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Modelling and Optimisation of Pressure Irrigation Systems

By

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ABSTRACT

Trickle and sprinkler irrigation systems together represent the broad class of pressurised irrigation methods in which water is carried through a pipe system and is distributed close to the plants. The major aim of this thesis is to develop a mathematical model for the optimum design of pressure irrigation systems and thus achieve major cost savings. Throughout the study outlined in this thesis two optimisation approaches (full enumeration and genetic algorithms) are utilised. As a result, this thesis is divided into two sections: Section I deals with models in which a fixed layout for the piping system is considered and the enumeration approach is utilised and Section II considers models in which the piping layout is not fixed and the genetic algorithm is utilised as a relatively new approach to optimisation problems.

In the first section (which covers chapters 1 to 5) a review of the design and optimisation of pipe networks is undertaken. This emphasises branched networks which are used in pressure irrigation systems. Then a simple model for a Subunit with one control head is developed. A number of factors affecting the least cost solutions including the geometry of field, irrigation interval and irrigation time, slope and the positions of the manifold and supply pipes are examined. The model is extended to more complicated cases dealing with multiple subunits in which the agronomical and the agrotechnical aspects of irrigation systems are taken into account. In this model, a field is divided into a variable number of subunits in the X and Y directions. At each iteration of division the optimisation process is carried out to find the least cost solution considering various combination of subunits being irrigated simultaneously.

In the second section, the optimum layout (connection between nodes) and also optimum component sizes considering capital and operating costs are investigated. In this section, a new method called genetic algorithms (Gas) is used for optimisation. A general model using Gas dealing with optimum layout, pipe sizes and pump selection for any branched pipe system is developed. This model may be applied to any branched pipe system supplying a drip or sprinkler irrigation system or supplying just a number of hydrants. A sensitivity analysis of GA parameters in this section is performed. The effect of various values of probability of crossover, mutation and also using different population sizes and seed numbers which create different sequence of random numbers is examined. The optimisation procedures considered in this thesis demonstrate considerable potential to produce cost savings in the design of pressure irrigation systems.

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