Design and Evaluation of Traveling-Gun Systems: the Simulation Model TRAVGUN

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Abstract

The aim of this work is the development of a software application for design and evaluation of traveling-gun systems, allowing the correct management and design of these irrigation systems to solve the problem of lack of efficiency that these systems typically show. This application was developed in Visual Basic 6.0 and includes a database in Access 2000. This model has two main functions, one is the design of new systems and the other is the evaluation of systems already in operation aiming at improving their management. The TRAVGUN model is constituted by calculation modules (hydraulic design and evaluation) and a database. The design module executes the hydraulic sizing of the systems, searching in the database for the equipment (guns, pipes and travelers) that verifies the design criteria. With this first selection it simulates the functioning of each gun in the gun simulation module, where is simulated the distribution of water depths in fictitious collectors, as it would occur if a field evaluation was performed. In the design module, the simulation of the application depth profile is done assuming a triangular precipitation distribution profile based on the gun discharge, wetted radius and wetted angle. Based on these data (fictitious collectors) the performance indicators are computed and it is verified if these values are acceptable. At the end of the process the user retains the system that presents better results. The evaluation module, computes the performance indicators for systems to be evaluated in the field, based on field evaluations, as well as for systems being designed. The database stores information relative to the equipment, field evaluations and several auxiliary parameters necessary to the functioning of the model. The TRAVGUN software is an easy and helpful tool both for technicians and farmers, thus allowing to make the most appropriate decisions concerning their systems.

Key words: hose-reel sprinkler systems, traveller guns sprinklers, design and evaluation of sprinkler systems, simulation.

1 Introduction

The traveling-gun systems are often characterized by low application efficiencies, low distribution uniformities, and high application rates that often produce runoff and erosion. However, the experience shows that these problems could be solved if the traveling-gun systems were designed properly (Tiercelin, 1998; Tarjuelo, 1999). With this objective, TRAVGUN is a tool for design of new traveller gun systems and for performance analysis of systems already in operation based on field evaluations.

This model was built with the objective of providing a user-friendly and accurate simulation tool. Thus, it intends to build a bridge between the scientific knowledge and the field practice, so fulfilling goals of rural extension and support to the farmers. The main challenge consisted of the development of a software application that is simultaneously easy to use and precise in simulating the reality.

This model can operate either stand alone or associated with other models, for example its database concerning the equipment can be shared with the DOT\textsuperscript{mm}/h model (Pereira 2005) where both of them use the same information about guns, preventing information duplication. On the other hand the crop data (crop water requirements) will have to be supplied by a scheduling model like WEBISAREG dealt in a companion paper (Branco et al., 2005).
2 Model Structure

TRAVGUN is constituted by logical modules and a database. The calculation modules are for system design and for performance analysis. The database stores information about the equipment, field evaluations and several parameters required to make the model running.

Fig. 1 shows the conceptual structure of the model. The system design module executes the hydraulic sizing of the system, searching in the database the equipment (gun sprinklers, pipes and travelers) that verify the design criteria. With this first selection it simulates the functioning of each gun with the gun simulation module. This module simulates the distribution of water depths that fall at given points perpendicular to the travel path as it would occur if collectors were placed in a field evaluation when an evaluation is performed. Using these water depth data, the evaluation module computes the performance indicators of the system, and verifies if these values are acceptable. After an iterative process, the user selects the system that presents the better performance results in the analysis. The evaluation module is also applied to systems in operation but using field data of the gun evaluation.

![Conceptual structure of the model TRAVGUN](image)

The methodology of hydraulics design follows the approaches proposed by Keller and Bliesner (1990); the Darcy-Weisbach equation is used. The system design module make a system design optimization based on the performance indicators of that system, selecting the best system from the database using an automatic search process. The user introduces several design criteria relative to performance and the model runs the simulation until getting the system that comes closer to these conditions. As output, the model returns the selected system (gun sprinkler, pipe and traveler) and the value of simulated performance indicators.

The evaluation and performance analysis module computes performance indicators of traveling-gun systems with the data collected in the field evaluations. The evaluation module allows to simulate different towpath spacing, changing the degree of overlapping, and to get different distribution uniformities. The algorithm of the evaluations uses the methodology proposed by Keller and Bliesner (1990) and Pereira (2002). The computation of the performance indicators is based on the following data collected in the field: volumes collected in the catch containers, catchers grid; characteristics of the traveling gun (travel speed, discharge, wet diameter and wet angle).

The methodology used in this program to simulate the application depth profile according to the gun wetted angle, is an evolution of the methodology proposed by Keller and Bliesner (1990). The model simulates the variation of the wetted angle using a triangular profile in opposition to a uniform profile. Figure 2 summarizes the algorithm used in the simulation of the application depth profile.
Gun sprinkler data
Discharge, Wetted radius, Wetted angle

Jet profile equation

Profile equation above catchers

Application time × Application rate = Water depth collected in the catchers

Compute average application rate in all catchers

Fig. 2. Schematic representation of the gun simulation procedure.

The database stores information about the gun sprinklers, the pipes and the travelers, in order to allow choosing the most adequate equipment in accordance to the design criteria. The field evaluations data are also stored in this database, which is used to compute the systems performance indicators and to simulate several options (ex: towpath spacing) in order to better regulate and to improve the management of the evaluated systems.

Concerning the database, this application works as front-end which makes possible to extract and to introduce information in the Access database (back-end). Thus, the TRAVGUN has a module that corresponds to the functions of a Database Management System (Fig. 3) that bind the numerical models with the database, and allows the user to execute the following actions in the database: add, delete, update or query data.

The use of a front-end application has special importance in the case of this model essentially for two reasons. In first place this model is still in development, and therefore it is important to be able to change the version of the application without loosing the data already stored in the database. In second place, the
results of this model depends on the quality and extension of the data stored in the database and. Therefore if more equipment data is available in the database better will be the simulation results because the possible alternatives are increased.

The connection between the database and the program (numerical modules) is made through queries that run in a sequential way at the time that information are asked for to the user through the graphical interface, facilitating the data introduction and preventing errors.

Figure 3 corresponds to the Windows Form where the information relative to guns is introduced. It can be evidenced that introduction of data has to be made on a sequential way, where you choose first the manufacturer, later the available models for this manufacturer and finally the sprinkler nozzle. The manufacturer, contrarily to the others two items, cannot be added in this form but in another form to prevent that different users introduce different names for the same manufacturer, thus ensuring information integrity. It may also be verified that the data asked in the data grid is exactly equal to those supplied in the manufacturers catalogues (metric units) available in the Internet. Therefore, this example serves to show that care was taken to verify if the information asked by the user is easily available, taking into account the users requirements.

3 TRAVGUN application

TRAVGUN was applied to the irrigation projects Vigia and Lucefeciit located in Alentejo (Pereira 2005), mainly the evaluation module (fig. 4 and 5), which. was used to calculate the performance indicators and to simulate different widths of towpath spacings and then to produce farmers advices. Its application revealed successful, allowing to simulate different widths of towpath spacing, in a easy and fast way, less laborious and time expensive then using traditional spreadsheets.
Fig. 5. Evaluation module – Traveler characteristics.

Figure 6 shows an example of the results obtained with the evaluation module, unfortunately relative to a poor designed and managed system.

Fig. 6. Performance indicators.

4 Conclusions

The TRAVGUN model, having a user-friendly interface, allows the design to be made easily, reducing significantly the time spent and leading to a lesser cost of the projects and an increased quality, mainly
because several alternatives may be easily handled and compared. It is conceived to be used by a broad audience, so the database allows the model to search a large part of the information following relatively simple inputs by the user.

This model also serves to support improving systems under operation. TRAVGUN application to Vigia and Lucefecit irrigation projects revealed successful and enabled farmers advise.

Future developments include the adoption of alternative application depth profiles, which are already in development, and to consider the effects of the wind.

5 References

Branco R. P., Teodoro P. R., L. S. Pereira, 2005. WEBISAREG – Web Based Decision System Support for Irrigation Management (this issue)


