Imperial College London

Johannes Spinneken

Wave generation and absorption using force-feedback control

Period of Study: 2006-2009

Supervisor: Professor C. Swan

Abstract / Description of Thesis

This thesis concerns absorbing wave machines where the absorption strategy is based on a force-feedback approach. A theoretical model, describing their behaviour correct up to second order, is developed. At first order, this model seeks to provide a theoretical transfer function, linking the demand signal to the amplitude of the desired progressive wave. In the context of force-controlled wave machines, this transfer function may be regarded as the equivalent to the well known Biesel coefficients; the latter linking the demand signal and the progressive wave mode for position-controlled machines.

Furthermore, it is shown that the absorption mechanism affects the first-order transfer function. As part of a comparative study, a consistent framework for optimum absorption controllers is presented. An approach utilising a numerical optimisation procedure is formulated and compared to other available techniques. This work is also relevant to related disciplines, including the successful operation if wave energy devices.

Whilst the comparison of optimum absorption strategies is limited to first-order, a detailed investigation of the effects arising at second order is also presented. In so doing, the influence of the nonlinear hydrodynamic feedback, induced by the force-driven approach, is discussed. In the case of flap-type wave machines the dry-backed paddles have a significant benefit over position-controlled machines in that they seem to introduce a significant amount of spurious wave content, in some cases more than that associated with equivalent piston-controlled machines. In considering these effects, the operation of both machine types is carefully examined.

At present, the development of the second-order theory is limited to uni-directional waves. However, a separate study concerning the generation of oblique waves is included and a first0order force transfer function for the operation of wave basins is presented. Throughout the thesis, the theoretical work is supported by extensive experimental evidence. The generation and absorption of uni-directional regular and irregular waves is investigated. In addition, the practical generation capabilities of a multi-directional wave basin are also assessed.