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A study on the key performance indicator of the dynamic positioning system

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Abstract

The dynamic positioning system (DPS) maintains an offshore vessel's position and heading under various environmental conditions by using its own thrust. DPS is regarded as one of the most important systems in offshore vessels. So, efficient operation and maintenance of the DPS are important issues. To monitor the DPS, it is necessary to define an appropriate key performance indicator (KPI) that can express the condition of the DPS from the perspective of operational efficiency and maintenance. In this study, a new KPI for the DPS is proposed considering the efficiency of the machinery and controller, the energy efficiency, and the environmental conditions in which the DPS is operated. The KPI is defined as a function of control deviation, energy consumption, and environmental load. A normalization factor is used to normalize the effect of environmental load on the KPI. The KPI value is calculated from DPS simulation and model test data. The possibility of applying the KPI to monitoring of DPS condition is discussed by comparing the values. The result indicates the feasibility of the new KPI.

Keywords: Dynamic positioning system; Key performance indicator; Condition monitoring

1. Introduction

Over the past few decades, Condition Monitoring (CM) and Condition-Based Maintenance (CBM) have been widely adopted in a variety of industries. CM involves the detection and collection of information and data that indicate the state of a machine (ISO 13372, 2004). CBM is a type of preventive maintenance based on the data collected from CM. It is conducted by forecasting the state of a machine based on analysis and evaluation of parameters related to the condition of the item to be maintained (Bengtsson, 2004). CM and CBM technologies have been shown to reduce the cost of maintenance, increase reliability, and improve operational safety (Rao, 1996). These technologies are gradually being applied to several types of equipment in ships and offshore structures. Li et al. (2012) developed a condition monitoring and fault diagnostic system for marine diesel engines using information fusion technology. Eriksen (2010) proposed condition indicators, Technical Condition Indexes (TCIs), for condition monitoring of ship engine auxiliary systems. Paik et al. (2010) developed a real-time monitoring system for a full-scale ship based on a wireless sensor network and data transmitted over power lines.

The Dynamic Positioning System (DPS) maintains the position and heading of an offshore vessel by controlling thrusters, propellers, and rudders. The DPS is one of the most important systems in offshore vessels. Because the DPS consumes more energy than other equipment, it is important to operate the DPS as economically as possible. In addition, as offshore vessels are increasingly being used in deep waters and harsh environments, it is necessary to ensure proper maintenance of the DPS. Therefore, CM and CBM technologies must be applied to the DPS.

Typically, a DPS is composed of three parts, as shown in Fig. 1: the generation, propulsion, and control elements. A diesel generator is the main component of the generation element. When power is generated, it is delivered to the propulsion elements via the switchboard. The propulsion element

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contains several electric motors, shafts, propellers, and thrusters. Thrust is produced by the power delivered from the generation element and by the control signal input from the control element. The control element generates control signals according to the required thrust. The control signals consist of rotational speed, azimuth angle, etc. The thrust required for the vessel is calculated in the control element considering the vessel's current position and heading, environmental conditions, and other user-inputted parameters.

As a DPS is a combination of the aforementioned components, a proper Key Performance Indicator (KPI) of the overall condition is necessary for monitoring of the DPS. The KPI can be used not only for condition monitoring but also for maintenance purposes. For instance, it can be assumed that the KPI signal will gradually decrease when monitoring the status of the DPS for a long period of time, as shown in Fig. 2. This results from various factors, such as degradation of the machinery and non-optimized tuning of the controllers. When the value drops below a certain level, it generally indicates that the condition of the DPS is worse than expected; it may indicate that maintenance actions need to be taken, such as checking the condition of the equipment and controllers. Therefore, the KPI provides a basis for determining the condition of the DPS and taking any necessary maintenance-related actions.

When monitoring the condition of the DPS, generation efficiency, propulsion efficiency, position and heading deviation, and energy efficiency could be considered as indicators. However, generation efficiency reflects mainly the efficiency of the machinery, specifically that of the generator system, rather than the efficiency of the DPS. Propulsion efficiency is subject to measurement error in that it is difficult to measure the exact thrust from a number of propellers; therefore, it is not a practical indicator.

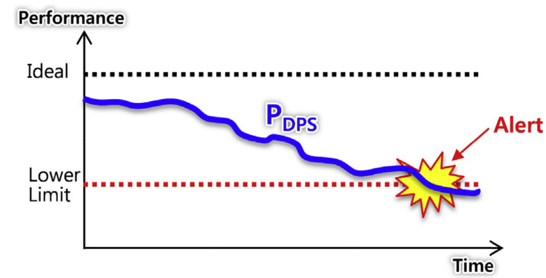

Fig. 2. Example of DPS KPI monitoring.

Other indicators have been used to reflect the condition of the DPS. Kongsberg Maritime described the effectiveness of the DPS controller *Green DP*, which is based on the energy consumption of the system (Hvamb, 2001), and ABB adopted a new control system, *Weather Optimal Positioning Control*, and verified its effectiveness by comparing control deviation (the position and heading deviation of the vessel) and energy consumption (Fossen and Strand, 2001). However, even in those cases, there is no direct relationship between position and heading deviation and energy efficiency. Furthermore, the influence of environmental conditions on the system was not included in those indicators.

To reflect the overall condition of the DPS properly, position and heading deviation and energy efficiency should be taken into account together, along with the influence of environmental conditions. Therefore, in this study, a new DPS KPI is suggested, which takes into account the condition of the relevant machinery and controller, energy efficiency, and environmental conditions.

To verify the feasibility of the DPS KPI presented in this paper, DPS simulation and model test data are used to

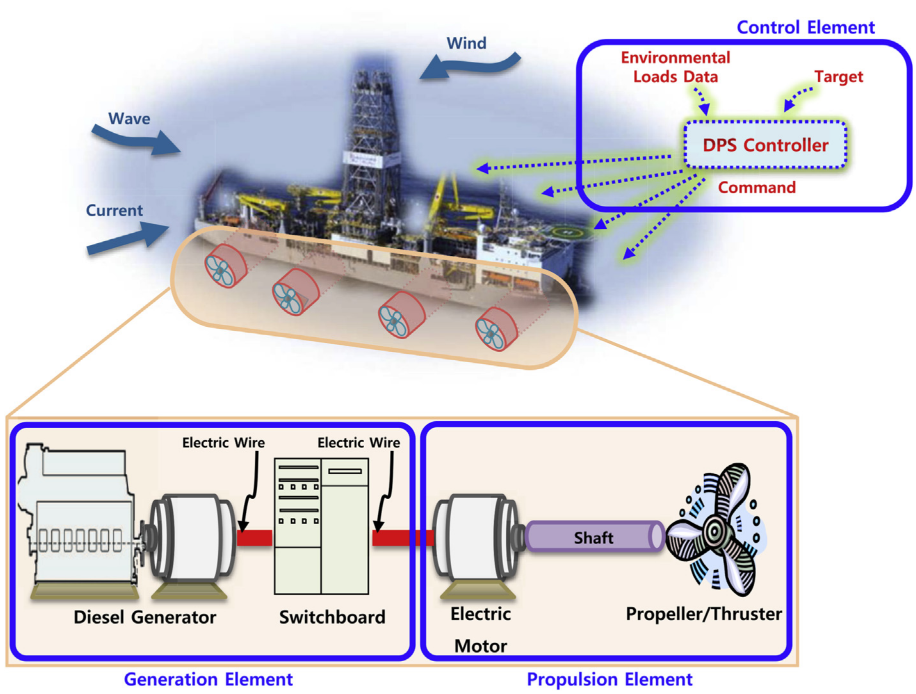

Fig. 1. Configuration of a DPS.