PROTOTYPING OF A CATHETER PUMP FOR THE MINIMALLY INVASIVE LIQUID LUNG CATHETER

Christoph Janeczek[2], Paul Ecker[1, 2], Martin Elenkov[2], Benjamin Lukitsch[1], Thomas Keck[2], Michael Harasek[1], Margit Gföhler[2]

1. Institute of Chemical, Environmental & Bioscience Engineering, TU Wien, Austria

2. Institute of Engineering Design and Product Development, TU Wien, Austria

Introduction

Patients with severe forms of respiratory failure frequently require mechanical ventilation and membrane oxygenation therapy to support their lung function [1]. An intravenous membrane oxygenator, consisting of a hollow fiber membrane packing and a drive unit, is proposed as a minimal invasive respiratory assist device.

The usage of a blood pump deals with major challenges in the design of an intravenous device, specifically overcoming the pressure drop caused by the membrane packing and enabling a controllable blood flow. Apart from the complex design, pump production for experimental investigation poses a difficulty due to the small size of the individual pump parts.

In this study, we demonstrate the rapid prototyping process of a micro mixed flow catheter pump using different lithographic based approaches. Pump characteristic experiments were conducted, showing the functionality of the manufactured parts.

Materials and Methods

Two 3D printers, a Formlabs Form 2 (Formlabs, Somerville, USA) and a Kudo3D Titan 1 (Kudo3D Inc., Dublin, USA) were used for this studies purpose. Both printers utilize liquid photo polymeric resin coupled with a curing process. The former using a selective laser curing system (SLA) the latter is based on digital light processing (DLP).

Using digital microscopy (VHX-6000, Keyence, Osaka, Japan) the quality of fabricated parts in regard to pump dimensions, is determined.

Additively manufactured parts were processed and assembled with the motor and housing parts of the intravascular device to a lab prototype. Subsequently, pump characteristics were acquired in a static test loop.

Results and Discussion

The results of the manufacturing process clearly indicate the feasibility of both printers to reliably produce thin structured, complex parts down to 300 µm wall thickness (Figure 1). In regard to dimensional accuracy, digital microscopy revealed a marginal better performance of the SLA printer. Due to the polymeric additive material, mechanical stability of thin structured parts is limited independent from the used 3D printer. Surface treatment is therefore advantageous. The assembled and tested lab prototype was able to provide a blood flow of about 0.7 to 1.2 l/min, compensating the pressure drop caused by the membrane module. This is considered sufficient for the intravascular application.

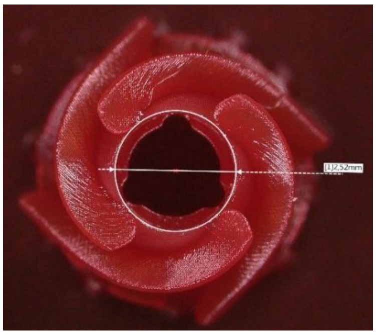

Figure 1: Digital microscopy image of an additively manufactured blood pump rotor.

Conclusion

A simple and reliable prototyping process for a miniaturized blood pump, using lithographic based manufacturing processes was developed. The assembled product was successfully tested in a lab environment. Pump characteristics show sufficient performance for the intended purpose. Although production quality was suitable for pump tests, the mechanical stability of the printer material does not allow long term usage of the prototype. Therefore, more sophisticated production techniques have to be considered for the final commercial product.

References

1. Pinhu, et al., *The Lancet,* 361**:** 332-340, 2003

Acknowledgements

This work is supported by the Austrian Research Promotion Agency (FFG). Project: MILL – Minimal Invasive Liquid Lung. Project number: 857859.