Current Status Report on Melted PEEK Wire Joint

By

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Design Background:
This design is based off an idea of Craig Kline, Indiana University, who first proposed using a flame torch to heat PEEK tubing to the gold plated tungsten wire, his initial work was in an attempt to find a substitute to glass bead that would utilize existing equipment. His first samples of this design were available in mid October, less than 2 weeks after Duke University reported their findings on the glass beads failing. His initial study with this material showed promise as a sound solution with the only exception being the lack of a “mechanical bond” to reinforce the joint should the interaction between the PEEK and wire fail. The lack of “mechanical bond” still plaques this design as it did the glass bead design with the added complexity that polymers are more inclined “age” over time, this aspect is one of the most difficult to test for. Several test have been adopted in the last few week to evaluate this design for long-term aging (ref. Wire Joint Alternatives, John Callahan, 30Jan02).

The design is similar to the current glass bead, in that, a single material that come in a tube form and uses heat to melt the material to the gold plated wire. The major difference is the PEEK material has shown to have little to no reaction to Hydrofluoric acid in test run at Indiana (Ref. Tests of TRT module materials in Hydrofluoric acid Ogren/Morris/Rust 14Nov01). The PEEK material is validated for use in the active gas region of the TRT and is currently specified for use in the duct system for the active gas.

Through the help of contacts at Dupont Plastics we were guided in the development of this design by changing the process to heat the wire vs. heating the PEEK, this type of bond is considered to create an interaction between the two materials vs. the compressive strength only of the PEEK on the wire.

PEEK Material Technical Data:

Tensile Strength at Yield = 22,800 psi / 157 Mpa (91 lbs for .36mm tube)

Melting Point = 633°F / 334°C
Figure 2. PEEK Bead made using laser
The current design consists of PEEK tubing that is commercially available in .36mm by .050mm tube through Upchurch Scientific. This tubing allows the .031mm gold plated tungsten wire to be placed inside the lumen. (Ref. PEEK Wire Joint Assembly Diagram Curt Baxter)

Production
Indiana has assembled approximately 50 wire joints as of February 2002 using various techniques to heat the Wire / PEEK and create a bond between the two. The latest and
what is considered to be the most controlled method for production would include the use of a low powered laser (10 watt). This method is the most attractive at this time due to the precise amount of power that could be transferred to the wire. This method in combination with good optical and positioning equipment could provide a very stable process for melting and bonding the PEEK to the gold plated wire. The first joint made using this process (see Fig. 2-4) was tested and the wire broke and the bead held together.

Size
Size of the wire joint has an important role due to the stringing requirements. Based on a sizing study, the PEEK bead has the best profile characteristics from a stringing standpoint which could reduce the cost of stringing. (Ref. Prototype Wire Bead Comparison Chart by Curt Baxter)

The Process:
- Wire is placed into the tube from both ends to the point that both wires overlap each other inside the lumen.
- Current is monitored using a Ohmmeter between both end of the wire and the wires are moved in opposite directions until current is lost.
- The laser is applied to the wire on each end of the PEEK tube

There is limited experience with this method, but joints with considerable strength have been produced using laser power. The focus prior to this point has been to use current (.4 amps / 1.5 volts) to create the heat on both ends. Both methods have been capable of producing joints but through prototype builds using the current the consistency of melt was difficult to control due to both end being heated at one time. This uncontrolled
heating created a yield of 60% after two days of trial builds. Based on the observation of the laser process the consistency of the bond would greatly increase to close to 100%.

**Cost**

**Equipment:**

<table>
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<tr>
<th>Tooling Costs (1 Station)</th>
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<tbody>
<tr>
<td>Laser</td>
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<tr>
<td>Optics</td>
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<tr>
<td>Positioning equipment</td>
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<td>Total</td>
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Peek material is available in small quantity for $5.00US per foot this equates to $.07 per joint.

The timing estimates are rough at this point the process could be greatly improved through optics and automation. The current estimates are 8 wire joints per hr. based on the prototype builds that have produced an average time per joint of 9.9 minutes per joint. This assumes some improvements due to automation and development of better techniques. The labor cost would be approximately $2.00 per joint for a total per joint cost of approximately $ 2.10.