Spyder Wrap Pattern Generator operational theory.

Paper ball shell hemispheres are taped on a custom CNC machine using Gcode. The wrapping has two main phases, Wrapping and Burnishing. Wrapping happens by rotating a completed paper ball with water active paper tape. The wrapping happens in a specific pattern so that after tape has been applied in a straight line part way around the shell, one motor slows down and causes the tape line to skew slightly so it no longer crosses the pole.   
  
On the next revolution the same thing happens again but the next wrap is out of alignment from the first one. This process is repeated until the shell has one complete layer of tape covering the surface. If this were to continue, it would leave the poles uncovered. Once the shell has one full layer applied, based on *Wraps Per Layer,* an overwrap step is applied. The *Overwrap %* variable is used to add a percentage of the circumference to the current wrap before starting a new layer. By doing this, we cause the pole of shell to move to a different location so the current pole gets covered and we get a somewhat uniform layer thickness around the shell. The number of times this shift happens is based on the *Total Layers*  variable.

Once the total layers have been applied, the machine *End of Main Wrap* section would be referenced. This gives the machine specific commands so that it resets itself, displays notifications on the screen and makes a chime to alert the user it is done and to get ready for Burnishing.

**Burnish Stage**

**Burnishing:** This is what we refer to the packing phase of the wrap. When wet gummed tape is applied, it goes on slightly loose based on environmental factors that affect how soft the paper is, how fast the gum was activated, wrap speed and pressure. The Burnishing stage is required to compress the tape fully and allow the layers to fully adhere to each other. When burnishing starts, the tape needs to be manually guided from the wetting station past the rollers and onto the shell. If the tape is taken up too quickly it makes a mess so we throttle the motor speed until the tape is through. The burnishing pattern is not as critical as the wrap pattern since no tape is being applied. In the past this has simply been a copy of the original wrap pattern. Ideally the Burnish stage calculations would start with the last calculated circumference of the shell instead of the original measured size.   
  
Once Burnishing is completed, the machine needs a series of commands to reset itself and reload the wrap pattern. Depending on the machine it is running on, we may need to reference the name of the file to get it to reload again, other machines its simply an internal command such as M2500 that resets everything.

**Shell size Variables:**  
**Shell size:** This is the nominal size of a shell, for reference only.  
**Measured Size:** Actual diameter of the measured hemisphere  
**Diameter %:** This is used to fine tune the wrap pattern, sometimes shells wrap better when they are calculated as either slightly larger or smaller than the measured size. It’s easier to see how an adjustment affects the pattern by changing a percentage rather than a decimal on the measured size.

**Circ +: (circumference increase)** This variable is added to the diameter of the shell on every wrap or every layer. This compensates for the fact that every wrap adds thickness to the shell itself and without adding in the increase in size, the pattern gets skewed quickly. This variable requires trial and error to dial in correctly.

**Total Kick:** This is how much of the total circumference of a single wrap is dedicated to the skewing part where one motor slows down causing the shell to rotate slightly sideways

**Kick Ratio:** this is how much less the Y axis travels in the Kick phase of the current wrap. This affects how aggressive the sideways rotation is.

**Shell Description:** This may be displayed on the machine’s LCD display when the file is loaded to give basic shell information such as type and size of tape to use. This should be inserted into the Startup Gcode section with a \\ in front of it or allow a custom reference in the startup Gcode section that can call this field.

**Pattern Name:** This should be used when saving the file and it is also referenced at the end of the Gcode text to have the machine automatically reload the file and go to the beginning again.

**Wrap Speed Variables**

**Wrap Feed rate:** This is how fast the machine rotates the ball in inches per minute (estimated). This needs to be indicated at the start of the coordinates by specifying F#### after the coordinate.

**Burnish Feedrate:** Since no tape is being applied, we don’t need to worry about how fast the glue can activate so we can run at a higher federate. This sets the max federate for Burnishing  
**Burnish Layers:**  Burnishing doesn’t require as much time as applying tape so we adjust this setting based on what looks good.   
**Burnish Start Speed:**  When we start burnishing, there is about 3’ of tape that needs to be guided to the shell. This feedrate is set to give us time to guide the tape in by hand before it increases to full speed.

**Burnish Ramp Steps:** When wrapping shells, it’s helpful to allow the shell to gain momentum before it goes to full speed. The Burnish Ramp steps would insert several F numbers into the code to tell the machine to increase speed on each wrap. This is not critical and whatever makes sense for steps is fine using whole numbers rounded to the closest 25 possibly. For example. 500-1500 might be 500, 850, 1200, 1500.

**Estimated tape feet.** The machines are based on the number of steps in inches the wheels travel but it is helpful to convert those inches of travel on the X axis to feet. This calculation could also be inserted into the *Startup G code* section to indicate how many feet of tape will be applied to the current shell. Tape comes on 500 or 1000’ rolls and when we are close to the end of a roll its helpful to know how much we need for the next shell.

**Water Pump Variables.** Some of the machines have automatic water pumps built in to wet the tape and others use auto leveling. The water pump controls get activated with a command built into the firmware that activates a relay. The relay activation and stop code gets inserted into the text behind the coordinates so it’s a continuous operation. Depending on the shell size, smaller shells use less water so it may only need to turn on for a couple of seconds. The time it’s on is based on wrap lines that pass before the off command is inserted. Large shells use water much faster and need to activate several times through the entire wrap. If the cycles per shell indicates more than one, the first one should activate immediately and turn off after the duration lines is met, the rest of the water activations should be divided up equally among the rest of the wrap. A cycle of three would be divided into 3rds with the first activation at the start, 2nd activation at 33% and the 3rd activation at 66%. This way, when the next shell starts, it will refill its own water.

**Export:** When exporting, the file should be saved as a standard text file with whatever name is specified in the Pattern Name field, including the extension. Depending on the machine being used I’ve seen .gco, .tap, .gcode and a couple others.

**Opening and saving configurations:** I would like the configuration files to be stored in a text file but with a special extension of .mum to indicate its part of this system (mum is an inside reference for the machine and our group). It can be a human readable file.