Harnessing Technology Maintenance Process of Tidal Energy Converter

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Abstract. Tidal energy has become an alternative solution for energy source in the future especially for countries with vast ocean such as Indonesia. Tidal energy converter is relatively new which resulted in different concept or even prototypes. The design of tidal energy converter must consider the simplicity of the maintenance process. How is the existing prototypes of tidal energy converter maintenance process. This paper evaluate the existing prototype which use floating platform such as Larantuka strait and Madura strait prototype which use Darrieus turbine, T Files turbine which use golov turbine, BlueTEC and Horizontal Axis Tidal Current Turbine (HATCT) which use horizontal turbine. The evaluation are based on several criteria such as operational check, inspection and maintenance of harnessing technology or turbine arm where shaft, gearbox and generator are included in the arm which can be called as harnessing technology. The results of comparison shows that the tilted method of maintenance has advantages of visual inspection. The comparison also shows that there is still room for improvement for the design regarding the onsite maintenance by providing larger deck. As the answer of the comparison, a novel design concept is offered using turbine arm with motor for tilting the arm and larger deck area.

Keyword: Tidal Energy, Prototype, Maintenance process, Turbine arm

1. Introduction
Tidal current energy is one of the possible solution for renewable energy in the future especially countries with ocean. Indonesia is one of country with vast ocean area, it means Indonesia has enormous potential of ocean renewable energy [1] [2]. There are several types of tidal power energy concepts. It can be differentiate based on the platform type or turbine type. The platform usually can be classified as floating platform or fix platform while the turbine can be differentiate based on horizontal axis or vertical axis turbine. Whatever the type of the tidal energy, it must be equipped with drivetrain such as gearbox, shaft, alternator and other system [3]. One of the important component is the drivetrain of the tidal energy system. The design of the drivetrain and other structure must considers the maintenance process, the operational aspect and the dynamic load [4].

The technology of tidal energy converter is relatively new therefore the technology offered is very variative [5]. Most of the drivetrain design is mounted to platform and protected by arm which covers the drivetrain. If the tidal and wind energy converter are compared, there are similarities among them.
2. Method

In order to evaluate several design of the turbine arm, there are several criteria are applied. The maintenance requirements of tidal energy converter falls into following categories:

- Operational checks
- Inspection and maintenance drive train, rotor, hardware control systems, hydraulics, electrical control, braking system and tower.
- Simplicity in maintenance process

The first similarities among turbines are the components which can be found in any concept of tidal energy converter [8]. Each system must consist of rotor or turbine, gear box and shaft, generator, control, power inverter, power transmission system as can be shown in Figure 1.

![Figure 1. Typical System of Tidal Energy Converter](image)

By considering that each system will have similarity in the system, this paper compares the simplicity of maintenance process from several tidal turbine especially in Indonesia and other tidal turbine. There are several tidal turbine which is already become a prototype and deployed in location. This paper will compares several prototype of tidal energy converter which use floating platform such as Larantuka strait tidal energy converter [9], Toyopakeh nusa penida [7], Madura strait [10], BlueTEC and HATCT. Each of the device will be reviewed for the turbine arm including gearbox, generator and the maintenance process.

3. Results and Discussion

3.1. Results

3.1.1. Larantuka and Madura Strait Prototype

Larantuka strait is one of the huge potential of tidal energy in Indonesia [11], the field measurement conducted by Harman et.al shows that the current has maximum velocity of 2.5m/s.
There was a prototype of tidal turbine tested in Larantuka strait which designed to produce 3.5 kW electricity using darrieus turbine installed on a floating platform [9]. It use a single turbine attached to a catamaran platform where the shaft rotates the generator through pulleys and vanelts.

The maintenance process of larantuka turbine requires the turbine, shaft can be conducted by lifting the turbine by releasing the drivebelt first. The similar concept to Larantuka turbine is proposed by Indonesian agency for the assessment and application of technology (BPPT) in Madura Strait. It consist of catamaran platform with one 3.5kW vertical axis turbine [12]. The system consist darieus turbine, shaft and connected to gearbox through gearbox. For the maintenance process, the turbine can be tilted from vertical position to horizontal position without dismantling the while system as can be shown in Figure 4.
After the development of the first prototype, the second prototype was introduced and tested. A catamaran platform with twin darrieus turbine.

3.1.2. Nusa Penida Strait Prototype

The third prototype which has been tested in Toyopakeh strait is T Files [7]. There is small technical information can be obtained in academic reference regarding this prototype. It uses a gorlov turbine and installed on a catamaran platform and claimed to be able to produce 10,000VA rated power generated from a permanent magnet generator. The diameter of the gorlov turbine is 1m and height 1.2m.

The maintenance process of T Files is by tilting the arm of the turbine level to the platform. It has the similar method of maintenance to the previous prototype which is by tilting the arm of the turbine. All the prototype of platform were designed to accommodate single turbine exept the twin turbine of Madura strait.

3.1.3. Horizontal Axis Tidal Current Turbine (HATCT) Prototype

The development of tidal energy converter in Indonesia is less developed compared to certain country in ASEAN such as Malaysia [1]. In order to complete the comparison of the turbine arm, other types of tidal turbine arm must be included. There are at least two other floating tidal turbine that can be compared, the Bluetec proposed by scottsrenewable energy. A tidal energy converter which use jackup for the maintenance process of the turbine and its system is reviewed. The prototype is based on horizontal axis turbine with drivetrain is submerged as can shown in Figure 6. The system is horizontal axis tidal current turbine or HATCT [13]
The HATCT is installed in a floating platform and the whole drivetrain is submerged under water during operational mode. The turbine will be lifted using steel wire and pulleys. The rotor itself has diameter of 7.5m and the system designed for 60kW output with max current speed is 2m/s as can be shown in Table 1.

Table 1. Rotor Design Parameters

| Design parameters | Values     |
|-------------------|------------|
| P rated           | 60 kW      |
| v rated           | 2 m/s      |
| CPrated           | 0.4        |
| N                 | 3          |
| Diameter          | 7.5m       |
| nrated            | 36 rpm     |
| ρ                 | 1025 kg/m³ |

Figure 6 shows that the drivetrain is submerged and it must be watertight during all the operation of the system. The submerged system is more complicated related to maintain the tightness of the seal for the gearbox, shaft, generator. But this submerged system offers shorter shaft compared to system where the drivetrain is not submerged. The submerged concept must be able to be monitored for its system health [5] [14].

3.1.4. BlueTEC Prototype

The Bluetec system is designed by bluetec and has been tested in the netherland waters. It has two horizontal axis turbine installed to cylindrical platform [15] [16] [17]. The modular platform has dimension of 24.3 m in length and weight 25 tonnes.
The BlueTEC platform is modular, it can be easily being transported [18]. During the test conducted in Texel, it able to produce 400-500kW using two horizontal axis turbines. The gearbox, shaft and generator is submerged under water and for the turbine maintenance, the turbine must be tilted above water and transported to land based maintenance facility.

3.2. Discussion

Based on several types of tidal harnessing technology previously discussed, there are some similarities. There are prototypes where the turbine arm which cover shaft, gearbox and generator submerged under water while the other are not submerged such as Larantuka and Madura prototype. The submerged type may provide a compact and neat turbine arm (drivetrain). The submerged device must maintain its tightness for water ingestion or leakage as its drawback. The other consideration is the monitoring process, the drivetrain can not be visually inspected without lifting the whole system out of the water on the other hand the unsubmerged system can be easily visually inspected but it has drawback on the longer shaft and appears untidy compared to submerged system.

The maintenance process can be classified as two method, tilted or lifted. Prototype which use tilted method for its maintenance process are Larantuka, Madura and BlueTEC. This tilted method may provide simplicity in maintenance process but the design of the hinge of the turbine must be able to withstand the dynamic load from the environment. The other advantages is the possibility for insitu maintenance of the turbine without removing the whole system. While the lifted method may requires a crane or winch installed on the platform that powerfull enough to lift the whole system. The comparison summaries can be shown in Table 2

4. Conclusions

From the previous discussions it can be concluded that each design have their advantages and drawbacks. Most of vertical axis turbine uses tilted method for maintenance simplicity and the equipment such as gear box is not submerged. This might be the solution for vertical axis turbine installed on floating platform, eventhough there is still room for improvement for the design such as:

- Hinge design to withstand dynamic environmental load from wave, current and wind,
- Provide enough space on deck for insitu maintenance,
For the improvement of the vertical axis turbine arm might use the proposed design as shown in Figure 8. The design has turbine arm which can be tilted using motor and the platform has enough space to conduct insitu maintenance.

Table 2. Summaries Of Tidal Harnessing Technology Floating Platform

| No | Device Prototype                  | Output  | Platform          | Turbine type                     | Turbine Arm                        | Maintenance process                  |
|----|-----------------------------------|---------|-------------------|----------------------------------|------------------------------------|--------------------------------------|
| 1  | Larantuka and Madura              | 3.5kW   | Floating Catamaran| Darrieus, Vertical Axis          | Gear box, generator above water    | 90 Tilted level to deck              |
| 2  | T Files                           | 10,000VA| Floating Catamaran| Gorlov Turbine, vertical axis    | Gear box, generator above water    | 45 Tilted to deck                    |
| 3  | Horizontal Axis Tidal Current Turbine (HATCT) | 60kW   | Floating Catamaran| Horizontal axis 3 blades         | Gear box, shaft, generator submerged| Lifted using winch and steel wire    |
| 4  | BlueTEC                           | 400-500kW| Floating single Hull Modular Platform | Horizontal axis 3 blades         | Gear box, shaft, generator submerged| Tilted using motor and transported to land based |

Table 3. Summaries of Operational Check and Inspection

| No | Device Prototype                  | Operational Check                     | Inspection of system             |
|----|-----------------------------------|---------------------------------------|----------------------------------|
| 1  | Larantuka and Madura              | able for Visual and monitoring system | visual method                    |
| 2  | T Files                           | able for Visual and monitoring system | visual method                    |
| 3  | Horizontal Axis Tidal Current Turbine (HATCT) | Monitoring system based | Monitoring system based |
| 4  | BlueTEC                           | Monitoring system based                | Monitoring system based          |
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