The Oscillating Water Column based wave energy plant

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Introduction

Wave energy is one of the promising forms of renewable energy from the oceans. The incident energy from waves can be given by E= 0.55 H_s^2 * T_z [kW/m] where Hs is the significant wave height and T_z the zero crossing period. For example, Hs = 1.45 m and T_z = 9 seconds would yield about 10 kW/m.

There are several principles of converting wave energy into electrical energy. The research in India is focused on the oscillating water column (OWC) approach (Fig.1). In this scheme energy conversion occurs in a three stage process. Sea surface elevations are converted to pneumatic energy in the OWC, a turbine converts the pneumatic energy into mechanical shaft power and a grid connected generator coupled to the shaft of the turbine forms the final stage.

A near shore bottom standing OWC with an opening of 10 m was erected in Vizhinjam in Kerala as part of the initial Indian research programme. Several laboratory and field studies have been conducted in the past decade towards realisation of a commercial device. The overall efficiency of the OWC based wave energy plants have been historically constrained by the lack of a good turbine.

Fig.1. The Indian near shore OWC wave energy plant

Analysis of turbines tested at Indian plant

The difficulty in designing a good turbine is that the flow is oscillating in nature and can vary widely from season to season. The Wells' turbine, Linked Guide Vane (LGV) impulse turbine and Fixed Guide vane (FGV) impulse turbine were the conceptually different turbines tested in the Indian wave energy plant. The overall wave to wire efficiency could at best approach 25 % with these turbines. We conjectured that it would be better to use unidirectional turbines in a carefully designed topology to improve the turbine efficiency.

A twin unidirectional turbine topology

The unidirectional impulse turbine topology promises high efficiencies over a broad range of flow coefficients.Fig. 2 shows the plan view of the twin unidirectional turbine for an OWC plant. The OWC is connected to two unidirectional turbines T1, T2 which are coupled to a common electrical generator. There are no valves. During intake, the air flows from T1 into the OWC and during exhaust the air exits the OWC via T2.

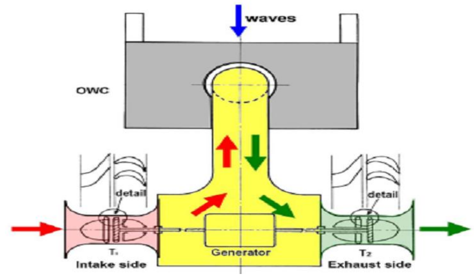

Fig.2. Twin unidirectional turbine topology

Laboratory model of the twin turbine topology

The unidirectional turbines used in the lab model had a diameter of 165 mm. Each of the unidirectional turbines were coupled to two 375 W, 3000 rpm, 50 Hz, three phase squirrel cage induction motors. The electrical machines are directly connected to the grid. An oscillatory flow test rig is used to create a bidirectional flow similar to that observed in an OWC. The experiments validated the concept of the topology. It was observed that there is a very small flow in the reverse direction for each of the turbines.

Results

Fig. 3 shows the efficiency improvements possible in the Indian wave energy plant estimated with the new concept.

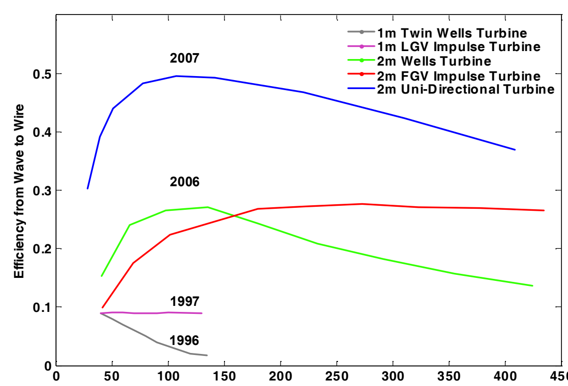

Fig.3. Wave to wire efficiencies of turbines tested in the OWC wave energy plant

We have scaled our laboratory results to show that the design and manufacture of 50 GWh per year is feasible. Further, the design for Indian conditions shows that the technology is viable for island communities even today at an estimated price of Rs 4.82 / kWh. The west coast mainland has higher potential than the east coast and the economics of wave power based on the current design at Rs 5.82 / kWh have been estimated for a plant in Valiyathura in Kerala. These results are without any subsidy.

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