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Master's Program Biomedical Engineering

Abstract of Master's Thesis

Titel:

Design, implementation, and evaluation of a fatigue test setup for small structured parts of mechanical heart valve prostheses

Abstract

The heart is the muscular pump of the human body, providing a continuous blood flow which is necessary for oxygenation of the organs. As each organ in the body, the heart can be affected during lifetime, which might result in a defective function of the heart valves. Disorders of the heart valves are usually solved with heart valve prostheses. There are different types of prostheses, biological and mechanical ones. Biological prostheses are implanted more often, but mechanical heart valves are still implanted due to their longer durability.

In the Department of Cardiac and Thoracic Vascular Surgery of the University of Lübeck, a novel mechanical prosthesis was developed. Within the project, fatigue tests for small structured parts of the mechanical heart valve prosthesis were required. Thus, scope of the thesis was the design, implementation, and evaluation of a fatigue test setup. Out of these tests characteristic curves of the material testing were obtained and material properties were analysed and evaluated. As the presented valve incorporates small structures, one of the most important questions was, whether the structures have the same mechanical properties and behaviour like normal big components. Thus, calculations in valve construction could be used as they are, or they show a size dependence and the calculations should be adapted. For the test setup, aspects of materials science and testing were considered. Mechanical and construction methods were used, while the conditions were related to the standards DIN EN ISO 5840 and DIN 50100.

For the experimental setup a constant cyclic loading was chosen. Therefore, weights with defined masses were implemented due to the independence to the affecting environmental factors. The weights were utilized to load the specimen while the number of cycles until fatigue was counted. From the cyclic loading tests a characteristic stress-number curve was obtained. A comparison of this curve with known Ti-6Al-4V curves from literature showed similar behaviours. The fracture surfaces of the specimens were analysed with a scanning electron microscope (SEM). Evaluation of the SEM pictures gave similar results of the fracture behaviour as the theory of the materials failure defines. Characteristic break lines could be detected on the fracture surface of the specimens.

In summary, a fatigue test setup for small structured parts of mechanical heart valve prostheses was developed. The test resulst resembled similarities to normal big components as well as behaviours defined in the materials science and failure. This leads to the conclusion that the small structure of the given heart valve prosthesis is not influenced by grain boundary conditions for instance. Concluding, development of the designed mechanical heart valve prosthesis can be continued and calculations in valve constructions can be used without adjustment.

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