Hysteresis_notebook_Gregor

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0.1 Hysteresis lab - Benedikt Gregor

Physical measurements of components were taken with callipers Iron core measurements width, callipers +-0.01mm: 29.98, 30.18, 30.00, ruler: 31mm +-0.5mm height iron core, callipers +-0.01mm: 29.00, 29.00, 29.00, ruler: 28mm +-0.5mm length iron core, callipers +-0.01mm: 101.62, 101.50, 101.52, ruler : 101mm +-0.5mm

steel core length, callipers +-0.01mm: 102.82, 102.92, 102.90, ruler: 110mm +-0.5mm

width steel core, callipers +-0.01mm: 28.00, 27.98, 28.00, ruler: 27mm +-0.5mm

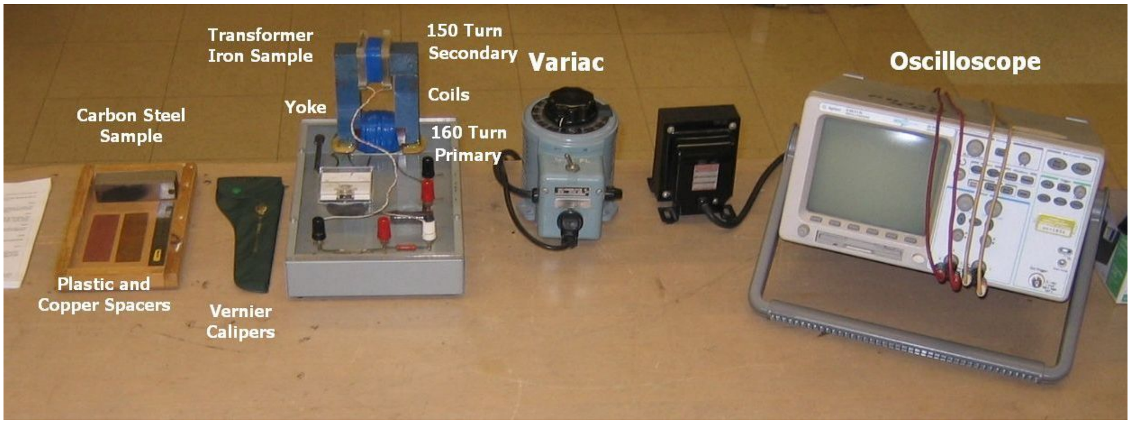
steel core height, callipers +-0.01mm: 27.56, 27.62, 27.50, ruler: 27mm +-0.5mm

height of yoke, callipers: 150.00, 150.00, 150.00

length of yoke, callipers +-0.01mm: 101.70, 101.90, 101.98

width of yoke, callipers: 30.40, 30.22, 30.10

Setup:



After the measurements we turned on the oscilliscope (2534 digital storage oscilloscope bk precision) and set channel 2 to a function of channel one, pressing horizontal and select x-y. Then we used a BNC to banana plug adapter and inserted it into channel one. Then the cables for the H field coming from the transparent box were plugged into the adapter for the x axis. Then was the B field plugged in for channel 2 also with an adapter and two banana cables.

We slid the iron sample into the secondary coil so that it is centered and then placed on the top of the yoke. With the variac set to 0 we turned it on and gradually increased the voltage. With the increase in voltage the oscillations in the yoke caused an ever louder buzzing sound. The hysteresis loop started to appear gradually from the center of the oscilloscope screen. It spread from the middle into its shape. To make the curve smoother the averaging function on the oscilloscope was used by pressing acquire and average for 256 cycles. The voltage was then further increased until the curve spans 400mV on the x axis. The scale was between 50 and 60 on the variac and the amperemeter read 3 on the A.C. scale. Next, the oscilloscope was set back to the time domain by selecting horizontal, main. The time resolution was set to 5ms per division. Then a USB stick was plugged into the oscilloscope and data was saved with save/load, external storage, new, file type csv.

Iron sample loop progression: The oscilloscope was returned to x-y mode again to examine the hysteresis loop progression. The Variac was turned and voltage was increased to about 30 on the scale with an aperemeter reading about 0.5. Using the manual cursor with channel one as the source and the scale set to CH1=50mV and CH2=100mV data points were collected. The variac is then increased to 40 on the scale with the amperemeter reading about 1 and the scale is changed to CH1=100mV. Followed up with an increase to 50 with the amperemeter showing about 1.5. Between those settings at least 15 data points have to be recorded.

Iron sample energy losses: The temperature of the iron sample was measured with an infrared temperature gun by mastercraft reading about 41.2°C. For comparison a 40W lightbuld was also measured which resulted in 42.5 °C.

Next the effects of plastic and copper spacers on the loop were tested. The spacer was slid between the iron core and the yoke so that it also passes through the secondary coil. With the plastic inserted the variac was turned up to around 70 (5.4 on amp scale) and the hysteresis loop looked more like a curve now with no descernable area using scales: CH1=200mV and CH2=200mV The copper spacer was only turned up on the variac to about 15 (1.8 on amp) on the scale. The instruments started shaking under the vibrations and the hysteresis loop had become oval shaped, or in other words a big increase in area. This was observed with the scales: CH1=100mV and CH2= 20mV

The same steps are now conducted with the steel sample. Turning the variac up to about 50 again (3 on amp) the hysteresis curve immediatly looks like it has more area than the iron one with scale CH1=100mV and CH2=100mV. When not turning off the variac without reducing the voltage to zero beforehand the sample becomes hard to remove as it magnetically still sticks to the yoke. Judging from the resolution of the oscilloscope and the adjustments of the cursor the error should be about +-2mV.

[33]:
```python
import numpy as np
import matplotlib.pyplot as plt
plt.rcParams['figure.dpi'] = 150
import pandas as pd

# iron sample measurements
iron_width = np.array([29.98, 30.18, 30.00])
iron_height = np.array([29.00, 29.00, 29.00])
iron_length = np.array([101.62, 101.50, 101.52])

steel_width = np.array([28.00, 27.98, 28.00])
steel_height = np.array([27.56, 27.62, 27.50])
steel_length = np.array([102.82, 102.92, 102.90])
```

```
yoke_width = np.array([30.40, 30.22, 30.10])
yoke_height = np.array([50.00, 150.00, 150.00])
yoke_length = np.array([101.70, 101.90, 101.98])

data1 = np.column_stack((iron_width, iron_height, iron_length))
data2 = np.column_stack((steel_width, steel_height, steel_length))
data3 = np.column_stack((yoke_width, yoke_height, yoke_length))
#print(data1)

# making a table to nicely read raw data
def table(data1, N):
    fig, ax = plt.subplots(1,1)
    column_labels = ["width [mm] +-0.01", "height [mm] +-0.01", "length [mm] +-␣
↪0.01"]
    df =pd.DataFrame(data1, columns=column_labels)
    ax.axis('tight')
    ax.axis('off')
    if N == "I":
        plt.title("Iron sample dimensions")
    elif N == "S":
        plt.title("Steel sample dimensions")
    else:
        plt.title("Yoke dimensions")

    ax.table(cellText=df.values, colLabels=df.columns, loc="center", cellLoc =␣
↪"center")
    plt.show()

table(data1, "I")
table(data2, "S")
table(data3, "Y")
```

Iron sample dimensions

width [mm] +-0.01	height [mm] +-0.01	length [mm] +- 0.01
29.98	29.0	101.62
30.18	29.0	101.5
30.0	29.0	101.52

Steel sample dimensions

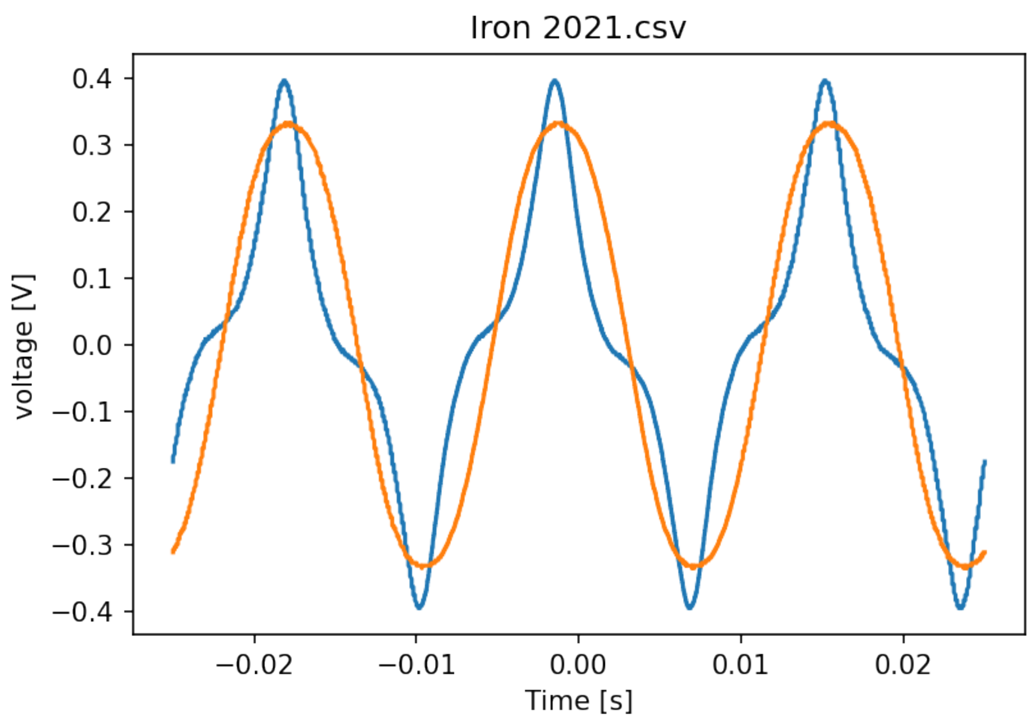
width [mm] +-0.01	height [mm] +-0.01	length [mm] +- 0.01
28.0	27.56	102.82
27.98	27.62	102.92
28.0	27.5	102.9

Yoke dimensions

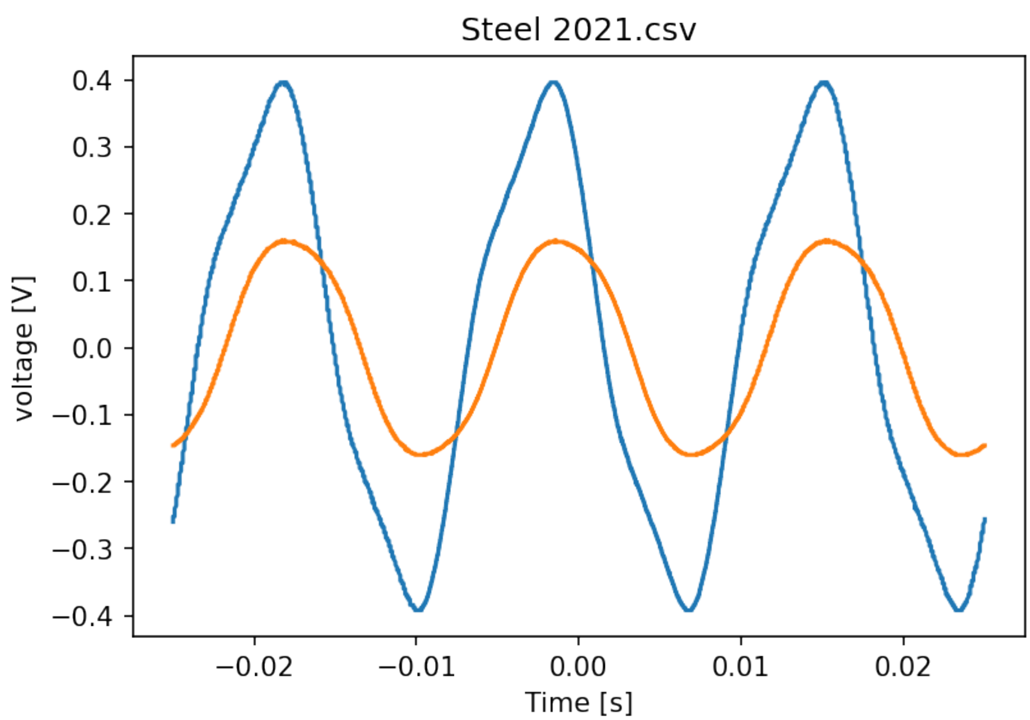
width [mm] +-0.01	height [mm] +-0.01	length [mm] +- 0.01
30.4	50.0	101.7
30.22	150.0	101.9
30.1	150.0	101.98

[29]:
```
def draw(file):
    array_in = np.loadtxt(file, delimiter=',', skiprows = 2)
    x = array_in[:,0] # taking first element of each row (first column)
    ch1 = array_in[:,1] # taking second element of each row (second column)
    ch2 = array_in[:,2] # taking third element of each row (third column)

    plt.plot(x, ch1)
    plt.plot(x, ch2)
    plt.title(file); plt.xlabel('Time [s]'); plt.ylabel('voltage [V]')
    plt.show()
draw("Iron 2021.csv")
draw("Steel 2021.csv")
```



Iron 2021.csv
voltage [V]
Time [s]
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.02
−0.01
0.00
0.01
0.02



Steel 2021.csv
voltage [V]
Time [s]
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
−0.02
−0.01
0.00
0.01
0.02

[ ]:

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