Designing a slurry pump drivetrain for a cutter suction dredge

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Introduction

Dredging is a method of excavating sediment from the bottom of a body of water to make space for infrastructures, such as ports or canals, or to simply move material to a desired location. Large machine systems known as dredges are used to excavate the sediment. These dredges use large pumps and pipes to transport the material elsewhere. This project focused on the technologies of the Cutter Suction Dredge (CSD) which uses a long rod known as the ladder to lower a large rotating cutter head into water. The cutter head then digs up sediment from the bottom of the body of water. A suction pipe is located behind and inside the cutter head and creates a vacuum pocket behind it, drawing in a mix of sediment and water. The mix of sediment and water, known as slurry, is pumped through a discharge pipe toward the dredge and can be transported to another location.

This project aimed to design a drivetrain for a Cutter Suction Dredge that would allow for a specific environment to be dredged. This was done by first selecting the environment, then calculating the sizes and specifications of different parts. Calculations for the throughput of the dredge (the amount of material being moved through the system) also needed to be made as the performance of the dredge is largely influenced by throughput (Wetta, 2010). After the parts were selected, more calculations were made so that individual components of the drivetrain could be created.

Materials and Methods

The dredging environment selected for the project is the Conowingo Dam. If the water behind the dam were to be dredged, the dredging would take place at about 20 feet into the water. The sediment in the water is a fine silt. With this information and formulas provided by Ellicott Dredges, a pump was selected. This pump is what would create the vacuum pocket behind the rotating cutter head, drawing in the slurry of water and sediment. After selecting the pump, an engine was selected and calculations were made for bearing loads. Selecting the engine allowed for engine mounts to be designed in Autodesk Fusion 360 (Figure 1). The engine mounts, engine, and transmission were then placed into a single model and were exported into a SolidWorks Simulation. In this program, Finite Element Analysis (FEA) was performed on the engine mounts. FEA allowed for the materials of the designed models to be defined and simulated how the models would perform in real life if subjected to the same loads. After performing FEA on the model, the components were redesigned to prevent any running failures.

Results

From the formulas in the Ellicott Dredges Employee Design Manual (1996), it had been calculated that a 12″ suction pipe and a 12″ slurry pump would be used if a dredge was actually being built for the Conowingo Dam. From this pump size, a Caterpillar C9.3 marine engine was selected for the design. The engine mounts were then designed according to the dimensions of the marine engine, as seen in Figure 2. After the mounts of the drivetrain were designed, they were placed into a single model with the engine and were exported from Autodesk Fusion 360 into the SolidWorks Simulation. The materials of the mounts were defined to be steel and FEA was performed on the components, as seen in Figures 3 and 4. After performing FEA, it became quite apparent that the higher portion of the engine mounts were too thin, causing the mounts to have a dangerous amount of stress and deflection. The models were redesigned to be thicker and reduce the localized stress and deflection of the mounts (Figures 5 and 6).

Conclusions

The purpose of this project to design a drivetrain for a Cutter Suction Dredge that would allow for a specific environment to be dredged was met. After simulating how the models would work if used for dredging in the Conowingo Dam, they produced values under the maximums for acceptable stress and deflection. According to the results, the drivetrain would properly function if it was actually implemented in a dredge. In the future, this project can be extended upon by selecting bearings to be used in a bearing box, designing the bearing box that drives pump operation, and producing engineering prints for the models that were designed. The bearing box would support the rotation of the pump and the engineering prints would theoretically allow for a manufacturer to produce the parts designed. In addition, it may be interesting to design and analyze dredge pump covers, as done in a 2008 study (Guangjie, Ruixiang, Zhengwei, & Zongguo, 2008). The quality of a dredge pump is very important to the overall functionality and safety of a dredge and thus designing proper, functional slurry pump covers would be very useful and beneficial to the dredging industry.

References