Initial Assessment of Mooring Solutions for Floating Wave Energy Converters

Jonas Bjerg Thomsen, Jens Peter Kofoed
Department of Civil Engineering, Aalborg University
Aalborg, Denmark

Martin Delaney, Stephen Banfield
Tension Technology International, Inc.
Eastbourne, United Kingdom

ABSTRACT

The present study investigates three different types of mooring systems in order to establish potential cost reductions and applicability to wave energy converters (WECs). Proposed mooring systems for three existing WECs create the basis for this study, and the study highlights areas of interest using a preliminary cost estimation and discussion of buildability issues. Using synthetic rope and variations in the mooring configuration has the potential of influencing the cost significantly. In order to quantify this potential, a simple quasi-static analysis is performed, which shows that a SALM type system can provide a paramount cost reduction compared to a traditional CALM type system with chain lines. Similarly, use of nylon ropes similarly appears to provide low cost.

KEY WORDS: Mooring; Station-keeping; Wave Energy; Synthetic; Chain; Quasi-static; Buildability

INTRODUCTION

Wave energy converters (WECs) have been the focus of much research and investigation throughout the last decades leading to a number of different concepts and devices. Some of these devices are floating structures with a need for systems that keep the structures on station and secure a minimal effect of environmental loads. Often a mooring system is applied which, by definition, is a system of lines connecting the floating structure to the seabed.

The layout of the mooring system and the applied components can vary significantly, give much different characteristics to the system and result in important differences in the cost. In moorings for WECs, the influence on energy absorption is also considered, and the systems are therefore characterized as either passive, active or reactive. The latter defines a system where the mooring provides reactive forces in the WEC and thereby influences the power take-off (PTO) while the passive and active systems respectively define a system with no influence on the energy absorption and a system where the mooring influences the dynamic response and energy absorption (Martinelli et al., 2012).

Mooring is a vital part of all floating structures and is a well-known concept in the oil, gas and naval sectors with a variety of different design standards, as e.g. DNV (2010), API (2005) and ISO (2013). The wave energy sector has adapted the experience from these sectors to a large extent, but still a large number of failures have been observed due to insufficient moorings as stated by Martinelli et al. (2012). In addition, the cost of moorings represents a large part of the total structure cost, estimated to be in the range of 10-30% (Carbon Thrust, 2011; Fitzgerald, 2009; Martinelli et al., 2012). In comparison, the same articles estimate the cost of station keeping systems in the oil and gas sector to be approximately 2% of the total structure cost, which is also more easily covered by the available finances, and consequently the encouragement towards further optimization is not as distinct. Additionally, Carbon Thrust (2011) states that there is only little potential of cost reduction in the existing types of mooring system and highlights innovation and use of alternative materials as potential approaches towards cost reduction.

This study investigates the potential of a number of mooring solution candidates to be applied on an existing WEC. This device is characterized as being a large floating structure with a passive mooring system and represents devices such as Floating Power Plant, LEANCON Wave Energy, KNSwing and Wave Dragon, cf. Fig. 1.

---

Figure 1: Large floating WECs with passive mooring systems. Top left is Floating Power Plant (2015), top right is LEANCON Wave Energy (2015), bottom left is Wave Dragon (2015) and bottom right is KNSwing.