PRESS RELEASE

Cutting paper with ultrasound

More precise cut edges, less cutting force and therefore a longer tool life: cutting folded sheets with ultrasound technology makes all this a tangible reality. A joint cooperation project conducted by Fraunhofer IPA and bielomatik GmbH came to this preliminary result. A follow-up project is to verify the suitability of the innovation for industrial applications. Scientists are still on the look-out for companies interested in participating.

Processes for cutting stacked sheets of paper are incredibly advanced in technological terms. Having said that, quality defects are still occurring when cutting bound layers of paper with a cover. Particularly when the cutting edge first plunges into the bound layer very large forces are exerted for a short period on the cutting edge and the paper. Consequently, if the paper pushes the cutting edge sideways or forwards during cutting, the layers of paper at the bottom are shorter or longer than those at the top. The result is an undercut or an overcut. Conversely, the paper may be deformed by the cutting edge before it penetrates. The sheets on the top are bent downwards and jump forwards after cutting. They are then longer, producing a "mushroom cut". In practice, these cutting errors frequently overlap. The use of ultrasonic technologies offers a promising solution with regard to cutting processes for multiple layers of paper. Blades subject to ultrasonic vibrations cut with less force, which is why they are considerably leaner and therefore cause less displacement. In a cooperative project within the framework of the "AiF Arbeitsgemeinschaft industrieller Forschungsvereinigungen ›Otto von Guericke‹ e.V." Fraunhofer IPA together with bielomatik GmbH from Neuffen has used ultrasonic technology to develop the basis for a continuous cutting process.

Use of ultrasonically-supported cutting

"A detailed analysis of the existing systems for the ultrasonically-supported cutting of various other materials validated the innovation in relation to the paper industry", says Frank Eicher from the Image and Signal Processing department at Fraunhofer IPA. Existing applications using ultrasonic vibrations are largely used in the area of machining, and here too the main aim is to minimize friction forces and signs of wear and tear. Similar cutting processes can be found primarily in the food industry, albeit only to prevent food residues sticking to the blade. Cutting forces do not play a key role.

Eicher explains: "The underlying principle when cutting with ultrasonically stimulated tools is based on the generation of high-frequency electrical alternating voltages and their conversion to mechanical vibrations through what are known as energy converters that work according to the reciprocal piezoelectric principle." Ultrasonic systems for processing are operated in resonant frequency, which requires a very precise balance

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between the ultrasound generator and the connected vibration system. This consists of an acoustic transducer, also called a converter, and the cutting tool, which is set into resonance vibration by inducing the ultrasound. The highest demands are placed in particular on the vibrational behavior of this so-called cutting sonotrode. With state-of-the-art control technology tools can nowadays be stimulated with ultrasonic vibrations to vibrate in a controlled and beneficial manner at their resonant frequency.

Initial experimental system

An experimental system was conceived and the vibration system designed for the application was then integrated into it. Slight skewing of the layers of paper stimulated what is known as a shear cut. The project partners also designed the configuration of the system in such a way that cutting was possible with or without ultrasonic support. This simplified the direct comparison of the cutting forces. "By using ultrasound the process forces were reduced by up to 50% during the cutting process, which led to a reduction of the material stress in the cutting area," Eicher commented. This means that the strain on the cutting blade or sonotrode is reduced and the product life is extended. In addition, the lower process forces decisively reduce the effort required to secure the item to be cut. This all has a positive impact on the cutting quality and the operating costs. In a next step, the experimental design is to be optimized to create a purely ultrasonic cutting system in order to fully exploit the full ultrasonic potential. This is precisely what the engineer would like to focus on in the course of another funded project in cooperation with interested companies. Frank Eicher is optimistic when it comes to the potential of the ultrasonic process: "The use of ultrasound to increase edge quality and tool life for cutting of layers of paper is a unique selling point. It can take a company to technology leader in cut edge quality."

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