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Alternative Cutting Technologies for Separating Organic Material

Cutting is one of the basic operations for processing materials in many industrial fields, especially in agriculture. This is why, in the past, these mechanical procedures were mainly developed into mature systems. In order to satisfy the increasing requirements on cutting devices, it is necessary to research possible additional, alternative cutting methods for agricultural utilisation, in addition to further develop existing methods.

Fig. 1: Possible techniques for agricultural cutting

The Institute of Agricultural Machinery and Fluid Power (ILF) at the Technical University of Braunschweig has been looking into the utilisation of alternative cutting methods in the field of agriculture for some time now. Water-jet cutting plays an important role within this research.

A selection of existing alternative cutting methods will be presented here, together with an assessment of their potential in agriculture. Additionally the present project on water-jet cutting of sugar beets, which is a 3-year DFG-financed research programme, will also be presented.

Alternative cutting methods

The cutting methods presented here represent a selection, which is already established in the industry. Industrially processed materials are, contrary to those in agriculture, mainly inorganic. However, research into the field of agricultural and forestry technology has shown that some new methods are being utilised in prototypes.

For laser cutting, a coherent and monochromatic ray of light (parallel light with a single wave length) is created and aimed at the material to be cut. Special lenses ensure that the ray is focused near the surface of the material. Due to the fact that the rays are partially absorbed by the material, there is a considerable local heating of the point where the rays hit. This heating, together with the simultaneous addition of gases (according to procedure), causes burning, melting, or evaporation of the material, at the focussed point, which enables the material to be separated. The heating is caused by the molecules swinging until their cohesion is lost.

The cut-ability of a material is reliant on its degree of absorption. Spectral analyses of wood, grass and straw were carried out in [3] in order to relate this fact to organic materials. It could be seen for the above mentioned materials that in the frequency range of generally used types of lasers, such as CO_2, diode and Nd:YAG, no peaks occurred during absorption. Early experiments showed the insufficient cut-ability of these materials. With the added difficulty of focussing over long ranges, it seems that an agricultural utilisation would not be feasible [3]. Some time in the future specialised laser could solve this problem.

Cutting with an ultrasonically stimulated blade represents a further diversity of the traditional method. The high frequency stimulation of the blade rests between 15 and 70 kHz at an amplitude up to approx. 50 µm. A frequency range of about 20 kHz is common in industrial utilisation. The stimulation is created by a generator, which has a

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The research project, „Water-jet cutting of sugar beets“ has the financial support of the DFG (German research institution), Flow Europe GmbH and Hammelmann Maschinenfabrik GmbH.

Keywords
Cutting technologies, water-jet cutting, sugar-beets

converter in the circuit. In this converter the electric oscillation is transformed into a mechanical movement. This movement is then amplified and introduced into the blade (Sonotrode). This method is used e.g. in industrial processing of textiles, synthetic materials and foods. The advantages of this method can be found in higher cutting speed with an up to 75% lower cutting power requirement. A general utilisation of this method in the field of agriculture and forestry is not unknown at this point of time. However, research is being carried out at the University of natural resources and applied sciences in Vienna with regard to its utilisation in wood processing. Utilisation in the range of agriculture and forestry seems to be just as possible as in the food industry.

Yet another cutting method is the band saw, the installation of which is very easy. The continuous band is powered by a driving capstan and redirected over the tension reel opposite. Apart from the more usual fields of the processing of wood or metal, the Institute for Agricultural Technology in Bornim (ATB) is carrying out research in the utilisation of a continuous band mowing machine. The machine developed has a mowing width of 3 metres with a total weight of approx. 100 kg. The load for the carrying vehicle is low, which is advantageous when using greater widths. One disadvantage, however, is the lacking possibility to transport the cut material.

Analogous to water jet cutting, which is described hereafter, is cutting by means of air blasting, by which the medium, compressed in a tank is released via a nozzle into the ambient air. In industry the medium of compressed air is mainly used for cleansing purposes at a working pressure of approx. 1 MPa. There are aggregates offered, working at higher pressures of up to more than 20 MPa, however portable utilisation is questionable due to their size. Tests carried out in the institute on green plants showed that the utilisation of air blasting could only remove the less stable parts of the plants. Better results were attained by adding sand to the air. The performance of compressed air blasting proved to be most particularly insufficient compared to water jet cutting, due to the reduction of the blasting medium and lower working pressures. One field of utilisation for compressed air blasting in agriculture and forestry is presented in *Figure 1*, which shows a machine to remove weeds (cleansing blasting).

Water jet cutting of sugar beets

Water jet cutting is an eroding process without an actual blade. The water, which is under high pressure, is pressed through a nozzle with a very small diameter forming a fine jet with a high velocity (up to 900 m/s). One must differentiate between pure water blasting and abrasive jet blasting. The pressure generators for both cutting methods can be divided into two categories, pressure transducer units and plunger piston high pressure pumps. Further details about the procedures and the equipment used can be found in [1].

Subsequent to the positive results of cutting tests using agricultural materials, during the first research project run by the ILF, the results attained in [2] are to be utilised and extended in a project which is running at the moment. The research is to be carried out on sugar beets, as water jet cutting has shown particularly good results with homogenous materials.

The cuts presented in [2] were made, without exception, at high pressures of up to 350 MPa and using small nozzles with a diameter of less than 0.33 mm. The cutting capacity is therefore mainly due to the pressure, using a very low volume flow of water. What would the situation be if instead of increasing the pressure, the volume flow of water was to be increased in order for the total capacity to remain constant? This question was researched in early tests during the project. For this, not only the pressure transducer unit (max. 3.7 l/min), described in [2], was put in operation, but also the plunger piston high pressure pump from the company Hammelmann, which was available at ILF. This pump enables a volume flow of up to 11 l/min at an operational pressure of up to 190 MPa. It can also be run parallel to the first mentioned unit. Preliminary tests show that cutting with this modified combination produced promising results.

Apart from increasing knowledge about cutting with large volume flow, units for reducing power requirements for cutting are being examined. For example, energy losses as shown in [2] can be explained by a prerequisite water buffer in the cutting gap.

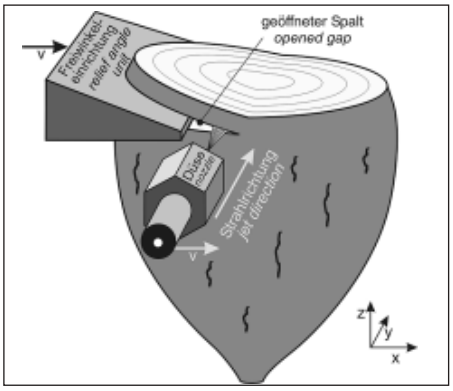

Fig. 2: Relief angle unit

The water drainage out of the gap could be enhanced by means of a relief angle unit following the water jet (*Fig. 2*), thus lifting the cut material.

It is also to be examined whether a reduction in water consumption might be plausible. Water consumption is an essential component, particularly when attempting mobile utilisation of water jet cutting.

Summary and prospects

In particular, cutting with ultrasound or water jet is prospectively suitable for agricultural utilisation. In the case of ultrasonic cutting, the cut can be enhanced by means of the high frequency stimulation of the mechanical blade. In the case of water jet cutting, the separation of the material is carried out by a completely different principle, an undefined „blade“, in the form of a high velocity jet.

During the first research project, carried out at ILF, it was found that water jet cutting of agricultural products, particularly in the case of sugar beets, proved most promising. In the subsequent tests, the results of the first tests can be extended and research into energy reduction as well as reduction of water requirement can be carried out.

Literature

Books are identified by •

[1] *Ligocki, A., und H.-H. Harms*: Schneiden von Zuckerrüben mit Hochdruckwasserstrahl. Landtechnik 57 (2002), H. 6, S. 360-361

[2] • *Ligocki, A.*: Schneiden landwirtschaftlicher Güter mit Hochdruckwasserstrahl. Dissertation, ILF, TU-BS, 2005

[3] *Ligocki, A.*: Unveröffentlichte Diplomarbeit, ILF, TU-BS, 1999