An interview with Jason Weiss, Engineering Manager for Moog's Naval Systems Business Unit, about the technology his team uses to create systems that perform reliably in the unforgiving undersea domain

I: You lead the engineering team for Moog's Naval Systems Business Unit, - the premier supplier of custom designed, high performance motion control solutions for mission critical undersea applications. What are some of the unique challenges in designing for the undersea environment?

JW: The most obvious challenge is that our systems are submerged in sea water for long periods of time. The salt concentration in sea water makes it extremely corrosive, much worse than something that just gets wet from rain or other sources. So a lot of the conventional things you would think about for keeping metal objects from rusting like galvanization, anodizing, or even using stainless steels, simply aren't adequate for what we're trying to do. Ideally, you'd just make everything out of Titanium alloys, which can be very resistant to the effects of sea water over a long period of time. But very often that's not economically feasible. It really comes down to careful material selection. And that's not only about using the right alloys, but also thinking about the combinations of materials that will be in contact, or at least close proximity to each other, to make sure you're not creating galvanic couples that can dramatically increase corrosion rates.

I: I guess salt isn't the only thing in sea water that you need to worry about. Can you talk a little about biofouling?

JW: Biofouling is what we call it when microorganisms, which are present throughout the world's oceans, accumulate on a surface and create some deleterious effect. For example, causing valves to stick or changing the friction characteristics of a set of gears. This is another factor we have to account for in making material selections. We can use special copper alloys to repel microbes in critical locations and we've also worked with special coatings and surface treatments in particularly sensitive applications. In some cases where we know we can't completely avoid accumulations, we actually design mechanical wiper systems to remove microorganisms from the inside of our devices.

The other major challenge to deal with is the crushing pressures our equipment is exposed to at depth.

I: What kind of pressures are we talking about?

JW: Well, the average depth of the ocean is about 12,000 feet, but many of our systems are qualified for operation at up to 20,000 feet, which allows for operation everywhere except in the deep ocean trenches like the Mariana. At that depth, our equipment is exposed to over 8,900 pounds per square inch, which is about 605 times atmospheric pressure. Even for a small actuator, which might have a surface area around 90 square inches, that's over 400 tons of force; the mechanical equivalent of setting a fully loaded 747 airliner on top of your equipment. So if you had to design a housing to resist that pressure the size and weight would be prohibitive and typically equipment for deep undersea operation is pressure compensated. This means it's filled with oil and you incorporate a flexible feature that causes the pressure of the oil on the inside to increase at the same rate as the sea water on the outside. That way, there's no differential pressure across the housing and it doesn't need be very strong. Of course nothing comes without tradeoffs. Oil filled housings are going to tend to leak, and we've learned a lot over the years about how to design seals that minimize that leakage. Recently, we've come up with some really exciting proprietary design innovations that allow us minimize the oil filled volume and may eventually eliminate the need for pressure compensation altogether.

With electromechanical systems, you also have to think about the electronics. Traditionally, fragile electronic components are placed in pressure vessels, completely isolated from the environment. But those pressure vessels are large, heavy, and expensive. More recently we've been incorporating pressure tolerant electronics into the oil-filled part of our systems. That can bring a major cost advantage, and has only become feasible through decades of learning about which electronic components will withstand the pressure and how to design around those that can't.

I: What sort of equipment does Moog supply for the undersea systems we've been discussing?

JW: Our Naval Systems business unit is probably best known for our actuation systems inside US Navy nuclear submarines, performing functions in a multitude of systems from the torpedo room to the propulsion plant and even the trash disposal. But for over two decades now, we've also been supplying electro-mechanical systems on unmanned vehicles such as fin control actuation systems, electronic controls, and motors for thrusters, main propulsion, and ballast control pumps. Probably the most famous vehicle that's relies heavily on Moog hardware is the deep submergence research vessel ALVIN; the one Dr. Robert Ballard used to explore the wreck of Titanic. We built thruster motors for ALVIN and it also uses Moog servovalves in its manipulator arms and a sonar system from Moog's Tritech subsidiary. We've also recently developed hydraulic fin actuators for the Remote Multi-Mission Vehicle, or RMMV, that the US Navy will deploy from the Littoral Combat Ship to look for undersea mines. On that vehicle, Moog's hardware will replace an undersea industrial grade system. Commercially available products really can't meet the needs of today's challenging military applications.

I: What sort of professional background did you bring to this role?

JW: I'm a mechanical engineer by education, with Master and Bachelor degrees from Rensselaer Polytechnic Institute and the University at Buffalo. Since so many of our systems are electro-mechanical, I've had the chance to pick up quite a bit of electronics technology know how "on the job". And I've spent most of my career working on systems for the undersea domain. Before I joined Moog, I worked for prime contractor to the US Navy Nuclear Propulsion Program. I also made a brief foray into developing hardware for spacecraft and rockets; another very unforgiving environment.

I: How do you expect the demands on undersea technology to evolve over the next few years?

JW: I think customers are going to continue to want to be able to accomplish ever longer and more challenging missions autonomously. That is to say, without human intervention. That will place increasing pressure on propulsion and control systems to be extremely reliable and efficient. But of course, projects are never undertaken independent of financial constraints. That's why I will be keeping my team focused on developing products that will meet the reliability and endurance demands of future long duration autonomous undersea missions at an affordable price point.

About Moog Inc.

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