Optical Cable Link for Small Buoys

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ABSTRACT

In an era of large volume digital data transfer, the Navy requires rapid communications with a variety of sea-floor-based ocean sensors. These sensors record vital information such as salinity, temperature and ocean currents. The data transmitted to monitoring stations is used for both research and defense. Optimally, the tethering system would incorporate an optical fiber cable, because of its ability to transfer large amounts of data quickly. However, optical fibers may break if subject to large tensile stress. Our team has been tasked with designing a prototype tethering system for small buoys that incorporates an optical fiber cable that is stiff enough to alleviate excessive strain caused by ocean waves and currents, but soft enough to keep the buoy afloat. We first used analytical spring models to design a system that would meet the requirements. After brainstorming different suspension methods we chose a coiled spring. We developed a manufacturing process that includes an oven and a mandrel to form the spring. We tested the spring by hanging weights and using a motor to cycle the spring at different lengths. We compared our results to our theoretical data. Our measured spring constant suggests that our spring system is soft enough to keep the buoy afloat. The cyclic testing indicates that the prototype shielded the optical cable from experiencing excessive strain by maintaining a negligible transmission loss. These promising results provide the groundwork for further exploration as the Navy continues to develop this technology.

BACKGROUND

• Buoy systems gather and send information across the ocean surface interface to atmosphere interface
• The Navy desires capability to use optical fiber in small buoys systems in lieu of copper wire
• Design a spring system that will alleviate stress and strain on optical fiber caused by wave motion

METHODS

Spring Material
• Nylon 6-6 is a polymer that has a high yield strength, stiffness, and is a thermoplastic

Manufacturing Process
• The oven consists of a steel pipe wrapped with heater tape controlled by a Variac
• Fiberglass insulation encloses the oven to keep the tubing at a uniform temperature
• The optic fiber was fed through the tube before forming the spring, as we couldn’t pull it through after the spring was formed
• The working temperature of the tubing was 170° Celsius; this was monitored using a thermocouple
• When the tubing was flexible we wrapped it around the mandrel and clamped it into its coiled shape
• We then quenched the spring in water to help it keep its shape

RESULTS

We measured the spring constant of our spring by hanging weights and measuring extension.

Hanging Weight Test

We cycled our spring with Optic Fiber hooked up to a power meter and receiver. We tested at 3 and 6 inches extension.

Cycles vs. Optical Power

CONCLUSIONS

• Our prototype shielded the optical cable from experiencing excessive strain by maintaining a negligible transmission loss under 10,000 loading cycles
• The measured spring constant suggests that our spring system is soft enough to keep the buoy afloat and stretch the needed distance to move with the sea state
• A better material than Nylon 6-6 should be sourced to improve performance of the suspension system in an ocean environment
• An improved method of spring forming can be designed to help manufacture a reproducible spring
• A housing for the spring should be developed to reduce drag and protect the spring from the ocean environment

ACKNOWLEDGEMENTS

NAVFAC EXWC Oceans Department
Bradley Hunter: Ocean Scientist
Warren Bartel: Ocean Engineer
Kevin Wolf: Mechanical Engineer
Marcus Rasulo: Geotechnical Engineer
Mike Garcia: Mechanical Engineer