STABILITY AND PERFORMANCE ANALYSIS OF CLASSICAL DECENTRALIZED CONTROL OF IRRIGATION CANALS

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Abstract: Irrigation canals have a series structure which is generally used to design multivariable controllers based on the aggregation of decentralized monovariable controllers. SISO controllers are designed for each canal pool, assuming that the interactions will not destabilize the overall system. It is shown that, when the canal pools are controlled using the discharge at one boundary, the multivariable decentralized control structure is stable if and only if the SISO controllers are stable. The performance of the multivariable system is also investigated, and it is shown that the interactions decrease the overall performance of the controlled system. This loss of performance can be reduced by using a feedforward controller. Experimental results show the effectiveness of the method.

Keywords: Irrigation canal, Decentralised control, Application, Stability and Performance Analysis

1. INTRODUCTION

Irrigation canals are used to conduct the water from its source (a river, a dam) towards its users (pumping stations or individual farmers). Managing irrigation canals efficiently *i.e.* satisfying water users and at the same time minimizing the losses of water resource is an increasingly important issue. It is recognized that automatic control can improve the management of irrigation canals.

An irrigation canal is a multivariable system presenting strong interactions between subsystems. However, a wide number of applications and many publications use a decentralized technique to design controllers for irrigation canals (Weyer, 2002), (Seatzu, 2000), (Schuurmans, 1997), (Deltour and Sanfilippo, 1998), (Baume *et al.*, 1999), (Reddy *et al.*, 1992). In these cases, simple controllers are first designed for each canal pool, and are used together in order to control the overall system. Usually, the classical distant downstream control policy is chosen for each pool, where the downstream water level is controlled using the upstream discharge. This is a monovariable controller design problem, usually solved with simple PI controllers. Feedforward controllers are then added in order to reduce the interactions between each canal pool (Schuurmans, 1997), (Jreij, 1997). Such a design method usually gives a correct controller for the whole system, since the system appears to be stable. However, this method has never been analyzed using modern automatic control tools (Skogestad and Postlethwaite, 1998).

Why do essentially monovariable techniques work on a multivariable system? In this paper the analysis of the question is done using theory and classical control tools. A systematic and rigorous methodology for analysis and design of linear decentralized controllers for a canal with multiple pools taking into account the interactions between each pool is proposed. It is explained why the decentralized control method leads to a stable multivariable closed-loop system. The robustness and the performance of the closed-loop are also investigated. It is shown that the static feedforward