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Micromilling Tool Wear Real-Time Monitoring System

Micromilling is a material-removal manufacturing process for producing parts with features measured in microns that have sub-micron manufacturing tolerances, often done via computer numerical control (CNC). A rotary tool called a micro end mill etches designs into the material with a toothed, multi-headed drill bit. A chip is cut away each time a tooth passes through the material, but when the teeth of the end mill dull, passes of the teeth miss the material and the etching becomes dominated by rubbing and compression. This creates rough surfaces and burred edges that cause manufacturing defects and can eventually break the end mill, potentially injuring the operator and/or damaging other machine components. Currently, when a machinist suspects burring they must stop cutting, remove the end mill, and visually measure its radius under a microscope. This delays manufacturing, and leads to inefficient end mill performance depending on the skill and experience of the machinist.

Researchers at ASU have invented a system based on minimum chip thickness to monitor and adjust for micro end mill wear in real time. Chips are collected by a vacuum affixed to the stationary part of the end mill spindle that feeds the chips to a scrolling ribbon coated with adhesive. The number of chips on the ribbon are then counted by a computer that processes images recorded by a macro-lens video camera. The minimum chip thickness effect states that a tooth cannot produce a chip thinner than about a third of its cutting edge radius, so as the teeth of an end mill dull, the number of chips increases relative to the number of end mill rotations. The system's algorithm automatically adjusts the material feed rate to prevent burring and optimize end mill wear, and computes the end mill's cutting edge radius in real time. With this system a machinist no longer has to estimate when to check the end mill, saving time and production material, and can safely replace the end mill before it damages additional equipment.

Potential Applications

- CNC Machining
- Micromilling
- Precision Tooling
- Optics
- X-Ray Lithography

Benefits and Advantages

- Efficiency – Maximizes micro end mill lifetimes and recovers time lost to their manual inspection.
- Quality –Fewer rough surfaces and burred edges reduce the number of product defects down the line in the manufacturing process.

- Retrofit – Can be installed on any existing milling machine.
- Safety – End mills can be replaced before they break, causing injury or damage to other machine components.

For more information about the inventor(s) and their research, please see

Dr. Angela Sodemann's directory webpage