On Marine Growth Removal on Offshore Structures

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I. Introduction to Marine Growth

Throughout many years the oil and gas (O&G) industry has faced problems with marine growth (MG) attaching to the offshore constructions. The marine growth causes additional weight and increases the circumference and roughness of the structure, which result in increased wave load [1]. Consequently, material integrity is affected as well as risk of overturning moment. To avoid these disadvantages, the operators within the O&G industry periodically remove the marine growth. Previously, this job was carried out using divers. During the last two decades, ROVs have taken over the task, increasing safety significantly [2]. However, this solution is still expensive, mainly due to large vessels required, and ineffective due to poor control of the ROVs. The wind industry also faces the problems caused by marine growth. Partly, the problem is currently overcome by over-dimensioning the foundations. However, the MG problem will increase in the future, where super-optimization in design is required, and the wind industry will therefore also rely on periodically cleaning of the structures to stay competitive. This counts for both monopiles, jackets and floaters.

1) Increased wave load on the structures due to larger diameters and more surface roughness.
2) Fatigue cracks and damages are very hard to identify without removing the MG / Biofouling. It is a huge safety and environmental risk if these damages are not identified and repaired.

A reduction in costs for operation and maintenance of the O&G platforms and in construction of wind farms, results in cheaper energy production, making the market more competitive [3]. Further, a significant reduction in steel consumption for production of wind turbine foundations, and avoidance of fuel consumption for large vessels during the MG removal campaigns, enhances the work towards a reduction in greenhouses gases [4].

II. State-of-the-Art Actions

The challenges caused by marine growth is typically overcome either by over-sizing the construction or frequently removing the MG. Within the O&G industry periodic MG removal campaigns are carried out as part of the maintenance programs. This is a requirement for both inspection of the structure and in consideration of design criteria for material fatigue and overturning moment. For the wind industry, MG removal is only carried out for specific inspection tasks, as the foundations are typically oversized to meet the additional loads due to MG.

Over-sizing: The marine growth is taken into consideration during the design phase of the new foundations [5]. This means that the foundation is designed to withstand the increased drag forces caused mainly by waves and also to withstand the extra weight impact from a maximum MG estimation.

Foundation over-sizing significantly reduces the requirement for MG removal. However, it is necessary to ensure material integrity for the structure and such inspections require a clean structure. Therefore, marine growth removal is a part of operating a wind farm even though the structures are designed for maximum marine growth.

90% of the wind turbine generators in Europe are built on monopile foundations. Over-sizing such foundations leads to an increased foundation weight by 5-12%. An 8% increment corresponds to approximately 60 tons additional steel per foundation, which induce increased production costs and have an adverse impact on the environment. Hence, a cost-competitive solution for marine growth removal as an alternative to structural over-sizing might make the wind energy more competitive in the long term [4].

III. Typical removal process

MG removal is generally performed according to the process depicted in Figure 1.

The process can be divided into five steps:

1) Periodic inspection campaign for determining the amount of marine growth. Typically, this is carried out by ROVs

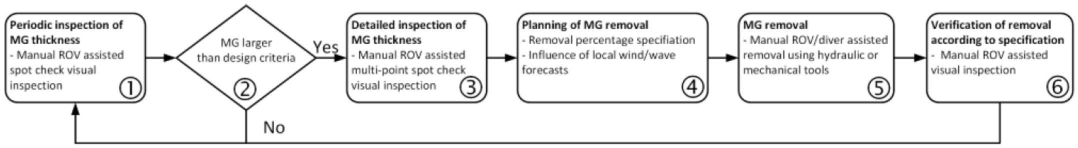

Fig. 1. State-of-the-Art marine growth removal process in offshore O&G structures.

2) Decision-making: Is the marine growth layer above allowed threshold? If yes, go to step 3.
3) A more detailed multi-spot inspection is carried out for providing the operators with more details.
4) Based on step 3 the planning of the upcoming removal campaign can be carried out.
5) MG removal can be carried out. This is typically done by ROVs
6) After the MG removal a new inspection is carried out in order to evaluate the cleaning performance.

It is clear that this is an expensive and time-consuming process due to the multiple steps towards the cleaning operation. However, since all the inspection outcomes are based on the MG removal performance (step 5), the remaining of this study will focus on the actual MG removal (step 5).

IV. Autonomous cleaning using ROVs

Historically, sub-surface MG has been removed by divers, but in recent years remotely operated vehicles (ROVs) have overtaken the cleaning task with a pilot operating the ROV from a ship launching the ROV [6]. ROVs are cheaper than divers, however, relatively inefficient in harsh offshore environments due to underwater streams, waves and the effect from the attach tether. In most cases, a high-pressure water jet is used as cleaning actuator, which also is an acting force on the ROV [7]. Autonomous underwater vehicles (AUVs) are rarely used due to the need for robust and reliable solutions [8], although AUVs do not have any tether attached like ROVs, limiting the amount of disturbances. Automation can potentially improve the cleaning efficiency of ROVs where a robust and reliable feedback controller with decent disturbance rejection features can reduce operation cost of offshore MG removal [9].

V. Sumary and manuscript description

The remaining of the paper will describe the issues and possibilities which exist for ROV automation within the specific subsea MG removal operation for offshore structures. The existing disturbances will be highlighted, the development in sensor technologies will be examined and the state-of-the-art control strategies will be presented and evaluated. Lastly, some solutions will be proposed and a prediction will be given for the future of autonomous ROVs within offshore MG removal.

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