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Discussions and Closures

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Closure to “Initial Drop Velocity in a Fixed Spray Plate Sprinkler”

[No abstract available]

The writers appreciate this stimulating discussion. In the original paper, a new method for the estimation of the initial drop velocity in fixed spray plate sprinklers (FSPSs) was proposed. The idea behind the writers' research was to demonstrate the viability of a technique determining the previous drop trajectory using data obtained from a low-speed photograph. In the discussion, some fundamental principles for the hydraulic performance have been reported. For the most part the discussion seems to convey ideas for future research, instead of discussing specific topics in the original paper.

A new technology is pointed out by the discusser, i.e., the fluidic sprinkler. The inelastic shock described for FSPS does not take place neither in fluidic nor in impact sprinklers. As a consequence, head losses in fluidic and impact sprinklers are very low. Thus, initial droplet velocity can be approximated from the pressure at the nozzle.

Relationships for Nozzle Velocity and Discharge

In the original paper the proposed technique is applied to single nozzle FSPS. Eq. (1) in the original paper relates discharge and velocity just downstream from the nozzle. In the discussion, a different method for the evaluation of droplet velocity is proposed. It refers to rotating sprinklers using several nozzles. In the particular case of the device analyzed in the original paper (fixed, single nozzle), the proposed corrections are not necessary.

Eq. (8) in the discussion relates discharge and pressure. This is an alternative way to determine discharge and then velocity. In the original paper, this relationship was not used since experimental discharge data were available. Eq. (1) in the original paper provided an experimental v value already considering head losses at the nozzle. For that reason, Eq. (1) in the original paper was considered the best option to estimate jet velocity.

Head Loss Analysis Regarding Lateral, Riser, and Sprinkler Head

The discusser proposes a set of equations to estimate total head loss as the sum of head losses in different parts of the sprinkler. This method was not followed in the original paper since these head losses [typically below 2%, and already considered in Eq. (1) of the original paper] are assumed to be very low when compared with the inelastic shock losses resulting from the collision with the fixed plate (per Table 2 of the original paper).

The discusser points a sentence in the manuscript that states "a head loss coefficient be determined whose value is very close to 1." Please note that this is a mistake; head loss coefficient is very close to 0 (again, as compared with the inelastic shock losses).

General Observation on Final Results Presented in Table 2 of the Original Paper

The final results are collected and displayed in Table 2 of the original paper. In the original paper, initial relative velocity and kinetic energy loss computed by means of four different models, i.e., (1) Kincaid, (2) parabolic, (3) screening, and (4) ballistic, are presented for each sprinkler configuration.

As the discusser points out, the Kincaid model provides the highest values for initial relative velocity (thus, the smaller values for kinetic energy loss). The results of this model clearly differ from the other three models. Kincaid's model is only based on the nozzle and plate diameters. This model lacks key variables affecting the analyzed case such as the shape of the plate.

In general the parabolic model provides the smaller relative velocities. This makes perfect sense since no drag forces are considered in this model. Thus, the parabolic needs a smaller initial velocity to reach the photographed conditions than the ballistic model.

As pointed by the discusser, the original paper does not analyze the relationship between the relative velocity and the kinetic energy loss. The kinetic energy loss (%) increases as the relative velocity decreases. For a drop in the plate, this can be computed

$$\text{Kinetic energy loss}(\%)=[1-(\text{relative velocity})2]\times 100$$

Wind Drift Effect on Simulating Sprinkler Performance

The discusser asserts that wind greatly affects sprinkler performance. Wind effect is expected to be of great importance in the drops motion. The technique described in the original paper can be applied to wind conditions, under the assumption of constant wind velocity during droplet flight. However, one of the the aims of the original paper was to show that photographic data can lead to the estimation of initial droplet conditions, when assisted by an appropriate trajectory model. Wind effects were not considered in the original paper, in an attempt to simplify work and obtain accurate results. In any case, the work reported in the original paper should be understood as a first step in the application of a new technique. Future work should deepen in this subject and could consider windy situations.

Coefficient of Uniformity

As stressed by the discusser, the estimation of the coefficient of uniformity is the main idea behind the ballistic model. The original paper provides a method for the calculation of the droplet velocity just downstream from the FSPS plate. This velocity is a required input condition for the ballistic model. Thus, in accordance with the original paper, the application of ballistic models to FSPS is enabled and coefficients of uniformity may be calculated in future works.

Performance Indicators for Sprinkler Water Application Uniformity

The last paragraph of the discussion is also to be applied to other performance indicators in sprinkler irrigations. The data obtained with the proposed technique can be used in future works to determine water losses, distribution uniformities, and other commonly used performance indicators.

Effect of Uniform Lateral Slope on Water Application Uniformity

The issue raised by the discusser has moderate application in the case of the irrigation machines implementing FSPS (center-pivots and rangers) since the lateral slope changes with the movement of the irrigation lateral. In addition, pressure regulators are typically installed upstream from the sprinklers. However, this issue is of practical application in the design of energy-efficient irrigation machines. The minimization of pressure at the machine inlet is a very important target.

Hydraulic Design Criteria for Sprinkler System

As previously discussed, FSPS are commonly installed in irrigation machines, using a pressure regulator just upstream of each sprinkler.