PI & CARBON REDUCTIONS

The Dutch & UK Approaches

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Some Background

An assessment of the potential for PI energy savings was made some 20 years ago and the European Commission, represented at the time by Professor Pilavachi, in the 1980s took the bold step of supporting PI under its energy efficiency R&D programmes [1].

In the 1990s the then UK Energy Efficiency Office supported the development of strategies in three areas – compact heat exchangers, heat and mass transfer enhancement and process intensification (PI) – all related to saving energy.

The EEO Projections

Table 1. Potential Energy Savings due to Investment in PI in a Range of Process Unit Operations (UK Chemicals Sector only).

Compact heat exchangers – 16 PJ/a

Separators – 6.2 PJ/a

Reactors – 11 PJ/a

Overall plant intensification – 40 PJ/a (technical potential)

Effluent treatment – 1 PJ/a

The above data do not take into account the increased knowledge of the potential (and actual) applications of PI since the strategies were formulated.

In some instances the opportunities will have increased – in others they may have been superseded by other process improvements.

An important factor is that major process changes/plant replacement would be needed to realise the savings, and a second critical observation is that integration is necessary in all except minor unit operation substitution.

Effective integration can maximise emission reductions.

The Carbon Trust Viewpoint

Until relatively recently the Carbon Trust, the UK body overseeing implementation of parts of the UK Government’s strategy for reducing carbon emissions, had process intensification as one of its top priorities for action.

In 2005, however, a study by Arthur D Little (ADL) for the Carbon Trust (CT) effectively led to the downgrading of support for industry at the expense of renewable energy and buildings – both of course important areas but ones where activities should complement those affecting the process industries, not supplant them. The study for the CT considered ‘process substitution’ as the generic area in which PI would fall [2].

Carbon Trust – New initiative

. This was described as: "…..the modification or replacement of existing processes to result in less energy being consumed." The areas chosen for further investigation were "the potential to exploit micro reaction technology……and advances in heat exchanger technology." It is interesting to read the context in which these two technologies were discussed, summarised in the next paragraph.

With regard to advanced heat exchangers, the scope was extended to include electric (active) enhancement methods, as follows: "…..In some cases the combination of heat exchangers with alternative energy sources (e.g. microwaves or radio frequency) has energy efficiency benefits." However there were no specific recommendations in the document [2] to the types of advanced heat exchanger that should be supported. The micro reaction technology category was listed under 'micro fluidic processes', and the comments reported were slightly more positive: "Micro fluidic processes (reactions which occur at a micro scale *(sic)*) help to improve energy efficiency, mixing and product yield. There are many practical challenges to overcome in applying these processes to industrial applications, particularly in scaling up from small volume to bulk manufacture.

…… Substantial UK funding over a prolonged period would be required to compete effectively with the best research available outside the UK”. The authors had Germany and Japan in mind in making this conclusion.

The overall conclusion, that is contrary to what many involved in the application of PI believe, is that the areas of ‘micro fluidics for chemical processes’ and ‘ advanced heat exchangers’ should be reviewed periodically to reassess whether support is necessary. This effectively downgraded PI as a carbon-reducing tool in the UK.

The ADL/SenterNoven Report

Arthur D. Little also carried out a study with SenterNovem of The Netherlands on behalf of a number of continental European organisations, notably in Germany, The Netherlands and Belgium. I was involved in providing some information during the study [7]. The outcome was the identification of a plan for implementing PI in a number of sectors, using specified PI technologies, (now being fine-tuned by Dutch & German engineers). The effort was costed and potential stakeholders identified.

	Bulk Chemicals	Fine Chemicals	Food
Multifunctional equipment (advanced distillation)	50-80% energy savings in 15% of processes. 9-18 PJ	Limited to separation processes, i.e. 10% of sector. Increase efficiency by 50%, saving <1 PJ	Drying & crystallisation. 10% total energy saving, worth 3-5 PJ
Micro/milli-reactors	A study by ECN in Holland suggests 20 PJ savings using heat exchanger-reactors. Micro-reactors extend this to 25 PJ.	Applications in 20% of processes in the sector saving 20% of energy – 1 PJ Reduce feedstock & additives by 30% in 10% of processes saving 5-7 PJ	Spill-over from fine chemicals: <1 PJ
Microwaves (Electrical enhancement)	*	Reduce feedstock & additives by 20-40% in 5% of processes: 2-3 PJ	20-50% saving in 10% of drying market: 1-1.5 PJ 10% energy reduction in product processing: 1-1.5 PJ

	Bulk Chemicals	Fine Chemicals	Food
High gravity fields (E.g. Spinning disc reactor. HiGee)	*	Reduce feedstock, solvents etc. by 50% in 5% of processes: 1-3 PJ	Assuming 20% of electricity in food production goes to emulsification, mixing etc. 10-20% saving worth 0.5 PJ

The overall energy savings across the three sectors were estimated to be of the order of 50-100 PJ per annum by 2050. The energy savings were largely due to better selectivity and reduced energy use in separation processes, as well as improved control.

US DoE PI SUPPORT

The US Department of Energy has also initiated substantial programmes supporting PI in the process industries, [4]. Relevant to PI are the activities on hybrid distillation and novel reactors, together with advanced water removal (drying/evaporation) methods. The Industrial Technologies Programme (ITP) highlights the following points:

•Multifunctional reactors – e.g. Sandia slurry bubble-column reactor

•Fuel & electricity savings of >50%

•Reduced waste – e.g. less acid used in alkylation

•Potential savings of >70 PJ/a by 2020 (greater than the European target)

To conclude:

The recent (last 35 years) history of energy efficient processes has seen many technologies receive substantial R&D funding, periodic official support and subsequent neglect, and a plethora of excuses from ‘end users’ as to why investment in such a technology would not make good business sense. In general, the quality of the technology is good (PI & other areas) but progress has been hindered by the inconsistencies in decision-making and the ability of funding bodies to incorporate disincentives in their application procedures.

It is to be hoped that global warming will help to focus their minds and open their pockets!

References

1. Pilavachi, P.A. Energy conservation R&D in industry. Heat Recovery Systems & CHP, Vol. 7, No. 4, pp. 329-335, 1987.

2. Carbon Trust Research Landscape Study. Report CTC511, The Carbon Trust, 2005.

3. Anon. Building a Business Case on Process Intensification. Unpublished Report, Arthur D. Little and SenterNovem, July 2006

4. US Department of Energy – Energy Efficiency and Renewable Energy, 2007. See: www.eree.energy.gov/industry/saveenergynow