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Mini Review

A Mini Review of Research on Blade Fault Detection of Marine Current Turbine

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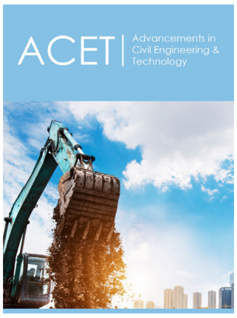

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Introduction

The global energy crisis prompted renewable energy sources to occupy the power market quickly. The ocean energy is inexhaustible. As a critical device for marine current energy conversion, a marine current turbine (MCT) is very important for safe and stable operation [1]. As the core component of MCT, the blade is prone to various failures due to long-term exposure to seawater [2]. This mini review will reveal the common failure phenomena in MCT, such as crack and biofouling. The failure phenomenon and several fault detection methods are also presented in this review. Finally, the point of view and future activities suggestions are given in the discussion.

Mini Review

MCT blade fault root causes

The fluid kinetic energy is converted into electric power through MCTs [3]. MCTs are mainly composed of turbine and generator, which is a typical mechatronics system [4]. The velocity of the marine current is the main factor that changes the operating state of the MCTs. Some blade fault root causes are summarized as follows:

A. Many types of equipment installed in the sea, such as MCTs, have become artificial reefs to attract various marine life [5,6]. The growth of marine life and the adhesion of marine pollutants will significantly reduce power capture efficiency [7]. The imbalanced fault caused by the blade biofouling is the main reason for the wear and damage of the transmission components of the MCT set.

B. When the flow velocity is large, generally greater than 8m/s, the turbine may cause cavitation and cause physical damage to the turbine [8]. MCTs have a high speed at the tip of the rotor blade and will encounter cavitation. This jet stream produces corrosion on the hard surface of the turbine.

C. Through environmental monitoring, the MCT noise has affected mammals' lives in the ocean, and there have been many cases of the shutdown of MCTs when mammals approached [9]. The impact of marine organisms or pollutants on the turbine, such impact failure may cause damage to the turbine and further cause serious consequences. Therefore, timely and effective detection and the recording of historical collision data are indispensable.

The method used in blade fault detection

In the current research, some novel fault detection methods have been used in the field of MCTs.

a) Taking image sensors, as an example, image sensor application in fault diagnosis of MCTs blade has a good prospect. When the blade is eroded, the image can be used as valuable fault detection information [10]. The reference [11] proposed a diagnosis method based on a deep separable convolutional neural network for the biofouling on the blades of MCTs. The status is identified through the fouled part and different pixels of the blade. However, the offset influence of the marine current flow on the image acquisition device and the MCT must be considered.

b) Fault diagnosis methods based on acceleration sensors have also been applied to MCTs [12,13]. For example, real-time methods based on vibration signals have been applied to detect, locate and identify blade faults. Due to the tremendous underwater noise, it is difficult to extract the fault information contained in the vibration signal. The turbines of MCTs will complete a complete cycle of motion at different angular velocities [14]. Variable speed usually applies different vibration signals to the various components of MCTs, which interferes with the final fault feature extraction. In the background of MCTs, it is necessary to consider how to remove the influence of noise and trend items.

c) The fault diagnosis method based on stator current (current flowing in the electrical generator) has attracted more and more attention in recent years due to its advantages of non-invasiveness and easy access [15]. In the fault diagnosis of MCTs, the core idea of this method is that when the MCT components failure, the amplitude of certain specific frequency components in the stator current will appear or increase due to the occurrence of the fault, which is called fault indicators. These indicators are reliable indicators for detecting the existence of faults.

Point of View and Future Activities

The utilization of stator current analysis seems to be a good option and future trend for fault diagnosis and monitoring of MCTs. However, when using frequency domain information to process the stator current, the fault characteristics are usually submerged in the main frequency and noise. This noise and interference include the problem of low-frequency trend items caused by periodic marine current fluctuations. The use of frequency domain information also weakens the real-time nature of the diagnosis method. Not only that, compared with other land-based generators, how to eliminate the influence of random waves and turbulence on the stator current signal is also a crucial issue. Therefore, several suggestions are given as follows:

A. Establish a multi-sample fault database of MCTs at different flow rates and improve the fault database of MCTs by modeling historical data to use machine learning-related algorithms for fault diagnosis.

B. The fault diagnosis method of combining different sensor signals across latitudes can be considered for highly complex situations of MCTs.

C. Through the state monitoring of MCTs, environment information such as flow velocity, surge, and turbulence can be monitored in real-time, which is helpful to provide additional information on severe ocean conditions (tsunami, typhoon), weather warnings, etc.

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