PhD Public Defence

Title: Investigation and Optimisation of a Discrete Fluid Power PTO-system for Wave Energy Converters

Location: Pontoppidanstræde 101, Room 23

Time: Monday 16 June 2014 at 13.00

PhD defendant: Anders Hedegaard Hansen

Supervisor: Associate Professor Henrik Clemmensen Pedersen

Moderator: Associate Professor Michael Møller Bech

Opponents: Associate Professor Søren Juhl Andreasen, Dept. of Energy Technology (Chairman)
Takao Nishiumi, Japan National Defence Academy
Matthias Liermann, American University of Beirut

All are welcome. The defence will be in English.

After the public defence there will be an informal reception in Pontoppidanstræde 101 room 25/27.
Abstract:

Patents on ocean wave energy dates back to 1799, however no wave energy converter (WEC) concept have a commercialised device. The cost of energy produced with wave energy converters is very high compared to traditional energy sources. Even when compared to energy from wind turbines wave energy needs cost reductions. Hence, next to political will, the main obstacle for a commercial break through of wave energy technology is the high cost of energy. Initiatives to lower costs are made in areas of minimising structural costs and increasing the energy production per device.

Wave Star A/S has recently focused research on improving the power take off (PTO) system converting the mechanical motion of the floats into electricity. This has brought attention to discrete fluid power (DFP) technology, especially secondary controlled common pressure rail systems. A novel discrete PTO-system has been proposed and found feasible for the Wavestar WEC. However, with a technology shift from a continuous to a discrete fluid power PTO-system, new challenges emerge.

The current project investigates and optimises the novel discrete fluid power PTO-system proposed for the Wavestar WEC. Initiating from an investigation of energy extraction by WECs utilising a discrete PTO force, an investigation of the system configuration is conducted. Hence, the configuration of the multi-chamber cylinder and the common pressure rails are investigated for the discrete fluid power force system. A method for choosing the system configuration for a given wave climate is demonstrated. From the energy extraction by WECs employing a discrete PTO force it is seen that a discrete system with relative few applicable forces may yield energy extraction levels close to that of a continuous PTO force system. The system configuration investigation show how the wave climate naturally influence the optimal system configuration yielding maximal energy output, and how one may choose the system configuration based on the installation site.

The switching manifold is the control element of the secondary controlled force system. The force is controlled by connecting each of the cylinder chambers to one of the common pressure lines. Bidirectional check valves are proposed as a possible improvement of the energy conversion efficiency, since these enable passive valve shifts at a favourable low pressure difference across the switching valves. A model based feasibility study shows promising energy results for the bidirectional check valves, however, a minor increase in the force steps applied may be induced.

Due to the lack of cheap and commercial large fast on/off valves and especially bidirectional check valves, the current project further includes a conceptual design of a multi-poppet on/off valve and a multi-poppet bidirectional check valve. The conceptual design is based on a theoretical investigation of valve switching time dependency on various design parameters. Finally a set of parameters are given based on dynamical simulations of the designed valves. The valves are designed with a rated flow of 1000 L/min@5 bar and the active switching time for the designed valves is seen to be less than 10 ms. A combination of on/off and bidirectional check valve are proposed for the switching manifold when designed for use in wave energy converters.

Involvement in designing, installation and control of a full scale PTO test-bench has been under-taken parallel to the theoretical work. Preliminary force switching tests have been conducted to investigate the influence of valve switching time on the dynamic behaviour of the PTO-system. The results of these tests show that the pressure dynamic in the cylinder chambers and the transmission lines connecting the switching manifold and the cylinder chambers are highly influenced by the valve switching time.