LIÈGE université
Gembloux
Agro-Bio Tech

Le Corps professoral de

Gembloux Agro-Bio Tech - Université de Liège vous prie

de lui faire l'honneur d'assister à la défense publique de la dissertation originale que

Monsieur OULED TALEB SALAH Sofiene,

Titulaire d'un diplôme national d'ingénieur spécialité sciences agronomiques,

présentera en vue de l'obtention du grade et du diplôme de

DOCTEUR EN SCIENCES AGRONOMIQUES ET INGENIERIE BIOLOGIQUE,

le 19 novembre 2018, à 13h30 précises (personne ne sera admis après cette heure),

en l'auditorium GR (Bât. 2),

Passage des Déportés, 2, à 5030 GEMBLOUX.

Cette dissertation originale a pour titre :

« Case of a hydraulic splashing nozzle: Effect of the disk geometry on the sheet breakup ».

Le jury est composé comme suit :

Président : Prof. F. FRANCIS, Professeur ordinaire,
Membres : Prof. S. DORBOLO (Promoteur), Prof. F. LEBEAU (Copromoteur), Prof. B. SCHIFFERS, Prof. H. CAPS, Dr S. DEHAECK (ULB), Prof. A. DUCHESNE (Technical University of Denmark - Université de Lille, France).

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Summary

In the agricultural field, conventional farmers use Plant Protection Products (PPP) to control crop enemies as for instance weeds, diseases and pests. In practice, PPP application techniques are based on droplet clouds to carry the spray mixture containing the active ingredient and the adjuvant to the surface target. The PPP application efficiency consists in maximizing the deposition of the mixture on the target while reducing the environmental losses. However, the droplet characteristics within the spray affect drastically the treatment efficiency. For instance, small droplets (< 200 µm) are prone to drift while big droplets (> 300 µm) have the tendency to splash on a specific target surface.

The widely used agricultural nozzles produce a liquid sheet that disintegrates into ligaments leading to droplets with various diameters and velocities. Hence, the generated spray is characterized by a wide droplet size distribution (*RSF* = 1) resulting in potential drifting or efficiency losses due to splashing phenomena. The spray must deliver an optimal droplet distribution in term of diameters and velocities by reducing the extent of the droplet size distribution. The design of new agricultural nozzles is a challenge for the practitioners in the field of agricultural nozzles.

As the simplicity, the robustness, the low cost and the high flow rate ranges are required for the agronomic application, the Savart configuration namely a round jet impacting vertically a motionless disk is the ideal candidate for the massive production of droplets. The Savart sheet develops in the air (outside the disk) and it results in random breakup leading to wide droplet size distribution as in the case in hydraulic nozzles. As the used flow ranges are high in the PPP application, the obtained sheet on the disk is turbulent. The challenge is to tame the turbulent sheet. I propose to split the sheet into individual jets using textured disks by acting on the semi-free film or by inserting the right structures directly in the free sheet. Then, the jets break up according the Plateau-Rayleigh mechanism and lead to a narrower droplet size distribution. Therefore, this thesis aims to study experimentally the effect of the disk geometry on the sheet break up. This study is seen as a practical guide for specialists in fluid mechanics who desire developing the generation of drops with controlled sizes.

One firstly detailed the experimental setup based on the impact of a turbulent jet on a non-textured disk. The disk configuration constitutes our reference case to which results on textured disks are to be confronted. The sheet was characterized through several parameters: The mean velocity *U,* the mean thickness *h and the ejection angle φ* that depends on the disk geometry and on the flow rate *Q*. As the jet flow is turbulent at the impact, local disturbances in the film triggered downstream the disk edge the appearance of random holes at a distance *R'* (from the jet axis) in the liquid sheet. These holes lead to the disintegration of the sheet into droplets. Furthermore, the produced droplets are characterized in term of diameters. The droplet size distribution is clearly wide (RSF values are close to 1) that is similar to the case of hydraulic nozzles.

Moreover, one perturbed the semi-free film evolving on the disk surface. The case of a turbulent round water jet impacting a disk engraved along its circumference by a number *N* of radial grooves is addressed. By the insertion of grooves, one controls the turbulent flow and the film splits into a number *n* of liquid jets before reaching the disk edge. The phase diagrams presented as a function of the inside gap between grooves *d1* and the flow rate *Q* illustrate the transition between jet regimes. Droplets were characterized in term of their diameters and velocities. For all configurations including an engraved disk, the obtained droplet size distribution is narrower compared to the ungraved disk and to the standard flat fan nozzle Teejet TP 65 15. The V_{50} is reduced towards smaller droplets in the case of the engraved disk configurations but it is still coarse compared to that of the Teejet nozzle.

Furthermore, one perturbed directly the Savart sheet, i.e. the free sheet evolves in the air. A number *N* of triangular prisms are set in the sheet at a radial distance *r* from the jet axis. This radial distance is strictly greater than D/2 (D = disk diameter) and less than or equal to R' (for which the holes appear in the sheet). Once the number of prisms and the distance from the injector is fixed, the geometry is determined by the size of the prism and the distance *b* between two successive prisms. When increasing the flow rate *Q,* the jet numbers are *n = 0*, *n = N* and *n = N** (elastic coalescence of jets) for large *Q*. One used a geometrical model that explains the generation of individual jets through these structures. Then, the emitted droplets are characterized in term of diameters and velocities. The droplet size distribution is narrower compared to the non-textured disk and the hydraulic nozzle TP 65 15 with the same spray class. The V_{50} decreased by decreasing the external gap *b* between two neighboring textures at the same radial distance *r* from the jet axis. Also, the V_{50} decreased by increasing the radial distance from the jet axis as the sheet thickness decreases. However, we are limited by *R'* due to holes appearances.

Finally, one concludes on the fundamental findings and on the role that the developed nozzle could play in applications. Also, one proposed some original perspectives to the present thesis such as testing the triangular prism textures in the case of the liquid sheet produced by a standard hydraulic nozzle.