Monitor. Control. Optimise.

Make to Order Process Platform

Control of Novel Small-Scale Continuous Reactors

The Need…

A new generation of continuous small-scale reactors has recently come onto the market, that will enable manufacturers of high-value, low volume products to move away from traditional batch processes.

These micro reactors can be used in parallel, to achieve production scale-up without the associated chemical engineering problems.

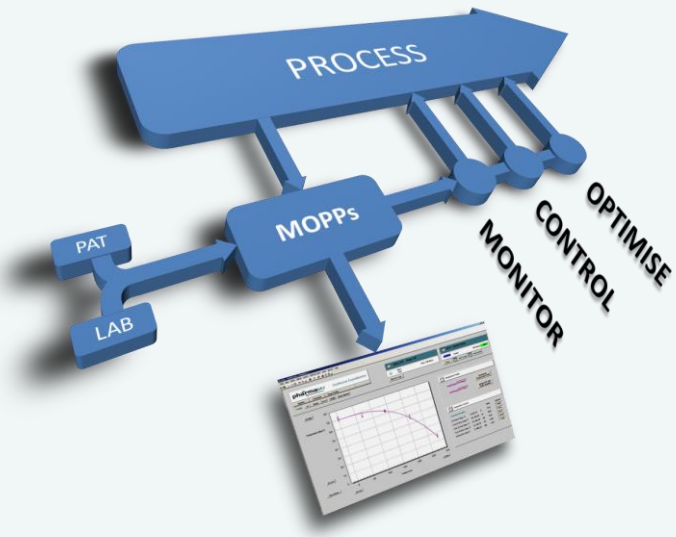
Typical benefits of such systems include waste reduced by 10-15%, energy reduced by 40-70% and solvent hold-up that is in the order of 10% of the equivalent batch process.

The major benefit of these reactors is the ability to manufacture a number of products using a single reactor by rapidly adjusting the operating conditions, with little waste material during the transition.

The Problem…..

Currently these reactors are operated in a staff-intensive fashion, with manual operation to identify suitable operating conditions and adjust the process during operation.

There is a need to automate not just the operation of the process during normal manufacture – to reject external disturbances such as feedstock variation – but also the ability to identify the operating conditions required for new products, in a less time-consuming manner.



The Objectives…

Apply advanced automation techniques to two of these novel reactor systems to allow more precise control of product quality and where possible optimisation of yield.

Design and deploy software tools to simplify the Process Development methodology which is currently used to determine process settings. These software tools, in conjunction with the continuous micro reactors, improve rapid prototyping and produce less waste material, whilst examining many feasible operating regions for each product.

Develop a strategy and associated control system to simplify the scale-up options for commercial manufacture, by achieving transferability between similar reactors.

Optimise the use of the quantitative knowledge gained in the preliminary reactions to predict the set-up requirements in downstream units.

EPSRC
Centre for Innovative Manufacturing
in Continuous Manufacturing and Crystallisation

cpi

PERCEPTIVE ENGINEERING LTD

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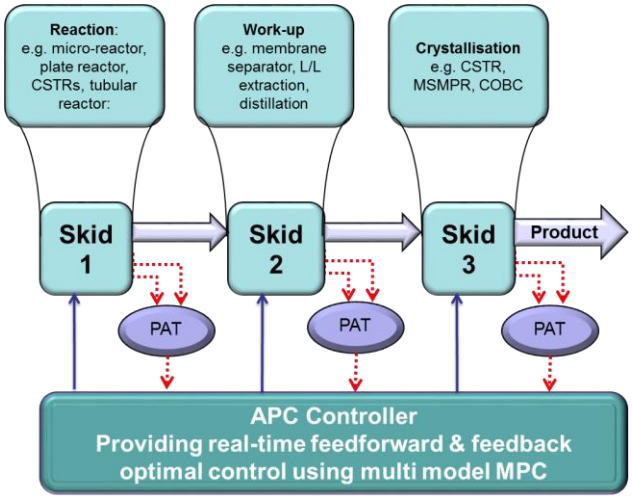
The Strategy…

Two reactor types were used to allow the project to demonstrate the benefits of advanced automation with PAT on two common processing stages in pharmaceutical and fine chemical manufacture. A Corning® Advanced Flow™ reactor to represent the API reaction stage and a Cambridge Reactor Design Rattlesnake Continuous Crystalliser to represent the crystallisation stage of downstream processing.

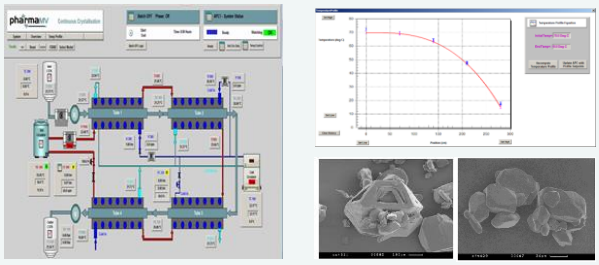


These reactors were supplemented with ancillary units, process instruments and on-line PAT analysers that can be controlled remotely via process automation rather than manual intervention. This set up not only allows the exploitation of the benefits described above, but also gives staff the ability to operate the process remotely, which is of particular interest if the process is hazardous or needs to be operated in a controlled environments such a fume cupboards.

Automatic real time diagnostics for analyser monitoring and equipment fouling form part of the overall advanced solution to deliver a robust self contained processing Unit.

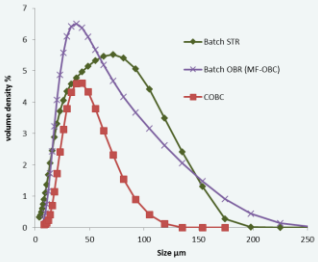
The Results…

An intuitive Graphical User Interface was developed for each system to allow easy adjustment of the process and the implementation of the Model Predictive Controllers. These controllers automatically adjust the process conditions (Flows, temperature profiles, feed ratios etc) to maintain optimal product properties (yield, concentration etc.). These properties are derived from 'Soft Sensors' based upon measurements from the PAT instrumentation.



Once the complete system has been configured and the basic controller models identified, the entire setup is easily adapted to incorporate new products or changes in the desired properties of existing products.

Batch vs Continuous Crystallisation



Crystalliser	Residence time	RPM/Reo
STR	2.5	500
MF-OBC	2.5	300
COBC	2.5	300

Crystalliser	Mean particle size	Yield %
STR	71.2	27.9
MF-OBC	37.6	31.2
COBC	37.6	37.3

The results have been demonstrated on both model compounds and products of true industrial interest and have shown a significant improvement in yield and ability to control PSD. The complete COBR with PAT enhanced automation is currently being demonstrated at the Centre for Innovative Manufacturing at the University of Strathclyde.