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TECHNOLOGY

CUSSONS RENEWABLES WAVE ENERGY RANGE

INTRODUCTION

Wave power has been a field of great interest in generating renewable energy. Students tend to be very aware of environmental issues and have a high motivation to study renewable energy. The wide range of designs of wave generators is a testament to the ingenuity of engineers, but also involves principles in fluids and mechanics that can be widely applied.

Wave absorbers can be categorised into four generic types, each of which is covered by a range of Cussons products.

- P6330 Floating buoy devices,
- P6335 A flexible pitching wave absorber,
- P6340 Oscillating air column
- P6345 Surge devices such as the TAPCHAN

All wave generators consist of two elements of interest to engineers. The capture of wave energy by its conversion into high energy fluid (the wave absorber), and the generation of electricity from the energised fluid. The scale of student laboratory experiments means that it is not possible to use the wave absorber directly to produce an electrical output so Cussons products split the two fields into wave generators as above and into electrical generators

- P3110 (range) Wells turbine for oscillating air movement
- P6367 Impeller turbine wheel

Many interesting engineering challenges are presented in the understanding of how a wave generator works. The considerations include

- The energy available from a wave
- Buoyancy and Archimedes principle
- Relationship between wave form and buoyancy
- Potential Energy in a fluid
- Pneumatic / hydraulic pistons
- Aerodynamics of lift and concept of relative velocities
- Symmetrical aerofoil blades and angle of attack

One of the attractions of the wave energy range is that all of these factors are related together in working machines, the performance of which are easily measured and controlled. Students are interested in the way that the wave generators perform and want to study the theory to understand the principles. Each manual lays out the theory behind the experiment in a way that allows the experiment to be part of a dedicated renewable energy module, or an interesting part of other modules.

The wave generators are designed for use in a 300mm water channel, such as Cussons P6275, equipped with a small wave generator, such as Cussons P6285. The wave absorbers can normally be mounted in other wave channels.

Wave Absorbers

P6330 Floating buoy devices

The traditional design of wave energy device is the floating buoy, either tethered directly to the sea bed or a damper plate. Cussons P6330 comprises of a wave channel floor mounted cylinder, arranged as a double

acting piston to pump water over the up stroke of the wave and separately the down stroke of the wave. The wave absorber is provided with two reservoirs to allow the timed collection of pumped water. The reservoir heights can be adjusted to provide a variable lift. A rectangular float is provided.

The P6330 is designed to accept a student's own design of floating buoy, but P6331 provides a range of four additional floating buoys to allow experiments on different shapes and sizes of buoy

P6335 Flexible pitch devices

The flexible pitch device, sometimes known as the Salter duck, initially created great excitement. The duck allows a larger amount of the waves energy to be captured than a floating buoy device, and like the buoy can be mounted away from the shore. Cussons P6335 provides a mechanism that pumps water in a similar manner to P6330. Whilst the full size devices have sufficient inertia to allow the pivot point to be within the floating device a small scale device is better served by fixing the shaft in relation to the channel walls.

P6335 allows a range of flexible pitch devices of the student's design to be fitted, whilst P6336 provides a range of four additional pitch shapes, to allow experiments on different pitch designs.

P6340 Oscillating air column design

The oscillating air column has gained in popularity since the commercialisation of the Wells turbine provided a direct use for the oscillating stream of air. In a student's laboratory experiment it is not possible to produce

sufficient air flow to power a Wells turbine, so the P6340 air column uses the oscillating air to drive a pneumatic piston connected in turn to a similar pump to the P6330.

Normally air columns are built into cliff faces although new designs provide a column on a floating deck. In either case it is possible to design a concentrator to focus the wave into the column and Cussons P6335 allows a student's design of concentrator to be fitted. Cussons P6345 provides four designs of wave concentrator to allow experiments on different concentrator designs.

P6345 Surge design

The most successful wave generator, over a long period of time has been the Tapered Channel device in Norway. This device concentrates the waves and guides them up a tapered ramp into a reservoir, from which a low head turbine extracts energy. Cussons P6345 provides a 2m

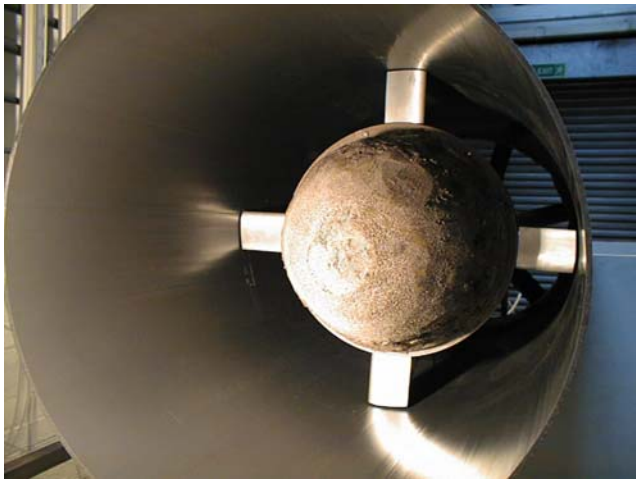
ramp, with adjustable angle of slope and adjustable angle of wave concentrator. The water exits the ramp into a reservoir for timed collection. P6346 allows additional variations to be given to the way the wave energy is concentrated.

Electrical Generators

Traditionally wave generators have been forced to use high pressure hydraulic motors to use the energy captured. The development of the Wells Turbine allows the direct use of oscillating streams of air, powering a turbine that continues to rotate in the same direction. Students find this apparent engineering anomaly to be very interesting.

Cussons P3110 Wells Turbine

The Wells turbine module comprises of a high speed rotating disc with four symmetrical aerofoil blades, which provide a forward thrust over a range of operating speeds. The blades can be changed for different configurations. The disc turns a shaft, (free to slide axially within ball bearings), and a small variable speed motor configured to act as a power generator. The unit is provided with a control box that displays current, voltage and wind generator speed. Speed is measured with a tacho generator.



The turbine spins within an air channel, each end of which is connected back to a joint flange, so that the inlet air can be shunted alternatively into each end of the channel. The duration of flow in each direction can be adjusted, as can the rate of flow.

Cussons P6367Impeller Turbine unit
Cussons P6366 Francis Wheel and P6369 Pelton Wheel unit

Each of these power units can be run on the P6360 Modular pump/turbine test bench. Whilst some wave generator systems use special motors to use the high pressure hydraulic oil, generated by the wave absorber, these are not suitable for student experiments. The P6367 is a suitable experiment for the output of a Surge wave absorber, whilst the Francis Wheel and Pelton wheel are suitable for output from the buoy and flexible pitch devices.

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