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Finding New Ways to Develop Novel Solutions to Persistent, Intractable Problems

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Abstract

Wedeven Associates is a small tribology research and engineering consulting firm located near Philadelphia, Pennsylvania. The company faced a variety of challenges associated with the COVID-19 pandemic as did most small businesses in 2020. As the company became fully operational again, Wedeven Associates was approached by a longtime client to solve a tribological problem the client's engineers had been trying to address for almost 14 years. The catch: Wedeven Associates only had a little over two months to do the work while complying with pandemic-related travel and meeting restrictions. This case tells the story of how the Wedeven Associates team met the challenge using virtual tools and a collaborative approach built on first principles. Readers are introduced to "tribology" as an engineering discipline and "first principles" as a problem-solving approach.

Keywords: entrepreneurial mindset, COVID-19 pandemic, tribology, first principles, problem-solving

Wedeven Associates: Finding New Ways to Develop Novel Solutions to Persistent, Intractable Problems

It was October 2020. The COVID-19 pandemic was in full force and Wedeven Associates was once again operational after getting through the shock associated with pandemic-related disruptions to projects and payroll. Vern Wedeven, company president, just signed a non-disclosure agreement with a longtime aerospace industry client for a new project. He was about to learn more regarding that commitment.

The problem to be solved was an intractable one on a proven aircraft that had been in service for 14 years: a highly stressed component was known to have limited service life but the current state was the client's best solution, even after years of development. This problem never grounded the aircraft, but short component service life meant constant maintenance. The client wanted a better solution than frequent replacement of the affected part.

Vern wondered how he and his team were going to meet this commitment. The client had been working on the problem for many years, yet Vern and his team only had until December 31 to complete their work. Budget cuts meant no money for the project in 2021. And to make the situation even more challenging, COVID-19 restrictions prevented Vern's team from meeting in person with the client or one another. Virtual meetings and secure electronic document exchange would be the best they could do.[1]

Wedeven Associates: Bringing Tribology Theory to Application

Wedeven Associates is a tribology research and engineering consulting firm. Tribology is the science of friction, lubrication, and wear associated with surfaces in relative motion (Mate & Carpick, 2019). We, humans, experience tribology in action every day. For example, when we

[1] Wedeven Associates is located in Edgemont, Pennsylvania, in the greater Philadelphia region. The company name and president's name are used with permission.

lace up our running shoes and hit the road or trail, tribology is at work. The soles of our shoes are in relative motion to the street or trail. Friction between our shoe soles and the running surface provides traction that enables us to move forward. This same friction wears down our shoe soles so that eventually they need to be repaired or replaced. Lubrication between shoe sole and running surface would reduce wear, but also impede our forward movement, like slipping on wet leaves on a sidewalk. In situations like this, we trade shoe sole wear for the advantages of friction. In mechanical systems, however, friction results in wear and heat generation, both of which limit the efficiency and useful life of system components. Wedeven Associates works on tribological problems in mechanical systems. Their solutions typically increase system efficiency and improve the useful life of the component or system by reducing wear and heat, all of which improves service life and saves their clients money.

Wedeven Associates was born from an idea: to bring tribology theory to application, thereby revolutionizing the way tribology technology is created and applied. Following his doctoral research in the United Kingdom and a career path that included working for NASA and a selection of aerospace companies, Vern Wedeven concluded that there was a significant gap between tribology research and application. He saw an opportunity to bridge that gap by providing a service that nobody else was providing: simulating tribological conditions in the lab so as to allow measurement and eventual prediction of in-service results. The resulting data could then be turned into engineering solutions. To meet this need, Vern designed and fabricated a test machine based on fundamental principles of tribology, got a patent on his design, mortgaged his house for start-up capital, hired technical specialists to build the machine, and found his first client. That was 30 years ago.

Today Wedeven Associates has nine machines operating in the United States, Europe, and Asia, and the associated software to analyze almost any tribological problem in mechanical systems. Their staff of 10 associates includes engineers, machinists, and support personnel who all love the challenge of bringing tribology theory to bear on previously unsolved client problems. The team does this through the application of Wedeven Associates' distinctive competencies: surface documentation and analysis, novel fixturing and instrumentation, precision fabrication and finishing of specimens, failure analysis, and a company culture that thrives on engineering the science for practical problem-solving. Clients include companies from the oil, heavy equipment, and vehicle industries, but the majority of their clients are in aerospace.

"Our customer's failures are our success!"

The Wedeven Associates team has for years worked by the motto, "Our customer's failures are our success!" The challenge presented to Wedeven Associates by their aerospace client in October 2020 wasn't necessarily a "failure" in the classic sense. The aircraft was still in production and continued to safely and effectively perform the mission for which it was designed. The "failure" in this case was not being able to come up with a better solution for a mechanical system unique to that aircraft. A better solution would reduce wear on the component thus improving service life and safety, and reducing costs for both the client and aircraft owners. In the face of a very challenging timeline and consultation process limited to virtual tools like Zoom and securely shared files, Wedeven Associates began their work.

Some years ago, Wedeven Associates adopted the "first principles" reasoning or thinking process recently popularized by Elon Musk. The idea of first principles thinking is an ancient one, originating with Aristotle (Irwin, 1988). First principles thinking consists of deconstructing a problem to its most fundamental elements, discarding all assumptions about how to solve the

problem based on prior solutions, and beginning the problem-solving process anew based on the fundamental science or “first principles” relative to the problem’s basic components.

Elon Musk explains first principles thinking using Tesla battery development innovation as an example. He notes that batteries at their most fundamental are a combination of cobalt, nickel, aluminum, carbon, and polymers, all in a sealed container. He estimates that the cost of purchasing these materials is about $80 per kilowatt-hour of storage. The key to reducing battery cost from $600 per kilowatt-hour to something much more affordable was finding a novel way to assemble and utilize the constituent materials at a lower cost than the standard contemporary solution. The cost of a battery is not in the materials but the solution developed. The only way to find that novel solution was to set aside previously developed solutions and start fresh with first principles (Rose, 2012, September 7). In addition to battery development breakthroughs at Tesla, Musk employed first principles at SpaceX where his company reduced the cost of spacecraft launch by more than half compared to their most reliable competitors (Sheetz, 2020, April 16).

With first principles guiding their process, the Wedeven Associates team broke down their client’s problem mechanism into its constituent parts and isolated the surfaces in relative motion that needed attention. In most mechanical systems, the surfaces of interest are typically round, like a gear or ball bearing. The Wedeven Associates team focused their attention on the interface where the surfaces of interest interact with each other, no larger than the head of a pin. Once the components and target surfaces were isolated, they convened a virtual meeting of all the supply chain stakeholders: the relevant materials scientists and engineers from the aircraft, component, and lubricant manufacturers. The Wedeven Associates team explained the problem as they saw it from a first principles perspective, then guided by first principles, led the group through a series of virtual problem-solving events over the following weeks.

Central to first principles thinking is challenging one another's assumptions about how to solve the problem based on prior solutions. The objective is to discard or break mental models associated with solutions to similar problems in the past, then develop novel solutions based exclusively on fundamental science and engineering facts. Vern and his team saw this happen in real-time as the virtually gathered stakeholders had sudden clarity on problem sources once their preconceptions and old mental models about the "right way" to solve the problem had been stripped away. Potential solutions "revealed themselves" as the team discussed the basic science and drew upon one another's engineering expertise. Simulation testing using Wedeven Associates' patented equipment revealed the root causes of the problem and validated new solutions (V. Wedeven, personal communication, January 15, 2021).

As Elon Musk notes, first principles thinking requires a lot of mental energy because you cannot access prior solutions to short-cut the process (Rose, 2012, September 7). First principles thinking is hard work and time-consuming. This Wedeven Associates project was no different. Through October and November, the virtual group developed alternative solutions that were then tested by socially distanced engineers using Wedeven Associates' proprietary machines and processes. Data were fed back to the interdisciplinary stakeholder team, and the next round of virtual iterative solution-seeking was engaged.

By mid-December, the entire stakeholder team was confident they had developed a novel solution to the client's problem, and the client agreed. Of course, the solution had only been tested in the lab. There was a lot of work to do before it could be put into production and utilized in the air. Prototypes would need to be built and tested, and that would take more time and money. There was more work to be done by the client but the Wedeven Associates team had accomplished what they were contracted to do: develop a novel solution to their client's

persistent, intractable tribological problem before December 31, supported by a convincing simulation, analysis, and reporting. And they did it in the middle of a global pandemic with no in-person collaboration using science-based first principles for rapid engineering solutions.

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