THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學
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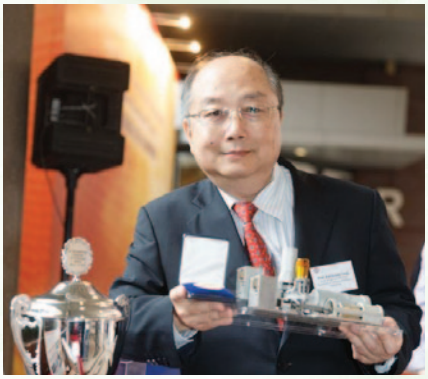
Technology Frontier

News Bite on PolyU's Innovation

Flying to the Moon of Mars

Exploration of the Red Planet made easy with cutting-edge space tools

For centuries, our interest in Mars and its surroundings has always been on the rise. Major space exploration organizations including NASA, the European Space Agency and the Russian Federal Space Agency have already sent unmanned spacecrafts there. Their missions focus on uncovering and studying soil samples for elements or live forms unknown to men. Fascinating excavation instruments were on board these spacecrafts for digging, scooping, grinding, and sifting of soil. Among the creators of these tools is Professor Kai-leung Yung from the Department of Industrial and Systems Engineering. Taking engineering to new heights, he has developed space tools that can survive the extreme conditions in Space. A conversation with this top-rated scientist revealed the engineering marvels that contribute to the advancement of our space research.



The Soil Preparation System developed by Professor Kai-leung Yung of the Department of Industrial and Systems Engineering is an engineering marvel that has changed the history of space exploration.

The Flight Model of the Soil Preparation System

"Is there any life outside the planet Earth?"

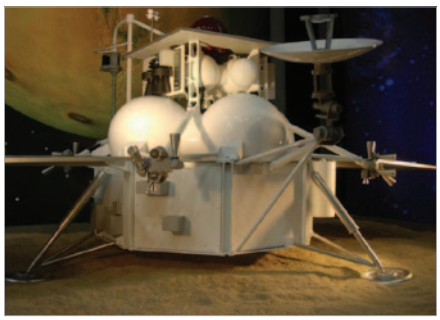
Our curiosity and thirst for the truth and knowledge have driven men to explore the outer space. One question that we constantly raise is whether extraterrestrial life exists. To help solve this mystery, Professor Kai-leung Yung, Associate Head of the Department of Industrial and Systems Engineering at The Hong Kong Polytechnic University (PolyU), and his team have been making awesome tools for space expeditions.

One of the outstanding space tools created by PolyU is the Soil Preparation System (SOPSYS), the prime excavation instrument designed for the unmanned Phobos-Grunt mission. A joint project between the Russian Federal Space Agency and the Chinese National Space Administration (CNSA), the Phobos-Grunt mission aimed at collecting and examining the soil of Phobos, the largest Martian moon, thereby understanding the origins of the solar system and finding traces of life there.

Designing and making effective space tools is the ultimate challenge in engineering. They have to be small, compact and completely reliable in face of intimidating conditions - vacuum, minimal gravity, extreme temperatures, cosmic dust and radiation....

Undoubtedly, SOPSYS is an engineering marvel that has changed the history of space exploration. It has recently been awarded a Grand Prize and a Gold Medal with the Congratulations of Jury at the 42nd International Exhibition of Inventions of Geneva.

"Instruments on spacecrafts are subject to fierce vibration during lift-off and landing. The vibration



A model of Phobos-Grunt lander

SOPSYS has recently won a Grand Prize and a Gold Medal with the Congratulations of Jury at the 42nd International Exhibition of Inventions of Geneva.

forces equal to gravity 20 times higher than Earth. Such magnitude can shatter any equipment to smithereens," said Professor Yung.

As small as a cigarette pack, SOPSYS is light and sturdy. It can bear the destructive forces from take-off and landing, which is amazing.

"Carefully designed by the team, the device's moving parts are wisely put together to achieve a perfect balance between weight and stiffness, so that stresses upon it are spread out. It is very tricky," added Professor Yung. Reaching for this level of precision is a complicated science.

SOPSYS makes Phobos soil ready for on-site atomic examination, by grinding and sifting. But in barely existent gravity, rocks and soil float in all directions. One might wonder how they can be gathered into a grinder.

Sounding like something out of a movie, Professor Yung told us the instrument has to regenerate gravity. "A tightly-sealed chamber is built to hold the soil. The soil within is impacted, rolled and moved until they turn into a near liquid substance, which is then allowed to shoot through a special sieve to regenerate the gravity needed in sieving."

The robustness of the system is incredible. SOPSYS is able to withstand radiation hazards and extreme temperatures. The temperature difference can be so great that it reaches 180°C in direct sunlight and hits minus 100°C in areas of shadow [1].

Professor Yung puts perfection on every space instrument that he developed, including the latest camera pointing system designed for Chang'e-3 mission. During this Chinese space mission, the rover Jade Rabbit, or Yutu, was sent to the moon in 2013 to examine its surface.

The system was composed of a 2-axis swivel mechanism on top of a pole supporting a camera on the lunar lander. It could roll the camera around in such high precision that pictures taken would form an accurate map of the moon surface. To survive the extreme heat, the device reflected heat and light in a brilliant way. It also moved intelligently to prevent the sun's radiation from hitting the camera system.

Reliability is on top of Professor Yung's mind. Space agencies highly value reliability since the failure of one component can lead to the failure of a billion dollar mission. Zero tolerance for error has pushed his creative skills to the limit and that's what keeps him interested. He loves to wrack his brains and explore new solutions.

Professor Yung and his team were also part of the Mars Express Mission, in which the spacecraft Beagle 2 was dispatched into space by the European Space Agency (ESA) in 2003. Other than extraterrestrial life, space ventures into the Red Planet will provide insight into how the universe forms and evolves. And scientists have been longing for smoking gun evidence of cosmic inflation and the big bang.

"As we study the universe with more advanced tools, we will learn new and exciting things, and wonderful discoveries will be on the way. It's fascinating to be a part of the epic journeys into the unknown," added Professor Yung.

[1] Jennifer Cheng (2012), "Digging into China's first moon mission", South China Morning Post, 8 May 2012.

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