AS Project
Sensing

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Airflow Using A Hot Resistance Wire For Measuring “Distance”

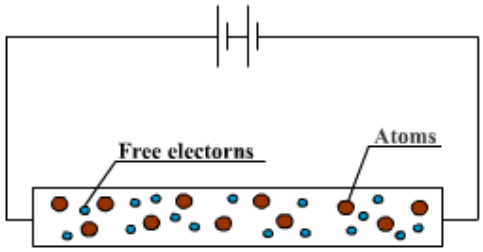
Airflow Using A Hot Resistance Wire

The aim of this project is to design and build a sensor that could detect the distance by using airflow and a hot resistance wire. I am going to use the a resistance wire with a high voltage of about 16 Volt, and then I will measure the changes of the voltage passing through the wire as the airflow pass the wire.

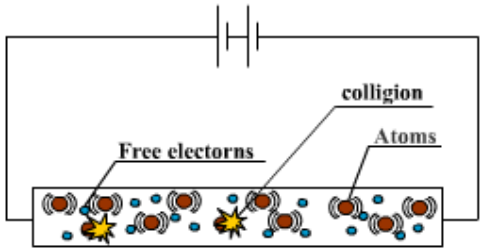
By measuring the changes of the voltage through the hot resistance wire we could know how far the source of the airflow will be.
My sensor is simply based on this idea:

"When we increase the temperature of a metal its atoms will start to vibrate because they gain more energy, this will increase the resistance because the chance of collision between the free electrons and the vibrated atoms will increase"

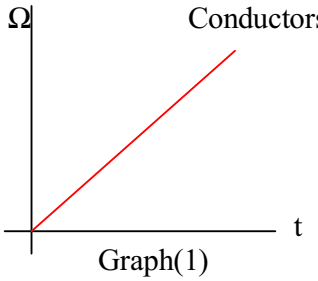
- A metal in a normal circuit



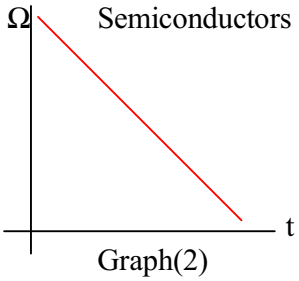
- The same metal after the temperature increased, where there are some collegians between the free electrons and the vibrated atoms.



This also can be shown in resistance against temperature graph as in graph 1 where as temperature increases the resistance increase as will, in contrast to this, in a semiconductor, as the temperature increase, the resistance decrease as in graph 2.



Graph(1)



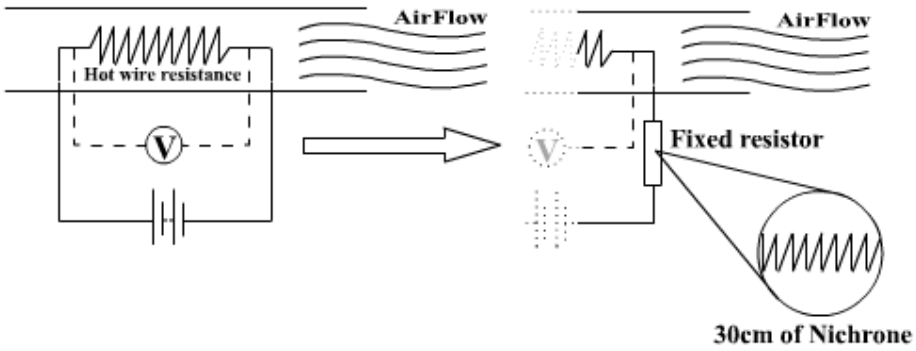
Graph(2)

Nichrome

The material that I am using in this sensor is Nichrome, which is made of Nickel / Chromium alloy and also it can include some Silicon and or Iron.
This material behaves as a metal, whether if there is some silicon or not because the silicon add to it is very small compared to the other metals. I am going o use this material as a variable resistor which will get hot when the current flow through. This material has a big resistance as a wire where most of the wires used manly has no resistance, so when the high current flow through it, it start to be hot and its resistance start to go up. This wire was used by Mr Edison to make his first filament lamp but the Nichrome did not fit for the propose and now I am going to try it again for another method.

Potential divider

The sensor is based on a potential divider circuit because I am going to measure the voltage change. We have to add a fixed resistor to the main circuit which must be in series with the hot resistance wire, where by adding the fixed resistor the voltage will be divided between the fixed resistor and the hot resistance wire.
With out the fixed resistant the voltage will be focused on the hot resistance wire and our reading on the meter we using will not change because the voltage is the same in all cases.



The hot resistance wire has a very small resistance which is just 3.5Ω. This was a problem for me because its hard to find a resistant with the same resistance but its fixed and it not effected with any thing, then I have considered to make my fixed resistance by making a new wire with a doubled length of about 30cm long, with a resistance of 6.5Ω. Where by increasing the length the resistance increase $(R \alpha L)$, this will give me a fixed resistance with a small resistance.

But the fixed resistor should be manly has the same resistance with the variable resistor which in my sensor the fixed resistor has a bigger resistance than the variable resistor.

The method:

- Connect the hot resistance wire (15 of Nichrome) in series with the fixed resistance (30cm of Nichrome).

- Connect them in series with the power supply and make sure that the power supply is off and in mode of about 16 volt.
  Power supply type: *IRWIN* *L.V Power Supply*
  240v input
  16v output

- Then connect the voltammeter or the multimeter you are using in parallel with the hot resistance wire.

- Then we have to try the circuit and measure the voltage through the hot resistance wire with no airflow.

- Then start to record the result from the voltmeter as you moving the airflow source towards or away from the hot resistance wire.

Reading and accuracy:

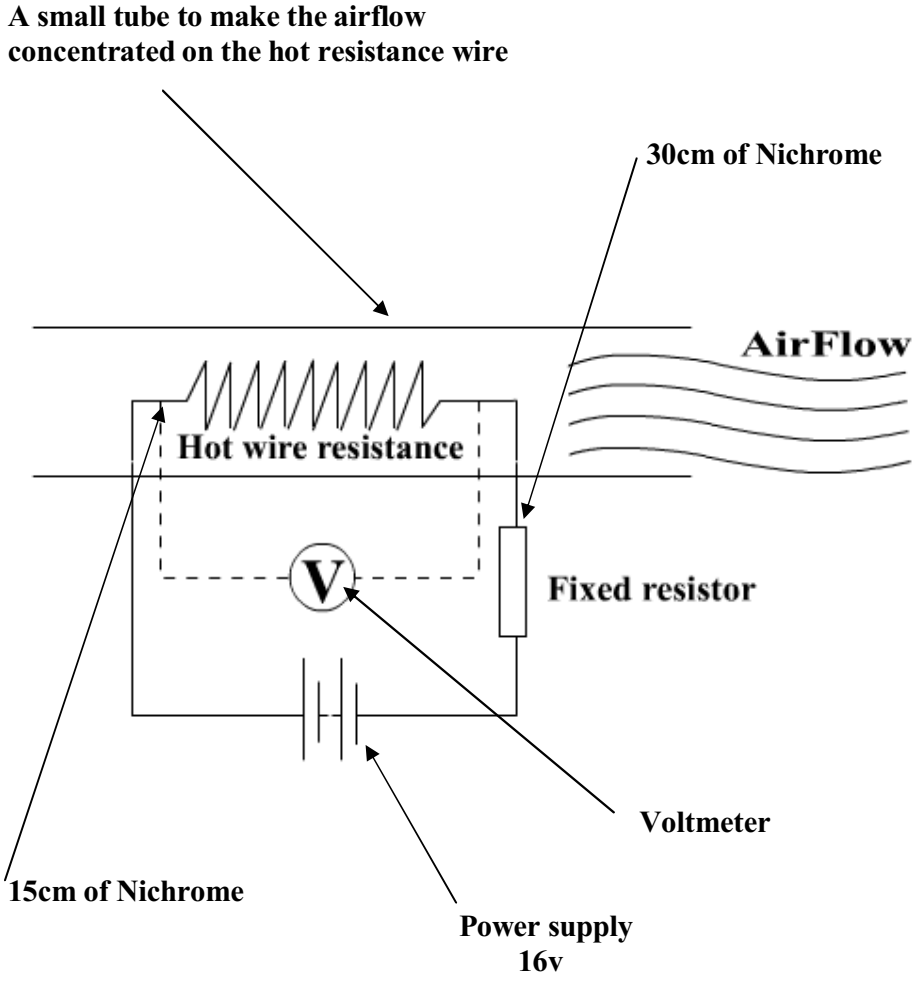
For more accuracy I am going to try this method more than once, see if there is a big difference between the first and second experiment, which means that we need to try the experiment again for the third or forth time.

The experiment should be doe all in the same temperature where the change in the room temperature could affect the results.

Also I think that we have to use the same equipments for every time because this will make the chance of the systematic error.

Safety:

Be careful with the hot resistance wire as its temperature increase.
Using the airflow source might case some problem so you should not leave the small things on the table and make sure that the circuit is conceited correctly.


A small tube to make the airflow
concentrated on the hot resistance wire
30cm of Nichrome
AirFlow
Hot wire resistance
V
Fixed resistor
Voltmeter
15cm of Nichrome
Power supply
16v

Results:

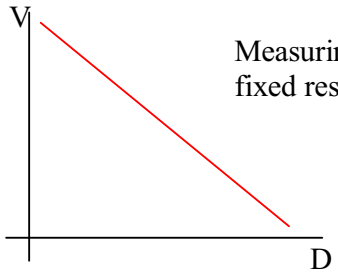
This is the table of the results taken from the voltammeter on the hot resistance wire by moving the airflow source 10cm every step:

	Experiment 1	Experiment 2	Average
Distance "Cm"	**Voltage "V"**	**Voltage "V"**	**Voltage "V"**
0	4.79	4.78	4.78
10	4.79	4.79	4.787
20	4.80	4.79	4.795
30	4.80	4.80	4.802
40	4.81	4.80	4.81
50	4.82	4.81	4.817
60	4.82	4.82	4.825
70	4.83	4.84	4.832
80	4.84	4.84	4.84
90	4.85	4.85	4.847
100	4.86	4.86	4.855
No airflow	5.00	5.00	--------

G1: This is the first experiment.
G2: The second experiment.
G3: Both the first experiment and the second experiment.
G4: The average of the first and the second experiments.

From the results and the graphs we could see clearly that the changes in the output is very small where there is a change for every 10cm of no more than 0.007V which is very small change, and this will effect the resolution of the sensor which is very important for a good sensor

I have calculated the changes of the output by measuring the changes on the hot resistance wire, but if we measured the output throughout the fixed resistor the changes will also stay in the same amount, but the only change will be that the voltage will decrease as the distance increase



Measuring the output voltage throughout the fixed resistance

Distance α Voltage

From the graph and the results we could see that the relationship between distance and the voltage output is a direct proportional relationship.

R=V/I As R increase V will increase R α V
When R increase D will increase R α D

If (R α V) and (R α D) **» D α V**

For example:

When the airflow source is away from the hot resistance wire of about 50cm the P.D=4.81v, and when the resistance of the hot wire goes up by taking the source of the airflow away from the hot wire resistance by another 50cm v also go up from 4,81 to 4.86v

This mean as "D" distance goes up from 50cm to 100cm, "V" voltage is also will go up from 4.81v to 4.86v (D α V)

Sensitivity

The sensitivity of any sensor or measuring system is the ratio of changes of output to changes of input. And the sensitivity I have got was very small.

If the Sensitivity = Output/Input
= Voltage/Distance (the gradient of the graph)

Gradient= $(Y_2-Y_1)/(X_2-X_1)$
Experiment 1 sensitivity = **$7.5x10^{-4}$**
Experiment 2 Sensitivity = **$9x10^{-4}$**
Average sensitivity = **$7.5x10^{-4}$**

Resolution

The resolution of a sensor is the smallest change it can detect or measure, and I contest with the sensitivity I have got very big resolution.

Resolution = Input/output
= Distance/Voltage (1/Senstivity)

Experiment 1 resolution = $1/7x10^{-4}$ = **1333Cm/V**
Experiment 2 resolution = $1/8x10^{-4}$ **= 1111Cm/V**
Average resolution = **1333Cm/V**

This means that every **1cm** change in the distance I will have **$7.5x10^{-4}$ V** change in my voltmeter.
And every **1V** change in the voltammeter need to change the distance of the airflow source **1333.3Cm**.

I found that the rate of the voltage output change of about 0.00075V for every 10Cm which this mean that I can generate a formula which will help me to predict the distance from the voltage output I have

00cm	4.78
Difference	*0.0075*
10cm	4.787
Difference	*0.0075*
20cm	4.795
Difference	*0.0075*
30cm	4.802
Difference	*0.0075*
40cm	4.81
Difference	*0.0075*
50cm	4.817
Difference	*0.0075*
60cm	4.825
Difference	*0.0075*
70cm	4.832
Difference	*0.0075*
80cm	4.84
Difference	*0.0075*
90cm	4.847
Difference	*0.0075*

If we take the average as a result:

Where 10cm $\longrightarrow$ $4.78 + 7.5x10^{-3}V$

20cm $\longrightarrow$ $4.78 + (2 \times 7.5x10^{-3})V$

The Differences is 0.007.5

D cm $\longrightarrow$ $(D/10 \times 7.5x10^{-3}) + 4.78$

$3x10^{-4}D + 4.78 = V$

$V - 3x10^{-4}D = 4.78$

$D = (4.78 - V)/(-7.5x10^{-4})$ …… AV1

For example:

The voltage output = 4,832

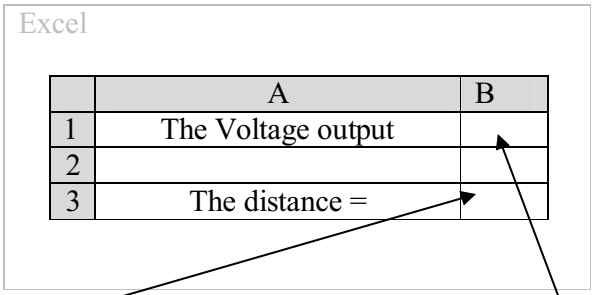
$D = (4.78 - V)/(-7.5x10^{-4})$

$D = (4.78 - 4.832)/(-7.5x10^{-4})$

D = 70cm

By using this formula I can measure the distance after I have got the output voltage from my sensor.

This can be presented in a computer program for example this can be done using MS Excel which is very simple program to use as formula of **(4.78-B1)/-(0.0007.5)**



Where the formula is entered =(4.78-B1)/-(0.0007.5)

The cell "B1"

Conclusion

I have started my sensor where I have found some problems first in designing and building the sensor where I had a problem in making a fixed resistor.
I have calculated my result by measuring the voltage output on the hot resistance wire, where I have tried the experiment two times to see if there is any error in calculating the results or any other systematic errors.
After drawing some graphs for my results I have created the average, which will be taken as the result for the whole experiment
The relationship between the variable (Distance) and the output (Voltage) was a direct relationship where $D \alpha V$.
The sensitivity and the resolution is also has been calculated for both of the experiments, then I have tried to generate a formula to be used to calculate the distance if we have the voltage output which was $D = (4.78 – V)/(-7.5x10^{-4})$.

Evaluation

The sensor I had mad using the hot resistance wire of Nichrome had many problems first it has very small sensitivity, which mean that the ratio of output change is very small compared to the input changes.
Also the resolution is very big which means that the output needs a very big change in the input. The sensor could not detect the changes in the distance many times where I was moving the airflow source quite fast because the response time was very long of about more than 1.5 second, This make the sensor not settable for this purpose, where I think that using another material which is very sensible to temperature like using semiconductor material will be easier and it will create a better sensor which I think that it will be sensible and it fit for the purpose.