Multi Objective Optimization Performance of a Floating Flexible System

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ABSTRACT

In the present paper a multi objective optimization mathematical model of a Floating Flexible System (FFS) subjected to regular incident waves is developed and presented. FFS is considered as a system for both wave energy production and protection. The performance criteria considered for the optimum design of the FFS are the produced power, the protection effectiveness of the area behind the FFS, and the structural integrity of system parts. A mathematical approach is developed, based on genetic algorithms and global criterion method, in order to properly address FFS’s design variables towards a most preferable (optimum) design.

KEY WORDS: Floating Flexible Systems (FFS); effectiveness; wave energy; genetic algorithms; multi objective optimization problem; global criterion method.

INTRODUCTION

FFS present nowadays one of the most characteristic types of offshore and coastal structures that can be utilized in the sea environment in order to develop modern and sophisticated projects that address new trends and needs and satisfy new requirements. Floating island cities, floating entertainment facilities, floating emergency bases, floating storage bases of oil or water, floating wave energy devices, floating offshore wind turbines and/or sea water desalination plants, floating bridges and breakwaters represent characteristic current and future potential FFSs. The design of an effective FFS in terms of desired performance, properly defined, is the key element for their successful implementation. Performance should include the structural integrity of system parts that compose the FFS and more specifically the avoidance of any structural failure of the connectors of the modules of the FFS.

Meanwhile, significant opportunities and benefits have been identified in the area of ocean wave energy due to extremely abundant and promising resource of alternative, renewable and clean energy in the world’s ocean (Falnes, 2007). FFS present a major category of wave energy converters that up to now numerate a very large number of proposed and developed energy devices (Drew et al., 2009, Falnes, 2007 and Falcao, 2010). A large number of proposed wave energy devices are based on the harnessing of the relative motion between (a) two or more oscillating modules and (b) an oscillating module and the sea bed, and converting this motion into power with the utilization of a hydraulic Power Take-Off (PTO) mechanism. Fundamental design process and numerical modeling of this kind of wave energy converters are based on linear hydrodynamic analysis as have been developed by Falnes (1999), Falnes (2002), Payne et al. (2008) and Gomes et al. (2010); Michailides and Angelides (2011a and 2011b) proposed a numerical modeling of the same kind of wave energy converters (oscillating modules and PTO) based on linear hydroelastic analysis.

On the other hand, FFS are also utilized for protection effectiveness operating as breakwaters; these types of breakwaters present numerous advantages compared to fixed systems like: reduced environmental impact, relatively short duration of installation, mobility and relocation ability, flexibility for future extensions, application in deep water and/or poor foundation conditions, and lower in general construction cost. These positive effects result to a large number of proposed floating breakwater types as described by McCartney and Bruce (1985) and by Oliver et al. (1994). The most commonly used type of flexible floating breakwaters is the one that consists of rectangular modules connected flexibly to each other with connectors of appropriate mechanical characteristics. The investigation of FFS’s effectiveness that operates as a breakwater has been addressed by many researchers using numerical models based on hydrodynamics of rigid body (Isaacson, 1987, Williams and Abul-Azm, 1997, and Loukogeorgaki and Angelides, 2005) and/or on hydroelasticity (Michailides et al., 2009 and Michailides et al., 2010).

In both operating functions of FFS, namely, as a wave energy converter and as a floating breakwater their dominant design objective, in each separately function, is the increase of the produced power in terms of the averaged power that the PTO can extract and the increase of the protection effectiveness in terms of the wave height behind the FFS. The optimization performance procedure for both operating functions (as described above) of an FFS have been treated so far as a single optimization problem with or without the use of genetic algorithms (Elchahal et al., 2007, Gomes et al., 2010, Ryu et al., 2005, Loukogeorgaki and Angelides, 2009).

Genetic algorithms are stochastic optimization algorithms that gradually and efficiently have been implemented in single, as well as,