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INTERNAL MODEL CONTROL OF UNCERTAIN SYSTEMS: AN IMPROVED APPROACH.

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Abstract
Over the years, internal model control (IMC) design procedures involve casting the design problems in terms of H_2 and H_∞ norms of sensitivity functions in order to obtain the parameters of a robust controller. In frequency domain, these require the use of weighting functions, which are often obtained in a cumbersome trial-and-error manner. Moreover, the approach is implicit. In this paper, a simple, explicit one-degree-of-freedom (1DOF) IMC approach, which does not require any weighting functions is developed and its efficacy is demonstrated by solving IFAC-93 benchmark problem. An improved method of deriving IMC q is proposed. Worst extreme plant identified based on Nyquist stability criterion is used in controller design; this eliminates computational burdens associated with the use of analytic integral squared error criterion. The control problem is formulated using Zakian's method of inequalities (MOI). The explicit closed loop performance indices, and stability constraint are defined as a set of algebraic inequalities, whose solution guarantees robustness and performance trade offs simultaneously. Cascade PID controller is also considered because of its phase lead property which counteracts the negative phase introduced by the RHP zero of the benchmark plant. The simulation results of these simple controllers are favourable when compared with published results obtained from other simple and sophisticated controllers.

Keywords: *1DOF IMC, Worst extreme plant, Robustness, Nyquist stability criterion, MOI.*

1. Introduction
IFAC-93 benchmark plant [1, 2] requires a very close control. The control problem here is multi-objective in nature. This plant is uncertain in its parameters though within known intervals at different operating conditions. The task then is to design controllers, which meet the stringent closed loop performance specifications in the face of uncertainties at different operating conditions.

One successful approach for multi-objective control systems design is the Zakian's method of inequalities (MOI)[2, 3, 4, 5, 6, 7, 8] in which the closed loop performance specifications, either in time or/and frequency domain(s) are defined explicitly. It has been found to be very efficient. In this work, this framework is adopted for the control problem formulation.

An improved one-degree-of-freedom internal model control (1 DOF IMC) [9, 10, 11, 12, 13] algorithm is developed. A typical representation of 1 DOF IMC structure is shown in Fig.1; r is the set point; q is the IMC controller transfer function; U is the manipulated input; G is the nominal model of the plant; G_P is the actual plant; C is the classical equivalence of q; y is the output while d is the disturbance.

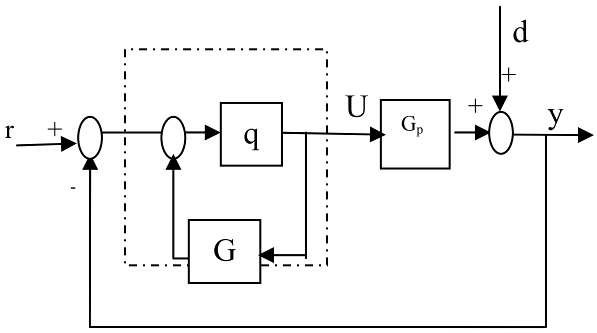

Fig.1 Typical 1 DOF IMC Configuration

For the IFAC-93 benchmark plant, many controllers (ranging from simple to complex, fixed to adaptive) have been designed; but a simple and efficient 1 DOF IMC controller has not been considered. On comparing with other controller forms, it offers a number of advantages namely: often, a single filter parameter is required for tuning (offline or online), it leads to zero steady-state tracking error which is one of the objectives to be satisfied for this plant, it overcomes the reset wind up problem which is common to classic feedback controllers, the controller is easily obtained from the