General Magnaplate Corp.

CASE STUDY

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Magnaplate Goes Against The Grain To Save Mars Exploration Project

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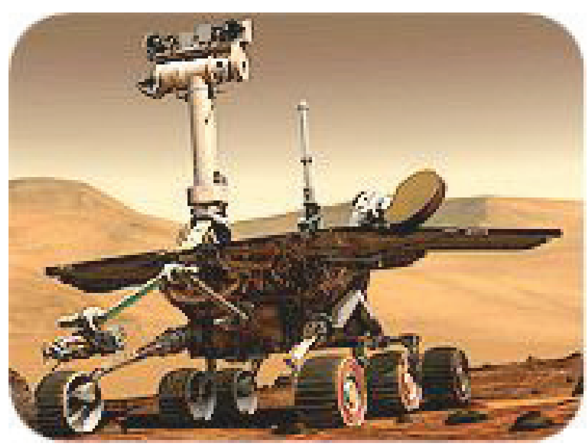
Magnaplate Develops High Friction Coating For Decent Rate Limiter On Mars Explorers

At the end of August, Mars, the fourth rock from the sun, was less than 35 million miles away from the Earth causing scientists and enthusiastic amateurs to stay up all night for a glimpse of the red planet with their naked eyes. Just two months before, in June and July, NASA launched two Mars Exploration Rovers to examine the planet and travel farther across its surface than any other craft had done before.

Man's fascination with Mars stretches back to the 1870s when Italian astronomer Giovanni Schiaparelli reported using a telescope to observe channels on the plant. This latest project to further explore the red planet came at a cost of around $800 million, with the two explorers taking off in June and July 2003 and due to land on the surface of Mars just seven months later in January 2004.

About a year before launch, the project faced a hardware need that threatened to delay progress toward launch. The problem was part of the development of the entry, descent and landing system of the Mars Exploration Rover (MER) project, which is designed to take the explorer from a speed of around 17,000 miles per hour to zero for a safe landing. This system comprises a shell that protects the MER from the tremendously high temperatures of atmospheric entry, a parachute designed to further reduce the module's velocity, three small solid retro-rockets, and a set of airbags designed to stop and cushion the Lander's impact with Mars and bring it to a rest.



The parachute is deployed when the speed of the vehicle is reduced to around 1,500 miles/hour, with the aim of further reducing the speed to 200 miles/hour. At this time

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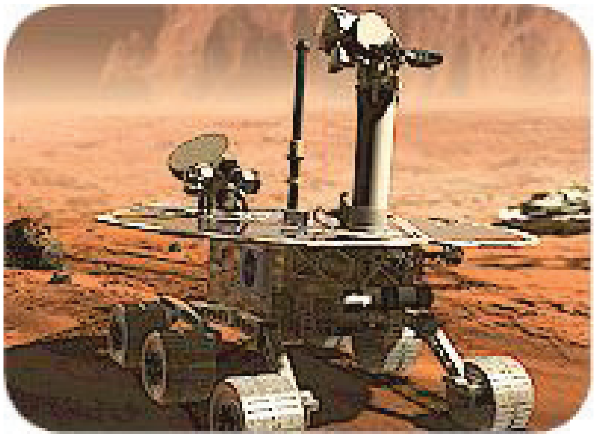
the heat shield is expelled quickly so that the landing module can lower itself from underneath the backshell, which supports the parachute and retro-rockets.

The design of the spacecraft requires the Lander to drop 20 meters below the backshell, so that the three retro-rockets pointing down can slow down the Lander without damaging it. The benefit of this design is that it negates the need for an active control system because it provides passive stability.



During the 1997 Mars Pathfinder mission, NASA used a descent rate limiter to enable the Lander to descend the required 20 meters below the backshell of the module. The team literally mounted a slightly modified version of a commercial device from an aircraft onto the Pathfinder. Descent rate limiters are usually used on aircraft to enable pilots to exit an airplane that is grounded but cannot open its normal doors. The device is designed to carry a weight of up to 300lbs, so it worked fine on Mars where the lack of gravity compensates for the added weight.

However the MERs are bigger and heavier than the Pathfinder, so the team at NASA's Jet Propulsion Lab found that this standard descent rate limiter could not withstand the greater mass increases and the tougher requirements. The key to the problem was a steel strap that was not strong enough to cope with the new scenario.

A troubleshooting team for the project came up with two possible solutions. The first was to try and replace the steel strap with different kinds of alloys that would be able to take the added strain. However, the problem with this answer was that it could take six to seven weeks to take delivery of the correct alloys, which, given the project's tight schedule, was simply not an option.

Plan two was to try and develop a device which could use synthetic rope such as Kevlar, that was strong enough and flexible enough instead of the steel strap, while waiting delivery of the new steel straps. This plan was fine apart from the fact that when rope is wound on a large spool it cannot take a large load because the top winding starts to bury itself in the other layers of rope. Therefore, the troubleshooting team needed a device that would enable it to store the Kevlar rope at low tension on two spools and pass the cord around a separate shaft to engage the brakes.

To achieve the continuous engagement of the shaft without the rope slipping required a very high friction surface. The Jet Propulsion Laboratory's machine shop had come up against a previous problem requiring a high friction surface that was solved by General Magnaplate, a pioneer in the development of surface enhancing metal coatings.

The head of our former California facility explained the scenario: "NASA's Jet Propulsion Lab had previously come to us with a problem where the support pads used to test the MER needed to have high friction levels so that the equipment would not move. This was a highly unusual problem for us because normally Magnaplate is asked to provide dry-lubricant coatings that actually reduce levels of friction."

"To solve the problem we did some R&D work on our Plasmadize product which is an enhanced thermal spray composite coating that provides high levels of wear and corrosion resistance at temperatures as high as 1300°F, and normally offers low-resistance dry-lubricity. We developed a new version of Plasmadize to provide high levels of friction especially for this project, and the results were very successful."

The day after learning of that earlier high-friction application, the rover project's troubleshooting team leader took the brake-engaging shaft to the General Magnaplate facility in Ventura, CA, which had it coated and delivered back to the Jet Propulsion Lab before the end of that day.

The following day, MER engineers took the part to the China Lake naval testing facility and were immediately able to trial the new design for the descent rate limiter. The high friction coating on the two-spool set-up worked perfectly. The next step was refining the design so that it could carry a heavier load while reducing the size from that of a computer monitor to about the size of a box of tissues.

MER engineers spent about six weeks refining the process, testing about two devices a week. Each test required a new coating so the MER engineers were in constant communication with Magnaplate. The coating developed by Magnaplate was the linchpin that made the whole device work. Because the device worked so well and could be integrated without any actual changes to the Lander, the troubleshooting team was given the go ahead to incorporate the new design into the spacecraft.

Working with Magnaplate enabled the MER team to develop a solution that doubled the load carrying capacity of the original device. By the beginning of December the new descent rate limiters were delivered to NASA in Florida. In June and July, team members held their breath as both Mars Explorer Rovers took off without any problems. The next test will come in January 2004 to see if the mechanism works in the rigorous conditions of Mars.