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ABSTRACT OF THE DISSERTATION

„Non-invasive methods of measuring the flow field in 3D-printed circulatory system phantoms"

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This doctoral thesis is devoted to development of measurement methodology regarding the distribution of *particle image velocimetry* flow field and *planar laser-induced fluorescence* concentrations in transparent systems created with the use of 3D printing to explore problems of the cardiovascular system. The motivation for pursuing this subject was a still high and common threat to human health and life caused by cardiovascular diseases. The first stage of the work was selecting adequate printing technology and materials allowing to create a phantom of a specific fragment of the cardiovascular system. This also involves development of the whole preparation process of a printing surface for optical measurements which require transparency and a smooth, flat surface. Moreover, the fluid used in the research must meet both the conditions of similarity to rheological properties of blood and optical conditions of the measuring equipment for laser anemometry. As part of the research, measurements were conducted in flow systems imitating the shape of cardiovascular system sections of humans, also thanks to the use of images obtained from patients' computed tomography. The results are used e.g. for validation of computational fluid dynamics. The scope of possibilities of the developed measuring procedure has been described in several publications, and new research possibilities are still emerging, with their results being prepared for further publication. Showing compatibility between experimental and computational fluid dynamics enables a precise mathematical analysis of the movement of blood elements in the natural environment, especially the determination of conditions for development of diseases or parameters occurring with various pathological changes. Better understanding of ongoing phenomena will facilitate earlier diagnosis and defining risks related to their occurrence. An additional benefit of the research was the development of cardiovascular models preserving the properties of live tissues - their elasticity and strength. This, in turn, allowed not only for conducting research with preservation of natural deformations depending on the pressure, but also appeared to be a great tool for training and exercise before complex procedures and surgeries, which reduces the risk of complications and patient discomfort.

Keywords: PIV, particle image velocimetry, PLIF, planar laser-induced fluorescence,
3D printing, refractive index, cardiovascular diseases, atherosclerosis, blood rheology