Micro Extrusion of Feedstock for Manufacturing Stainless Steel Micro Bi-lumen Needles

**Objectives**

This Ph.D. research work aims at developing a prototype of biocompatible stainless steel bi-lumen needles for assisted fertilization by feedstock extrusion processing. To achieve this, the study is divided into the following sub-objectives:

- Developing a process chain for feedstock micro extrusion processing
- Studying the effect of feedstock properties on micro extrusion processing
- Studying the influence of micro extrusion parameters on the geometrical features and surface roughness of the extruded bi-lumen tubes
- Identifying the 'product fingerprints' that better describe the dimensional accuracy of bi-lumen tubes to maintain the quality in-line
- Identifying the optimum debinding and sintering process parameters for extruded micro bi-lumen tubes
- Studying the effect of grinding and plasma polishing parameters on needle tip sharpening and surface polishing to fabricate bi-lumen needles

**Extrusion studies with 17-4PH stainless steel**

Feedstock properties are critical in achieving a product with high geometrical accuracy of bi-lumen tubes to maintain the quality in-line and necessitates developing a process chain by incorporating appropriate manufacturing processes to achieve the final geometrical, surface and structural properties required for the tube’s application.

**Setup for feedstock extrusion**

Extruded bi-lumen tubes using different feedstocks are critical in achieving a continuous extrusion of high aspect ratio parts. Feedstock and their binder contents influence the surface and structural properties of the extruded bi-lumen needles. Extrusion studies with 17-4PH stainless steel showed that variation of extrusion temperature and screw speed showed that:

- Feedstock properties are critical in achieving a continuous extrusion of high aspect ratio parts.
- Feedstock and their binder contents influence the surface and structural properties of the extruded bi-lumen tubes.
- Feedstock ageing could affect part surface properties with an increase in the surface roughness while retaining a similar homogeneity, porosity and structure in the cross-sections.
- Extrusion studies with 17-4PH feedstock gave an average roughness value of 0.40 µm which is a good value much less than the average metal particle size of the feedstock.

**Influence of micro extrusion parameters**

The feedstock micro extrusion studies carried out by varying the parameters showed that:

- Extrusion temperature and screw speed are very influential for geometrical features and surface finish of the tubes.
- The deviations of bi-lumen tube features were observed to be more distinct in the high extrusion temperature levels.
- Low extrusion temperature and screw speed produced low surface roughness and optimum geometrical accuracy and thereby, Tube diameter and roundness are found to be the product fingerprints to be monitored for ensuring the overall quality of the tubes in-line.

**Effect of grinding and plasma polishing parameters**

Effect of grinding and plasma polishing parameters on needle tip sharpening and surface polishing showed that:

- Selecting the proper grinding parametric levels is important and the optimum parameter selection can achieve a least Ra value of 0.01 µm on 17-4PH stainless steel.
- Plasma electro polishing process parameters, voltage and polishing time have significant influence on the surface finish of the treated sintered extruded bi-lumen tubes.
- Plasma polishing demonstrated the capability to polish the tube surface to Ra = 0.40 µm and which is a competing values to the commercially used bi-lumen needles in assisted fertilisation.

**References**


*Figure adapted from www.wiley.com*