ENGINEERING BY DESIGN®
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Pitch and Diameter Accuracy in Coil Winding Requires Accurate Tension & Angle Control

San Jose, CA. – October 2014 – ENGINEERING BY DESIGN, of San Jose, CA is manufacturing new coil winders that precisely control winding parameters when creating coils for catheters. The programmable wire tension can be accurately controlled down to extremely small values. Our systems can wind coils using .0004" diameter wire on a .001" mandrel using our closed-loop filament and mandrel tension control systems. System flexibility enables the filar tension to be recipe-controlled from 5 to 600 grams during the entire wind. New double head machines can wind up to 6 wires on each mandrel, and up to 12 wires on a single head machine.

Filament tension control accuracy is extremely important as tension variations cause pitch variations. And in multi-filar coils any tension difference between the filaments causes one coil to crowd out the rest and make the outside diameter inconsistent. Variations of as little as 5 grams at a wind tension of 50 grams (for example) can make the difference between a smooth coil and one that is unusable. A smooth and uniform 4-filar coil is shown with an outside diameter (OD) of .024" using .004" diameter filaments.

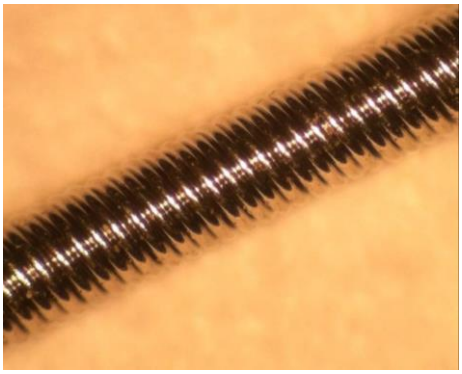

Figure 1, 4-Filar Coil

"The unique use of machine vision to measure wind angle without touching the filament and state-of-the-art control systems allows the manufacture of multi-filar coils with no gaps between coil groups," states Dale Henson, P.E. and President of Engineering By Design. This machine can increase productivity through reduced rejects and improved quality.

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The importance of accurate filament tension and angle control can also be seen in coils that have large pitch variations. Tight-pitch coils are wound with each wrap touching the previous wrap and maybe preloaded for stiffness. This is done by winding with the filament held at an angle that tilts toward the beginning of the coil. A larger tilt angle results in a stiffer coil. This type of coil is best produced using a servo system to detect the actual wind angle and then automatically adjust the angle to keep it within a programmed range.

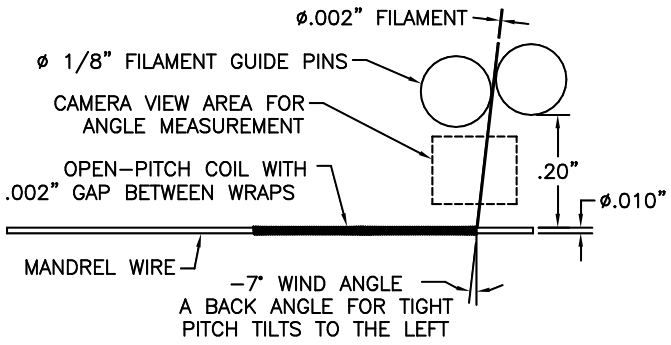

Figure 2, Winding Area Description

An open-pitch coil has a gap between each wrap. Figure 2 shows details of the winding area to clarify the text.

The accurate control of the gap is necessary as typical production tolerances may be +/-.0002" on a gap .002". The tolerances for measuring coil stiffness sometimes require average wind angle tolerances of +/- 1/2 degree. When combining a tight-pitch section with an open, or variable, pitch angle control is typically used for the entire coil. When using optical angle control a slight gap between the filament guide and the winding mandrel (often another small wire) must be maintained to provide an area for the camera to view the wire. This small gap (often between 1/8 and 1/4") limits the ability of the machine to control the pitch when forming an open-pitch coil. This is because the small gap allows room for the wrap point to move back and forth in response to angle and tension variations.

Figure 3 shows a series of multi-pitch coils stacked together to show how similar each one can be with proper control systems and techniques. This typical coil used in making catheters uses a .002" diameter metal filament wrapped onto a .009" OD wire mandrel. It shows a series of variable open-pitches from the left and ending with a short tight-pitch section at the right end before the cut ends.

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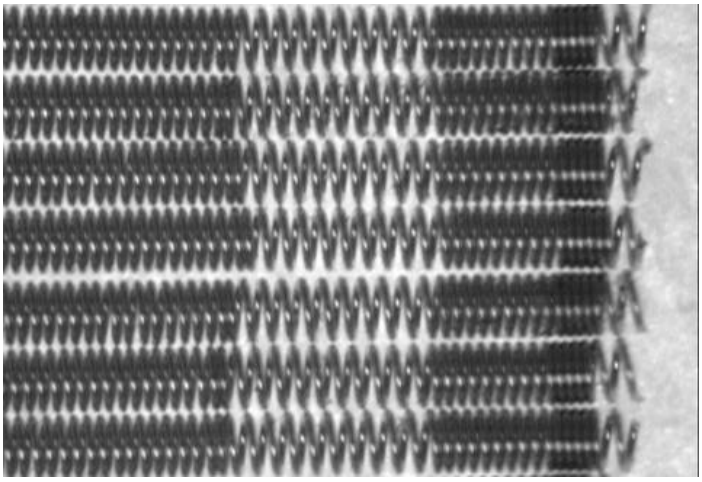

To create a coil with a combination of tight and open-pitch coils using angle control and a pitch tolerance of +/- .0002" the filament tension must be controlled to within 2 grams and the angle to within 1 degree. If the 25 gram tension for this coil increases by 1 gram the wrap point will be moved to the right (winding left to right) by about .0001" for a few turns until the angle control stabilizes it. This changes the gap or pitch by the same amount. Also if the angle changes by about ½ degree it can change the pitch by about .0001". If the manufacturing tolerance is +/- .0002" it is clear that tight servo control of these winding variables is critical.

Things that cause the tension and angle to vary during manufacturing are often cause by material condition variations that are typical of the wire manufacturing process. Variations in the filament diameter cause the pitch and angle to change and must be automatically compensated for. Cleanliness of the filament (usually supplied on a small spool) affects the pitch because any impurities can cause the filament to stick as it is removed from the spool and that causes a tension variation. Even the tension and accuracy of the wire manufacturer's winding of the filament onto the supply spool can cause tension variations as the filament is removed from the spool.