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STRUCTURAL ANALYSIS OF A ROTATING SHAFT MEMBER OF A FLOATING WAVE POWER GENERATING DEVICE

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Abstract

Main device of a floating wave power generating system is a plate structure attached to the shaft to absorb kinetic energy of approaching waves. The shaft needs to withstand resistance of an electric pump for it to generate power. In this paper, we investigate structural safety of associated shaft in relevant environmental loadings. We performed structural analysis and redesigned to obtain strength value for rotating shaft member. Finite element modeling and analysis of the structural members are presented in this paper using ANSYS code. Proper ways of applying boundary conditions for successful simulation of structural members are also presented. We have found that the analysis results are very sensitive to changes in relevant boundary conditions in the modeling process, and that the structure is safe in certain conditions.

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Introduction

Floating wave power generating devices in the ocean are developed using wave energy. Pendulum plate and shaft play a big role in converting wave energy to electricity [1]. In pendulum plate design, derivation of the optimal shape by a prolonged of exposure of the device to wave loads, inertia torque, buoyancy, and other external forces is necessary to ensure stability of the floating wave power generating device as shown in Figure 1 [2, 3]. In this paper, finite element analysis of the shaft of floating wave power generating device is performed for structural safety and stability.

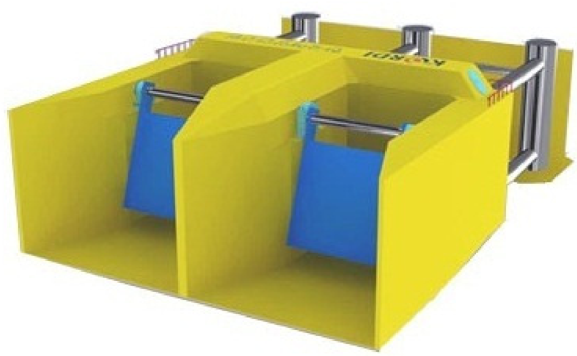

Figure 1. Floating wave power generating device.

Modeling of Shaft and Boundary and Loading Conditions

A shaft appropriate for finite element modeling for floating wave power generating was chosen for finite element modeling. Length, center diameter and the right end of the shaft were 6675mm, 360mm, and 276mm, respectively. Hexahedral elements are used for element division. Rapidly changing part geometry and stress points due to sudden nature of waves were expected and accordingly calibrated using a micro-element [4, 5]. SNCM815 is the material of the shaft; its density is 7830, the elastic modulus is 208 GPa, the tensile yield stress is 902MPa, and the Poisson’s coefficient is 0.3 (Figure 2).

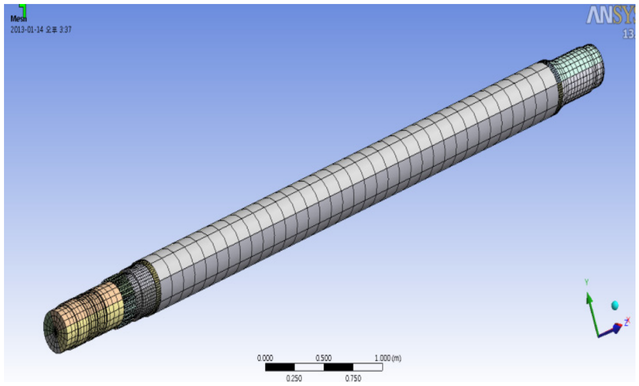

Figure 2. Finite element model of the shaft.

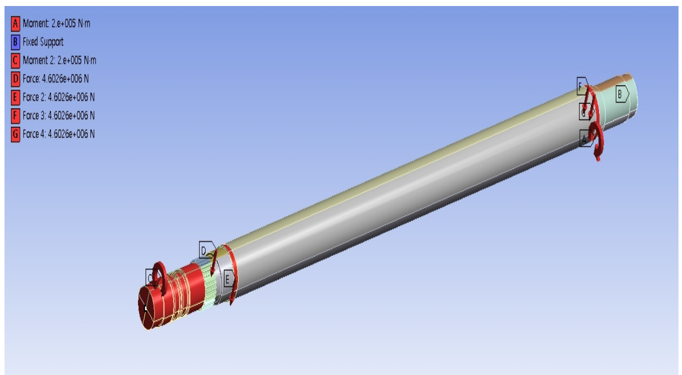

Figure 3. Boundary conditions and loading conditions on the shaft.

The simply supported boundary condition was applied on both ends of the shaft in order to fix the shaft for boundary conditions and loading conditions [6]. Torque acting on the shaft is assumed to disperse to the pendulum plate at the point of their connection. We considered both torque of resistance generated at one end of the shaft and bearing of the rotary vane pump (RVP) (Figure 3).

Finite Element Analysis and Results

Figure 4 shows Von Mises stress distribution on the entire shaft. Maximum stress occurs at the point close to the point of the shaft and the bearing's contact point [7]. We hypothesize that resistance is generated in the opposite direction of the torque acting on the shaft from the contact point [8]. When magnitude of the torque acting on pendulum plate and the shaft's contact point is increased from 200kNm to 950kNm, the maximum stress is smaller than the value of stress magnitude at a point close to the contact point (Table 1).

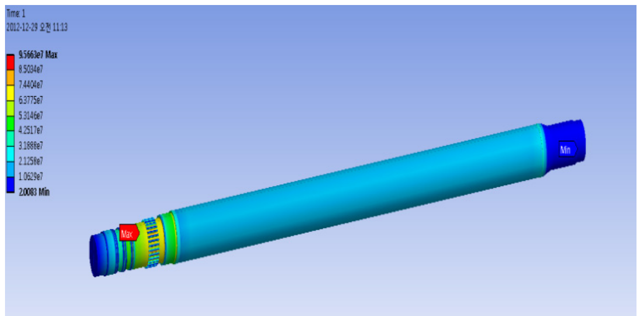

Figure 4. The distribution of stress from the shaft (Von Mises).

Table 1. The maximum stress from the shaft (Von Mises)

	The torque acting on the mating interface of pendulum plate and shaft (+)	Torque generated in a portion at one end of the shaft bearing and rotary vane pump (RVP) is coupled (–)	The maximum stress (MPa)
Case 1	200kNm	200kNm	95.66
Case 2	300kNm	300kNm	143.49
Case 3	400kNm	400kNm	191.33
Case 4	500kNm	500kNm	239.16
Case 5	600kNm	600kNm	286.99
Case 6	700kNm	700kNm	334.82
Case 7	800kNm	800kNm	382.65
Case 8	900kNm	900kNm	430.48
Case 9	950kNm	950kNm	454.40

Finite element analysis was performed on the shaft of the pendulum-type floating wave power apparatus. We assumed that torque acting on the shaft is dispersed in the two connections. We considered both the torque of resistance generated at one end of the shaft, as well as that generated at the bearing of the rotary vane pump (RVP). When the torque value was increased from 200kNm to 950kNm, magnitudes of the torque acting on the contact points of pendulum plate and the shaft are shown in Table 1. It was found that maximum stress generated in the shaft does not exceed the maximum stress value tolerated by the shaft. Therefore, we concluded that the shaft is safe.

Conclusions

In this study, we performed an analysis on structural stability of the floating wave power generating device assuming a primarily static load. When the torque force generated by the wave load on mating interface of the shaft and the pendulum plate was increased from 200kNm to 950kNm, maximum stress generated in the shaft did not exceed the maximum value tolerated by the shaft, and we therefore conclude that the shaft is stable. Because the resonance frequency of local installation does not overlap with the resonance frequency of the structure, the resonance frequency would not cause any disturbance in the pendulum plate or the shaft.

Acknowledgements

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