Newsletter

POLYTUBES
Polymer micro-tubes & tubular micro-components

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POLYTUBES PROJECT

The overall objective of the POLYTUBES project is to develop a process chain and corresponding micro-manufacturing platform for the manufacture of polymer-micro-tubes and tubular micro-components for medical and non-medical applications.
The proposed development aims to create new markets for EU SMEs with innovative and economically competitive micro-products and micro-manufacturing equipment to meet the needs for a wide range of emerging applications.
The development will also support the SMEs to increase business opportunities with new volume production capabilities in micro-manufacturing.
The proposed development could place EU in a pole position in the manufacture and innovative applications of micro-tubular products.

Within the Polytubes project, Swerea IVF has the responsibility to enable a volume production of polymer micro-tubes and deliver prototype polymer micro-tubes to the Polytubes consortium partners. Swerea IVF has built a polymer extrusion unit specially designed for the stable manufacturing of precision polymer micro-tubes. The equipment has a large degree of equipment set-up flexibility, enabling production of polymer micro-tubes of different dimensions and polymer types. The principal design consists of an extruder feeding a polymer melt to a gear pump which in turn delivers an exact and steady melt flow through a ring shaped die. The extruded tubular formed melt is drawn and cooled to achieve the desired tube dimensions.

To meet the diverse polymer micro-tube properties and dimensions requirements within the Polytubes project and its demonstrator products, there is a necessity to have a flexible equipment set-up, enabling modification of many equipment tooling and production parameters. The Swerea IVF extrusion equipment is shown in Picture 1.

1. Polymer micro-tube extrusion equipment.

The extruder and gear pump

The extruder ensures the condition of the polymer melt (e.g. temperature, pressure and flow) fed to the gear pump. The gear pump in turn delivers a precise melt flow to a ring shaped die inside the extrusion tooling forming the micro-tubes. A gear pump offers better “flow control” at these small flows than a corresponding extruder. Fittings have been specially designed and machined to connect the extruder to the pump and the pump to the crosshead. These are fitted with pressure gauges before and after the gear pump in order to control the state of the melt.

Extrusion crosshead and dies

To produce tubing with minimum tolerances it is important to ensure a balanced extrusion flow and to use a precise tooling geometry designed with the polymer’s rheological properties in mind. The chosen crosshead system is specifically engineered to provide minimum residence time and pressures but at the same time give upstream thermal balancing.
Inside the extrusion crosshead an appropriate die is fitted, see Picture 2. The dies are designed to shape steady melt flow into its desired ring shape. Different die heads and die tips are designed in order to produce the different sizes of micro-tubes desired. The dies mainly set the ratio between the outer and inner diameter of the tube. The exact dimension is achieved by setting other parameters.

2. Two examples of die set-ups.

To be able to control the inner diameter during the production of micro-tubes, a nitrogen gas pressure device is designed to optionally be attached onto the inner die tip metal tube and controlled by small pressure valves.

Drawing and collecting

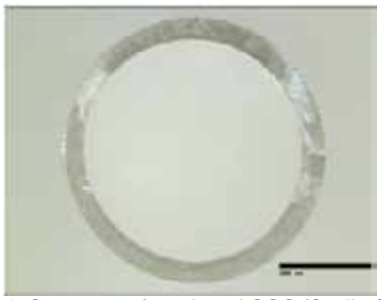
To achieve a molecular orientation in the polymer material and a uniform cross-section shape of the micro-tubes, it is important to have a certain degree of draw, i.e. to have a higher speed in solidified state than in molten state. The drawing deforms the melt into thinner tubes and can be achieved with the use of one of many available rotating roller equipments.
The shape is solidified as the polymer is cooled.
In some cases it is enough with surrounding air but cooling can also be more rapidly forced by leading the extruded tube into water at a suitable distance from the extrusion crosshead exit. The polymer micro-tubes can be cut into desired lengths or collected as one continuous tube.

Wide production possibilities

Swerea IVF has made a wide range of experiments, both based on theoretical calculations as well as fine tuning during extrusion. By varying polymer material, melt temperature, melt flow, die dimensions, nitrogen pressure, cooling conditions and draw ratios it is possible to reach a wide range of tube dimensions.

3. Produced COC (Cyclic Olefin Copolymer) polymer micro-tubes

Swerea IVF has so far produced polymer tubes from amorphous PC, PET-G and COC grades and crystalline or semi-crystalline PP, PET and PVDF grades.
Picture 3 and Picture 4 show examples of produced polymer micro-tubes. However, more or less any media (polymer melt, liquid, slurry, paste) with suitable flow properties can be extruded in the equipment by adjusting the correct equipment tooling and production settings. It is also possible to feed other materials than gases to the inner die tip metal tube. It could be liquids, powder slurries or polymer melts to produce tubes filled with another material.



4. Cross-cut of produced COC (Cyclic Olefin Copolymer) polymer micro-tube.

Contact info:
Erik Perzon PhD
Senior Scientist, Fiber Development
Swerea IVF AB
P.O. Box 104, SE-431 22 Mölndal
Visiting address: Argongatan 30, SE-431 53 Mölndal
Sweden
Phone +46 31-706 63 87 | Mobile +46 76-147 63 87
Fax +46 31-706 63 63
erik.perzon@swerea.se | www.swereaivf.se