Cutting of food products by ultrasound

Identification

Key words
Ultrasound, cutting, ultrasonic separation, ultrasonic amplitude, friction force

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How does it work?

Primary objective
Ultrasound application for cutting enhances the cut surface quality, lowers the energy for cutting and improves the cut exactness.

Working principle
Ultrasound is a cyclic sound pressure with a frequency greater than the upper limit of human hearing which can be used to induce mechanical vibrations [1]. Generally, an ultrasonic cutting system consists of a generator, a transducer, an amplifier and a sonotrode (blade) which is capable of applying frequencies in the low ultrasonic frequency range of 20-100 kHz [2]. The induced oscillation at the cutting edge of the sonotrode with defined vibration amplitude results in faster and more efficient cutting due to less mechanical cutting force needed in comparison to other conventional methods such as laser cutters and water jet cutters. The cutting blade is made of titanium which is quite inert towards foods and enduring materials. In fact, the vibration reduces the friction resistance at the cutting surface. Cutting with devices excited by ultrasound is a promising alternative to conventional cutting when the materials contain particles which differ in stiffness and elasticity from the surrounding bulk or when they consist of layers which exhibit largely differing mechanical properties. There are many benefits using ultrasound in food processing operations [5, 6, 7, 8].

Images

Additional effects
- Absorption heating that can affect negatively to soft food stuff (slight softening on the edges being cut).
- Cavitation that reduces the energy and time for cutting (cavitation is a high intensity flow of fluid at the local point of cutting, connected with pressure decrease).
- Sonochemical effects [1] which enables easier cutting by ultrasound (these effects cause high efficient chemical reactions)
- Temperature increase, off-flavour generation

Important process parameters
blade shape, geometry, frequency, vibration amplitude, time and size of the contact area [3], direction of oscillation related to cutting direction

Important product parameters
composition, structure (porous, non-porous), food state (solid or semisolid), shape
What can it be used for?

**Products**
Soft and hard cheese, snack bars, health bars, ice cream, bakery, frozen cakes and pies, frozen fish, prepared meats, pizza, gum and candy, fresh and frozen vegetables, bones.

**Operations**
Separation, cutting

**Solutions for short comings**
- Improved cutting quality and precision (cutting force increase by increasing cutting velocity).
- Reduced cutting forces in a continuous cutting operation
- Avoids wetting of cut material (compared to water jet cutting)
- Avoids noises and smoke and air contamination (compared to laser cutting)
- Increases the blade’s life
- Avoids adhering food products to the blade which makes cleaning more convenient

What can it NOT be used for?

**Products**
- Products with high content of fat and semi-liquid products
- Products that can be easily cut.
- Products with irregular shape.
- Products with many particles of solid nature.

**Operations**
Not advisable for high fat content products and semi-liquid products.

**Other limitations**
The tendency to burn at the cut surface during ultrasonic cutting in case of poor temperature control at the blade [2]. Additionally, acoustic cavitation occurring in the surroundings of a cutting sonotrode while cutting a high fat content material may initiate chemical reactions such as hydroperoxide formation, which during long-term storage could result in quality defect due to inducing radical chain reactions [4]. Blunting of the blade after about 30,000 hours of operation.

**Risks or hazards**
Temperature increase in cut surface – overheating, protection of users from ultrasound.

Implementation

**Maturity**
Commercially available with the frequency of 20 to 60 kHz.

**Modularity**
Easy implementation into current production lines. Ultrasound can be easily set for cutting methods.

**Consumer aspects**
Consumers perceive this method quite fast, clean and convenient.

**Legal aspects**
Protection of humans against ultrasound is necessary.

**Environmental aspects**
- Less energy required in comparison with the other methods.
- Product waste is reduced.

Facilities that might be interesting for you
Further Information

Institutes
TU Dresden, Université d'Avignon et des Pays de Vaucluse, University of Kiel, University of Glasgow

Companies
Newtech, Sonowave, Decoup

References

Source: