Hydrodynamic Properties of Multiple Floating and Submerged Bodies Analysed by a Panel Method

X. Lei, L. Bergdahl

Department of Hydraulics, Chalmers University of Technology, S-412 96 Göteborg, Sweden

Abstract

A computer programme based on a panel method is developed in order to investigate the interaction between waves and a system of floating and submerged bodies. Small-amplitude waves and motions and irrotational flow are assumed and the resulting linear problem is solved in the frequency domain with six degrees of freedom of each body. The developed computer programme is made efficient by using the Haskind relation for the calculation of forces and the symmetry or double symmetry of symmetric configurations.

The computer code is applied to a problem with a wave-energy device, consisting of a floating buoy connected by a pump to a submerged suspended plate. For a single wave-energy device, comparisons are made with results for vertical forces and motions calculated by the method of expansion in matched eigenfunctions. The agreement is good.

As practical applications, the effect of offset between buoy and plate and the effect of the shape of the buoy and plate are investigated.

The programme is coded in FORTRAN 77 and is presently run on a PC 386.

1 BACKGROUND

In the Department of Hydraulics, Chalmers University of Technology, work is conducted concerning the optimum efficiency of a class of wave power devices, consisting of a floating buoy connected to a submerged plate by some type of power take-off mechanism. To that end, a fast semianalytical method was used for the associated analytical problem, by expanding the solution in matched eigenfunctions for the vertical motion of the buoy and plate. Results from this activity were presented earlier by Berggren & Johansson1 (1992) and Berggren & Bergdahl2 (1991). A fast method is
vital in order to be able to make many calculations, as the applied power
take-off mechanism is nonlinear and has to be linearized for each tested
sea-state.

Then the question arises how accurate such a solution will be for a real
configuration e.g. with buoys of conical shapes instead of buoys with a flat
bottom or with offset between the surface buoy and the submerged plate.

To test some of these effects, it was decided to develop Lei's panel
programme for multiple floating bodies (Björkenstam & Lei3, 1990) into a
programme also applicable to a configuration of floating and submerged
bodies.

In this paper the influence on some of the hydrodynamic properties are
presented. The next step would be to evaluate the influence on the power
take-off and decide how reliable the fast semianalytical method is for
efficiency optimization. This has not yet been done.

2 DEFINITION OF HYDRODYNAMIC PROPERTIES OF THE HOSE
PUMP

A buoy riding in waves, connected to a submerged plate by an elastomeric
hose, has been proposed as a device for extraction of energy from waves
(Hagerman4, 1988). This device is known as the Hose Pump. The
elastomeric hose acts as a pump that is driven by the relative motion
between the buoy and the submerged plate. The submerged plate is moored
to the sea floor. Following Hagerman the concept is described as follows.
During the passage of a wave crest, the buoy heaves up stretching the hose.
The helical pattern of steel reinforcing wires in the hose causes it to
constrict as it is stretched, thereby reducing its internal volume. This forces
sea water out of the hose pump, through a check valve, and into a
collecting line to a turbine. After the wave crest has passed the buoy drops
down into the succeeding trough, the hose pump returns to its original
length, restoring its diameter to its unstretched value. This increase in
internal volume draws water into the hose through another check valve,
which is open to the sea. (See Fig. 1)

In order to analyse the dynamics of the wave energy device, properties such
as hydrodynamic coefficients have to be calculated. The problem is here
formulated linearly which means that the coefficients associated with the
harmonic motion of one of the bodies are calculated considering the other
bodies as fixed. The radiated waves associated with the body in motion will
cause a dynamic pressure. In a multi-body system this pressure will not
only be experienced by the body in motion but also by the fixed bodies.
This leads to an added mass and damping coefficient of the body in motion
as well as cross-terms of added mass and damping of the fixed bodies. In
the present paper added mass and potential damping including cross-terms
are presented for the cases with vertical motions of any of the bodies.