Optimization of an operating unit for eye surgery

Graduate

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Introduction: The company Oertli Instruments AG manufactures highly specialized devices and instruments for eye surgery, including the so-called Continuous-Flow Cutters (CFC), also known as vitrectors. Operations on the retina can only be performed once the gel-like vitreous body has been removed using a vitreous cutter. To make the procedures even less invasive, increasingly smaller instruments are used in vitrectomy.
The CFC have an opening at the tip with a cutting tool that can cut and aspirate the vitreous body at high frequency. The safety of the operation can be increased by raising the cutting rate, as this reduces traction on the retina. The vitrectors are pneumatically operated. An central element of the drive system is the valve block unit. The valves mounted on it enable the cyclic cutting process through alternating switching.

Definition of Task: This bachelor's thesis aims to increase the cutting frequency of the vitrectors from the current 83 Hz to at least 167 Hz, which corresponds to an increase in the cutting rate from 10000 cuts per minute (cpm) to 20000 cpm. To meet the increased demands, the valve block unit must be optimized in terms of fluid dynamics. The goal of this thesis is to identify potential fluid dynamic optimization for the valve block unit using the specified valves.

Result: During the course of this work, two potential concepts were developed: The first concept focuses on minimizing flow paths, while the second concept takes pressure reserves in the drive system into account.
The pressure build-up and release within the geometries were simulated using transient flow simulations in COMSOL Multiphysics. The realism of the simulations was verified through pressure measurements on manufactured prototypes. Both, the simulations and the measurements demonstrated that the optimized geometry can reduce pressure drop by about 10%, thereby achieving a higher cutting rate.

Operation setup with introduced light source and vitrector
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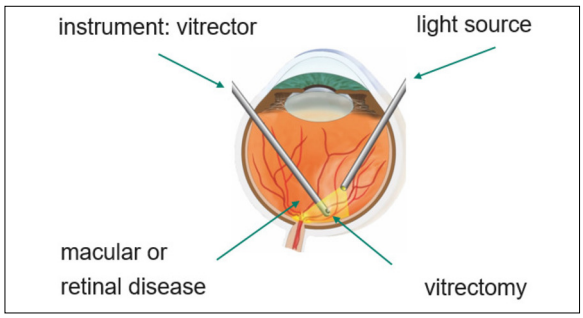

Vitrector with enlarged view of the cutting opening
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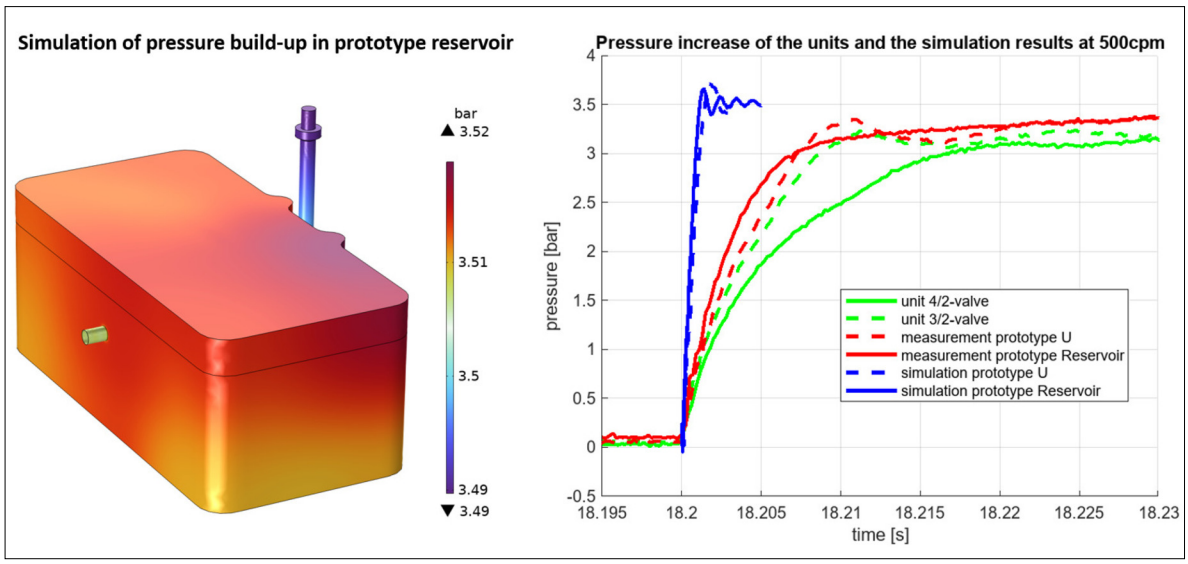
CFD simulation of the concept in COMSOL Multiphysics (left) and comparison between simulation and measurement (right)
Own presentment



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