374e On a New Rigorous Methodology for Instrumentation Network Design

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A cost optimal methodology for instrumentation network design for Data Reconciliation estimators was first proposed by Bagajewicz (1997). This model minimizes cost subject to precision and accuracy related constraints (residual precision, error detectability and resilience). Bagajewicz (2000) reviews all methodologies available at the time to solve the problem, and new added constraints (reliability). The solution procedure chosen for this problem was the one of tree search with certain bounding strategies. Later, Bagajewicz and Cabrera (2002) developed an MILP procedure and Chmielewski et al (2002) proposed the use of LMI to turn the problem into a mixed integer convex formulation. While the latter was never tested in large problems, and the former revealed some computational difficulties associated to scaling. In view of the highly combinatorial nature of the problem and the failed attempts, many researchers resorted to other methodologies that do not guarantee optimality, genetic algorithms being the method of choice (Sen et al., 1998; Carnero et al., 2001, 2005; Gerkens C., G. Heyen, 2004). The original tree searching method proved to be moderately efficient to solve small to medium size problems (10 units and 15 streams approximately), but is incapable of solving larger problems like for example a refinery crude topping unit. In turn, genetic algorithms have not been tested in such large systems so their efficiency is unknown.

In this paper, we present a new tree searching methodology based on cutsets. A cutest is a set of streams that divides the flowsheet in exactly two individually connected flowsheets. Cutsets are very useful because instruments placed in their streams provide software redundancy, that is, the ability to improve estimators through data reconciliation. For this method, we use all the cutsets of the flowsheet as elementary building blocks, thus being able to capture all possible solutions. We use a tree enumeration procedure, in which each node is a collection of cutsets and for which the same bounding procedure as in the original method proposed by Bagajewicz (1997) can be used. We will show that this method show remarkable improvement for medium size problems (from hours to minutes in certain cases), but is still incapable of solving refinery size problems. For these problems we will show a new decomposition procedure, which is rigorous and capable of obtaining the optimum for refinery size problems in reasonable time. We will show properties of this decomposition procedure and illustrate its efficiency.