TU Delft

Offshore & Dredging Engineering

Technische Universiteit Delft

Cold Water Pipeline Deployment for Offshore OTEC Power Plants

Ocean Thermal Energy Conversion is a relatively new renewable energy technology, aiming at producing clean electricity by combining deep cold sea water with tropical warm sea surface water. One of the biggest technical challenge for offshore OTEC plants is represented by the installation and deployment of the cold-water pipe, which is required to bring cold sea water to the power plant at the sea surface. The pipe is approximately 1000-meter-long, with an external diameter between 2.5 and 5 meter and a free hanging configuration from a floating structure, which results in a complex dynamic behaviour. Large bending stresses, high-tension loads, and the potential buckling risk must be reduced to ensure a safe and secure pipeline deployment. Pipelines of this size and in the great water depth required have never been installed before. This project, carried out at the company Bluerise, has the objectives to investigate how a very large diameter cold water pipe can be installed, and to assess the technical feasibility of the deployment method.

This is done by analysing existing and new methodologies for the deployment of large diameter pipes. After identifying HDPE and the Float and Sink Method as the best material and best installation method, respectively, from a technical and economical point of view, this study presents several approaches, both analytical and numerical, that can be used to model the pipeline during deployment, each with its own strengths and weaknesses. Examples of model theories used are the Catenary Theory, the Stiffened Catenary Theory, and the Euler-Bernoulli Beam theory. The different models are compared in terms of assumptions and results to identify the most reliable one for the pipe deployment and to find out whether the installation is safe for the pipe integrity. Based on this models comparison, this project also provides an optimization design of the chosen float and sink installation method, consisting of the use of counter weight and multi-point liftings, instead of a single point one. In general, the beam theory in the nonlinear framework represents a relative quick way to estimate the behaviour of the pipeline during deployment, giving the most reliable results among the models considered. In terms of installation capabilities, bending curvature and combined stresses from the base case result in a safe configuration, being lower than the maximum values allowed for HDPE material. From this analysis, a large diameter pipe can be safely installed through the float and sink method.

This research project provides an initial investigation on how a very large diameter cold-water pipe can be designed and installed for large scale offshore OTEC plants. Further research is required to deeply investigate the installation of the cold-water pipe. In this study the models are judged and compared based on the results from just one static configuration. This analysis should be conducted for every phase of the pipeline installation. This can be done by considering a range of the pull force values exerted by the tug boat on the pipeline, instead of considering only one value. It is recommended to extend the pipe-lay analysis also to the dynamic part. Waves and current influences on the pipe are not considered in this work. It would be very interesting to execute a model test of the deployment and validate the model with actual experiment. Solving the residual challenges for the cold-water pipe might represent the answer to the development of large scale OTEC plants.

Student
Alfredo De Sario
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Sponsor
Bluerise

Thesis committee
Prof.dr. A. Metrikine
Ir. Y. Qu
Dr. F. Pisanó
Ir. B.J. Kleute