Stress analysis of a portable oil spill skimmer frame for oil spills response and recovery (OSRR) activities

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ABSTRACT: Oil spill incidents can bring adverse effects to both human and aquatic life as well as the environment if there is not any efficient action taken to resolve them. There are ways of controlling the oil spillages which are using barriers and absorbent materials to recover the spilled oil mechanically. This paper emphasizes on the enhancement of the Portable Oil Spill Skimmer's frame in terms of its mechanical performance for better seakeeping ability and recovery efficiency of spillages in the open sea during oil spill response and recovery activities. The finite element analysis (FEA) method is employed to predict the behaviour of the frame structure whether it will fail or not.

Keywords: *Oil spill skimmer; Portable; Oil spillage response plan*

1. INTRODUCTION

According to [1], oil refers to all form of petroleum which includes crude oil, sludge, fuel oil, oil refuse and refined products. Without proper handling, the oil oftentimes ends up being released into the water sources like rivers and oceans. An action plan for oil spill response is highly critical for maintaining the environment around the field of oil spills. Previous research [2] claimed that the traditional methods of removing oil such as booms, skimmers, in-situ burning, chemical dispersion, etc. have common disadvantages of labour intensive, expensive, and high complexity as well as an additional treatment to separate the water from the recovered oil.

This paper describes the enhancement of the Portable Oil Spill Skimmer's frame previously developed in [3] in terms of its mechanical performance. With the ideal combination of the catamaran hull design [4]–[6] and frame structure, overall efficiency can be improved, so that the energy is conserved and at the same time, improving endurance over the operation of oil spill response and recovery.

2. METHODOLOGY

This section covers the methodology of the study, which consists of the stress analysis. The preliminary design of the Portable Oil Spill Skimmer will be analysed by using Ansys Mechanical software with FEA method to obtain the results of stress, strain and deformation values [7]. For the simulation, the boundary and loads must be defined at the appropriate location of the 3D model in order to produce results with accurate data in the form of equivalent von Mises stress to determine if there is any failure in the design stage. It is mainly performed on the structure in which the frame and hull are connected and uses static loading with uniform distribution to mimic the components during assembly. Figure 1 shows the static loading and applied constraint on the frame geometry.

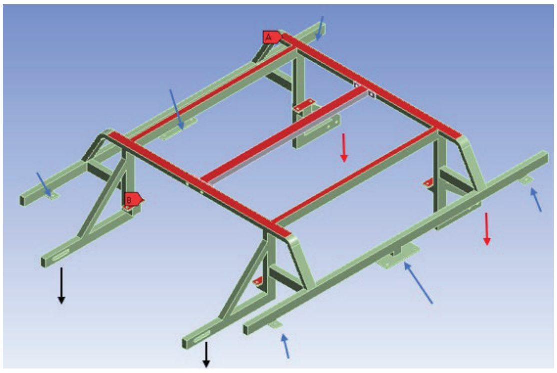

Figure 1 Static loading and applied constraint on the frame geometry

The loading to be applied on the frame is the overall weight of the moving components attached to the frame with a load of 15 kg or 147.15 N. Standard earth gravity will be applied on the simulation to mimic real-life conditions. The red area marked 'A' is for the load for components while 'B' is for the storage tank. The Fixed Support features are placed at the base plate where the frame joins the hull which are shown with blue arrows. There are also forces acting on the frame by the weight of the oil skimmer roller of 5kg at the front marked with black arrows and thrusters of 1 kg at the rear with red arrows.

3. RESULTS AND DISCUSSION

The conceptual design of the Portable Oil Spill

Skimmer has been produced by using SOLIDWORKS. This oil spill skimmer design is made up of a catamaran hull held together by a frame structure. The frame structure also acts as the mounting of components the skimmer and thrusters as well as it is the most susceptible for a breakdown during operation. So, the design of the frame, made from an aluminium hollow bar, is analysed thoroughly in order to prevent design failure and flaw.

3.1 Equivalent Stress Simulation

The result from the simulation when a total static loading of 21 kg or 206.01 N including the weight of skimmer of 5 kg and two thrusters of 0.5 kg each shows the maximum equivalent stress value of 16.851 MPa as shown in Figure 2. This design of the frame is safe as the stress value presented is lower than the yield strength of the material, which is at 280 MPa.

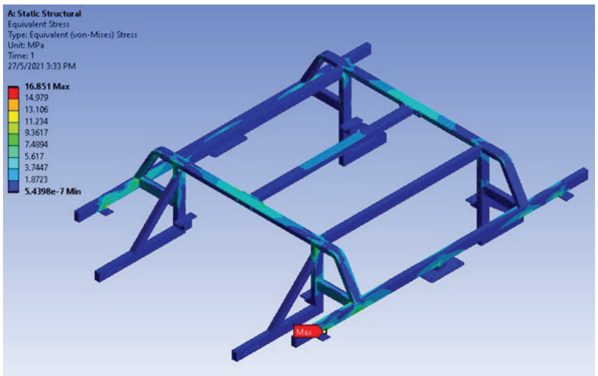

Figure 2 Equivalent stress of the frame

3.2 Equivalent Strain Simulation

The result from the stress-strain analysis simulation shows the maximum equivalent strain value of 0.25896×10^{-3} mm/mm given the static loading of 21 kg or 206.01 N. Figure 3 shows the result of the strain simulation.

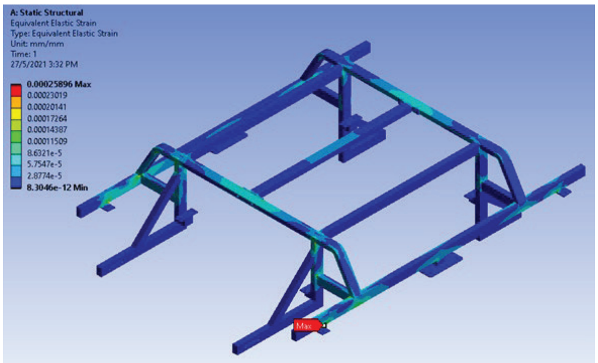

Figure 3 Equivalent strain of the frame

3.3 Total Deformation

The result from stress-strain analysis simulation shows the maximum deformation of 0.3742 mm given the static loading of 21 kg or 206.01 N. The maximum deformation occurs at the top middle bar of the frame as shown in Figure 4, and the value is very small and unnoticeable. Therefore, the frame for Portable Oil Spill Skimmer is rigid and will not distort.

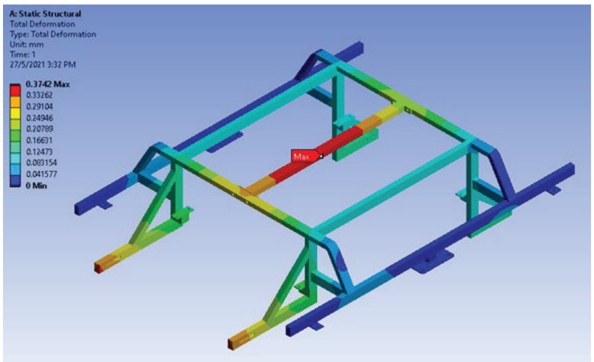

Figure 4 Total deformation of the frame

4. CONCLUSIONS

The results of stress-strain analysis simulation performed by using Ansys on the frame are stress, strain, a displacement which helps to predict the behaviour of the structure whether it will fail or not. This design of the frame is safe as the stress value presented is lower than the yield strength of the material and will be used for developing the prototype.

ACKNOWLEDGEMENT

This work was supported by Universiti Teknikal Malaysia Melaka through PJP/2020/FKP/PP/S01776. The authors would like to thank one of the authors' student, Chen, C.S. and Khong, C.M. for assistance with the 3D model design and stress analysis.

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