On the stick/slip phenomenon of a crew transfer vessel pushing its bow against an offshore wind tower during a transfer operation

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ABSTRACT

Crew transfer vessels (CTVs) play important roles for operation and maintenance in conditions of offshore wind. When engineers are needed to transfer to offshore wind facilities for various maintenance operations on site, in most cases, the captain of the CTV pushes the vessel bow against offshore the wind tower using propulsion to ensure easy and safe transfer. In such operations, differential motion from the normal wave-induced dynamics can occur because of noncontinuous static/dynamic friction at the contacting parts (fenders) between the bow of the CTV and the tower. The unexpected complex dynamics occurring in the transfer can have a severe impact on availability for offshore wind operation. Given these motivations, the author conducted both model experiments and numerical calculations to investigate the complex dynamics of a CTV pushing its bow against an offshore wind tower. A high-speed catamaran model and an offshore wind truncated model were used in the experiments. The numerical calculation was formulated for estimation of the stick/slip boundary based on frequency analysis. The author clarifies the effect of the friction coefficient at the contact locations and the bollard pushing force on the stick/slip phenomenon.

KEY WORDS: CTV; transfer operation; wave-induced motion; stick/slip phenomenon; model experiment; numerical calculation;

INTRODUCTION

When engineers (technical workers) are needed to transfer to offshore wind facilities for various maintenance tasks on site, in most cases, the captain and operational members of the CTV push the bow of the CTV against the offshore wind tower via propulsion (i.e., waterjets) to ensure easy and safe transfer. In this operation, differential motion from the normal wave-induced dynamics can occur because of noncontinuous static/dynamic friction at the contacting parts (fenders) between the bow of the CTV and the offshore wind tower. Figure 1 illustrates the friction around a fender. When the bow of the CTV is in a sticking condition (not moving), the static friction force applies and increases until reaching the maximum static force. If the friction force exceeds this maximum, transition of the friction force to dynamical friction occurs noncontinuously. This phenomenon is a classic topic in tribology. Unexpected complex dynamics associated with noncontinuous friction during the transfer operation can result in severe accidents and affect the operability (availability) of the offshore wind operation.

In offshore technologies, because the operation described above occurs daily, the mechanical analysis for the complex dynamics of working vessels in transfer has already been investigated by various researchers. For example, González conducted numerical calculations and model experiments. The numerical calculations included a time domain simulation considering noncontinuous friction forces, and in the experiments, a model was equipped with two Z-drives with four-bladed propellers. The comparison of motion RAOs (Response Amplitude Operators) and time histories between the model experiments and numerical calculations was discussed (González, 2015). Generally, numerical calculation has been the focus of most research. Wu (Wu, 2014), Barthelemy (Barthelemy, 2012), Jose (Jose, 2011) and Guanche (Guanche, 2016) conducted numerical investigation for CTVs in transfer operations. Wu proposed an evaluation method based on a constraint force at the fender at the sticking condition. Guanche developed a numerical model and applied the method to walk-to-walk accessibility assessment for floating offshore wind turbines. With these pioneer works considered, optimized (or practical) numerical calculations for complex stick/slip phenomenon at fenders play an important role but must be validated with experimental results or actual operational data for operability evaluation of CTVs.

Given these motivations, I conducted both model experiments