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Development of wash nozzles for more efficient vegetable cleaning

2.5 million t of vegetables are produced currently in Germany. The majority is washed on the farm before marketing. In the cleaning of vegetables, especially those for raw consumption, water of drinking standard must be applied, according to the food hygiene laws. Savings in drinking water and applied energy should be aimed for with the vegetables rapidly and gently cleaned.

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Keywords

Vegetable cleaning, washing jets, spray nozzle

Literature

Literature details are available under LT 02411 via internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

The cleaning of vegetable surfaces with water is a subject which has been scientifically investigated only to a very small degree. Only a little is known about the cleaning parameters of washing nozzles and these have considerable influence on the cleaning process. Determining these parameters is an important aim of the presented project.

Requirements of washing nozzles

The requirements made of vegetable cleaning machines with spray nozzles depend on a reliable optimising of the parameters cleaning effect, consumption of fresh water and energy input with the interacting factors optimally matched to one another (*fig. 1*).

Thus application of washing nozzles must result in jets meeting the following requirements:
- good microstructure, i.e. droplets of optimum size and velocity, and
- good macrostructure, i.e. sufficient contact of washing water on vegetable surface with optimum spray spread and area coverage.

Main factors for variation of jet parameters are operational factors and nozzle configuration. Conclusive factors, and thus the direct results from spray structure, are size and velocity range of droplets plus the geometry of the water jet.

Project main point

Within the project the most important factors affecting the cleaning action of the nozzles were at first determined together with the company Lechler. The application of different measurement methods enabled the establishment of the relationships between the influence parameters (fig. 1) and the cleaning effect, and showed possibilities for optimising.

On the basis of these fundamental investigations on a test stand an evaluation scheme was created for the problem-oriented selection of nozzles. During subsequent practical trials in stationary and mobile washing machines the nozzles were evaluated and optimised. During this, attention was paid to the limits of vegetable tissue robustness through too high spray pressures.

Method

For investigating the relationship of jet force and cleaning effect a standardised test method was created which allowed an objective determination and evaluation of the effects of the droplet impulse of different operational and nozzle parameters. For investigating the evaluation method the trial presented here featured standard nozzles LU 90-04, spray angle 90°.

Tekscan determination of distribution of power within the jet

[3] was consulted regarding fitting of sensors and the measurement system. Impact distribution on the sensor surface was determined by Tekscan sensor, the effect resulting from the different flow relationships in the creation of the droplets and from the in-

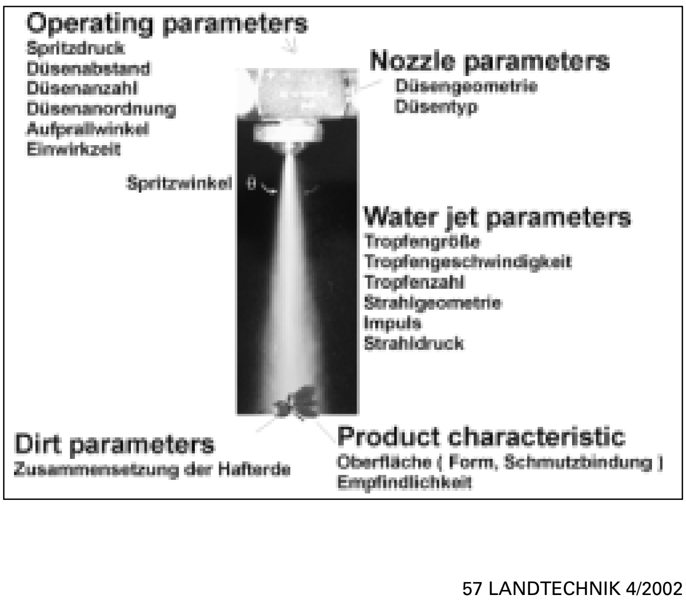


Fig. 1: Factors effecting the cleaning process with washing jets

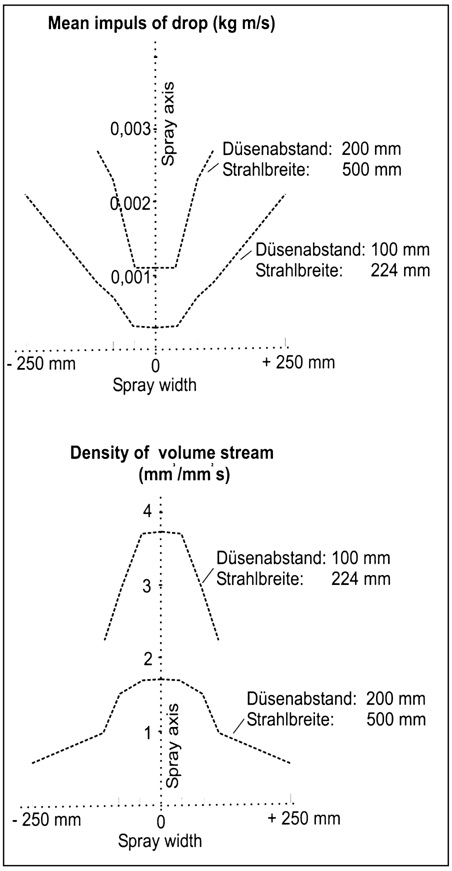


Fig. 2: Variation of the jet parameters mean drop impulse and volume flow density (VSD) over the jet width at a spraying pressure of 2.5 bar

fluencing of the droplets through the surrounding atmosphere. The binary measurement values in ASCII format were calculated with an ATB developed calibration procedure [5] in values of force (N).

Simultaneous determination of droplet size and droplet velocity in the spray jet

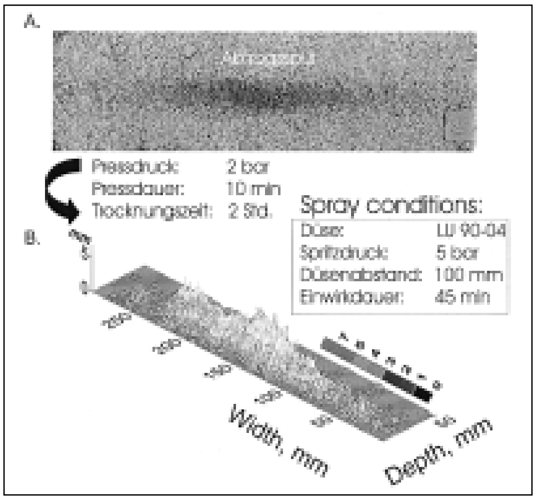
The basis and principles of the phase duplicator measurement technique are comprehensively described in [7]. The phase duplicator particle analyser (PDA) enabled droplet size and velocity in the spray jet to be measured. The variability of the jet parameter within the spray area was taken account of in the spatially based observation of the spray area.

The possibility of simultaneous recording of droplet sizes and velocities enabled droplet energy to be observed. From the distribution data of the jet parameters and the liquid distribution measurements, characteristics such as volume current density, droplet current density and impulse flow density could be determined (*fig. 2*) enabling evaluation of nozzle cleaning potential.

Development of standardised measurement bodies for validating droplet impulse

A standardised measurement body was developed for determining relationship between jet energy and cleaning potential using low-pressure nozzles (*fig. 3*). As basis for analysis of impulse force effect of different operational and nozzle parameters the depth and volumes of surface tissue removal, as measured by laser scanner, was taken into account, characterising information being cross section of the tissue removal scratches.

Fig. 3: Material removal by the water jet: A. Removal trace in a standardised measuring body; B. Result of measuring the material removal with a laser scanner



Trial results

Analysis of different spray pressures and distances between nozzles and vegetable

The differences in droplet and droplet volume distributions achieved through altering spray pressure were relatively low. It could be seen, however, that the number of droplets >300 µm were reduced by increasing spray pressure with, at the same time, the number of droplets in the lower droplet size class up to 250 µm increasing. This in the end led to a reduction in the average droplet diameter. Contrary to the size development, an increase in spray pressure led to a substantial velocity increase for all droplet size classes. This increase was tendentially more characterised with smaller droplets than bigger ones. The associated increase in spray impulse led to higher impact pressures.

The measurement of liquid distribution over jet breadth and depth showed that higher concentrations of spray water in and around the core area of the jet occurred. Additionally, these demonstrated a tendency to limited enlargement of the spray breadth (spray angle) under increasing spray pressure. Contrary to the spray breadth, a spray pressure increase of 2.5 to 5 or 8 bar reduced the spray depth by a third which in turn led to increases in droplet and volume current density and impulse flow density (the impact pressure).

The PDA measurements over the whole spray area showed that the droplet size as well as the droplet velocity only varied to a limited extent in association with the nozzle distance (a ≤ 200 mm). It could be seen, however, that with the increase of the nozzle distance more smaller droplets were registered with simultaneous reduction in the proportion of larger droplets. The velocity losses were more marked with smaller droplets than with larger ones, i.e. smaller droplets lose their impulse force more rapidly. Through the impulse reduction of the individual droplets caused by their disintegration, and velocity reduction through air friction plus the more intensive reduction droplet number and volume per area unit much less force values were registered on the sensor surface

Conclusion and outlook

- A rise in pressure caused a small reduction in the average diameter of the distribution (MVD). A rising spray pressure caused, on the other hand, significant increase in the average droplet velocity which resulted in an increase in impulse of individual droplets.
- Because of the larger proportion of small droplets and the broad spray area, the resultant jet characteristics (volume, droplet current and impulse flow density) are relatively small for the nozzle LU 90-04. It is thus less suitable for washing vegetables.

With the methods worked out here, the possibilities for evaluating the nozzles with regard to their cleaning effect on a test stand are demonstrated, involving optimisation and modification of washing nozzles for a more efficient vegetable wash. This first results offered here indicate that this potential can be achieved.