

Vacuum Pumps for Mars

A Case Study

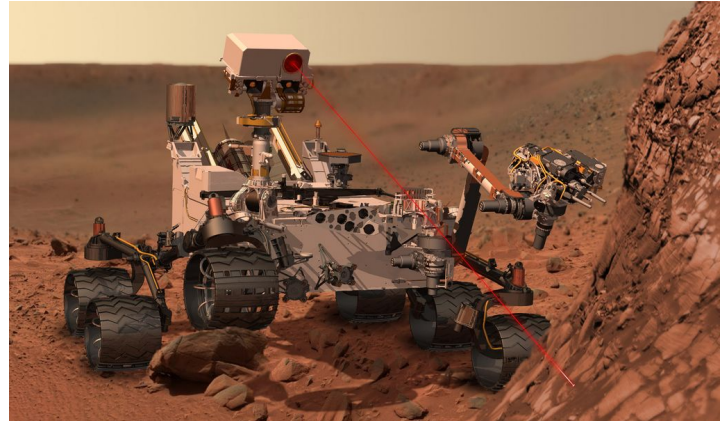
Challenge

With its rover named Curiosity, the Mars Science Laboratory mission is a long-term NASA effort to carry out robotic exploration of the red planet. Curiosity was designed to assess whether Mars ever had an environment able to support small life forms. Curiosity uses the Sample Analysis at Mars (SAM) instrument package to investigate the Mars' surface. SAM includes a miniature gas chromatograph (GC) and mass spectrometer (MS) to determine the chemical composition of gas and volatilized rock samples. The GC/MS requires extremely low pressure to operate with sufficient sensitivity and accuracy. Developing the vacuum pumps necessary for the mass spectrometer was a significant challenge. NASA's requirements for the pumps included small size and mass, low power draw, wide operating temperature range, and the ruggedness to survive launch, spaceflight, and landing. "No existing pump in the world could meet these excruciating requirements," according to Rodger Farley, SAM vacuum system engineering lead at the NASA Goddard Space Flight Center.

Creare Solution

Enter Creare as one of the only companies in the world with the expertise and willingness to meet NASA's needs. Creare has the necessary competencies in miniature high-speed motors, precision machining, and balancing of small rotational components. We applied these skills to design, build and qualify a pair of wide-range pumps for the SAM package. The pumps rely on a rotor with small fins that spins inside a three-piece stator (also finned) to push molecules out and to create a vacuum. Since Mars atmospheric pressure is low enough, the pumps can exhaust directly without an additional "roughing" stage.

After a rigorous construction and qualification process, our pumps were integrated with SAM and Curiosity by NASA. The rover mission launched from earth in 2011 and made its dramatic landing on Mars by sky crane in August 2012. The pumps have been operating flawlessly since landing and have enabled important scientific discoveries.



Artist concept showing Curiosity rover at work on Mars



Creare built the world's smallest vacuum pump – about the size of a C-cell battery



Installing the Sample Analysis at Mars instrument package in the Curiosity rover

Impact

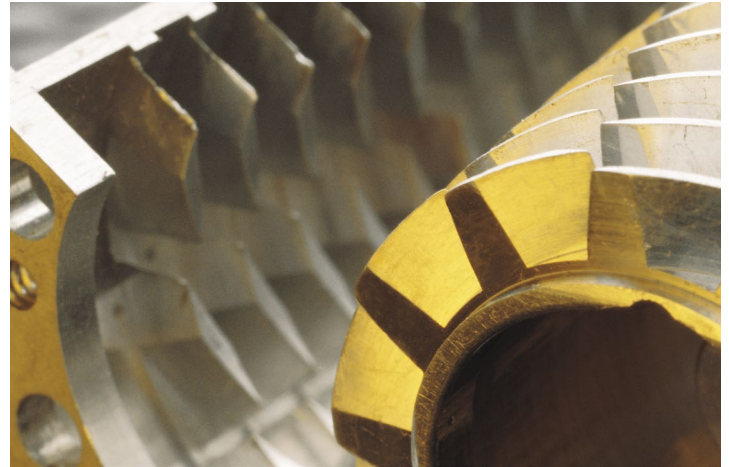
Thanks to SAM and its Creare vacuum pumps, Curiosity has detected substances including sulfur, nitrogen, hydrogen, carbon, and oxygen that are associated with life. Originally, the Curiosity mission was planned to last for two years. However, after more than six years on the Martian surface, the rover and its scientific instrument systems continue to work successfully, greatly expanding our knowledge of the planet.

After our success with the SAM system, Creare continued to work on more vacuum pumps for another Mars mission that includes a mass spectrometer: ExoMars. This mission is being developed by the European Space Agency with a current 2020 launch target. Because the ExoMars mission will not benefit from a relatively soft landing resulting from the sky crane that MSL used, the shock and vibration specifications were much more extreme and required significant re-engineering of the pumps. The re-engineered pumps were qualified to the new standards and have been installed on the mass spectrometer instrument and await the mission launch.

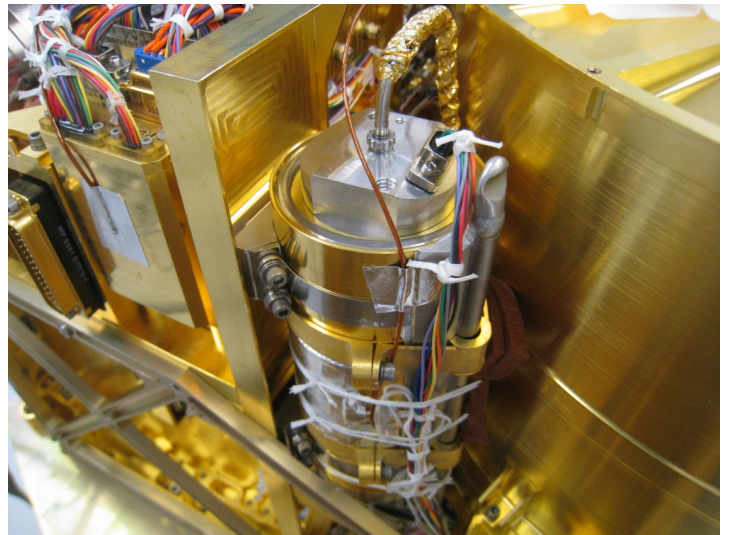
In addition, Creare engineers have developed a small roughing pump that integrates with the high vacuum pump while only slightly increasing the small envelope. This innovation opens up applications on earth such as detecting weapons of mass destruction and explosives. This miniaturized technology may soon allow security personnel to more effectively screen luggage in airports and other cargo while in-transit.

About Creare

Founded in 1961, Creare LLC is an innovative technology and product development company located in Hanover, New Hampshire. We serve government and industrial clients with engineering R&D services that include analysis, prototype design, fabrication, and testing. Our clients include large and small companies and government agencies in the aerospace, defense, medical, energy, and process industries. Creare means "to create" – we create value for our clients when we solve their most difficult problems. We also help integrate new technologies into their products, systems, and processes.



Close-up view of the fins on prototype pump rotor and stator



Creare's miniature vacuum pump installed on SAM



Cutaway view of vacuum pump rotor and one piece of stator



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V1.0 2019