

Research topics

Sub-ambient Systems and Low Temperature Separation

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Abstract

Low temperature (sub-ambient) processes require heat rejection to refrigeration systems. The result is that the operating costs for such processes are usually dominated by the cost of power to run the refrigeration system. For large-scale systems, multiple levels of refrigeration, cascaded systems and mixed refrigerants are used. This, coupled with a high degree of heat integration, makes the design of such systems extremely complex because of the complex interactions that occur. This project has developed systematic approaches to the design of complex low temperature systems. Also, such refrigeration systems are often used to provide the cooling for low temperature separation. This project has developed methods for the simultaneous design of separation and refrigeration systems.

Project description

The design of low temperature processes is dominated by the power consumption of the refrigeration system. The design of a sub-ambient process involves design of the core process (often distillation), the heat exchanger network and the refrigeration system. These three components are inter-linked and the designs interact with each other.

A method of targeting shaft power for a simple cycle has been developed using basic thermodynamic considerations. Complex cycles are formed by decomposing them into simple cycles, taking account of the interactions between them. All of the options used by designers to improve refrigeration systems such as multiple levels, economisers, pre-saturators, intermediate heat rejection and sub-cooling can all be analysed. This provides reliable methods to predict power requirements so that design options can be quickly and reliably screened. The method has been tested against a wide range of refrigerants across a wide range of conditions and gives consistently accurate predictions. Cascade and mixed refrigerant systems can be analysed. For mixed refrigerants, methods have been developed to optimise refrigerant composition.

The complex refrigeration systems used in the process industries are often required to service the cooling requirements for low-temperature separation. In this situation, the separation system and the refrigeration systems should be designed together. Options for low temperature separation include simple flash separation, dephlegmators and low temperature distillation. The most appropriate combination of these needs to be selected, in the best sequence, and designed simultaneously with the refrigeration system. Methods to provide such solutions have now been developed.

The methods have been applied to a number of industrial cases, such as ethylene and liquefied natural gas processes.