ABSTRACT

A generalised mathematical model describing the dynamic behaviour of multi-stage refrigeration systems has been developed and applied to a two-stage cycle with a single component working fluid, propylene. Initially, a non-linear simulation model was developed using ACSL, and from it a linearised model was derived and validated. The model is known to be truly interactive.

Based on the ACSL model, heuristics were used to identify and test several control cases. The comparison between cases was based on assessing the integral square error (ISE) in the response of a process stream outlet temperature (TP1o). The performance of temperature cascade control was best in terms of ISE despite slight deterioration in the performance of other control loops. With control of liquid refrigerant level in two of the three process vessels being needed, control of the receiver level improved ISE, but at the expense of not being able to guarantee that heat transfer surface in the evaporators remains covered.

As a basis for control system design, the linear model was used to test a number of published techniques that deal with the selection of controlled / manipulated variable sets, give guidance on pairing and measure the strength of interaction for fixed pairings. All methods investigated agreed that the system was highly interactive. Apart from that, they gave different recommendations which, on many occasions, contradicted the system's observed performance under simulation.

In contrast to most published interaction analysis methods which are based on the system transfer matrix **G**, a new steady state interaction measure, denoted as Input / Output Interaction Array (IOIA), has been proposed based on the full space state model. This proved able to reveal the strength of interaction between manipulated and measured variables. It was tested on three different cases (including the refrigeration system) where its results agreed with the performance observed under simulation.