

Process Intensification For a Sustainable Enterprise

Process Intensification (PI) is a unique way of interacting fluids to bring about chemical transformation by adopting a continuous mode of operation over conventional batch processing. Using a laminar flow concept, typical gas-liquid, liquid-liquid and gas-liquid-solid interactions are enhanced by orders of magnitude. This is achieved by interactions at a molecular level that are maximized by flowing fluids through high surface area equipment. This concept of processing has enabled the development of compact, energy efficient equipment which is able to achieve economically and environmentally superior and sustainable results. This technology has broad application over a wide range of manufacturing sectors.

Conceptually PI emulates nature's designs for processing which involve laminar flow. *"It is a sobering thought that if chemical engineers were given a free hand to design the human digestive and metabolic system, our bodies would be much larger and require many kilowatts to operate them."* Green Chemistry 1999

Advantages

Improve:

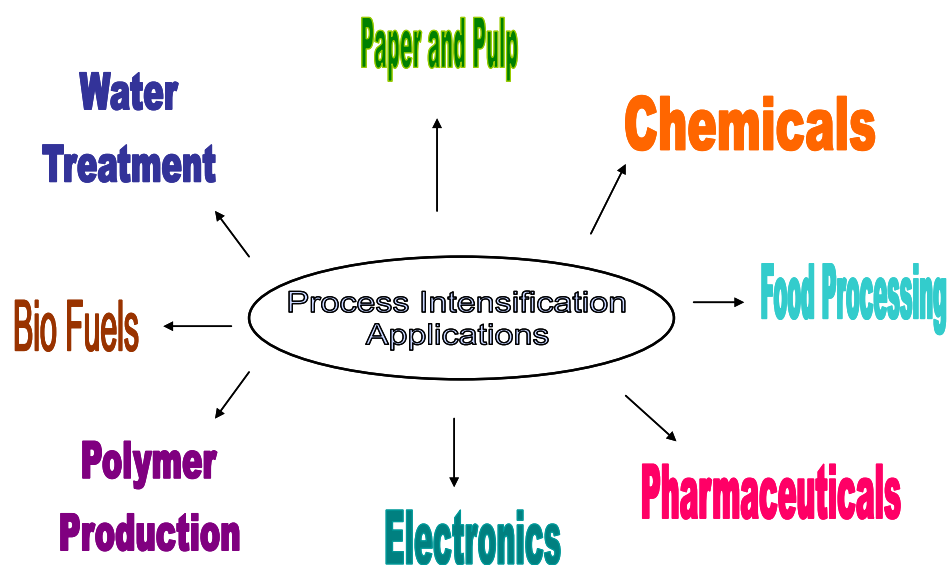
- Production rate
- Product quality
- Speed to market, as lab scale equals full scale
- Ability to change products according to market demand
- Process safety
- Environmental performance

Decrease (without impairing production rate):

- Energy use
- Solvent use
- Resources required
- Cost of processing systems
- Equipment size
- Waste levels
- Cost of waste treatment systems
- Downstream purification costs
- Downtime for cleaning

Also:

- Avoid typical scale-up problems (space, efficiency, equipment)
- Enable operation under severe process conditions not tolerated in conventional units



Changes from Traditional Processes

- Move from batch to continuous processing
- Use intensive reactor technologies with high mixing and heat transfer rates in place of conventional stirred tanks
- Consider opportunities to improve the process technology and underlying chemistry at the same time
- Combine two or more functions that usually are carried out in different equipment.
- Replace certain chemicals (including catalysts)
- Avoid, minimize or substitute solvents



Conventional

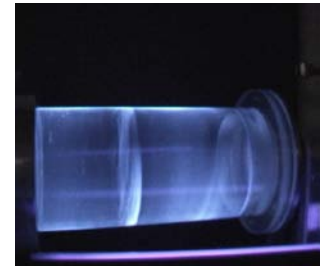
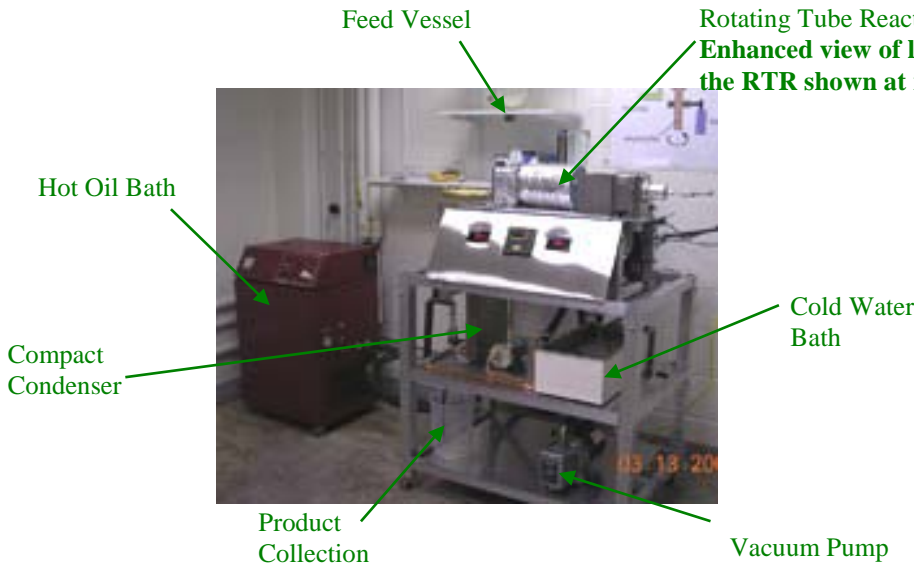


Intensified

Intensified process plants have already been piloted in several manufacturing facilities. A typical demonstration facility located at Clarkson University can be seen below and is capable of the following:

- Efficient solvent removal
- Rapid heating and cooling
- Polymerization
- Nano particle production

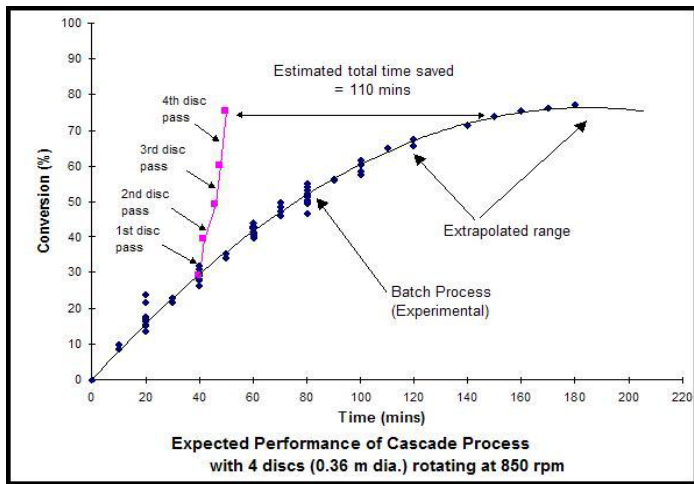
This demonstration facility has shown energy savings upwards of 30% for the above mentioned processes.



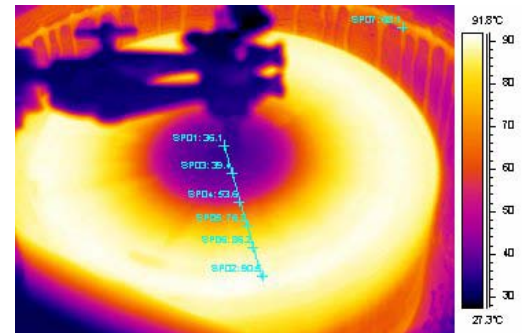
Demonstration Facility

PI Applications

- **Optimizing yield**
Plastics, Bio fuels
- **Avoiding solvents**
Electronics, Paper
- **Speeding to market**
Pharmaceuticals
- **Optimizing heat transfer**
Food Pasteurization



superior styrene polymerization rate (pink data points) via PI over conventional batch process



uniform thermal processing of mayonnaise on a thin film rotating reactor