n.5

December 2011

# Newsletter

POLYTUBES

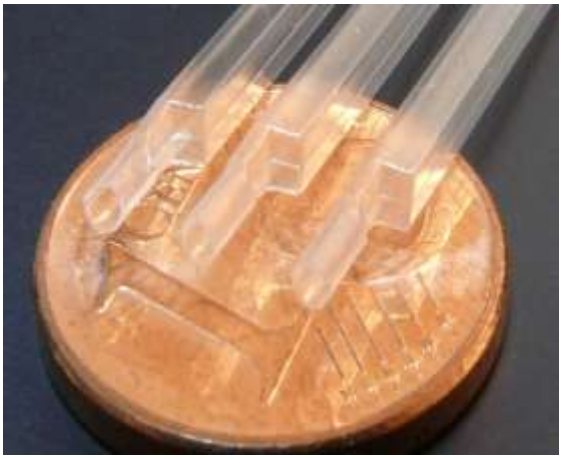
Polymer micro-tubes & tubular micro-components

## POLYTUBES PROJECT

*The overall objective of the POLYTUBES project is to develop a process chain and corresponding micro-manufacturing platform for the manufacture of polymeric micro-tubes and tubular micro-components for medical and non-medical applications. The proposed development aims to create a new market for EU SMEs with innovative and economically competitive micro-products and micro-manufacturing facilities 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 tubular micro-products.*

# Expansion of polymeric micro-tubes

The task of the Cologne University of Applied Sciences within the Polytubes project includes the development of process and machine system for the volume production of polymer micro-components by expansion forming. Against the background to provide fundamentals and guidelines for a suitable machine design, investigations into micro-tube expansion processes were conducted with the aid of a flexible prototype device. At first sight, the developed and analyzed process corresponds to a scaled-down blow forming process of polymer materials. However, the research work carried out has shown that several important requirements for an adequate design of process control, tool, and machine have to be considered when scaling down conventional expansion processes. Besides the realization of the forming machine system design, first prototype components were successfully manufactured from polymer micro-tubes.



***Demonstrator products made from polymer micro-tubes***

### Advantages of polymer micro-tube expansion forming processes

Tube expansion processes offer the advantage to enable the manufacture of hollow complex shaped components in one-piece design on an economic basis for volume production. Against this background, a wide range of conventional macro-products is manufactured today by tube expansion processes, like blow forming of polymer components or hydroforming of metal parts. However, many medical applications as well as non-medical applications from consumer goods show an increasing demand of hollow complex shaped micro-products made from polymer material. The lack of suitable volume production facilities gave rise to the research work briefly presented here, which consists in the development of a tube expansion process for the shaping of polymer micro-components as well as a prototype production system capable of volume manufacturing.

***Development of forming tool elements***

# Newsletter

## Scaling down blow forming

There exist various challenges when scaling down blow forming processes for the expansion of polymer micro-tubes. Besides component handling, this concerns in particular the thermal management of the overall shaping process, detachment of the formed component from the forming die cavities, forming tool design, and sealing strategies to pressurize the workpiece. Shaping of polymer micro-components by blow forming requires, as well as conventional forming of polymer macro-parts, the application of a specific and elevated workpiece temperature. In conventional processes, either the stored thermal energy of a just extruded tube is used to obtain a heated initial workpiece, or an external heating of a preformed injection moulded initial part is conducted. However, the considerably small volume of micro-tubes impedes that once a certain heat energy is induced, this energy immediately dissipates by radiation when the heated part is inserted into the forming tools, and with this the workpiece temperature falls below the required forming temperature. Therefore, new strategies for the thermal process management were developed and tested for the polymer micro-tube expansion, which enable the application of a specific workpiece temperature during the shaping process. This strategy includes the cooling-down of the formed component at process termination to improve the product's dimensional quality. Adhesion of the heated and formed micro-component at the shaping die cavity shows a significant impact on process reliability and product quality. Exceeding a critical amount of adhesion force can result in distortion of the formed component when it is detached and removed from the forming die cavity. This impact of adhesion forces is higher for micro-tube forming compared with conventional blow forming. Although the adhesion forces are of similar dimension for micro- and macro-forming, the resulting stresses within the wall of the micro-component, when it is detached from the die cavity, are higher due to the thinner wall thickness of these micro-parts. In principle, common mould-release agents could be applied. However, this application means additional effort and process time, as well as the eventuality of deposition of release agent residua in the die cavity. Against this background, suitable coatings for the die cavity will be tested with the objective to replace the use of mould-release agents.

***Design of forming machine system for polymer micro-tubes***

## Development of forming tool elements

Important subjects concerning the design and manufacture of the forming tools consist in the determination of a suitable mould parting line and measures for die cavity venting. Parting lines with a symmetrical material distribution within the two forming die halves are recommended. For the case of parting lines that lead to unsymmetrical material distribution, a locally adapted thermal energy supply is often necessary, in order to obtain the required forming result. Suitable knowledge concerning the tool manufacture in the here required micro-dimension is of importance to ensure the aimed accuracy of the formed components. That concerns in particular the design of measures for die cavity venting to avoid air locked between the formed component and die cavity wall.

## Machine system and forming trials

First investigations into fundamentals of micro-tubes blow forming were conducted with a test device that enables flexibly to try-out of various designs of forming machine elements as well as thermal management of the process. Forming tests of polymer micro-tubes were conducted with tubes with outer diameters between 600 µm and 1300 µm. Suitable process parameters as well as optimized cycle times were investigated for various tube materials, such as PA, PET and PC. Based on the achieved results, the design of an automated machine system was developed, capable for volume manufacture of polymer components made from micro-tubes. The machine system contains more than ten actuators and enables the pressurization of the formed micro-tubes below about 1300 µm size with pressures of up to 50 bar. The system, which is currently under construction, will be finished in January 2012.

***Contact:***
***Prof. Dr. Christoph Hartl***
***Faculty of Automotive System Engineering***
***and Production Engineering***
***Cologne University of Applied Sciences***
***Betzdorfer Str. 2***
***50679 Cologne***
***Germany***
***E-Mail:***
***christoph.hartl@fh-koeln.de***