ChaMieCHECKING THE IDEAL GAS LAW WITH A STRATOSPHERIC BALLOON IN THE ASGARD-IV PROJECT

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ABSTRACT

The goal is to check the ideal gas law, $pV = nRT$, with the measurements from the ASGARD-IV project. To measure the ideal gas law, the temperature, volume and pressure are needed. To become these values, sensors are used in the ASGARD-IV's gondola. The temperature and pressure were measured by sensors, while the volume is determined by pictures of the stratospheric balloon.

1. The ASGARD-IV project

The ASGARD-IV project is an annual project for schools to measure values of several variables using a stratospheric balloon. The SHD's project this year was to check the ideal gas law within the flight of the balloon. To check this, the values of the ideal gas law are based on the measurements from the project. Temperature and pressure are measured by sensors, while volume is based on pictures made from the FlyCamOneHD. These sensors were controlled by an Arduino Nano, a microcontroller. Instead of wires, a PCB is used to connect the sensors to the Arduino.

2. Pressure measurements

To determine the pressure an altimeter (Parallax' MS5607) is used. On this module there is a high-linearity barometric pressure sensor. With this sensor the pressure to heights can be converted. If the pressure is low, the height will raise and vice-versa. When the pressure is measured, we have one of the variables for the ideal gas law.

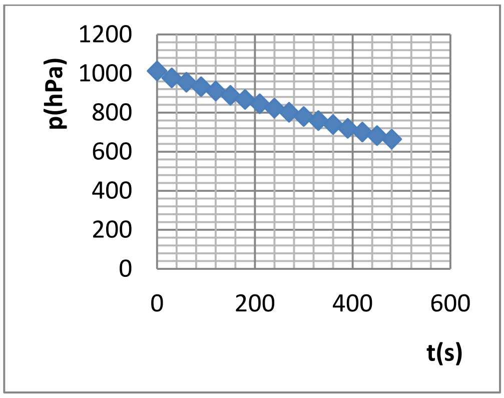

Figure 1: p(t)-graph

3. Temperature measurements

The temperature is directly measured by the altimeter MS5607. So it is measured in the same way as the pressure. On the altimeter there is a high-resolution temperature output which determines the temperature at different heights.

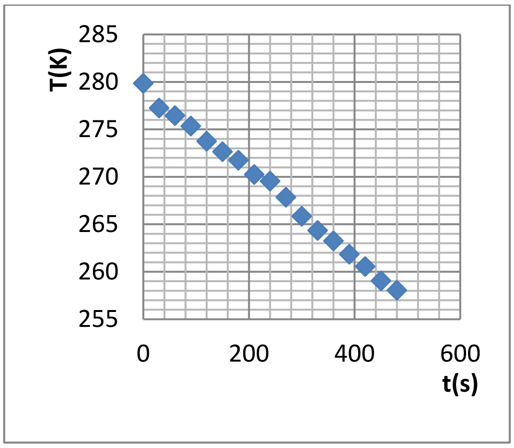

Figure 2: T(t)-graph

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The data of the pressure and temperature comes from the KMI. The KMI provides data from their professional equipment.

4. Determining volume

The balloon is considered to be a sphere. The volume of a sphere is $V = 4\pi/3 * r^3$. As the formula shows, the only variable is the radius. The radius is measured in a special way, i.e. by pictures of the stratospheric balloon. The FlyCamOneHD took a picture every 10 seconds. After 10 seconds the balloon gets a bit higher so the pressure decreases. When the pressure gets lower, the balloon will expand and so the radius of the sphere will become bigger. So by using the photos, the radius is measured on scale. This way of working may not be that precisely, but it gives an idea of what the volume approximately will be.

Figure 3: Balloon at 10m

Figure 4: Balloon at 3000m

As the pictures show, the diameter of the balloon seems bigger in figure 4 at a height of 3000 meters, than the balloon in Figure 3 at an height of 10 meters.

5. comparing the measurements

In a 30 second interval, all the variables are measured. The volume, pressure and temperature. The pressure and temperature decrease when the time increase (fig1 and fig2). The volume becomes higher with the time as is showed in the table.

In the table are all the measurements which are needed to determine the ideal gas law. As the previous points shows how to determine the variables of the formula $pV = nRT$, the variables can now be filled in.

t (s)	r (cm)	V (cm³)	p (hPa)	T (K)
0	2,400	57,906	1013,3	279,85
30	2,625	75,766	977,8	277,25
60	2,625	75,766	955,6	276,45
90	2,675	80,179	932,8	275,35
120	2,675	80,179	910,6	273,75
150	2,700	82,448	888,7	272,65
180	2,700	82,448	867,5	271,75
210	2,750	87,114	845,4	270,25
240	2,750	87,114	823	269,55
270	2,775	89,511	801,9	267,85
300	2,775	89,511	780,1	265,85
330	2,825	94,437	759,4	264,35
360	2,825	94,437	739,1	263,25
390	2,850	96,967	719,6	261,85
420	2,850	96,967	700,7	260,55
450	2,875	99,541	682,5	259,05
480	2,875	99,541	664,2	258,05

Figure 5: Table with the measurements

To know if this idea worked well, every solution in this project needed to become the same constant value when the variables are filled in. When the variables are filled in, the graph shows an almost constant line what indicates us that it is actually possible to check the ideal gas law with a stratospheric balloon. We can see the constant line in the graph in Figure 6.

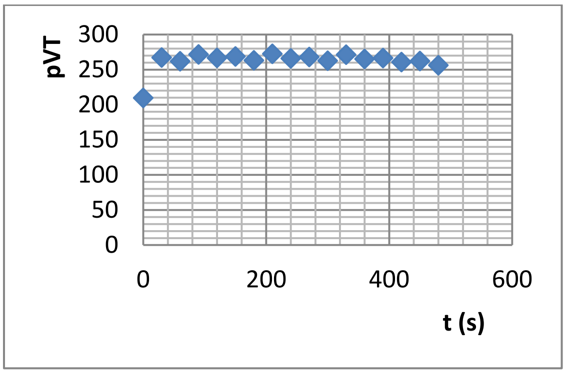

Figure 6: pVT-1(t)-graph

Conclusion

As the measurements and graphs show, the experiment seems to work. The graph of the ideal gas law shows an almost constant line what refers that the ideal gas law approximately can be measured by the technique of the stratospheric balloon. If the volume was more strictly determined, the graph would probably have shown a much more constant than it shows now. So it is possible to check the ideal gas law with a stratospheric balloon.

Acknowledgements

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