PROTENSIVE

Spinning Disc Reactors

The Spinning Disc Reactor (SDR) is a new technology - steadily becoming more acknowledged by the chemical production industry.

This technology allows processing to be carried out on a rotating disc, using thin fast-moving films.

The liquid flowing on the rotating disc tends to form waves, and these together with the hydrodynamic characteristics of the fluid flow result in -

- Low inventory within the reactor providing intrinsic safety.
- High liquid surface-to-volume ratios that can be maintained during scale-up.
- Rapid heat and mass transfer.
- Plug flow - every molecule has the same experience.
- Intense mixing environment.
- Control of crystal and particle sizes and shape (with narrow size distribution).

This technology is now brought to you from Protensive Limited the world leaders in this technology holding a range of patents in this and other intensified technologies. With their highly experienced team of chemists, chemical engineers and innovative thinkers, they can -

a. Carry out tests to validate the technique with your materials and reactions.
b. Help you to develop the application to semi-technical and then production scale operations.-
c. Supply a wide range of standard bench-top systems for laboratory use.
d. Design and supply special larger systems for production and semi-technical use.
e. Provide a variety of dedicated accurate feed systems and control systems.

This brochure describes some of the standard systems and gives examples of their use.

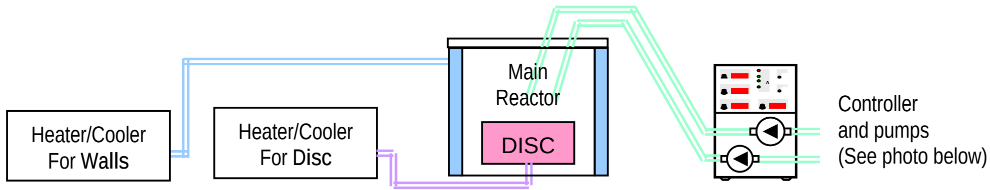
Two bench-top Spinning Disc Reactors are shown with their associated

1. Controlled Temperature bath(s) - The choice here is a function of
   a. Disc temperature range required
   b. Wall temperature range required
2. Feed pumps Control system – are shown on the next page

These novel reactors with their short residence times need to be matched with customers' processes. It is rarely appropriate to try to operate SDRs under the same conditions as batch reactors. Protensive have considerable skills and experience in this area and should be consulted.

Standard Systems

A typical system will consist of –



1. **Main Reactor**, with its spinning disc

Standard systems are available for both laboratory use and semi-technical plants.

SDR Type	Disc Diameter	Description	Typical max throughput	
			Kg/hour	Tonnes/year*
101	10 cm	Lo-cost Laboratory (for use at atmospheric pressure only)	10	80
102	10 cm	Small Laboratory **	10	80
201	20 cm	Medium Laboratory **	60	480
302	30 cm	Lab/Semi-Technical plant Unit **	150	1200

- Annual throughput (wet product) calculated on operating 8,000 hours per year.

** These units are designed for use under vacuum and under pressure (see Technical Specifications)

The choice is defined by the processes to be carried out (pressure / temperature / speed), the required throughput of materials, the number of feeds required, if counterflow gas is needed etc.
Protensive can help you choose.

Integrated SDR Controller and Pump(s) system

2. **System Controller** provides a compact integrated controller to –

a) Control the disc speed
b) Monitor the vessel pressure
c) Control the feed speed from one or two integral feed pumps.

This advanced control system offers (as selected by the operator) both

i) completely manual control, and
ii) computer control via a USB interface

Controller Type ONE PUMP	Controller Type TWO PUMPS	Pump Specification			
		Min typical throughput	Max typical throughput	Min typical throughput	Max typical throughput
P-20		No pumps – this unit provides reactor control only			
P-21-L	**P-22-L**	0.3 ml/s	3.5 ml/s	1 kg/hour	12 kg/hour
P-21-M	**P-22-M**	0.5 ml/s	7 ml/s	1.8 kg/hour	25 kg/hour
P-21-H	**P-22-H**	2.5 ml/s	24 ml/s	9 kg/hour	86 kg/hour

The choice is defined by the processes to be carried out, the required throughput of materials, and the number of feeds required. Protensive can help you choose.

3. **Controlled Temperature Circulators** –

A range of units are available to provide heating and cooling of the disc surface (reaction temperature) and where necessary separate heating and cooling of the vessel walls to control the exit liquid temperature.

4. **Computer control** and monitoring are available (with the latest USB port interface).
This option allows control of the system as well as data logging and automatic control of the system (e.g. the stoichiometric ratio between the feeds can be set)

Remember - Protensive are happy to help with all aspects in choosing your system.

Technical Specifications

Reactor Types 102 and 201

- **Standard system** can be used with pressures to 8 bar absolute or under vacuum.
  All systems are individually pressure tested prior to dispatch.
  A pressure relief valve is included, as is pressure measurement and indication.
- **Temperatures** - Reaction on the disc and separate control for the walls (if required) from -20°C to + 240°C (depending on the system specification and heat/cool systems used).

  REMEMBER because the processing takes only a fraction of a second, much higher reaction temperatures than a conventional reactor can be used and are recommended to obtain the maximum benefit of this technology
- **Speeds** - continuously variable from 300 to 3,000 rpm.
- **Instrumentation**
  - Pressure monitoring and display (Bar absolute)
  - Disc speed set, on/off and indication (rpm)
  - Feeder speed set, on/off and indication (ml/s) for each feed system
  - Full interfaces for the computer control and data logging (***Option C1***).
- **Ports in cover** provided (as standard) - others can be designed and manufactured for your applications.
  - THREE feeds (usually one or two liquids and Nitrogen gas)
    (with special geometry to ensure the correct feed position on the disc)
  - Reaction gas feed point
  - Pressure monitoring point
  - Gas/nitrogen Bleed valve
  - Vacuum port
- **Outlet port** provided (as standard) –

  With our unique design which allows sampling and removal of product during a rin without affecting the vacuum or pressure within the vessel.
- **Materials of construction**

  As standard, all contact parts excluding the disc surface are manufactured from 316 Stainless Steel with PTFE composite seals. The disc surface may be supplied in either 316 stainless steel, or chrome coated copper.
- **Options**

  A wide range of are available, including heat/cool systems, pulse-free feed systems.
  - Disc and vessel wall heating and cooling systems.
  - The special “PT high-heat-transfer” disc systems.
  - Dedicated Feed systems.

Reactor Type 302

As above, except that as standard, The maximum pressure is 5 bar absolute and the disc speed is 150 to 1500 rpm

Reactor Type 101

As above, except that this unit is designed as a low-cost system to operate at atmospheric pressure only.

Protensive can also use their wide experience to design and manufacture **bespoke systems**

- Special materials (e.g. Titanium)
- High temperatures (up to 400°C).
- Larger systems (e.g. for plant and production use).

Technical Specification – Standard Feed systems

- As standard, the feed pumps are constructed from 316 stainless steel with carbon gears.
- Maximum temperature for continuous running is 80°C.
- Pump heads are individually earthed to allow use with solvents.

Other specifications, including special pump materials, different ranges of throughputs etc are available.

Sizes (cm) and weights (kg)

	width	height	depth	weight		Width	height	depth	weight
Type 101 & 102	26	42	33	35	**Type 302**	48	49	42	54
Type 201	38	45	36	42	**Controller**	19	27	33	13

Typical Applications

Spinning Disc Reactors are of great use in many applications. The examples given here are a few from the many applications already successfully carried out using this technology.

Crystallisation and Precipitation

The powerful vapour-stripping characteristics of the spinning disc reactor, arising from the thin turbulent liquid film on the disc surface, can be used to create a very useful precipitation technique.
In combination with the plug flow characteristics of the spinning disc reactor, this can offer -

a) Excellent control over particle size selection, together with

b) A relatively narrow particle size distribution.

Enhanced mass transfer to the thin liquid film from a gas above can also be a useful technique to produce precipitates with a narrow particle size distribution.

Exothermic Reactions

Fast exothermic reactions can be conducted in the thin turbulent film on a spinning disc reactor, using much higher temperatures than could be contemplated in stirred tanks.
This is because the superior heat transfer performance of the unit -

a) Carefully controls temperatures, and

b) Concludes reactions in a residence time of just 1 to 2 seconds.

Inventories in the disc chamber are relatively tiny, making trivial the consequences of any localised run-away.

Material exiting the disc chamber can be cooled as it descends the disc chamber walls, and transferred to storage or further processing under safe conditions.

This combination of excellent control and low inventory can lead to higher yields in an inherently safe system.

Stripping of Volatile Components from Polymers

Polymers are often manufactured in a solvent or in solution in their monomer. These solvents need to be removed before the polymer is sold. However removal of the solvent or monomer to very low levels is difficult in traditional equipment because the small molecules are trapped in the bundled polymer chains and despite the use of vacuum and temperature their removal is problematic.

The SDR with its combination of shear and film draw enables residuals to be removed to very low levels.
For example industrial polystyrene has a styrene level of about 500ppm, and this can be reduced to less than 50ppm by treatment on a disc.

This technique offers an important breakthrough for polymers in food packaging applications

Heat treatment

Raw milk needs to be heated to a specified temperature for a particular time in order to treat it.
This process is classically carried out on plate heat exchangers, but build-up on the plates makes cleaning a significant issue.

The SDR with its self-cleaning characteristics and excellent heat transfer performance (overall coefficients at least 10kW/m2/K) is a tenable alternative.

We have also developed in-situ non evasive cleaning techniques where these are required.

The apparatus described here and its applications are covered by patents which include -

WO 00/48728	WO 00/48730	WO 00/48731	WO 00/48732
WO 00/48729	WO 01/60511	WO 03/008083	WO 03/008460

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