

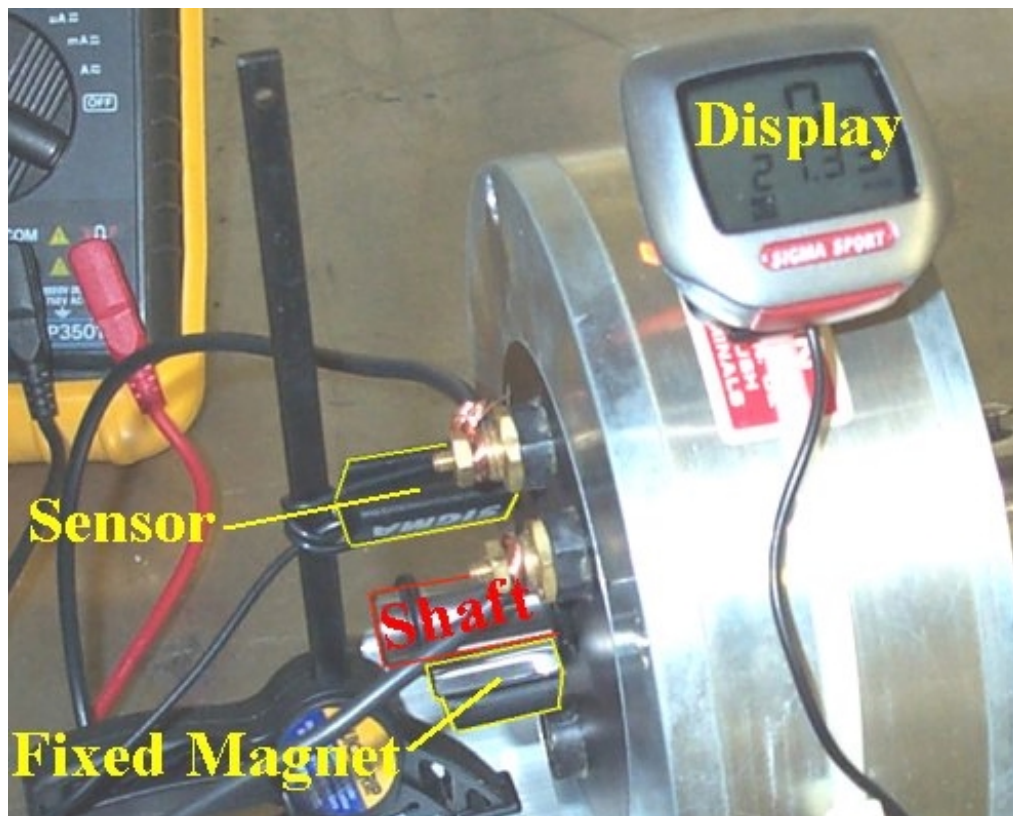
Sigma Sport BC-500 computer as an inexpensive tachometer.



In order to successfully spin cast paraffin grains for the hybrid rocket motor we need to be able to reproduce the same manufacturing conditions each time we make a new grain. One important consideration in doing this is making sure that we have an precise method of measuring and setting the RPM of the apparatus.

It was recently brought to our attention that an inexpensive bicycle computer could be used as tachometer. The tachometer recommended is the Sigma Sport BC-500. It can be purchased for between \$15 - \$20 dollars and works quite well for our purposes.

No major modification to the bicycle computer or to the spin caster needed to be made. The sensor works on the hall effect. The sensor was held with a small 'kwik clamp' fixed to the spin caster base and placed about 5mm away from the fixed magnet element that is held on the motor shaft with an elastic band.



The problem with this bicycle computer is that it doesn't actually give you a RPM output, but instead it gives and mph or km/hr output. Though it is possible to map this velocity output to a RPM output. This is done by making the bicycle computer prompt you for a wheel circumference or "Wheel size" and then giving it the value of 1667. This number is a conversion factor that will cause the computers km/hr output to be the same as Revolutions per Minute. only scaled down by a factor of 10.

Explanation:

We are trying to map

$$\frac{\text{revolutions}}{\text{minute}} \quad \rightarrow \quad \frac{\text{km}}{\text{hr}}$$

the problem is that the units don't match

$$\frac{1}{\text{time}} \neq \frac{\text{length}}{\text{time}}$$

we must convert our revolutions to a physical distance by

$$\text{revolutions} \cdot \text{circumference}_{\text{wheel}}$$

So then what is the required circumference to enter into the computer that will equate 1 RPM to 1 km/hr??

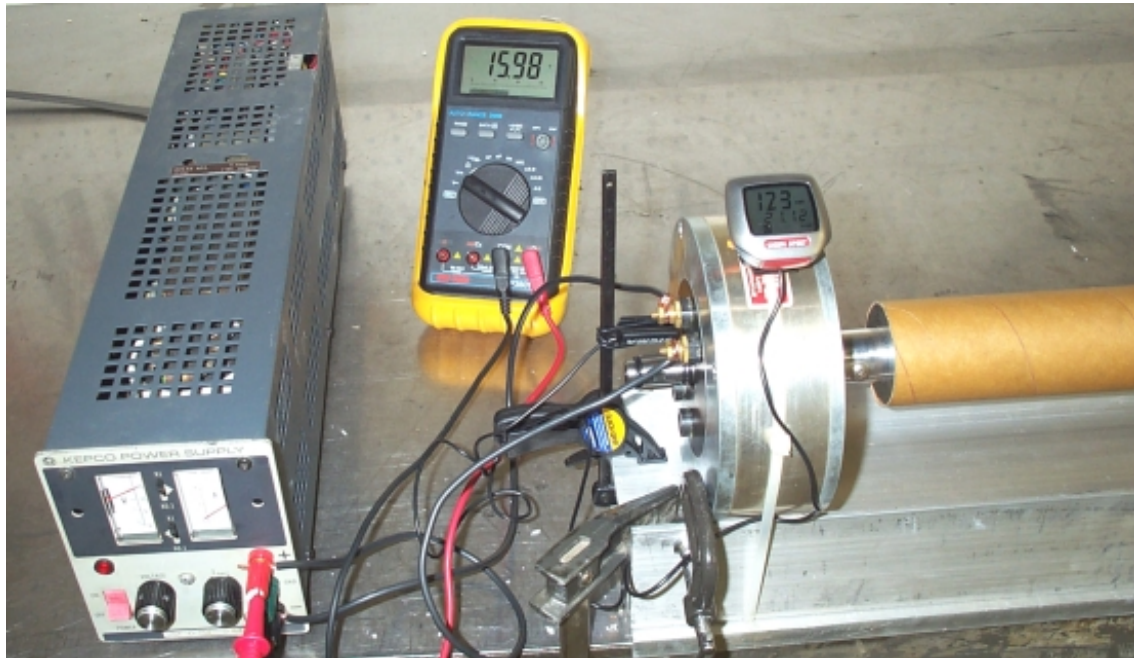
$$\frac{1 \cdot \text{revolution} \cdot \text{circumference}_{\text{wheel}}}{1 \cdot \text{minute}} \cdot \frac{60 \cdot \text{minutes}}{1 \cdot \text{hr}} \cdot \frac{1 \cdot \text{km}}{1 \cdot 10^6 \cdot \text{mm}} = 1 \cdot \frac{\text{km}}{\text{hr}} \quad (\text{EQ 1})$$

Solving for wheel circumference we get a value of 16667 mm. This is outside of the input range of the BC-500 computer so we scale it down by a factor of 10 and let:

$$\text{circumference}_{\text{wheel}} := 1667 \text{mm}$$

Substituting this value back into EQ 1 we find that 1 RPM is equal to 0.1 km/hr or to put it another way 10 RPM is equal to 1 km/hr. Therefore what ever the display on the BC-500 says, we multiply this number by 10 and that is our RPM value.

Verification



To verify that what we are reading on the new BC-500 tachometer is in fact an accurate representation of the RPM of the motor we did a slow speed, manual count of the revolutions over a one minute interval (measured with a stop watch).

A voltage was selected on the lab supply that was near the value that caused a single digit variation in the output of the BC-500. For example, the voltage that caused the display of the BC-500 to go from a 4 to a 5 should equate to the voltage between 49 to 50 RPM.

Once the voltage was set and measured with a DMM we counted the revolutions of the motor in a 60 second period and recorded the data. We decided not to try a visual count of anything more than 60 cycles/min because it was a hassle and the few data points we can get at the lower RPM should give us an idea if the output is truly correct.

Results of first test

Voltage	physical count	scaled for later graphing	Sigma BC-500
1.331	61	6.1	6
1.192	50	5	5
1.052	40	4	4
0.912	30	3	3

For a second test we ran the lab supply to full scale and viewed the output on the BC-500 to see what kind of RPM range we could get. We then plotted the data to see how linear the behavior of the motor was.

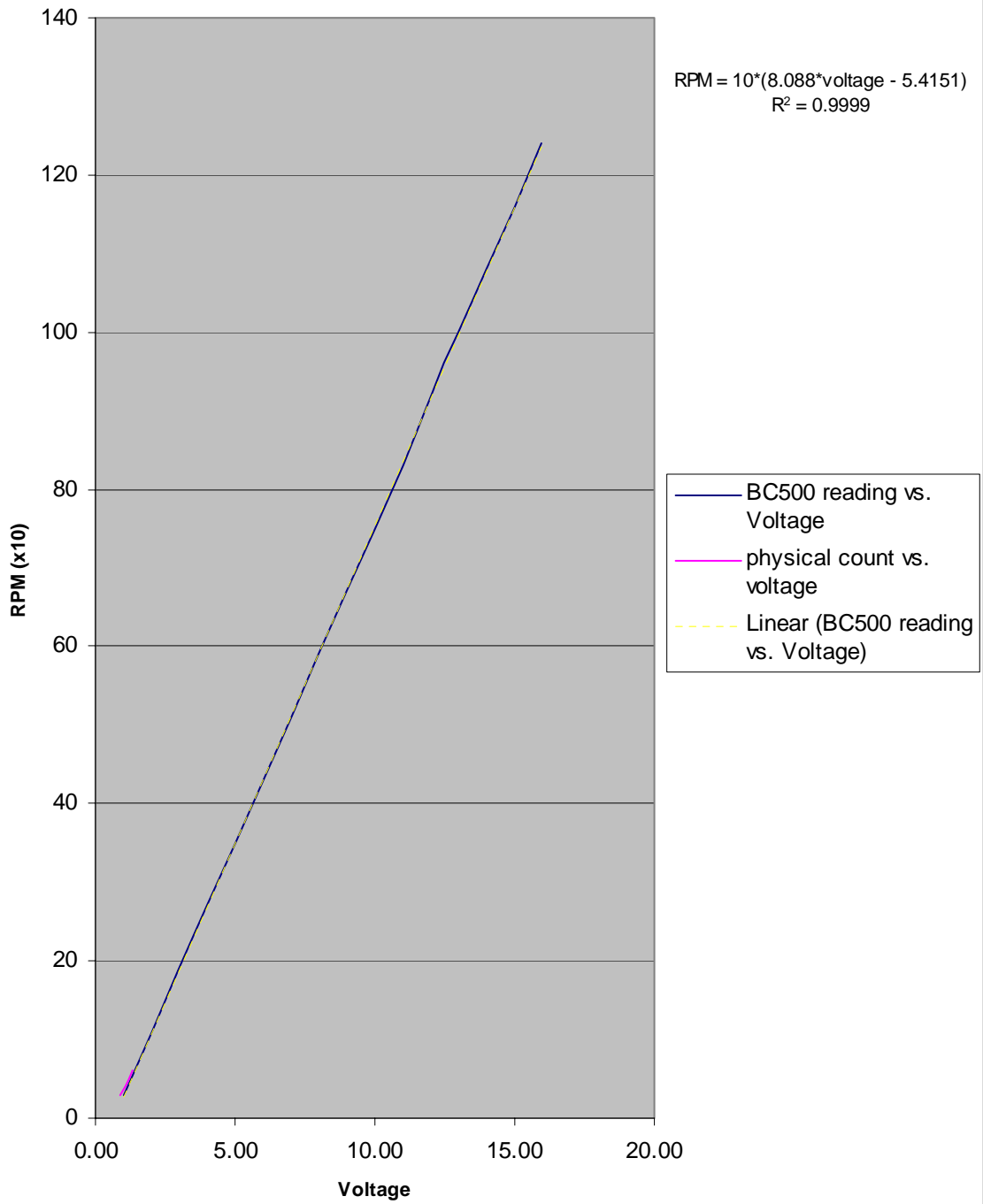
Results of second test

Voltage	Sigma BC-500 output
15.96	124
15.00	116
14.00	108
13.00	100
12.00	92
11.00	83
10.00	75
9.00	67
8.00	59
7.00	51
6.00	43
5.00	35
4.00	27
3.00	19
2.00	11
1.00	3

The two tests were graphed and a curve fit to the data with fairly good accuracy. We are confident that we can read the output of the BC-500 tachometer as a representation of the actual RPM of the spin caster to the nearest 10's, which should be good enough for our casting process.

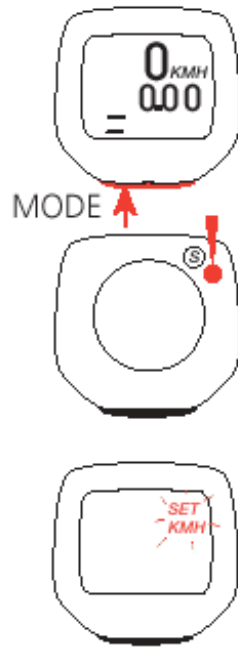
If it was necessary we could determine the actual RPM with higher resolution by using the formula ($RPM = 10 \cdot (8.09 \cdot \text{voltage} - 5.42)$) but in practice we will probably settle on the best RPM to spin the paraffin at from the display on the BC-500 and then in future runs just adjust the lab supply to the correct voltage that gave us that RPM.

RPM vs Voltage



The procedure for altering the BC-500 is as follows:

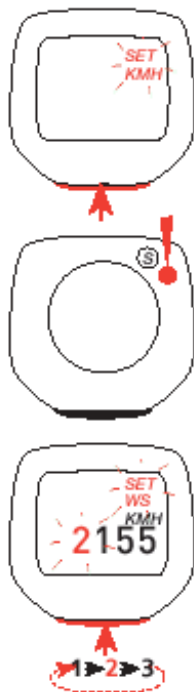
STEP 1



SET **WS** Radgröße · Wheel size · Dimension de roue ·

- GB** Set wheel size
- USA**
- Press MODE until  (no  mode) appears on display.
 - Press SET on the back for 3 sec. with a pointed tool.
 - KMH and SET appear blinking on display.

STEP 2



SET **WS** Radgröße · Wheel size · Dimension de roue ·

- GB**
- USA**
- Enter KMH or MPH with MODE (clock at KMH 24h-display, at MPH 12h-display!)
 - Confirm with SET.
 - The display shows the input standard of wheel size. Choose the number with MODE.
 - Confirm with SET and go to the next position.

STEP 3



SET WS Radgröße · Wheel size · Dimension de roue ·

Enter 1667 for wheel size.

- GB** • Find out the number corresponding to your wheel size out of table **C** "Wheel Size Chart" (next page). Enter this number.
- USA** • Alternative: calculate/determine WS (Tab. **A** or Tab. **B**)
- Confirm and quit with SET after the last position.

You can now read the output of the computer directly as RPM.....remember to multiply the number you read by 10!

