

A NEW CONCEPT OF CENTRIFUGAL BLOOD PUMP USING PIVOT BEARING SYSTEM: THE CONVERSION OF THE SPIRAL PUMP INLET PORT

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Abstract. *A new concept of centrifugal blood pump has been developed in Institute Dante Pazzanese of Cardiology laboratories, a long-term Left Ventricle Assist Device (LVAD), durable, and implantable. As proposed by Nosé (1998), the method applied is to convert the Spiral Pump (SP) to this new LVAD. Nowadays, the SP is in the last clinical tests for cardiopulmonary bypass and has proven to be a safe and reliable option (Andrade, 1996). However, this system has some inconveniences like limited durability and blood leakage. A stainless steel shaft and two bearings hold the SP's impeller. A seal made of silicone rubber avoid the contact between the blood and the pump's internal parts. To overcome these problems, Takami et al. (1997) adopted a completely sealless pivot bearing system in their pump. The SP's inlet port is located on the top of the external cone in the same place to be used by the top pivot bearing. The aim of this study is to prove that an eccentric lateral inlet port could be used, making the pivot bearings a viable system to the SP. It was manufactured a prototype with an eccentric lateral inlet port. Comparing the hydrodynamic performance of the original SP with this prototype its performance curve were plotted. The prototype showed lower values of flow versus pressure ahead than the original SP curves. Even lower, the result was very similar to the original SP's hydrodynamic performance. Since the proposition was to test the viability, the eccentric lateral inlet port, as well as the pivot bearing system, is an option to be applied in SP. As future works, we will study the mechanical hemolysis of this new pump design.*

Keywords: *Implantable Centrifugal Blood Pump, Cardiopulmonary Bypass, Spiral Pump, Left Ventricle Assist Device, Hydrodynamic Performance of Blood Pumps.*

1. Introduction

A new concept of centrifugal blood pump is been developed. It is an implantable long-term Left Ventricle Assist Device (LVAD). Dr. Nosé (1998) proposed a step-by-step development strategy to the conversion of a two days' antitraumatic pump (Phase 1) to a 2 weeks' antithrombogenic pump (Phase 2) and, after this step, the conversion of this device to a durable, implantable, and long-term blood pump (Phase 3). The method is to convert the Spiral Pump (SP)

to this new durable LVAD. Nowadays, the SP pump is in the last clinical tests for cardiopulmonary bypass and has proven to be a safe and reliable option. The SP could be used as Extracorporeal Circulation (ECC) and Left Ventricle Assist Device (LVAD). The ECC is a necessary technique during open-heart surgery. Comparing a centrifugal blood pump with the conventional roller pumps, it is safer and causes less damage to the blood cells. When this process happens with the red blood cells, it is called hemolysis (Andrade, 1996).

However, SP system has some inconveniences like limited durability and blood leakage. A stainless steel shaft and two bearings hold the SP's impeller. A seal made of silicone rubber avoids contact between the blood and the pump's internal parts. But sometimes, this seal allows blood leakage around shaft. The possible failure could cause hemolysis and compromise system's reliability. To overcome these problems, Takami et al. (1997b) adopted a completely sealless pivot bearing system in their pump, as seen on the Figure 1.

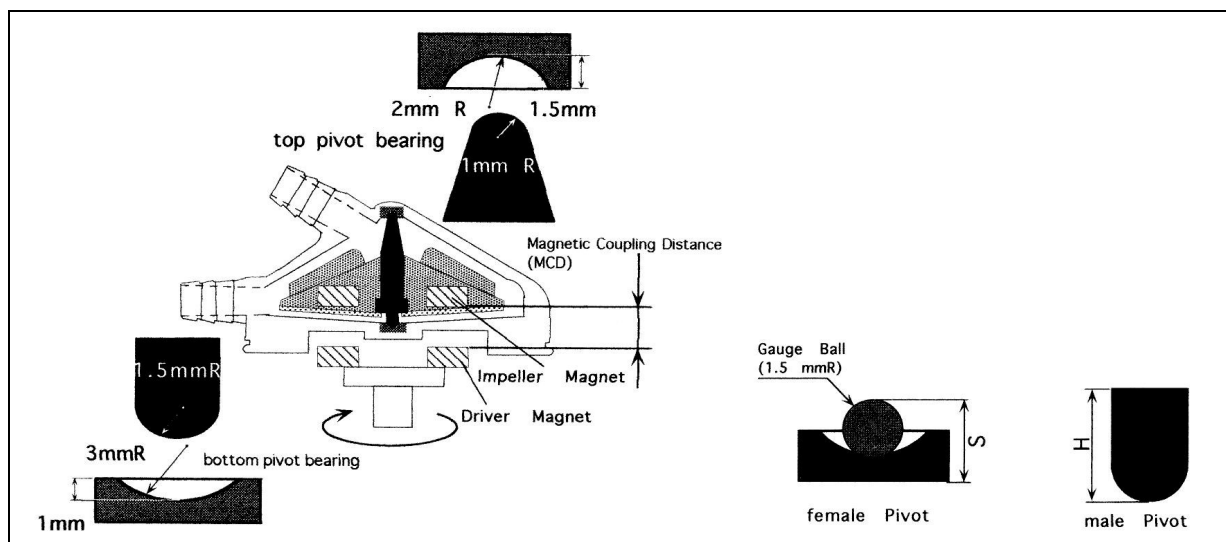


Figure 1. A schematic drawing of Gyro C1E3 pump with ceramic pivot bearing solution, the pump head and driver magnet are shown (Takami, 1997a).

To apply this improvement, SP inlet port must be located in another place because it is on the top of the external cone in the original design. This place is the same to be used by the top pivot bearing. The aim of this study is to prove that an eccentric lateral inlet port could be used without big changes on the pump's hydrodynamic performance characteristics. This conclusion must point that the ceramic pivot bearing system is viable to be part of our new LVAD, the implantable long-term centrifugal blood pump.

2. Materials and methods

A prototype was manufactured with an eccentric lateral inlet port. This prototype is a conversion of the SP's original feature with an eccentric inlet port. With both pumps working in a mock circuit, we compared their hydrodynamic performances and plotted their performance curves. This way it was easier to predict the best in two different inlet configuration possibilities.

2.1. Mock Loop Test

The hydrodynamic characteristics were studied using a closed mock loop test. (Andrade *et al.*, 1996). The circuit was filled with 37% glycerin-water solution at 25 °C simulating the density and viscosity of the blood. The circuit consists of a polyvinyl chloride reservoir used in ECC. This reservoir has the capacity of 4.0 l. At this reservoir, there are two flexible silicon tubes with 1/2" also used in the ECC circuit, see Figure 2.

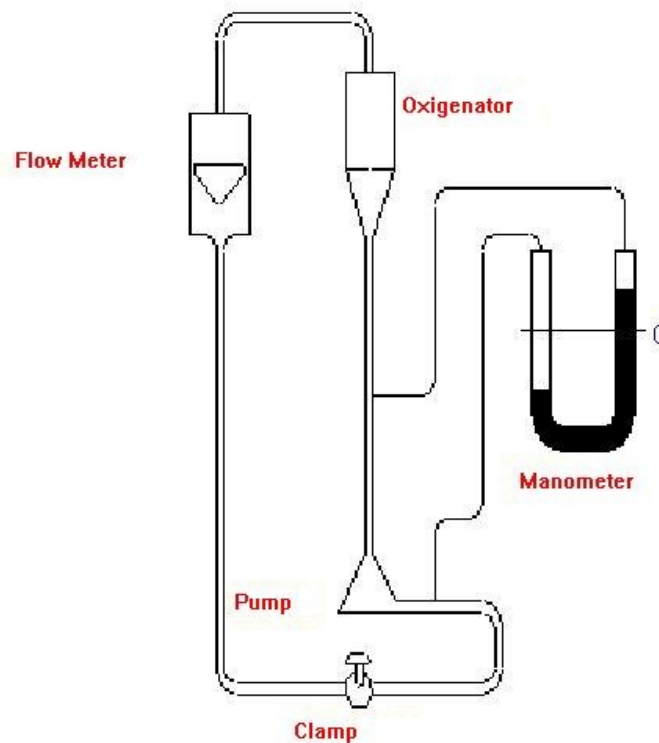


Figure 2. The Closed Mock Loop Test used to study the hydrodynamic characteristics of the pumps.

An adjustable clamp was used to control the flow of solution in the inlet tubing of the reservoir. Pressure monitors were connected at the pump inlet and outlet. A flow meter was used to measure flow at reservoir inlet tube during these tests. Clamping reservoir inlet tube flow was fixed between 0.5 l/min and 9.0 l/min increasing it in steps of 0.5 l/min. With the motor controller, the pumping rotations were fixed at 1,000 rpm, 1,500 rpm, 2,000 rpm, 2,500 rpm, 3,000 rpm, 3,500 rpm, and 4,000 rpm. Each pressure coordinate was measured changing flow in a fixed rotation.

3. Results

With data collected from hydrodynamic performance test of each inlet port design, separated tables were built. For each rotation of each inlet port one curve was plotted and from this a mean curves graph was plotted. In order to simplify, this graph was made only with two mean curves from both pumps. It was decided that rotations would be 2,500 rpm and 4,000 rpm because its features. The rotation of 2,500 rpm is a common rotation in ECC. The 4,000 rpm is generally a great rotation in ECC. The curves are shown at Figure 3.

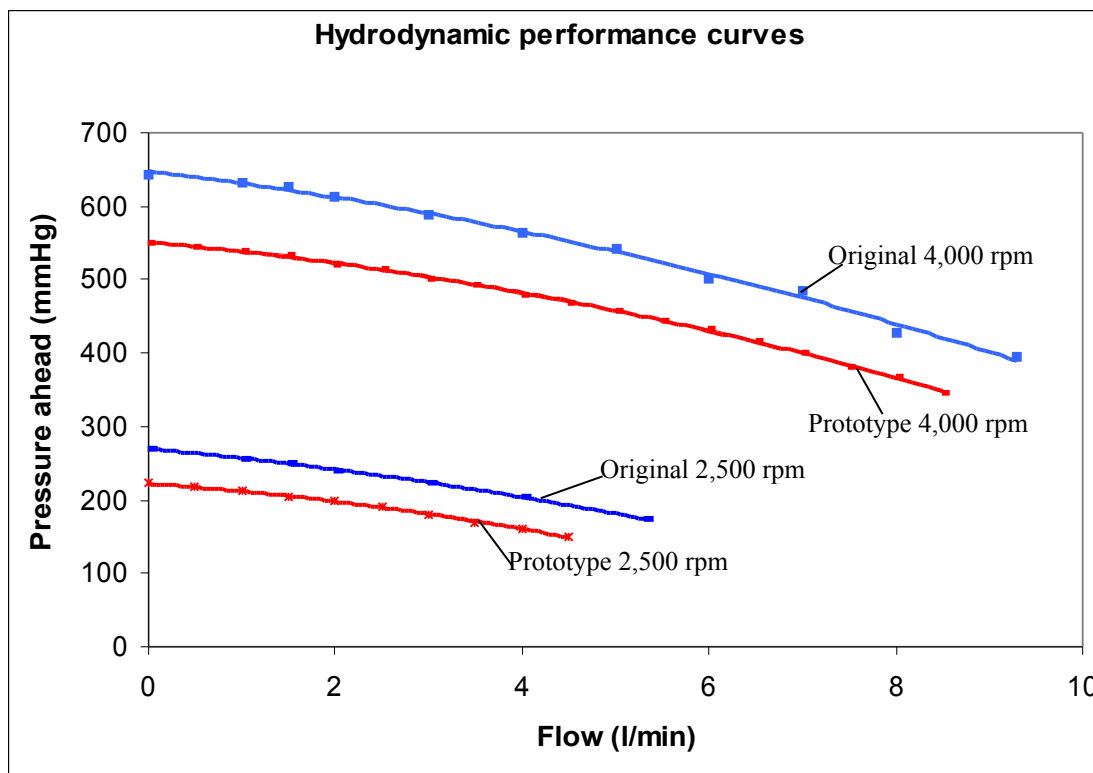


Figure 3. The Hydrodynamic performance curves of the SP for 2500 rpm and 4000 rpm. The original design is represented in blue and the prototype with the modified inlet port is represented in red.

3. Conclusion

The prototype showed lower values regarding the relation flow versus pressure ahead than the original SP. Even lower, the result was considered very similar to the original SP hydrodynamic performance. Therefore, the eccentric lateral inlet port as well as the pivot bearing system is a possible option in SP system. As future works, mechanical hemolysis is been studied for this new pump design.

5. Acknowledgements

We would like to thank the CNPq and Capes by partially financing this project.

6. References

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