DROP QUANTIFICATION OVER A SPRAY NOZZLE-PLATE SYSTEM

Marcelo Bacci da Silva*, Alexandre Antônio Santana* and Aristeu da Silveira Neto*

Department of Mechanical Engineering -Federal University of Uberlândia
38400-206 – Uberlândia – MG – Brazil
Email: mbsilva@mecanica.ufu.br

The object of this study is to present a methodology that permits quantification of drop generation over a spray nozzle-plate system. By means of this spectrum quantification, it is possible, not only to characterize existing spray nozzle systems, but also to suggest new types of these systems. Preliminary results demonstrate the viability of this methodology, which, in turn, can lead to broad practical application.

INTRODUCTION

A spray nozzle-plate system[1], as illustrated in Figure 1, is composed of an injection nozzle which projects a jet of water against a conical plate. The jet is concentric to the plate and a liquid sheet forms after the plate. The liquid sheet flows in a radial direction outward from the plate, and breaks up into drops[2].

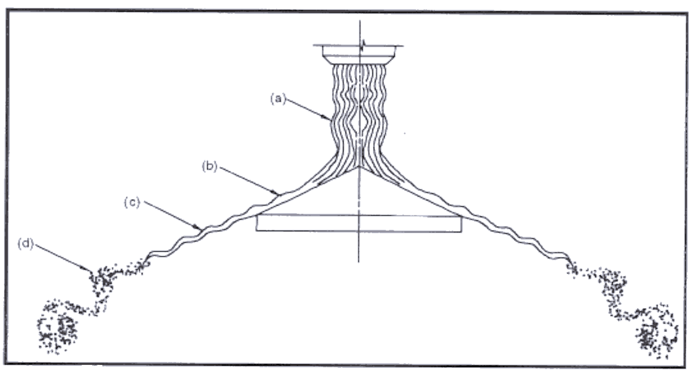

Figure 1: A spray nozzle-plate system.
(a): liquid jet – (b): liquid jet on the plate
(c): free liquid jet – (d): drop formation

A fundamental knowledge of drop formation in a spray nozzle-plate system is very important in relation to the reduction of water and energy consumption, improving the uniformity of the irrigation area by reducing the undesirable effects of soil erosion and drop evaporation, thus optimizing the agricultural production. This improvement depends on the drop distribution and the physical phenomena that determine drop formation.

EXPERIMENTAL METHOD AND APPARATUS

The methodology used to quantify the drop spectrum is based on high speed filming techinique to capture the high frequency phenomena in order to better understand the physics question involved. The experimental setup used to investigate the drop formation is shown in Figure 2. At the start, water flows from a water source to the injection nozzle which projects a jet of water against a conical plate and then the drops are formed. The images of the drops were captured by a high speed camera and were digitalyzed to permit treatment by software.

A table of results is then obtained and transferred to software to be manipulated. A schematic diagram of experimental apparatus is shown in Figure 3.

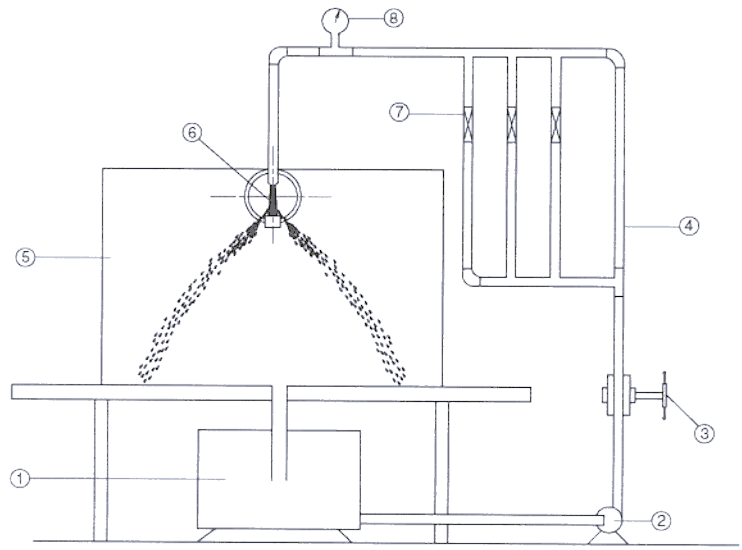

Figure 2: Experimental Apparatus.
1: water source – 2: 2,24 KW pump – 3: valve
4: PVC piping 25 mm in diameter – 5: collector chamber – 6: injection nozzle and conical plate
7: three flow meters – 8: manometer

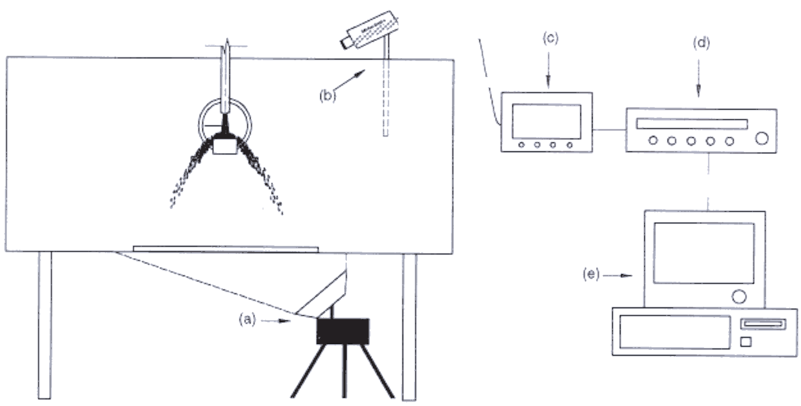

Figure 3: Schematic diagram of experimental apparatus.
(a): two1000 W lamps – (b): high speed camera
(c): camera monitor – (d): super VHS video
(e): frame grabber software (image analysis)

RESULTS

A quantitative study of high frequency phenomena, as in the case of drop formation on nozzle-plate systems, is necessary to specify the structure and geometry of drops[3]. This specification demands maximum precision because the quality of soil wetting is directly affected by the size, quantity and distribution of drops[1]. The study and analysis of the water flow rate (Q) as this affects drop size is demonstrated by the following histograms:

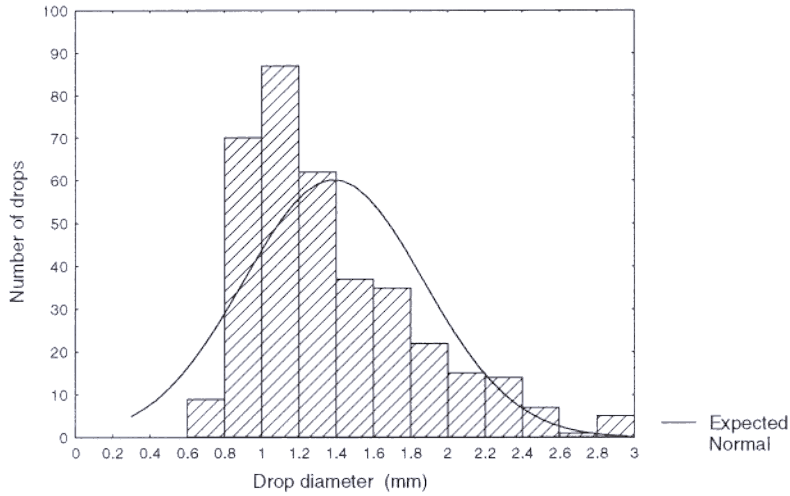

Figure 4: Drop diameter distribution – Q = 47.2 cm^3/s

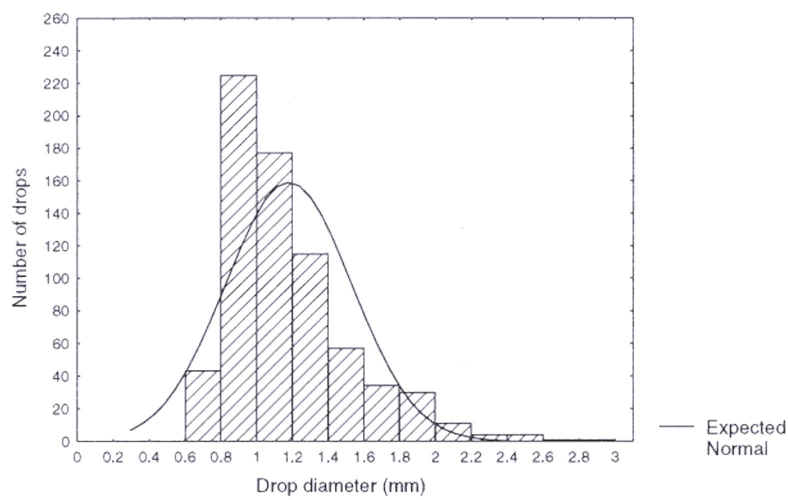

Figure 5: Drop diameter distribution – Q = 69.4 cm^3/s

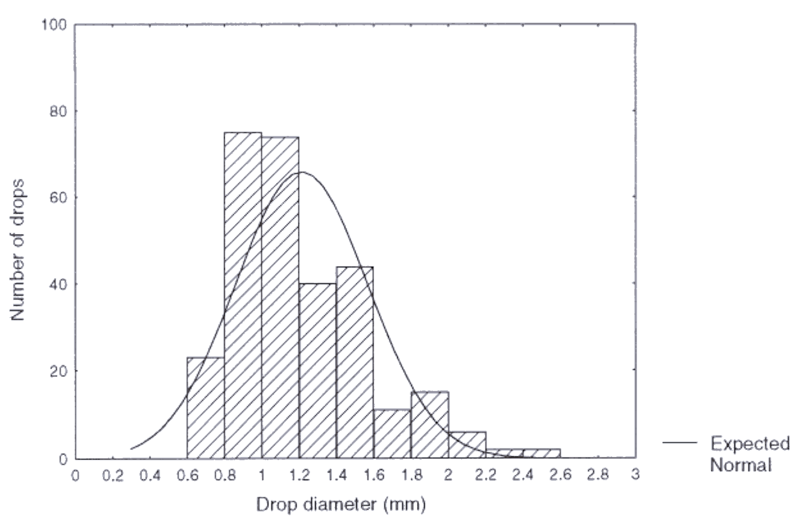

Figure 6: Drop diameter distribution – Q = 91.7 cm^3/s

It can be noted that there is a strong tendency, as indicated by statistics, for the formation of drops having a diameter of 1 to 2 mm. It can be seen that, by increasing the water flow rate, an increase in the number of drops is achieved, which is to be expected. In all the figures analysed above, it can be noted that, when the drop diameter shrinks to zero, the number of drops likewise zeroes, an expected physical reaction. It can also be observed that in the case of diameters larger than the maximum in the spectrum, once again the number of drops falls to zero, indicating a limit to the number of drops that can be formed by this system.

CONCLUSION

The methodology developed in this work seems to be good in accordance with the results presented. The quantitative study of the number of drops as a function of the shape of the curve is in agreement with existing literature[2].

REFERENCES

Amorim, L. M.; Silva, M. B. and Silveira Neto, Experimental Investigation of the Flow Transition over a Spray Nozzle-Plate System, *Two-Phase Flow Modelling and Experimentation*, Vol. 3, pp. 1929-1935, 1999.

2. McCreery, G. E. and Stoots, C. M., Drop Formation Mechanisms and Size Distributions for Spray Plate Nozzles, *Int. J. Multiphase Flow*, Vol. 22, No. 3, pp. 431-452, 1996.
3. Mao, C. P. et al., Drop Size Distribution Investigation of Flow in an Annular-Conical Passage, *Journal of Flow Visualization and Image Processing*, Vol. 2, pp. 113-123, 1995.