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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Plasma skimming in the spiral groove bearing refers to excluding red blood cells from the ridge gap having tens of micrometers into the groove gap of the bearing inside a hydrodynamically levitated rotary blood pump. Plasma skimming in spiral groove bearings was verified, and the high-efficiency plasma skimming is considered a potential method to prevent hemolysis inside the narrow bearing gap. However, no study reports the method to improve plasma skimming in the spiral groove bearings' design. Therefore, this study aims to reveal the method to improve plasma skimming inside the bearing gap and optimize the design of spiral groove bearing to obtain both high-efficiency plasma skimming and sufficient load-carrying capacity in a hydrodynamically levitated rotary blood pump.

Firstly, plasma skimming was verified in an experimental shearing test rig with physiological level hematocrit conditions up to 44%. The shearing test rig can provide rotational speeds ranging from 500 rpm to 900 rpm and a shearing gap up to 240 μm. The hematocrit decline of sampled blood from the shearing gap when the gap decreased under 100 μm indicates the potential of inducing plasma skimming to the clinical rotary blood pump.

Secondly, to figure out the design of spiral groove bearings on plasma skimming, three different spiral groove bearings with different deflection angles to the assumed flow directions of the red blood cells were designed and manufactured. Considering the dominant influence of shear stress inside the bearing gap might carry red blood cells from the groove gap to the ridge gap, it is hypothesized that the spiral groove bearing with the smallest deflection angle to the flow directions of the red blood cells has the best plasma skimming efficiency. An experimental device that mimics the flow conditions of the ridge gap in the rotary blood pump was designed and manufactured. With this experimental device, the plasma skimming effect was evaluated quantitatively by analyzing the occupancy ratio of moving red blood cells on the photographed visions with a high-speed camera. The plasma skimming effect of the three spiral groove bearings at hematocrit conditions ranging from 1% to 30% were compared. The statistical analysis result shows that the spiral groove bearing with the smallest deflection angle reaches the best plasma skimming efficiency.

Thirdly, to further explore the conditions for improving plasma skimming, the spiral groove bearing with the best plasma skimming effect was employed, and the flow direction of red blood cells was adjusted by varying the rotational speed of the rotor inside the experimental device. The decline of analyzed hematocrit inside the ridge gap results indicates that the plasma skimming effect is improved when the deflection angle decreases. In addition, the complete exclusion of red blood cells was observed when the flow directions of the red blood cells were in the same direction as the tangent of the groove.

Next, A hydrodynamically levitated rotary blood pump was designed and manufactured to simulate the actual flow environment, which is similar to the clinical centrifugal rotary blood pump. The designed hydrodynamically levitated rotary blood pump can achieve a pump head of 100 mmHg and flow rate of 5 L/min with rotational speeds over 2400 rpm. The actual flow directions of red blood cells inside the ridge gap of the spiral groove bearing in the designed pump were analyzed and recorded with a high-speed camera. Based on the revealed design principle that the spiral groove shape should be designed following the flow directions of the red blood cells, an optimized spiral groove bearing aiming for both excellent plasma skimming effect and adequate load-carrying capacity was optimized. The load-carrying capacity of the optimized spiral groove bearing was analyzed by discretizing the Reynolds equation using the central difference method. Then the optimized spiral groove bearing was manufactured and installed in the design hydrodynamically levitated rotary blood pump. Repetitive blood tests were conducted to examine the optimized spiral groove bearing induced plasma skimming effect. The results show that the optimized spiral groove bearing reaches excellent plasma skimming effect approaching complete exclusion of red blood cells from the ridge gap near the outlet of the spiral groove bearing at hematocrit up to 40% and ridge gap size around 20 μm. The testified plasma skimming effect is in great accordance with the expected improvement of plasma skimming.

This thesis reveals the method to improve plasma skimming inside the bearing gap by designs of spiral groove bearings. The basic parametric studies and application of the optimized spiral groove bearing provide insights into utilizing plasma skimming to prevent hemolysis in the future development of hydrodynamically levitated rotary blood pumps.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).
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