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The development of a snow cleaning system for µ-CMM stylus tips

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Abstract: Contamination adhered to the surface of a micro coordinate measuring machine (µCMM) stylus tip significantly impairs the dimensional accuracy of the CMM systems, potentially causing dimensional errors that are over ten times larger than the uncertainty of a modern µCMM. To reduce such errors, this study investigates removing the surface contamination on µCMM stylus tips using a high velocity flow of CO_2 gas and dry ice particles. This process is known as snow cleaning. Two different types of snow cleaners were evaluated in the study, and a novel multi-nozzle system developed to address the challenges of cleaning occluded features and balancing forces on the stylus. A cleaning force close to the rated probing force of the styli can be achieved. And the developed cleaning device was able to eliminate the need for stylus rotation and reduce net force, bringing it closer to on-machine cleaning application.

Debris-induced error

On a modern µCMM, diameter of the commercial stylus tip goes as small as 125 µm, with measuring uncertainty less than 250 nm. However, a debris of a few micrometre in size could cause significant dimensional errors. Therefore, regular cleaning of the stylus tip is critical in maintaining accuracy and extending useful life.

Snow cleaning process

The snow cleaning process removes particles and contamination in the micrometre and sub-micrometre range, using a high velocity stream of solid CO_2 particles. On contact with a surface the 'snow' transfers momentum to the contaminants overcoming their adhesion to the surface.

- Two types of snow streams studied: pure CO_2 & mixture stream.
- Cleaning efficiency demonstrated in previous publications.
- Impact force during cleaning measured (with laser) to be close to the probing force of the stylus.

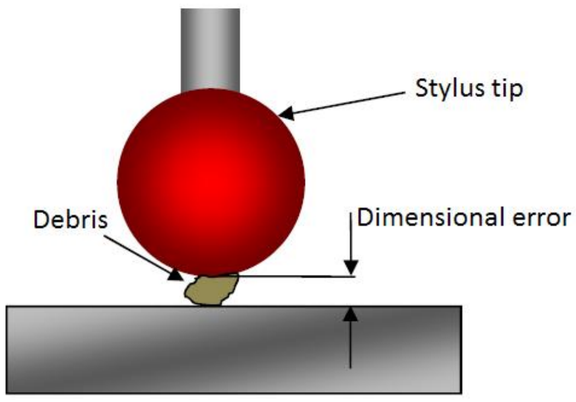

Fig 1. Illustration of the dimensional error of a µCMM caused by surface contamination.

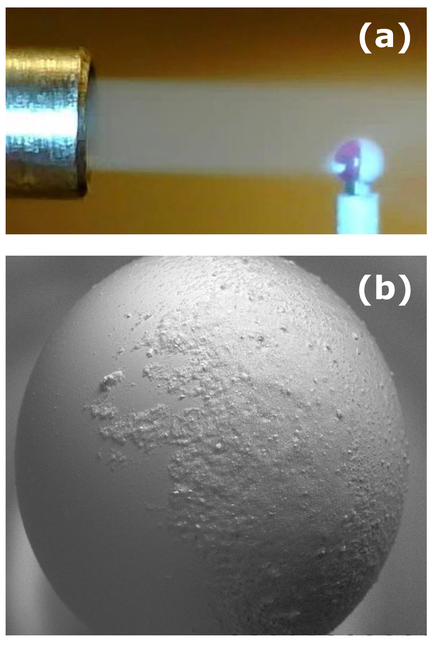

Fig 2. A Ø1 mm stylus tip (a) being cleaned with snow stream, and (b) after one time snow cleaning.

Prototype development

A novel snow cleaning system for µCMM styli has been developed for on-machine cleaning. There are a few challenges:

- Without stylus rotation, cleaning of the entire tip sphere cannot be achieved with a snow stream.
- Higher impact force improves cleaning capability, but also increases risk of damaging the fragile stylus.
- Extended exposure to snow stream causes build-up of snow on the tip surface, obstructing further cleaning.

To address the above challenges, the prototype was developed with the following features:

- 3 nozzles oriented at 120° apart to cover the entire tip sphere.
- 3 nozzles with identical geometry and located equidistantly to balance the impact force.
- Solenoids used to provide short pulses of stream in order to alleviate snow build-up.

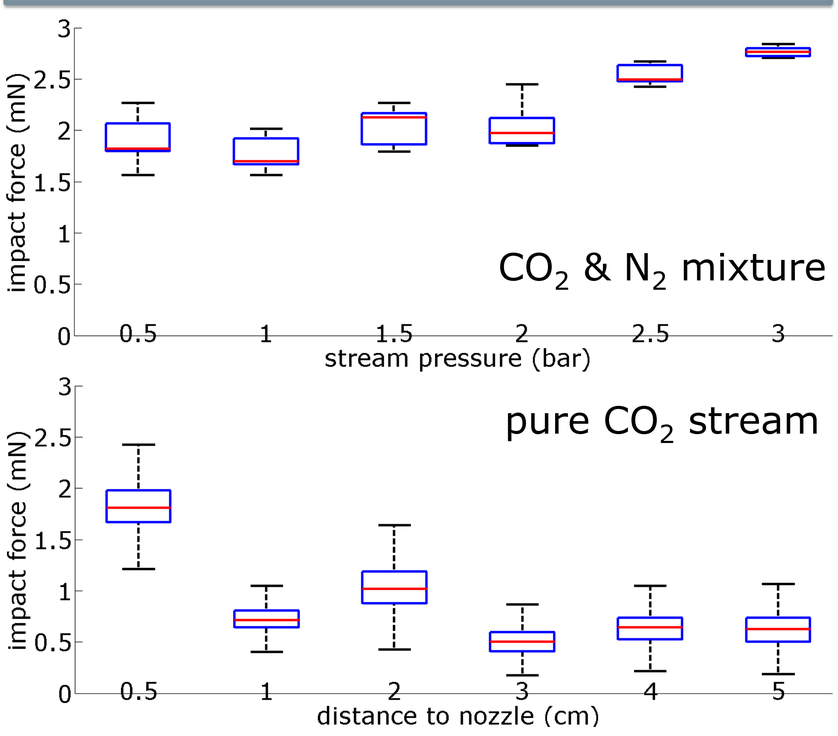

Fig 3. Measured impact force on a Ø1 mm stylus tip during snow cleaning.

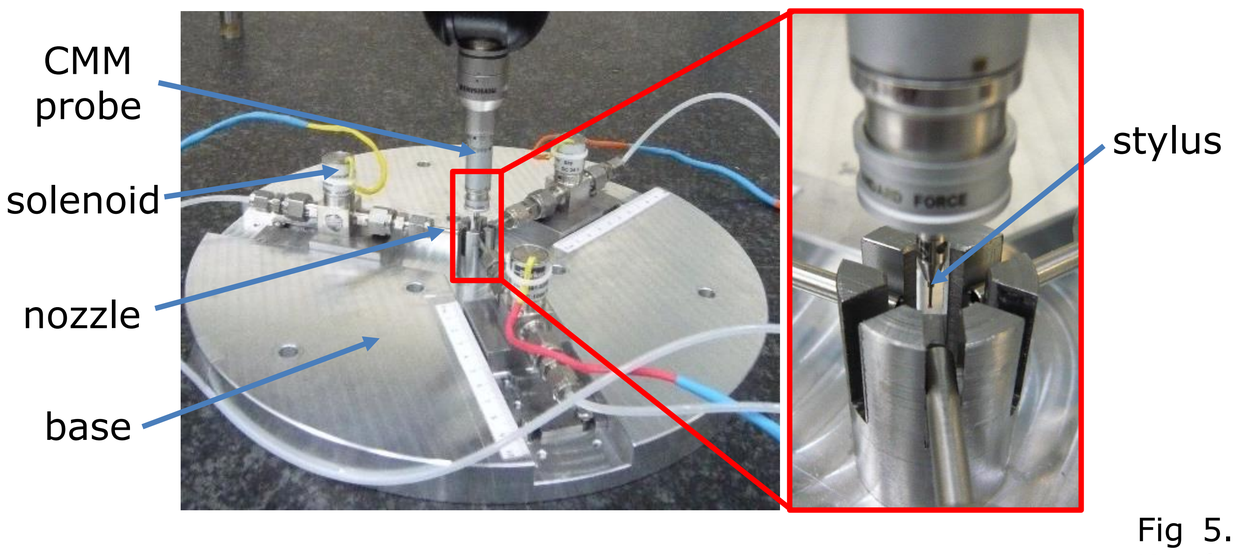

Fig 4. Snow cleaning system developed for on-machine cleaning of µCMM styli.

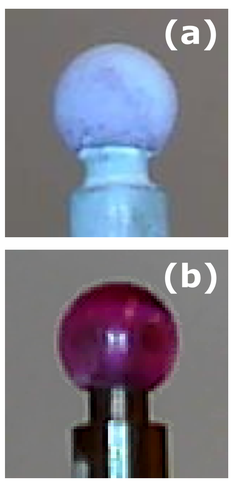

Fig 5. A contaminated stylus tip (a) before and (b) after cleaning with the developed snow cleaning system.

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