

POCCET: A Compact Cleaning Tool For Miniature Planetary Rovers

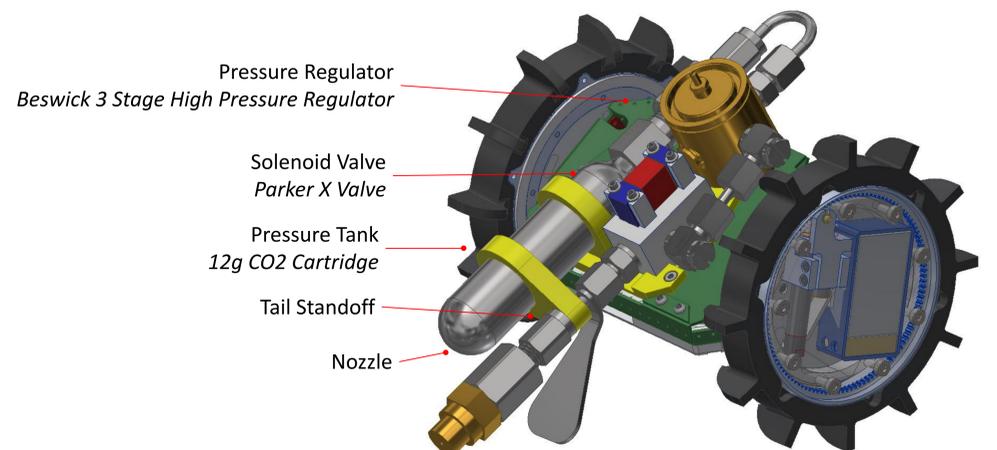
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Introduction

A major problem in space exploration is dust contamination. Dust covers rock samples and makes it difficult for rovers to take accurate in-situ measurements. Onboard instruments such as cameras and spectrometers (e.g. APXS) require relatively clean surfaces in order to make meaningful measurements of their target samples. In addition, dust prevents equipment such as camera lenses and solar panels from working efficiently. Due to these problems, there is a need for dust removal tools that are effective on a wide range of surfaces.

To meet this need, Honeybee Robotics developed POCCT (PUFFER-Oriented Compact Cleaning and Excavation Tool), a small tool that can be mounted on miniature robots to remove regolith from natural and artificial surfaces. POCCT is based on a simple and robust pneumatic architecture. Liquid carbon dioxide is stored in an onboard canister to provide greater than 800 psi vapor pressure at 20°C. Downstream of this tank, a pressure regulator reduces the gas pressure to 40 psi, and a microfluidics solenoid valve controls the flow of gas out of the system. A nozzle at the outlet shapes the flow of gas and consequently the geometry of the cleaned surface.



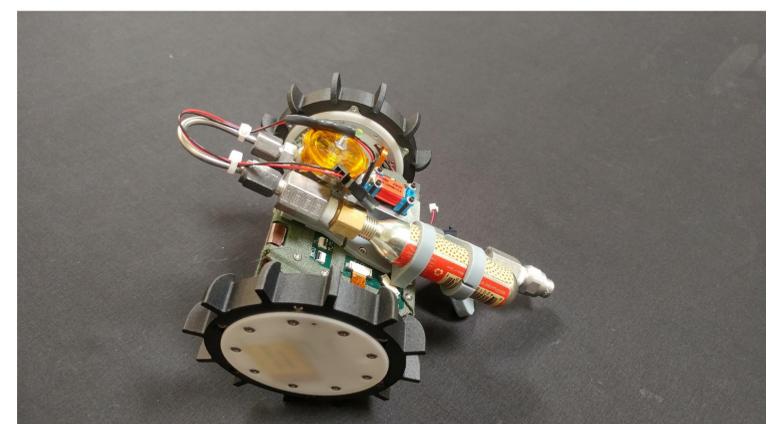
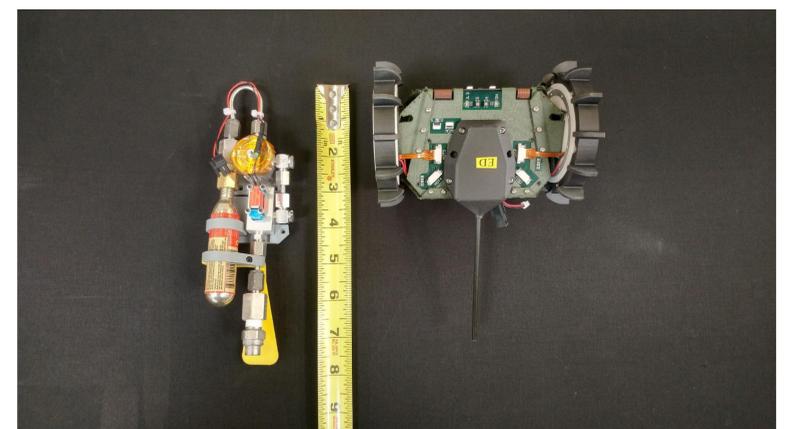
System Overview

A POCCT prototype was built, integrated, and tested with one of JPL's latest PUFFER prototypes [2]. Tests were conducted under soft vacuum conditions (~10 Torr) to demonstrate POCCT's ability to clean lunar regolith simulant (JSC-1A) off vesicular basalt rock samples and a solar panel. On a horizontal surface, POCCT can clean off a layer of dust 10 mm deep and ~15 cm² in area in six seconds. In addition to cleaning dust off surfaces, POCCT can be used to trench through regolith to expose near-surface lunar ice. While this iteration of POCCT was designed to interface specifically with PUFFER, a similar system can be built and integrated into nearly any exploration vehicle.

The POCCT prototype carries enough CO₂ to support approximately 24 seconds of nominal cleaning operations. During this time, the volumetric flow rate is steady and cleaning performance is relatively consistent. Subsequently, the flow rate will begin to decrease as the tank is depleted. POCCT can continue to be used with this reduced flow, but the cleaning performance will eventually suffer. In testing, POCCT utilizes a nominal burst duration of six second, and can execute four full cleaning operations. However, this cleaning duration can be adjusted based on the expected amounts of dust or decreased to prolong the useful lifetime of the tool.

This iteration of POCCT was intended as a proof-of-concept prototype and uses commercial off-the-shelf hardware. The prototype weighs 280 g, compared to PUFFER's 270 g. With POCCT mounted on top, PUFFER remains mobile, but trafficability on steeper slopes is noticeably diminished. A flight-like POCCT design would use custom hardware and has the potential to be significantly lighter and more compact. With this initial POCCT prototype, Honeybee Robotics successfully demonstrates the feasibility and usefulness of a compact cleaning and excavation tool for miniature planetary rovers.

Testing



Application

