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# Positioning of a Floating OTEC Plant by Surface Intake Water

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## ABSTRACT

**Under normal OTEC operating conditions, a floating body could be kept in a global position, within a given radius, without the need for mooring lines or thrusters if the momentum flux from the surface seawater intake or the effluent discharge is adequately distributed around the hull. This problem is studied in the presence of steady external forces that act on the platform-pipe system in regular seas, and a positioning model is developed. The model is then applied to a sample OTEC plant to determine the technical feasibility of the solution in particular cases. The proposed positioning model can be used to determine the distribution and amount of momentum flux necessary to keep the plant in position.**

## INTRODUCTION

In an OTEC process, warm seawater is fed to the plant from the surface of the ocean, while cold seawater is pumped from the deep ocean by means of a long cold-water pipe (CWP). The mixed effluent discharge pipes can be moderate in length, extending to a depth sufficient not to interfere with the warm-water intake. When warm seawater flows through lateral openings, slightly above the keel of the platform, momentum is generated. This momentum flux can be used to balance, either partially or totally, the external forces exerted on the platform and attached pipes, to achieve positioning without the need for additional power thrusters (Nihous and Vega, 1993).

Consider a floating OTEC plant which has openings, possibly circular ones, on its underwater sides near the keel. The momentum of the intake water can certainly propel the hull. Suppose now that we can continuously track the position of the plant by satellite or shore radio signals and can, therefore, determine the amount of drift from a given position. The warm-water intake pumps that are connected to the intake pipes, distributed around the hull, can then be turned on and off in such a way that the momentum necessary to overcome the drift forces is generated.

The external fluid forces that act on the system are due to waves, current and wind present in the area where the plant operates. These external forces correspond to different frequency ranges. Firstly, waves exert periodic forces and moments on the platform-pipe system. Secondly, second-order wave forces and moments induce steady potential-drift forces. And thirdly, there are steady viscous forces, especially on external pipes attached to the platform, due to the action of waves and current, and of current alone. Wind forces and wind-gust effects can potentially be of significant magnitude for thrust requirements. However, these effects are not included in the present work. Clearly, the importance of wind forces must be determined before the final analysis of the positioning problem is completed.

Since the main purpose of a floating OTEC plant is to produce electrical power, the global positioning of the plant is of utmost importance as the tension in submarine power cables, linking the power plant to shore, must stay within acceptable limits. We shall assume that the power cable system can be designed to withstand wave-frequency periodic motions. Under this reasonable assumption, we consider here the higher-order drift forces and moments, due to both potential and viscous effects in regular waves. The issue of irregular-wave excitation is left for future studies.

Our present objective is to design the warm-water intake pipes such that the corresponding momentum flux should provide steady forces equal and opposite to the external, steady loads due to waves and current. If this can be achieved, then the plant will undergo periodic first-order motions only, and therefore its mean position will stay within a given radius. In the following, we propose a method to solve this global-positioning problem. The details of the present work can be found in Ertekin et al. (1992a, 1992b). In the latter reference, a slightly different formulation of the problem is used and applied to the positioning of a 100 MW OTEC plant.

## GLOBAL POSITIONING

Consider the plan view of a possible OTEC plant in Fig. 1a. $P_{x1}$ through $P_{xNI}$, and $P_{z1}$ through $P_{zNJ}$ refer to the warm-water intake pipes along either side of the platform. $F_x$, $F_z$ and $M_y$ are the horizontal forces and moment, respectively. These external loads act steadily on the platform. The intake flow rate and the velocity of the intake are denoted by $Q_{xi}$, $Q_{zj}$ and $V_{xi}$, $V_{zj}$, respectively (Fig. 1b).

The equilibrium equations can immediately be established, relating the external forces and moment to intake flow rates and velocities. These equations must be supplemented by a constraint equation since the sum of all intake flow rates must be equal to the total warm-water intake flow rate $Q_p$, required to overcome the external drift loads. If one assumes that $F_x$, $F_z$, $M_y$ and $Q_p$ are known, the unknown variables to be determined then are the

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