Simulating CoV from nozzles spray distribution: a necessity to investigate spray distribution quality with drift reducing surfactants.

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Simulating CoV from Nozzles Spray Distribution: a necessity to investigate spray distribution quality with drift reducing surfactants.

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Abstract

This paper aims at showing possibilities of spraying quality control through nozzle flow distribution (CoV), especially when a drift reducing surfactant is used. The effect of nozzle height combined with hydraulic pressure was achieved considering a homothetic translation of flow rate. In all cases of FF 110 02 (standard or air injection), the evolution of CoV with nozzle height shows periodic pattern where the effect of surfactant concentration revealed critical CoV variations. As a result, the use of such surfactant shall necessarily be preceded by flow distribution evaluation in order to adjust the boom height adequately. The use of a nozzle simulator may greatly help to develop boom adjustment guidelines.

Keywords : Flow distribution – Nozzle – CoV – Drift

1. Introduction

Flow distribution under a spray boom is one of the major macroscopic parameter of spraying quality. It is dependant on several parameters such as spray angle and the recovery between nozzles mainly depending on the boom height [Debouche et al, 2000]. Transversal spray distribution was widely studied in the past due to the effect of boom movements (mainly yaw and roll) [Chapple et al, 1993], [Lardoux et al, 2007]. Original work was also done on the capability of a single nozzle spray pattern to determine worn nozzles [Maertens et al, 2005]. A comprehensive literature is existing on the effects of surfactants or coformulants, especially those aiming at reducing spray drift, in terms of their impact on droplet sizes [Miller and Butler Ellis, 2000], [Stainier et al, 2006]. However, very few researches were dedicated to the effect of chemicals on spray angle and spraying quality. The simulation of flow distribution with regards to boom height and working pressure is studied in order to recover acceptable CoV accordingly to [EN 12761-2].

2. Materials and methods.

Flow distribution of a single nozzle placed at 50 cm height is measured with a 5 cm channel test bench compatible with ISO 5682-1. The maximum capacity of patternator is 3 m (60 channels). Flow rate collected by each channel is driven to a tube mounted on individual weighting cell. When the volume collected in the tube reaches 400 ml, all tubes are moved apart form channels, weighted and emptied. Each measurement consists of 3 repetitions at the same position. In case of flow distribution measurement under a complete boom of 10 m (20 nozzles), the patternator is moved by steps of 50 cm with 3 repetitions by step.

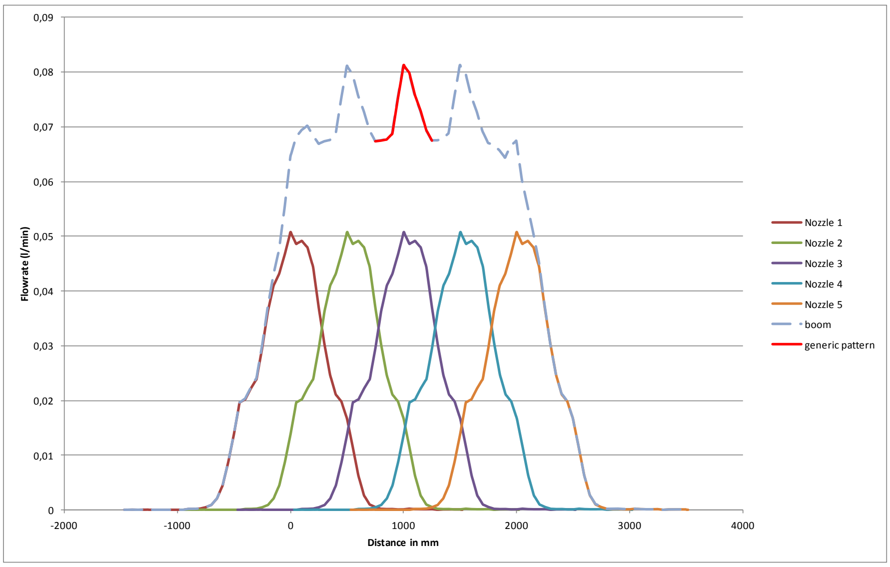

FIGURE 1: Single nozzle replication – boom pattern – generic pattern FF02 2.5 bar

A generic pattern of 50 cm length is calculated form the overlapping from beside nozzles (Fig. 1). As all nozzles are identical, the distribution Cov can be calculated directly on the generic pattern (10 values) with the following formula: CoV = standard deviation/mean. The effect of nozzle height is then simulated assuming a homothetic translation of distances with nozzle height and an inverse translation of flow rates (Fig. 2).

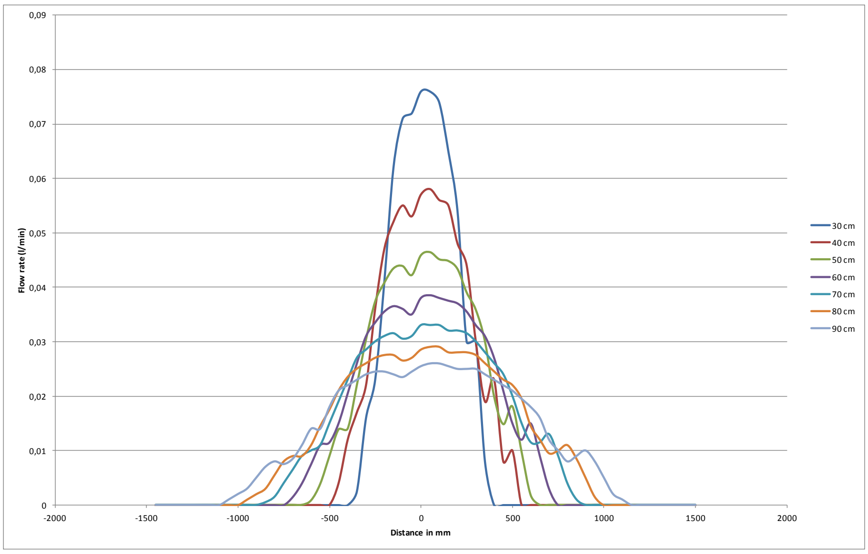

FIGURE 2: Homothetic translation of flow rates distribution with nozzle height FF02 2.5 bar

A flat fan 110 02 nozzle was tested at 30 up to 90 cm height and pressures of 2.5 and 5 bar with water. A model mixture with a highly effective surfactant was tested for concentrations from 0.03% to 0.12%.

3. Results

3.1. Feasibility of homothety.

CoV of 5 different nozzles of the same type (FF 110 02) were measured depending on the nozzle heights (40 – 50 – 60 - 70 cm) for 5 pressures from 1.5 – 2 - 2.5 – 3 - 3.5 bar. Simulated CoV were calculated from values at 50 cm and simulated for other heights with a homothetic translation with acceptable correlation R^2 of 0.87. The simulation showed quite similar results for high values of nozzle heights and hydraulic pressure as results were sometimes less uncertain for low pressure and low heights. It is to say that the spatial resolution of the test bench is 5 cm. In order to get more accurate results, the simulation process needed values every cm calculated by linear interpolation.

3.2. Evolution of CoV according to nozzle height and hydraulic pressure.

3.2.1. Pure water (table 1).

TABLE 1: Combined effect of pressure and nozzle height on CoV values FF 02.

	Pressure				
Nozzle Height (cm	1.5 bar	2 bar	2.5 bar	3 bar	3.5 bar
30	13.03%	11.04%	9.56%	8.84%	8.46%
32.5	10.56%	7.93%	5.33%	4.14%	4.39%
35	11.99%	6.43%	3.43%	2.72%	2.76%
37.5	11.56%	5.62%	3.45%	3.89%	3.35%
40	11.67%	4.67%	2.88%	3.77%	3.39%
42.5	12.11%	4.60%	2.91%	3.51%	3.51%
45	11.30%	3.62%	3.04%	3.86%	4.74%
47.5	9.89%	3.20%	4.19%	4.95%	5.66%
50	7.81%	4.42%	5.98%	6.55%	6.68%
52.5	4.01%	5.92%	6.96%	6.90%	6.46%
55	2.93%	7.10%	7.31%	6.94%	5.85%
57.5	3.71%	8.15%	7.34%	6.71%	5.15%
60	5.48%	8.19%	6.60%	5.74%	3.87%
62.5	7.64%	8.01%	5.68%	4.46%	2.51%
65	8.92%	6.97%	4.28%	2.99%	1.60%
67.5	9.47%	5.71%	2.97%	2.13%	1.61%
70	9.89%	4.57%	2.00%	2.18%	2.19%
72.5	9.33%	3.25%	1.50%	2.76%	2.46%
75	8.32%	2.24%	1.94%	3.49%	2.68%
77.5	7.20%	1.68%	2.31%	3.67%	2.40%
80	4.93%	2.11%	3.20%	4.24%	2.65%
82.5	3.93%	2.20%	2.76%	3.47%	1.72%
85	2.47%	2.43%	2.51%	2.94%	1.47%
87.5	1.36%	2.97%	2.47%	2.63%	1.17%
90	1.82%	2.90%	2.03%	2.10%	1.08%

One can see on Table 1 the effect of nozzle height on the periodic variation of CoV for a given pressure. The general trend is a decrease of CoV while nozzle height increases, showing the influence of overlapping in the quality of spraying. Table 1 shows also the cooperative effect of pressure with nozzle height. Increasing pressure allows acceptable CoV for nozzle heights from 30 to 90 cm. Improper combinations of pressure and height may involve less satisfying conditions.

3.2.2. Surfactant

A drift reducer surfactant was used at different concentrations (0.03% to 0.12%) to simulate the effect of CoV. Single distributions at 50 cm height revealed immediate shift in the CoV values as the spray angle (Table 2) was strongly narrowed, proportionally to the concentration of surfactant. A first measurement at 50 cm height showed CoV varying from 20 to 40%. The evolution of simulated CoV vs. nozzle height is shown on fig. 3.

TABLE 2: Evolution of spray angle for 99,98% of total flow rate for FF 02 standard and Air Injection Height 50 cm – Resolution in angle definition is +/- 4°

	FF 110 02	FF 110 02 AI
	Spray angle (°)	Spray angle (°)
Water	94,7	103.2
C1 0.03%	80	n.d.
C1 0.06%	70.6	79.1
C1 0.08%	66.9	75.7
C1 0.1%	63	72.1
C1 0.12%	63	64.5

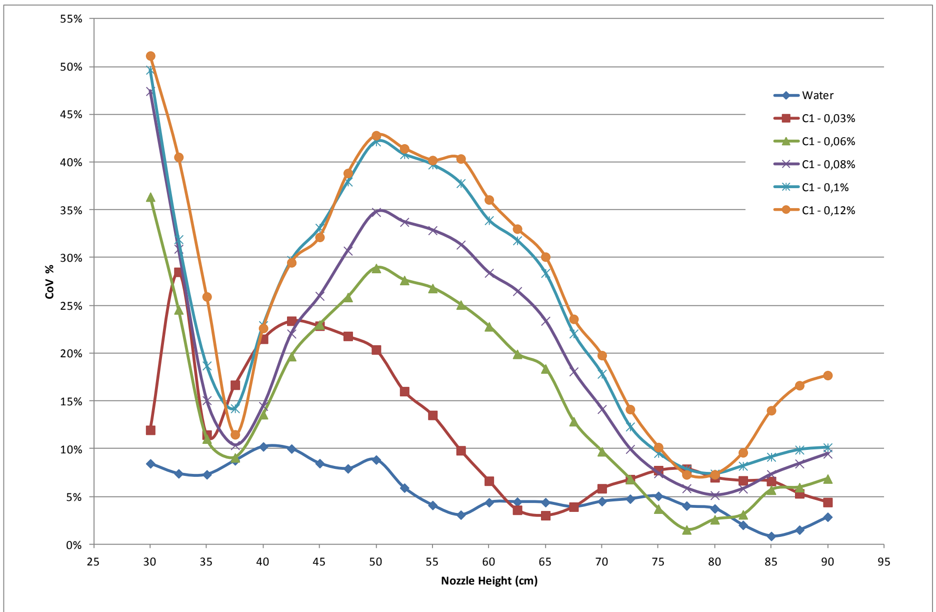

FIGURE 3: Distribution CoV for water and surfactant as a function of nozzle height: 50cm measured – other heights ::simulated.

The same evolution of CoV vs. nozzle height was found for water and surfactant mixture with a semi-periodical curve but the amplitude of CoV was much greater in the case of the surfactant with values up to 45%. As a practical consequence, the prediction of the negative impact of surfactant on the spray distribution and the benefit of optimizing boom height and working pressures are possible. In all cases, lowest CoV were obtained for heights around 37 cm or 80 cm as worse values of CoV were visible at 50 cm height. Practical consequences of this study rely on the necessity of the boom height adjustment in order to maintain an acceptable spraying quality.

3.2.3. Case of Air injection nozzle.

In the case of an air injection nozzle (FF IA 02 2.5 bar), results were similar to the reference nozzle FF 02 for pure water (Fig. 4). However the combination of surfactant with the air injection nozzle amplified the effects on reduced spray angles as well as CoV degradation (Table 2).

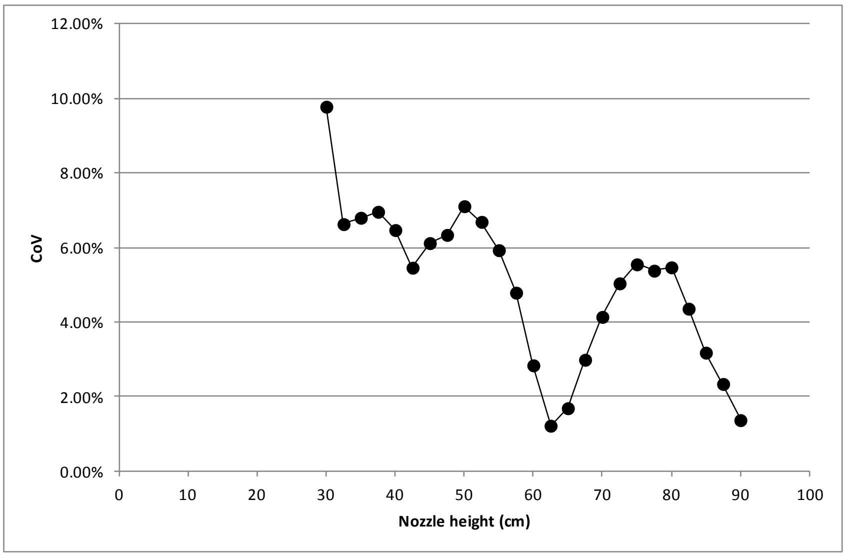

FIGURE 4: Simulated CoV for FF AI 02 @ 2.5 bar with pure water

4. Conclusion

This paper aims at showing the effect of surfactant C1 on spray angle and the consequences in terms of spray quality degradation. This illustrates the notion of sprayability of surfactants and chemicals in general. With the help of a distribution CoV simulator based on homothetic translation of flow rate and distances with nozzle height, it is possible to predict a wide range of realistic situations and possible curative adjustment of boom heights. Moreover, this work shows that a correct flow distribution is required before any drift evaluation in the field or in a wind tunnel.

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