MSc Graduation Subject

Structural-dynamic Topology optimization of Offshore Hammer Anvil for Noise Emission

I Introduction

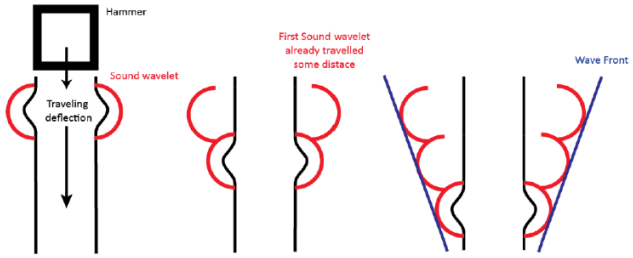
Heerema Marine Contractors (HMC) is a world leading marine construction company for the oil and gas industry which owns and operates a fleet of vessels for installing structures at sea. The fleet of HMC includes 3 out of 4 of the world's largest semi-submersible crane vessels (SSCVs). With dual crane tandem lift installations performed over 10.000mT, heavy lifting is in the core niche of HMC.

SSCV Thialf performing a heavy lift

For the installation of offshore structures, HMC is increasingly confronted with regulations regarding the amount of noise produced during underwater pile driving, to reduce the environmental impact on marine life. In this context, HMC is investigating to reduce the underwater noise generated by offshore piling activities.

Problem description:

During offshore pile driving a hammer excites an impact force to the driven pile. The driven pile expands radially and a sound wavelet is created. Multiple wavelets create a wave front radiating from the pile, see figure below:

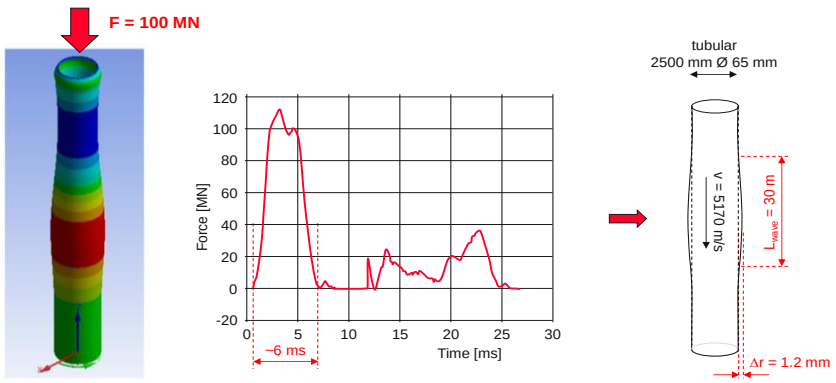


Wave front radiation from offshore driven piles

With the current offshore hammers an impact force of typically 100MN is given to the driven pile in typically 6 milliseconds. This impact force is traveling downwards along the pile at the speed of sound ~5170m/s in steel. The piles are producing noise levels above the regulations. As a measure of mitigation. the underwater noise is reduced for instance by applying bubble screens. These screens involve extra supply vessels and a large amount of compressors and are very costly.

Another option to reduce the amount of noise below water is to change the input force time diagram of the hammer used for pile driving. The shape of the impact diagram changes the amount of noise radiated from the pile. A typical force time diagram is shown in the figure below.

A way to influence this diagram is to change the design of the hammer anvil. This thesis assignment will focus on the structural optimization of the anvil in the offshore hammer, whilst maintaining good drivability of the pile. Because the impact force is a dynamic force time signal the topology optimization needs to optimize the dynamic response of the anvil. Numerical models predicting the sound produced by the pile are available within HMC.



Typical impact diagram

II Project

Goal

Goal of the MSc thesis is to investigate the possibility of performing a structural topology optimization of the hammer anvil in such a way that the anvil will produce a force time diagram in the pile, which radiates less noise to the water surrounding the pile, whilst maintaining good drivability. A noise reduction of at least 5dB is set as an objective.

Activities

The following activities within this project are envisaged:

- Develop a structural topology optimization model (in FEM) for the hammer anvil, which is subjected to a dynamic impact force of the hammer (FEM program ABAQUS available within HMC);
- Verify drivability effectiveness of the optimized hammer anvil using HMC's in-house software DynPac
- Obtain noise reduction levels based on the new hammer impact diagrams, with HMC's noise prediction FEM models.
- Provide a structural topology engineering tool capable of optimizing hammer anvils.

III References

References

1. K. Heitmann, S. Mallapur, T. Lippert, M. Ruhnau, S. Lippert and O. von Estorff, "*Numerical determination of equivalent damping parameters for a finite element model to predict the underwater noise due to offshore pile driving*", 2015, Hamburg University of Technology.

IV General

Requirements candidate

The candidate must have a background in structural dynamics / topology optimization studying mechanical engineering or offshore engineering. During the application process, he / she is expected to propose a thesis plan reflecting a 'plan of attack' for the described assignment. This plan will form the basis for entering into a student employment relationship with Heerema Marine Contractors.

Duration: 9 months

Location: HMC Leiden office

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