Abstract

On-line Fault Detection and Diagnosis(FDD) in process plants employing analytical redundancy techniques that use dynamic process models is receiving research attention in the recent years. The major techniques for these are based on the so-called Parity Space(PS) approach, Fault Detection Observers(FDO) and Parameter Estimation(PE). The first step in these approaches is to design an appropriate "residual" signal that remains close to zero in normal conditions but assumes significant nonzero values with the onset of faults in the plants. This thesis is concerned with the theory of residual generation using a continuous time dynamic model of the process.

In this thesis a new necessary and sufficient condition for design of a PS based residual generator has been derived. Under the PS based approach, new structural results on fault detectability and disturbance decoupling as well as new algorithms for exact disturbance decoupling are presented. PS and several FDO based algorithms for FDD have been cast in a unified form for the design of residual generators. This reveals the fundamental structure of all residual generators and the main objectives in their design. Based on the formulation, a new design algorithm using null-space computation for rational transfer function matrices is formulated. The method has the appeal of directness in incorporating frequency domain information related to disturbance and faults. Two existing algorithms based on the FDD have also been extended for exact disturbance decoupling under some assumptions. Finally, FDD algorithms based on PE have been considered. A new constrained estimation algorithm employing a bank of estimators, each with a different fault hypothesis, is proposed to be employed with a modified version of the Influence Matrix method. Several detection schemes for parameter change detection have also been proposed and tested in simulation. Another new algorithm for direct

physical parameter estimation has been designed. This algorithm provides immediate diagnosis of the physical parameters under fault.

The algorithms proposed in the thesis have been tested with numerical simulation. A large scale model of a multi-stage flash desalination plant and a chemical reactor for aromatisation of heptane have been used as case studies, to demonstrate the applicability of the proposed technique to practical problems.