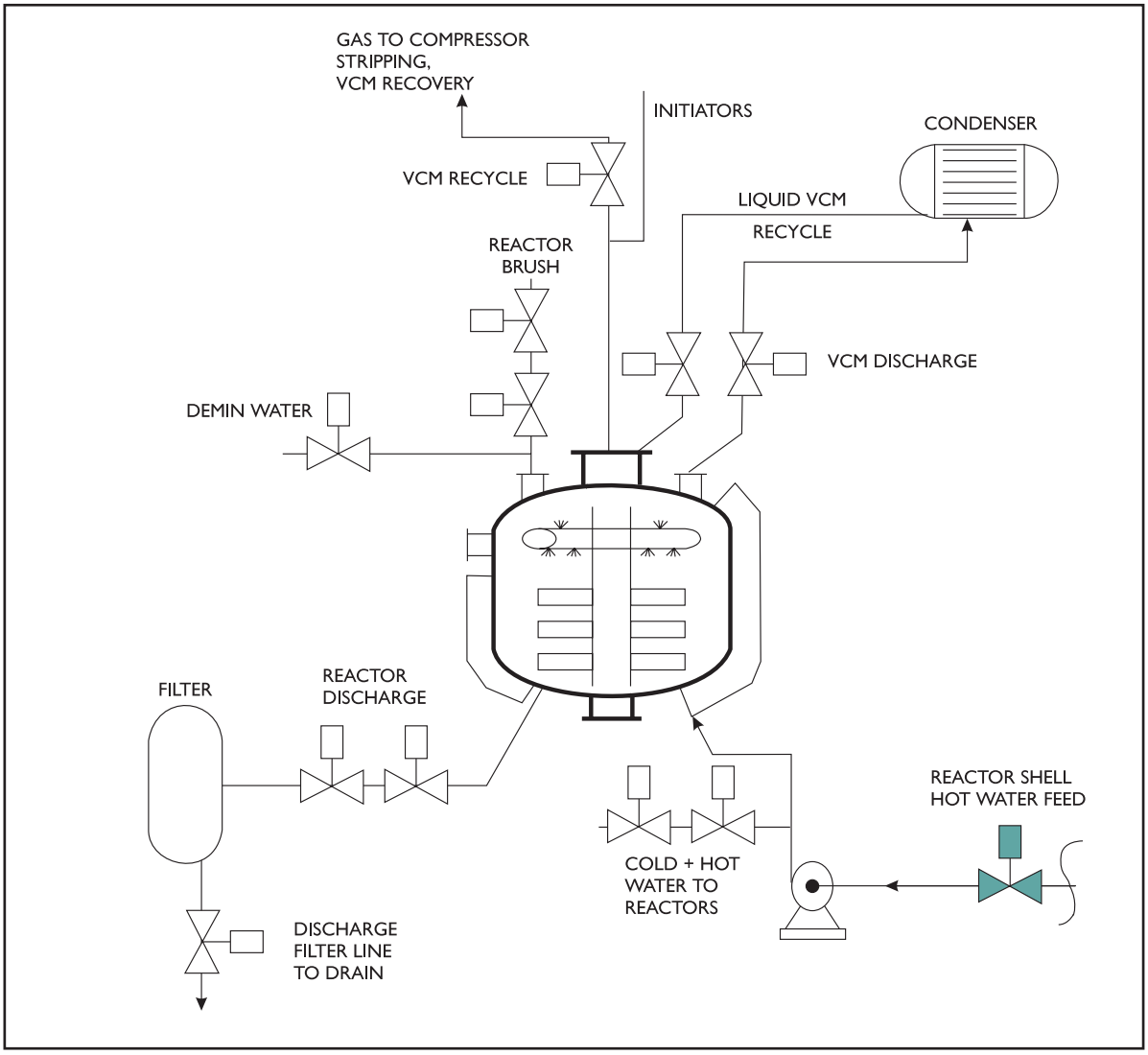
Polyvinyl chloride (PVC) reactor system



Introduction

Polyvinyl Chloride, or PVC, is the most important thermoplastic polymer after the polyolefins (polyethylene, polypropylene, etc.). It is produced as either a rigid or flexible (plasticized) material.

Rigid PVC is used to produce:

- ❑ Piping
- ❑ Automobile parts
- ❑ Roofing tiles

Flexible PVC is used to produce:

- ❑ PVC sheet
- ❑ Wire and cable coating
- ❑ PVC floor covering
- ❑ Automobile upholstery
- ❑ Furniture

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The demand for PVC is therefore affected by the:
- ❑ Building industry
- ❑ Automobile industry
- ❑ Consumer consumption

There are many applications for valves in this process, and this paper will introduce some of the applications and solutions proposed. The technology described is from Atochem, but the valve solutions can be applied to other technologies as well.

The PVC reactor is a batch process, where each cycle consists of:
- ❑ Reactor feed
- ❑ Hot water to reactor shell
- ❑ Vinyl chloride discharge to condenser
- ❑ PVC reaction
- ❑ Recycling of recuperated vinyl chloride
- ❑ PVC discharge through filters
- ❑ Reactor cleaning
- ❑ PVC product finishing

It is important to note that due to the carcinogenic nature of vinyl chloride, extra precautions must be taken to avoid leakage to atmosphere. In all of the following applications containing vinyl chloride, the valves were helium tested for tightness. As an extra measure, valve stem packing, tested to TA-Luft, is available.

Reactor feed

The reactor feed is a fairly simple application, with a requirement for tight shut-off and small flows, Standard Metso Automation series 3000 ball valves are used to provide a low cost, reliable solution.

During the PVC reaction, the enthalpy of the reaction is removed through the reactor shell and through discharge to a condenser.

Reactor shell water circulation

The hot water feed to the reactor shell is a service which can present cavitation and noise problems. Process conditions are normally:
- ❑ Water at 95 °C / 203 °F
- ❑ Flow: 300-400 m3/h
- ❑ Pressure: 2 bar / 29 psi
- ❑ Pressure drop to atmosphere.

In order to avoid the cavitation, noise, and resultant vibration, a rotary X series ball valve with Q-Trim was proposed.

The benefits are:
- ❑ Q-Trim breaks down pressure gradually to reduce noise and cavitation
- ❑ Rotary ball valve provides maximum flow capacity
- ❑ Capacity reduces time required to fill shell.

VCM discharge to condenser

Residual Vinyl Chloride Monomer (VCM) is discharged to a condenser during the reaction, to stabilize the process. Process conditions are usually:
- ❑ Medium: VCM gas
- ❑ Pressure: 1 bar / 14,5 psi
- ❑ Temperature: 65 °C / 149 °F

This application tended to block the former valve, due to unreacted polymer in the fluid. A cooling jacket was mounted around the Metso Automation segment valve, which inhibited the reaction and eliminated the valve blockage.

The benefits are:

Increased production due to:
- ❑ Tighter controllability with segment ball valve rangeability
- ❑ Tight shut-off eliminating loss of product
- ❑ Reduced loss of energy through high capacity flow path
- ❑ Reactor stoppages caused by valve blockage eliminated.

Recycling of VCM gas

VCM gas, recuperated from the reactor, is recycled to compressors for use in the next reaction cycle. The tightness of the VCM recycle valve is critical, as any loss of gas during the reaction could effect the product quality. In this application a flanged ball valve was installed, and helium tested for tightness.

- ❑ Medium: VCM gas
- ❑ Flow: 1500 kg/h
- ❑ Pressure: 10,7 bar / 155 psi
- ❑ Temperature: 95 °C / 203 °F

Reactor discharge

This is the most difficult application due to the viscosity and stickiness of the PVC product. The PVC discharge process conditions are usually:
- ❑ PVC in 2 phase flow
- ❑ Flow: 400 m3/h
- ❑ Temp.: 65 °C / 149 °F
- ❑ Pressure: 1 bar / 14,5 psi
- ❑ Density: 1100 kg/m^3

In this application, the segment ball valve selected actually increased production and reduced the maintenance required dramatically. The Metso Automation segment valve presents a larger bore area than any other valve of this configuration, and a polished inner surface further improves the flow. The valve was helium tested for tightness.

The benefits are:
- ❑ Maximum capacity for discharge of reactor
- ❑ Cutting and cleaning action of ball and seat eliminate wear and valve blockage
- ❑ Bubble tight shut-off maintains reactor process conditions during reaction
- ❑ Optional polished valve body inner surface reduces adherence of product.

PVC reactor wash

The reactor is washed out after each cycle, using demineralized water usually at the following process conditions:
- ❑ Demineralized water at 20/30 °C / 68/86 °F
- ❑ Flow: 20 m3 /h
- ❑ Pressure: 12 bar / 174 psi
- ❑ Temp.: 20/30 °C / 68/86 °F

A full ported ball valve installed in this application provides the unrestricted flow required, and helium testing assures the tightness required to avoid leakage of the water into the reactor during operation.

The benefits are:
- ❑ Full ported ball valve provides maximum capacity for rapid cleaning
- ❑ Bubble tight shut-off assures integrity of reactor process conditions.

PVC reactor cleaning

The reactor wash is an important element of the cycle, to prepare the reactor for the next charge of product. The cleaning brush used to wipe out the reactor internals comes into contact with PVC and unreacted VCM. The brush must be isolated after cleaning, to avoid having the waste drop back into the reactor, and to isolate the carcinogenic VCM.

Steam stripping

On some PVC processes, the VCM is steam stripped, or removed from the reacted PVC by injection of slightly superheated steam at 185 °C / 365 °F and 10 bar / 145 psi. The steam strips the unreacted VCM, which is purified and recycled as mentioned previously. This also prevents fugitive VCM emissions further downstream.

A metal seated X series ball valve with a unique scraping seat is used in order to avoid build-up of PVC on the reactor side. This “J” style seat prevents PVC from accumulating behind the seat and scrapes off any build-up on the ball in the seating area.

- ❑ Fluid: Steam
- ❑ Temp: 185 °C / 365 °F
- ❑ Pressure: 10 bar / 145 psi

Valve applications

Related application bulletin	Code	Issue
Reactor Shell Water Circulation	2722/14/01	3/03
VCM Discharge to Condenser	2722/14/02	3/03
Reactor Discharge	2722/14/03	3/03
PVC Reactor Wash	2722/14/04	3/03
PVC Reactor Cleaning	2722/14/05	3/03
Steam Stripping	2722/14/06	3/03

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