Capacity and performance profiles of process plant

Monash University Associate Professor, David Brennan, shares historical information on capacity and performance profiles on some of Australia's early process plants. This information was part of his PhD research studies back in the 1986. His research involved the technical and economic study of capacity growth and performance change in operating plants. Brennan drew on data from Australian plants in the chemical, mineral and petroleum processing industries. However, it was following a secondment at ICI Australia, that led to his curiosity into how process plants - like the earlier ethylene plants at Botany and many other Australian plants at that time - had achieved capacity growth during their operating lives.

While capacity data was drawn from some 71 plants, comprising 42 chemical, 17 mineral and 12 petroleum processing, a detailed assessment of nine plants was made. This is in terms of capacity growth and productivity changes in raw materials and energy consumption, manning, and cumulative fixed capital per tonne of product.

The chemical plants comprised chlor-alkali, vinyl chloride monomer, and the first ethylene plants at Botany, the carbon black plant at Kurnell, soda ash plant at Osborne, and the first phenol plant in Footscray. The mineral processing plants comprised the Bell Bay aluminium smelter and Kalgoorlie nickel smelter, while the petroleum processing plant was a catalytic cracking unit.

More detailed studies of the aluminium smelter, chloralkali plant and ethylene plant expansions incorporated the strategies, cost and performance details as well as changes in the technologies embedded in new plants. These three plants are important in the history of Australia's process industries:

- The Bell Bay plant was the first aluminium smelter built in Australia, commencing in 1955 with a capacity of 12,000 tonnes/yr of aluminium but expanded to 120,000 tonnes/yr by 1984. An Important aspect was the use of hydroelectricity.
- The chloralkali plant at Botany based on mercury cell technology commenced operation in 1944 with a capacity of 8,000 tonnes/yr and had achieved approximately 90,000 by 1980.
- The ethylene plant commenced operation in 1967 with a capacity of 63,000 tonnes per year and expanded to 100,000 tonnes/yr by 1983.

Expansions in the nine plants studied were achieved using strategies that included:

- equipment addition, mainly in parallel but sometimes in series with existing equipment
- replacement of existing equipment with equipment of greater capacity
- intensification of process or equipment
- exploitation of capacity margins

Exploiting capacity margins within the process typically arises from changes in feedstock or product composition. Margins are also derived from standard sizes of equipment in the initial plant, and from changes in technology and operating procedures. Systematic exploitation of capacity margins is often referred to as 'debottlenecking'.

Intensification, enabling increased production capacity for a given equipment item - most notably reactors - arises mainly from technology innovation.

Two basic types of expansion could be distinguished from the cases explored:

- parallel streamed expansion - where parallel addition of equipment is made at each process step
- constrained expansion - where parallel addition of equipment is precluded in at least one step within the process

Aluminium smelters typically undergo parallel streamed expansions, with additions of entire potlines (banks of electrolytic reactors). The ethylene plant studied underwent a constrained expansion with parallel addition of new improved design reactors, but with recycling of ethane unloading the capacity of downstream purification plant. Catalytic cracking units in petroleum refineries typically undergo constrained expansions, with the cost of the reactor-regenerator unit discouraging parallel addition of this unit; expansion has relied on improvements in catalyst and reactor design and debottlenecking of downstream separation equipment.

Some plants may undergo separate parallel and constrained expansions during their operating life. An example is the chloralkali plant studied which experienced incremental parallel streamed expansions through addition of new reactor cell banks, followed by a series of constrained expansions involving technology improvement and selective equipment addition.

See other links

Appendix 1 PhD thesis - D J Brennan
Australian chemical industry in the 1980s
About David Brennan - Monash University, Department of Engineering profile