Integrated Reactor Systems

- High heat flux capabilities
- High space-time yields
- Operating ranges from -200°C to +300°C
- Outperforms conventional reactors by up to 16 times
- Sustainable cooling rates above 2°C/min in full vessels
- Capacities from 1 L to 18,000 L

A new generation of reactors with high heat flux capabilities can now perform exothermic or endothermic reactions at a wide temperature operating range of –200°C to +300°C. These reactors are the key element in an integrated system that affords a typical pharmaceutical manufacturing facility the opportunity to reduce its operating costs while eliminating emissions of toxic, flammable and otherwise undesirable substances.

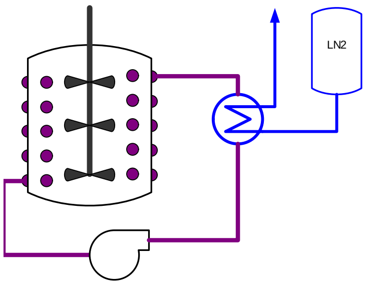
A state of the art unitary thermal delivery module is used to provide cooling or heating directly to the reactor externally at the vessel wall and internally within the reactor. This module uses working fluids that transfer energy while changing phase. The resulting constant temperature enables the specialized reactors to outperform conventional reactors by up to 16 times. Sustainable cooling rates above 2°C/minute and warm-up rates of up to 2°C/minute can easily be attained in full vessels. System capacities are available from 1L to 3000L for R & D facilities and pilot plant applications; 4000L and up for bulk pharmaceutical manufacturing.

Our reactors are designed to deliver fully scaleable performance ranging from 1L to over 12,000L. Existing reactor systems may be retrofitted to achieve lower temperature, additional heat transfer, better process temperature control and 'point of source' emission management.

Internal Cooling Integration

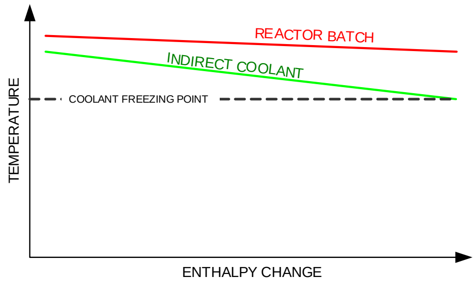
Standard reactor systems on the market today tend to rely on cooling methods that are inefficient at delivering refrigeration and ineffective at precise heat transfer control. These methods tend to involve circulation of a secondary working fluid through inner and/or jacket coils or circulation of coolants such as liquid nitrogen (LN_2) through inner and/or jacket coils.

These two methods are quite common because engineers attempt to employ designs that work at higher temperatures to low temperature applications. These methods, however, can only achieve limited performance and are not easily scaled up or down.

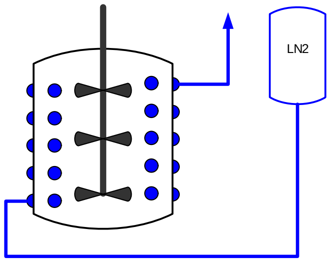


Typical Secondary Cooling

The circulating secondary fluid design can only work when higher desired reaction temperatures are needed. This is because most working fluids have higher freezing points than direct cooling using a working fluid that changes phase – at constant temperature - as it delivers refrigeration. The second problem with this method is that it relies solely on sensible cooling of the working fluid and therefore creates temperature gradients in the reactor unless perfect mixing is used.

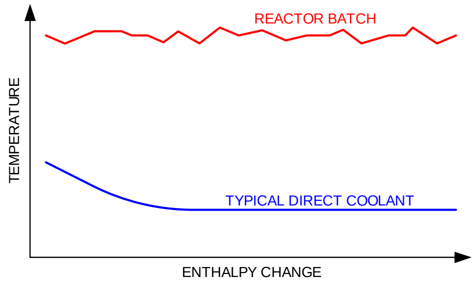


If we simply use a latent working fluid in typical half-pipe reactor jackets [and/or internal reactor coils] we address the issue of thermal driving force, however this is used in a highly ineffective way: in flowing pipes.

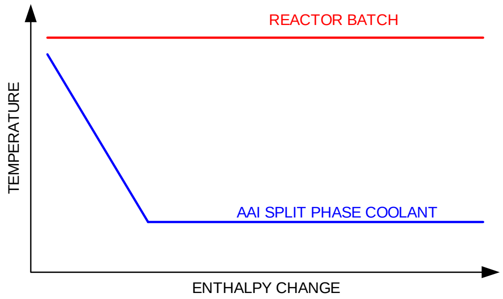


Typical Direct Cooling

When fluids that change phase [e.g. LN_2 or ammonia] are used for cooling, they of course boil off. But, when this occurs in a flowing pipe, regions of unstable two-phase flow and film boiling occur, which creates stability problems for the reactor and results in localized hot spots and poor temperature control.



The AAI reactor integrates a patented split-phase cooling method, which separates the working fluid [e.g. LN_2, ammonia, etc.] latent, isothermal heat transfer from the gaseous phase sensible heat transfer within the reactor cooling circuits. The result is efficiency, precise temperature control, large cooling duties, minimal gradients and total scalability.



Process Integration

Because of its total scalability and unique ability to precisely manage reaction conditions the reactor itself can handle multi-function operations. This means integrating several process steps into one system and eliminating complex and expense secondary unit operations.

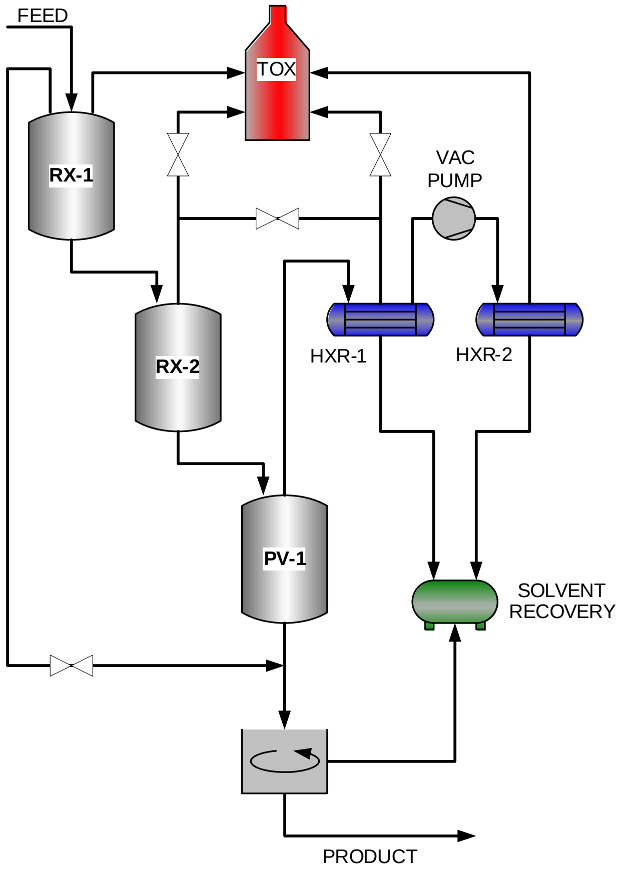
For processes with a high variability in batch sizes, a single system with flexible geometry is employed. This means that the upper section can be used when higher volume batches are needed, and the smaller diameter bottom only for small batch sizes.

Equal process performance is achieved in 10% - 100% of volume.

Figure-1

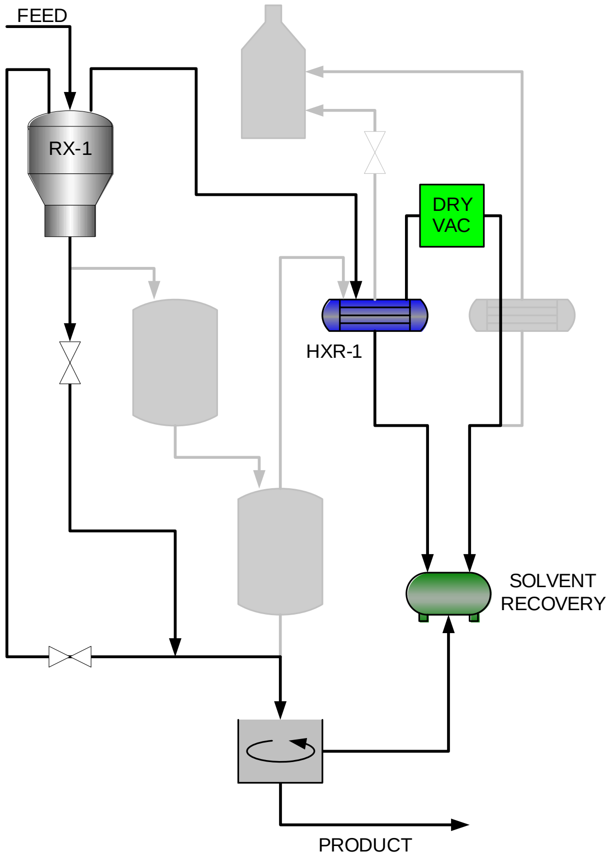
Typical process arrangements are compared to the integrated system below.

Typical Reactor Process



- RX-1, a high-alloy reaction vessel
- RX-2, a glass-lined reaction vessel wherein an intermediary (quench) reaction takes place
- PV-1, a glass-lined reaction vessel wherein vacuum distillation takes place (crystallization vessel)
- HXR-1, the main vacuum distillation condenser located upstream of the process vacuum pump
- HXR-2, a secondary condenser located on the discharge of the process vacuum pump, often called a “dry” vacuum pump based on high-speed close tolerance moving parts
- A centrifuge wherein the product is collected
- Single phase unitary heating / cooling system

Integrated Reactor Process



- RX-2, HXR-2, PV-1 and TOX are eliminated
- RX-1 is a multitask [patented] vessel designed to not only perform initial batch reactions but also undertake follow-up quench reactions otherwise tasked for RX-2 as well as the vacuum distillation step done in PV-1. RX-1 features flexible geometry (see Figure-1) and multiple heating/cooling circuits to maximize thermal response.
- The Arencibia Dry Vacuum system allows the integrated reactor system to make product with zero VOC emissions to the environment as well as provides for downstream beneficial & renewable utilization of the captured VOC
- Two phase unitary heating / cooling system

- Multiple Process Tasks, One Vessel
    - Hydrogenation
    - Acid Quenching
    - Evacuation
    - Crystallization
- Emergency Quench Feature
- Integral (Zero) Emissions Control
- High Space Time Yields
- High Allow Constructions
- Large Exotherm Capacity
- Integral Control System
- Flexible Capacity, 10% - 100%
- Turn-key Modular Design
- Integral active ingredient recovery

Contact Arencibia Associates, Inc. to learn more about Integrated Reaction Systems:

Arencibia Associates, Inc.
P.O. Box 248
Center Valley, PA 18034 USA
Tel: +1 610 282 2369
Fax: +1 610 282 1473
Email: info@arencibia.com
Web: www.arencibia.com