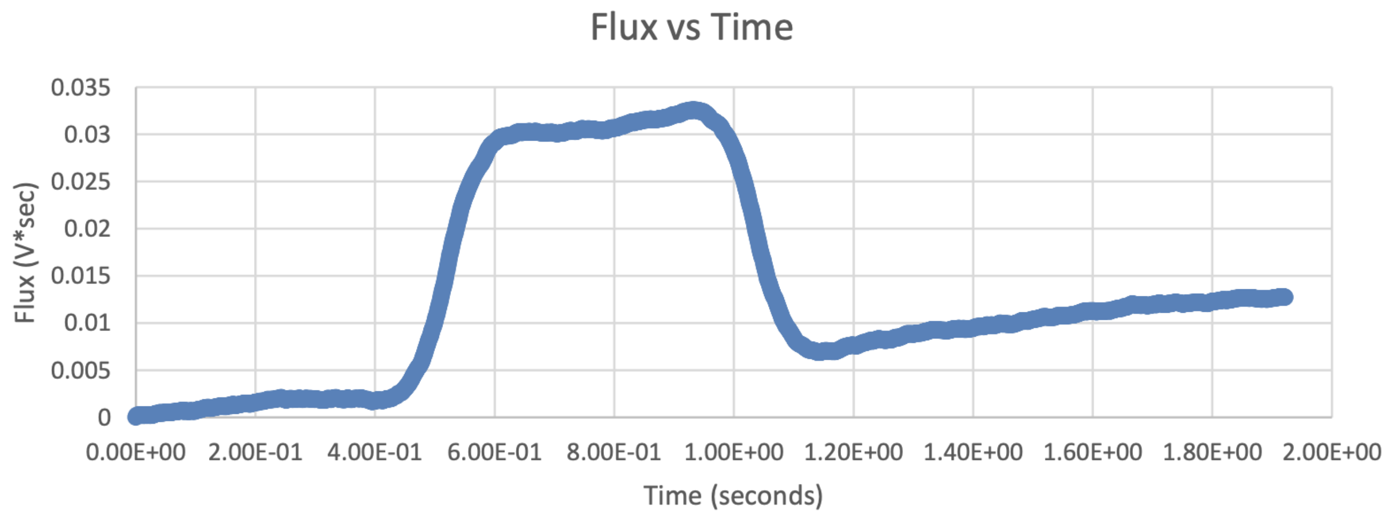

Figure 2- Flux vs Time (400 mm/s)

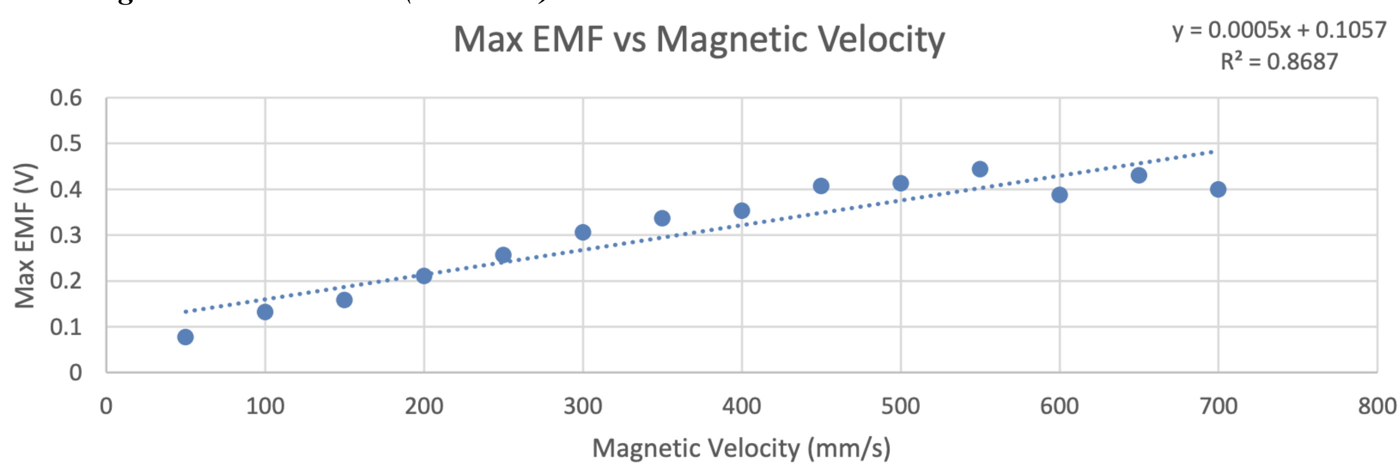

Figure 3- Max EMF vs Magnetic Velocity

Once the EMF and time for each magnetic velocity were collected, the EMF vs. time plot was generated to be 400 mm/s magnetic velocities. In figure 1 the EMF has one positive peak and one negative peak. The negative peak comes first at 0.5 seconds and the positive peak at 1.05 seconds. Once the EMF vs time plot was generated, then the student graphs the flux vs time plot, where the flux is the negative time integral of the EMF. This is where Riemann's sum is used to calculate the values numerically given that Riemann's sum uses the area under the curve to find a value. In order to calculate the flux The two factors that are calculated are from equation 2 and 3 which is Δt and $\bar{V}$ which gets plugged into equation one well equation for is used to find the actual flux value. The equation represents Riemann's sum and the values that are generated against the time that is shown in figure 2. figure 2 shows that there is a slightly positive trend as Riemann's sum sums up the consecutive positive values starting from 1.05. In figure 1 1.05 seconds marks the starting as values are centered slightly above zero. The max EMF versus magnetic velocity graph is shown in figure 3 and in order to generate the graph the student uses equation 5. The absolute value in this equation is taken for the maximum and minimum EMF given that there could be negative data points that can impact the collection of the magnitude for the EMF so we must use an absolute value function in order to find the maximum magnitude of the EMF. After completing all the trials there is a trendline equation generated on the plot and an r-squared value. The equation is y = 0.0005x + 0.1057 and the r-squared value is 0.8687 which shows a linear relationship between the max EMF and the magnetic velocity. Thus showing that the max EMF value increases as the magnetic velocity increases.

4. Conclusions

In conclusion, the data collected was at 400 mm per second which is shown in figures 1 and 2 and the equations plotted were $EMF = -d\phi B/dt$ and $\phi = -\int \varepsilon \, dt$. In figure 2 there was a slightly positive trend which is not a real representation of the actual relationship between the flux and the EMF since there could be measurement errors in the DAQ. In figure 3 it represented the max EMF and magnetic velocity which represents the relationship between the two factors showing that the max EMF will increase if the magnetic velocity increases. the relationship of the two is further determined by an r-squared value which is 0.8687. Throughout the execution of the lab, the student learns the relationship between the EMF, flux, and magnetic velocity.