Biomimetic Sealing System for Power Generation from Natural Energy

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1. Introduction

Renewable energy research and its application have been promoted to slow down climate change and maintain economic growth. Streamflow or tidal power is valued as a source of energy, and environmentally friendly and low-friction sealing systems that employ biomimetic technologies are proposed for its utilization. The proposed system is referred to as "Bio-Star", an abbreviation for Biomimetic System for Tidal power generation learned from Articular cartilage.

The Bio-Star was successfully developed using a hydrated material (polyvinyl formal; PVF) for lip seals. Polyethylene glycol (PEG) dissolved in distilled water, which is a non-Newtonian fluid, was used as a lubricant. These materials have low toxicity and low environmental impact. The biomimetic sealing system exhibits excellent frictional properties with extremely low ingress of water.

2. Micro-&cluster generation system

A micro-&cluster generation system has been developed for performance assessment of the Bio-Star (Fig. 1). Each individual generation unit is small and light, and can be easily placed or removed without the need for related infrastructure construction. A large amount of power can be generated by combining a number of generation units. This system has two rotating shafts in contact with the water flow, so that a new sealing system (Bio-Star) with extremely low ingress of water and low friction is required.

3. Materials and methods

Figure 2 shows the testing apparatus for the Bio-Star. A 30 mm diameter stainless steel shaft with a surface finish of 0.02 μm (Ra) is used. Two lip seals (40 mm O.D., 30 mm I.D., 5 mm thick) are molded from PVF with a pore diameter of 5 μm and are lubricated with PEG lubricant (Mw=2 million, 3 wt%) to separate the water and gas phases.

Oil seals and a mechanical sealing system in popular use are also compared with the PVF lip seals. The shaft rotates at 20 rpm at a water depth of 0.75 m and the direction of shaft rotation was changed every hour.

4. Results and discussion

The frictional torque and ingress rate for each sealing system are shown in fig. 3. The biomimetic lip seals have extremely low ingress of water with lower friction than the oil and mechanical seals examined. This result suggests that the biomimetic sealing system is promising for streamflow or tidal power generation applications.

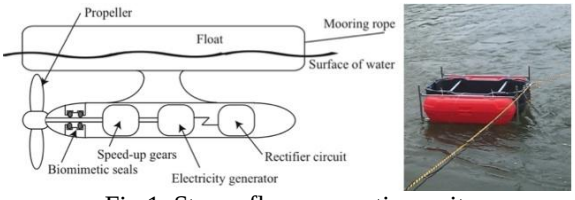

Fig.1 Streamflow generation unit.

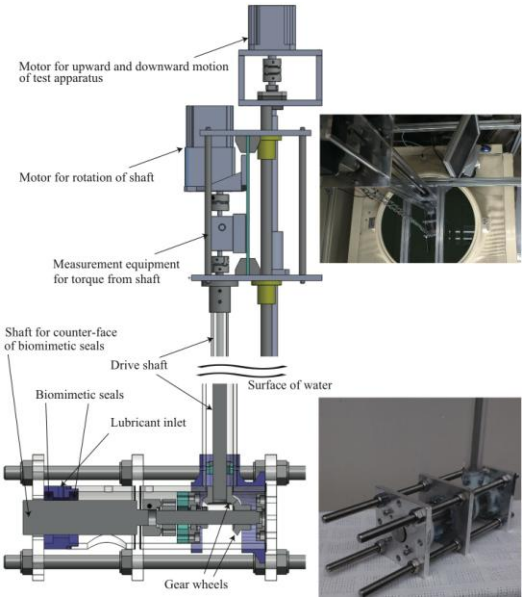

Fig.2 Testing apparatus for the Bio-Star.

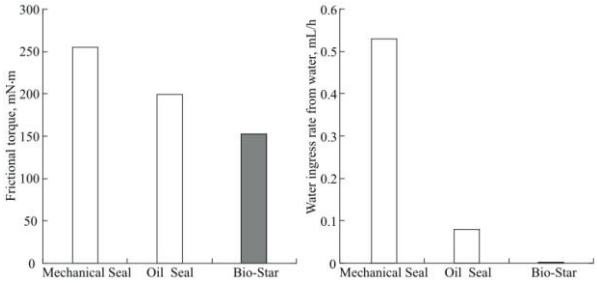

Fig.3 Frictional torque and water ingress rate.

5. Reference

[1] Nakanishi,Y., "Development of Biomimetic Bearing with Hydrated Materials", J. Biomech. Sci. Eng., 4(2), 2009, 249–264.