Faculty of Engineering

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Dynamic Characterisation of the Impeller-Bearing-Pump Housing System of a Rotary Blood Pump via Experiment

By:

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CERTIFICATE OF AUTHORSHIP / ORIGNIALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Michael Kai Hung Chung

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ABSTRACT

The VentrAssist implantable rotary blood pump (IRBP), intended for long term ventricular assist has been under development and tested for its rotor-dynamic stability. The pump consists of a shaftless impeller, which also acts as the rotor of the brushless DC motor. The impeller remains passively suspended in the pump cavity by hydrodynamic forces, which result from the small clearances between the outside surfaces of the impeller and the pump cavity. These small clearances range from approximately 50 μm to 230 μm in size in the version of pumps reported here.

The research presented in this thesis involved experimental investigations into the dynamic behaviour of the impeller/bearing/pump housing system. An initial experiment utilising an early pump and controlling system design was performed to analyse the critical speed of the system using Fast Fourier Transform (FFT) analysis. Results indicated that no critical speed was distinctly present during the operation of the pump.

Further to the initial experiment, a second experiment was performed to determine displacement of the shaftless impeller during operating conditions using Eddy-current and laser proximity sensors. The limitations encountered by the applications of the sensors provided for further investigation using Hall-effect sensors. The behaviour of the impeller/bearing/pump housing system as a whole was found to be in accordance with typical centrifugal pump behaviour.

Finally, by combining the two experimental methods, a final experimental investigation was carried out to determine the dynamic characteristics of the impeller/bearing/pump housing system of the rotary blood pump. Real-time measurements of the impeller's displacement were performed using Hall Effect sensors. A disturbance force was exerted onto the pump housing, causing the impeller to be displaced from its dynamic equilibrium position within the pump cavity. The impeller displacement was represented by a free decaying response curve, which indicated the impeller restoring to its equilibrium position. The free decaying response allowed for logarithmic decrement analysis to determine the damping ratio and eventually the damping coefficient of the impeller/bearing/pump housing system. Furthermore, the natural frequency and stiffness coefficient of the system were also determined.