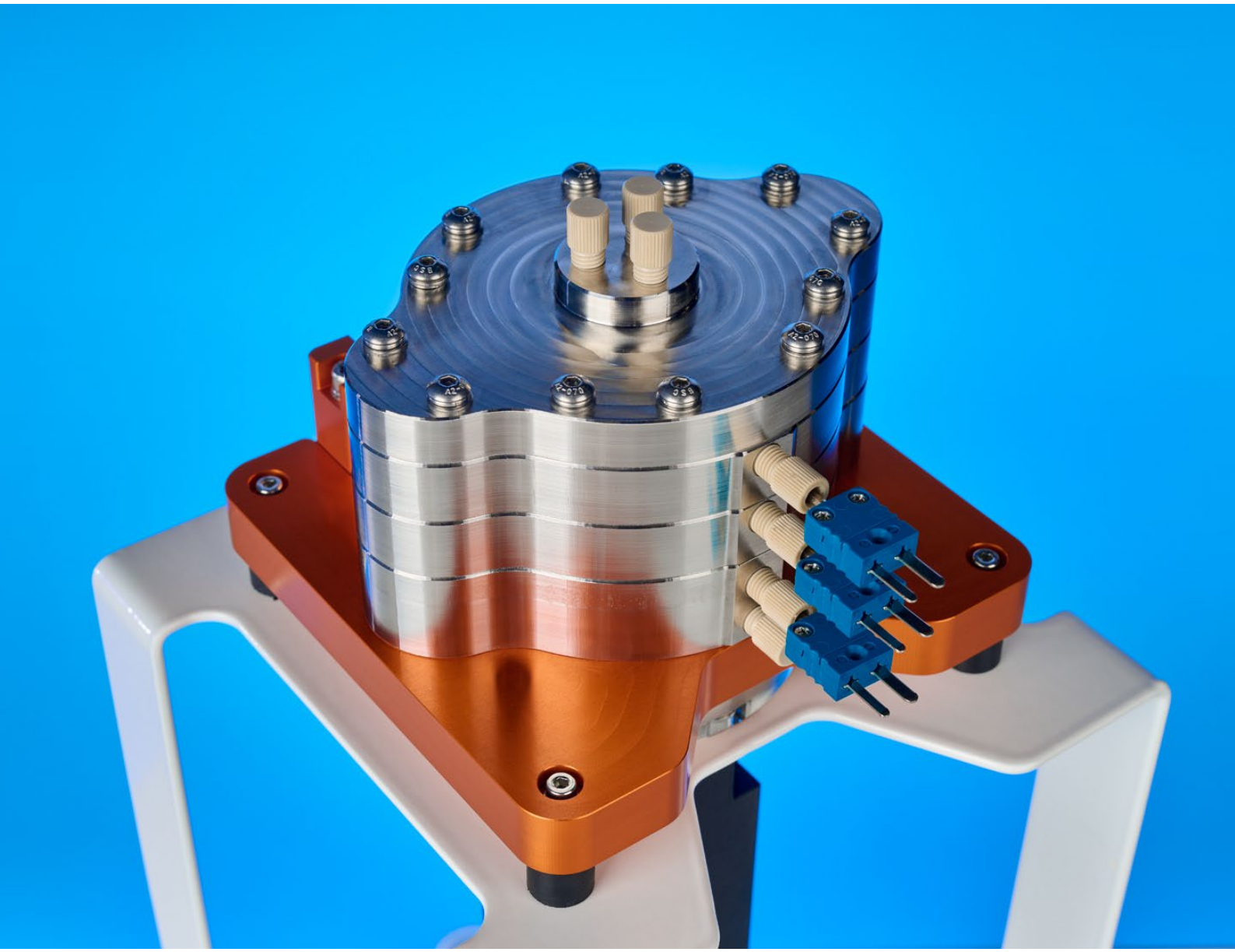
Product Information

SpinPro R2 Reactor



Contents

1.	**Introduction**	**3**
1.1	SpinPro Technology	3
1.2	Applications and Advantages	3
2.	**Reactor Design and Working Principle**	**6**
2.1	SpinPro R2 Overview	6
2.2	Process-Side Flow Path and Connections	6
2.3	Utility-Side Flow Path and Temperature Control	7
2.1	Scalability	7
3.	**Technical Specifications**	**8**
3.1	General Specifications	9
3.2	Electrical Power Requirements	10
3.3	Peripherals	10
3.4	Environment	10
4.	**Hydrodynamics and Mixing**	**11**
4.1	Flow Characteristics	11
4.2	Hydrodynamic Flow Regimes	12
4.3	Transition Radius	13
4.4	Residence Time Distribution (RTD)	14
4.5	Residence Time and Equilibration	15
4.6	Multiphase Mixing and Mass Transfer	15
5.	**Hydraulic Performance**	**16**
5.1	Process-Side Pressure Drop	16
5.2	Utility-Side Pressure Drop	17
6.	**Thermal Performance**	**18**
6.1	Heat Transfer Mechanism	18
6.2	Overall Heat Transfer Coefficient	18
6.3	Heat Generation by Viscous Dissipation	19
7.	**Contact**	**20**

1. Introduction

1.1 SpinPro Technology

SpinPro reactors are a type of chemical reactors called “dynamic flow reactors”. They combine the advantages of flow chemistry and continuous manufacturing with active agitation and high shear mixing. This leads to excellent heat and mass transfer rates in a very compact and hermetically closed system. In comparison with batch reactors or conventional flow reactors, the SpinPro excels at performing multiphase reactions, highly exothermic reactions and allows for accurate control in emulsification processes. Moreover, the SpinPro has proven its reliability in handling slurry feeds, precipitations and highly controllable continuous crystallizations.

The SpinPro R2 is a three-stage dynamic flow reactor based on rotor-stator spinning disc technology. It features three rapidly rotating discs (rotors), each with a diameter of 70 mm, enclosed within narrow stationary housings (stators). The rotor-stator gap is 0.5 mm. The modular reactor architecture provides an internal process volume of approximately 5 mL per stage.

The narrow rotor-stator gap combined with high disc speed generates intense shear and turbulence. These conditions promote rapid micromixing and the formation of fine droplets or bubbles in multiphase systems, thereby creating a large interfacial area for mass transfer. The reactor stages are integrated with dedicated utility channels to provide efficient heat removal or heat input close to the process fluid.

In conventional static flow reactors, mixing and transport performance are strongly linked to throughput. In the SpinPro, the imposed throughflow primarily determines residence time, while disc speed independently provides an additional handle on shear, turbulence and heat-transfer intensity. This decoupling enables a wider operating window for process development and scale-up.

1.2 Applications and Advantages

Key Advantages at a Glance

SpinPro combines advanced reactor technology with practical manufacturing benefits, delivering a powerful solution for efficient, flexible, and intensified continuous processing.

SpinPro Advantage	Customer Benefit
High-intensity micromixing	Faster reactions and enhanced mass transfer performance
Exceptional heat transfer	Precise temperature control and reduced cooling requirements
Dynamic solids handling	Reduced clogging risk and reliable processing of solids-containing streams
Independent shear control	Greater flexibility in process optimization and a wider operating window
Precise droplet and particle control	Consistent product quality and narrow size distributions
Compact, fully enclosed design	Reduced equipment footprint and lower process inventory
Continuous process intensification	Improved productivity and reduced capital and operating costs
Flexible start-up and cleaning	Efficient product changeovers and greater manufacturing flexibility

Proven Technology for Demanding Chemical Processes

SpinPro dynamic flow reactors are designed to tackle some of the most challenging processes in the chemical and pharmaceutical industries. With successful applications in production facilities worldwide, SpinPro technology combines exceptional mixing performance, efficient heat transfer, and precise process control to unlock new opportunities for continuous manufacturing.

From fast multiphase reactions and highly exothermic chemistries to solids handling, emulsification, and controlled crystallization, SpinPro offers a versatile platform for process intensification, enabling more efficient, reliable, and cost-effective production.

Multiphase Reactions – Accelerating Gas-Liquid Chemistry
Maximize mass transfer. Minimize reaction time.

SpinPro's high-shear mixing technology creates finely dispersed gas bubbles, dramatically increasing the interfacial area between gas and liquid phases. Combined with intense turbulence and rapid micromixing, this enables exceptional mass transfer performance, overcoming one of the major limitations of conventional reactors.

By accelerating gas-liquid mass transfer, SpinPro reduces reaction times from hours to seconds in suitable chemistries, increasing productivity and enabling more compact processing equipment.

Typical applications: Gas-liquid reactions involving Cl_2, CO, CO_2, H_2, H_2S, HCl, O_2, and SO_2.

Exothermic Reactions – Efficient Thermal Control for Demanding Chemistry
Manage reaction heat. Expand your operating window.

Highly exothermic reactions require fast and reliable heat removal to maintain process control and minimize unwanted side reactions. SpinPro's compact rotor-stator geometry, combined with efficient heat-transfer channels, enables rapid heat removal directly from the reaction zone.

This exceptional thermal performance enables operation at less extreme temperatures for selected processes, reducing reliance on expensive cryogenic cooling systems and improving overall process economics.

Typical applications: Organometallic reactions, chlorinations, nitrations, oxidations, and polymerizations.

Slurries and Precipitates – Continuous Processing Without Conventional Clogging Limitations
Handle solids with confidence. Keep your process moving.

Handling solids is one of the most significant challenges in conventional flow chemistry. SpinPro's dynamic mixing environment helps prevent particle settling and reduces the risk of solids accumulating within the reactor, addressing common causes of fouling and blockage in static flow systems.

This makes SpinPro particularly attractive for processes involving in-situ precipitation. By extending continuous processing capabilities to solids-containing streams, SpinPro opens new possibilities for chemistries traditionally considered difficult to implement in flow.

Typical applications: Organometallics (e.g. lithium or magnesium based), KOH, NaOH, organic and inorganic precipitations.

Emulsification – Precision Droplet Control for Consistent Product Quality
Create finer dispersions. Achieve greater consistency.

SpinPro's high-shear rotor-stator technology generates finely dispersed droplets, creating a large interfacial area and promoting rapid, efficient mixing between immiscible liquid phases.

Unlike conventional static flow systems, SpinPro allows shear intensity to be adjusted independently of throughput. This additional degree of control enables precise optimization of emulsification conditions, supporting narrow droplet-size distributions and consistent product characteristics.

The combination of controlled droplet formation and continuous operation makes SpinPro a powerful platform for applications where dispersion quality, reproducibility, and product uniformity are critical.

Typical applications: Emulsion polymerization, food processing, vaccine formulation, oil-in-water and water-in-oil emulsions, and nanostructured assemblies.

Continuous Crystallization – Engineered Particle Size Control
Control nucleation. Optimize particle characteristics.

Achieving consistent crystal and particle properties is essential in many specialty chemical and pharmaceutical processes. SpinPro combines intense micromixing with efficient heat transfer to provide precise control over temperature and concentration gradients during continuous crystallization.

These conditions promote rapid and uniform primary nucleation while limiting subsequent crystal growth, delivering controlled particle-size distributions and consistent product quality.

By offering an additional level of control over crystallization dynamics, SpinPro improves product consistency, streamlines downstream processing, and supports robust continuous crystallization processes.

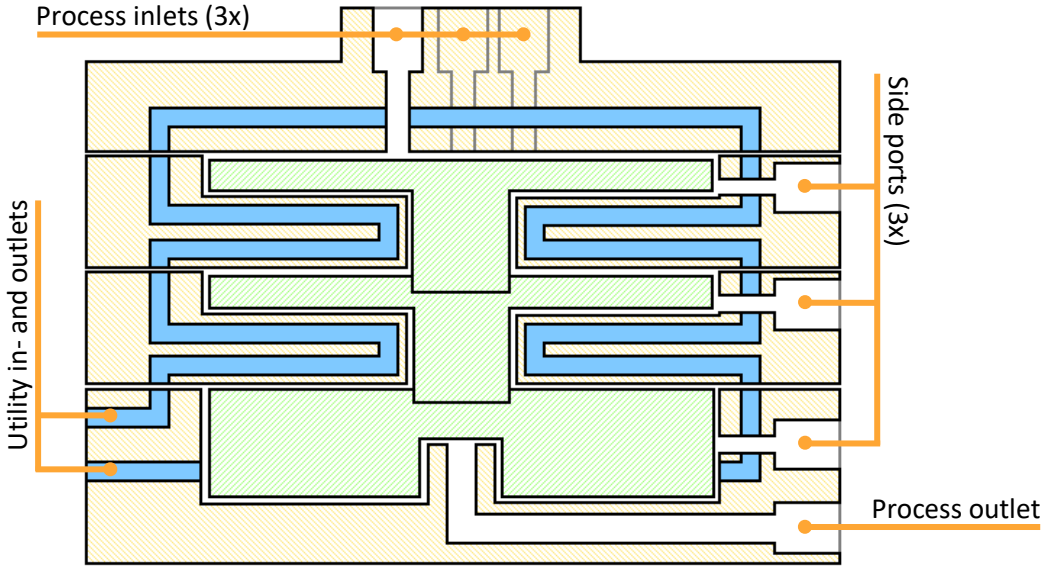
Typical applications: Cooling crystallization, aqueous (organic solvent-free) reaction systems, solvent/antisolvent crystallization, and ion-pair precipitation.

Performing your chemical processes in SpinPro leads to more efficient, more economical and intrinsically safer processes. In turn, this will significantly reduce investments (CAPEX) and operations costs (OPEX). Quality is improved, the yield can be increased with less byproduct formation and a general improvement on final product properties. Some processes can even be performed undiluted, saving tremendously on laborious workup steps, energy and solvent costs. Further advantages are found in the rapid and easy procedures for shut-down, cleaning and start-up. This allows production planning to rapidly switch between different products in the same installation.

2. Reactor Design and Working Principle

2.1 SpinPro R2 Overview

The SpinPro R2 is shown here in a three-stage configuration. Three rotating discs are mounted on a common central shaft and enclosed by stationary reactor plates. Integrated utility channels surround the process zones to provide heating or cooling throughout the reactor. The cross-sectional schematic below shows the main components, flow paths and connection locations.



Cross-sectional schematic of the three-stage SpinPro R2 showing rotating components, stationary housing, process channels and utility channels.

The schematic uses the following color coding:

Green: rotating components (rotors and central shaft).
Yellow: stationary reactor components (stators and housing).
Blue: utility channels for heating or cooling.
White: process channels and process connections.

2.2 Process-Side Flow Path and Connections

The process fluid enters through the central inlet at the top and passes sequentially through the reactor stages. Within each stage, the fluid is directed radially outward through the narrow gap above the rotating disc. At the disc perimeter, the flow turns and returns radially inward through the gap below the disc before entering the next stage. This alternating outward-inward flow pattern is repeated through the reactor before the process stream leaves through the bottom outlet.

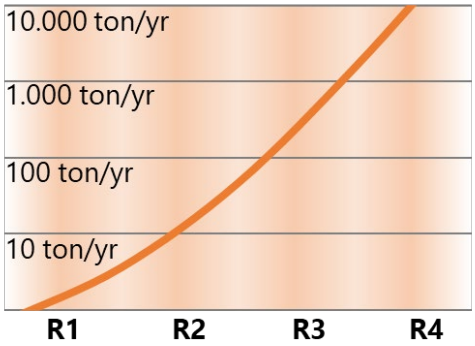
Additional process ports are positioned at the top and at the outer perimeter of the individual stages. These connections allow additional feeds, sampling or alternative process configurations where required. The exact port allocation should be defined for the supplied reactor configuration.

2.3 Utility-Side Flow Path and Temperature Control

The integrated utility channels are distributed through the stationary reactor plates and run in close proximity to the process channels. A temperature-controlled utility fluid circulates through these channels, creating a large heat-transfer area and a short conduction path between the process and utility sides.

The utility inlet and outlet are located on the side of the reactor and are hydraulically isolated from the process channels. The ports are connected to an external temperature-control unit for heating or cooling.

2.1 Scalability



SpinPro reactor platform scalability from laboratory development to production.

The SpinPro reactor platform is designed to support scale-up from laboratory development to production. Scale-up is based on maintaining the characteristic rotor-stator hydrodynamics and transport mechanisms across the SpinPro range, rather than relying solely on geometric enlargement.

3. Technical Specifications

The SpinPro R2 system consists of a compact reactor module and a dedicated control unit.

Reactor Module

The SpinPro R2 reactor includes an integrated servo motor and temperature sensor for precise process control.

- Dimensions (L × W × H): 200 × 200 × 448 mm

Temperature Measurement

The system is equipped with a custom-designed 3-wire PT100 temperature sensor with an M12 electrical connection.

- Direct temperature measurement inside the reactor or tubing
- Pressure-tight integration for reliable operation under process conditions
- Real-time temperature display via the control module

Control Module and HMI

The control module houses the drive electronics and provides operator control via an integrated Human Machine Interface (HMI).

- Cabinet dimensions (L × W × H): 370 × 160 × 350 mm
- Integrated 24 VDC power supply
- Designed to control the servo motor of the SpinPro R2

Power requirements:

- Supply: 230 VAC, single phase, 50/60 Hz
- Maximum current: 16 A

Electrical cabinet Includes

- Mains power input with fuses
- 24 VDC power supply
- Controller with integrated HMI
- Start/stop control
- Speed control via potentiometer
- Servo drive (amplifier) for motor control
- Connector for temperature sensor



3.1 General Specifications

Module size	SpinPro R2 Reactor: L × W × H: 200 × 200 × 448 mm Control Module and HMI: L × W × H: 370 × 160 × 350 mm
External size reactor	d = 100 mm, h = 50 mm
Disc diameter	70 mm
Distance between rotor and stator (gap)	0.5 mm
Material reactor	Hastelloy
Material static O-rings	FFKM
Dynamic seals	None. Magnetically coupled
Bearing	PTFE / Silicon Carbide Ball bearing
Rotation speed	1000 - 6000 RPM
Number of stages	3
Internal volume	One stage configuration: 5 ml Two stage configuration: 10 ml Three stage configuration: 15 ml
Operating Pressure	Up to 10 barg
Operating Temperature	-20 to 140 °C
Flow rate	0 to 200 mL/min
Process Connections	3× top inlet: 5/16-24 flat bottom threaded 3x side inlet: 5/16-24 flat bottom threaded 1x bottom outlet: 5/16-24 flat bottom threaded 2x temperature control fluid: 3/8” NPT(F)

Due to its small volume and maximum operating pressure, the SpinPro R2 is classified under the category ‘Article 3 Paragraph 3’ of the Pressure Equipment Directive (PED). The device complies with sound engineering practice and is supplied with a manufacturer declaration of conformity, conform PED.

3.2 Electrical Power Requirements

The SpinPro R2 requires 230 VAC single phase 50/60 Hz max 16A.

3.3 Peripherals

No peripherals are supplied with the SpinPro as a standalone product. However, if required, pumps or other peripheral process equipment can be supplied.

3.4 Environment

The user must wear Personal Protective Equipment (PPE), in the working environment in which the unit is installed. Country specific regulations, standards and directives applicable to the area of work and the involved chemistry must be observed.

The following environmental conditions must be observed (based on the drive):

- Environmental temperature: 0 to 50 °C
- Environmental humidity: 5 to 95 % (non-condensing)
- Storage temperature: -25 to 75 °C
- Altitude: 1,000 m above sea level
- Pollution degree: 2 according to EN 60204/EN50178

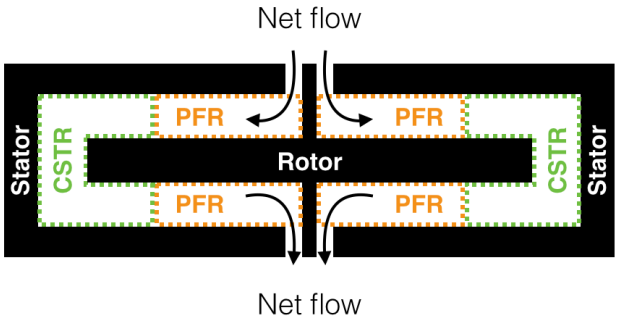
NOTE: Upon storage the reactor must be free of reagents and solvents

4. Hydrodynamics and Mixing

4.1 Flow Characteristics

The SpinPro R2 is based on rotor-stator spinning disc technology, in which a rapidly rotating disc operates in a narrow gap between stationary surfaces. The high tangential velocity of the rotor generates strong shear and, above the relevant transition, turbulent motion in the process fluid. The superimposed process throughflow introduces an additional radial velocity component, so the local hydrodynamics are determined by the interaction between rotation and throughflow.

Within each stage, two characteristic macromixing regions can be distinguished. Near the rotational axis, the imposed throughflow is dominant and the fluid follows a more plug-flow-like path. Towards the outer radius, rotational motion becomes dominant and stronger recirculation and backmixing occur, giving the region more CSTR-like behavior. The boundary between these regions is described by the transition radius. Across three stages, the reactor can therefore be represented as a sequence of plug-flow-like and mixed volumes.

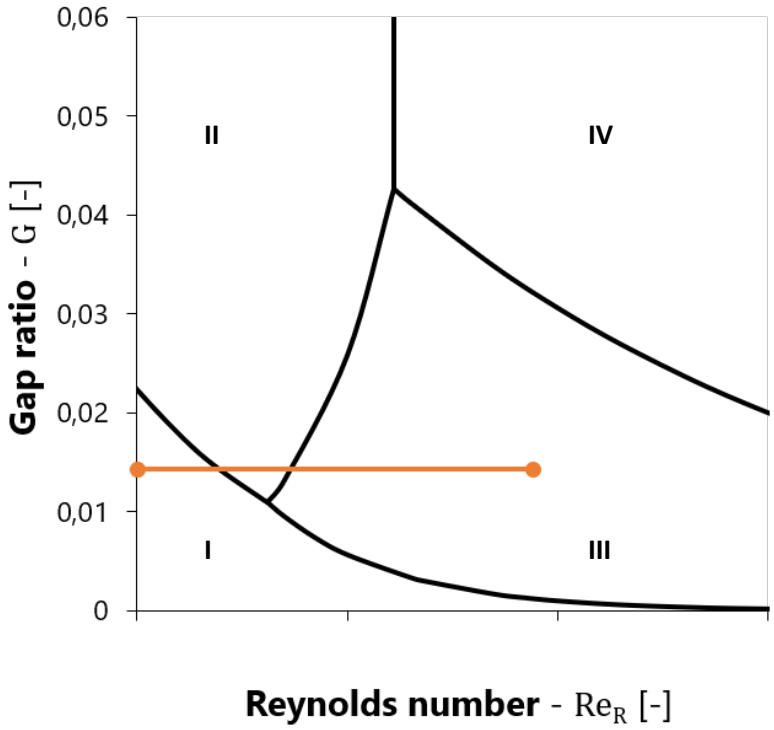


Simplified representation of PFR-like and CSTR-like regions within a rotor-stator stage.

At the microscale, mixing is intensified by the high local shear and turbulent eddies generated in the rotor-stator gap. Disc speed can therefore be used to adjust mixing intensity largely independently from the mean residence time imposed by the process flow rate.

4.2 Hydrodynamic Flow Regimes

The rotor-stator flow can be classified into four hydrodynamic regimes (I-IV) based on the rotational Reynolds number and the gap ratio. Regimes I and II are laminar, whereas regimes III and IV are turbulent. Regimes I and III are associated with torsional Couette-type flow, while regimes II and IV exhibit Batchelor-type flow with an inviscid rotating core between the boundary layers. For SpinPro operation, regime III is preferred because it combines turbulent flow with strong shear across the gap, avoiding the low-shear core characteristic of Batchelor-type flow.



Flow map with different flow regimes in rotor-stator flow. The orange line delineates the operating line of the SpinPro R2. Regime I – Laminar Torsional Couette. Regime II – Laminar Batchelor. Regime III – Turbulent Torsional Couette (preferred). Regime IV – Turbulent Batchelor.

In this graph, the following dimensionless numbers are used:

Rotational Reynolds number: $Re_R = \omega R_D^2/\nu$

Gap ratio: $G = R_D/h$

In which:

ω = disc speed [rad/s]

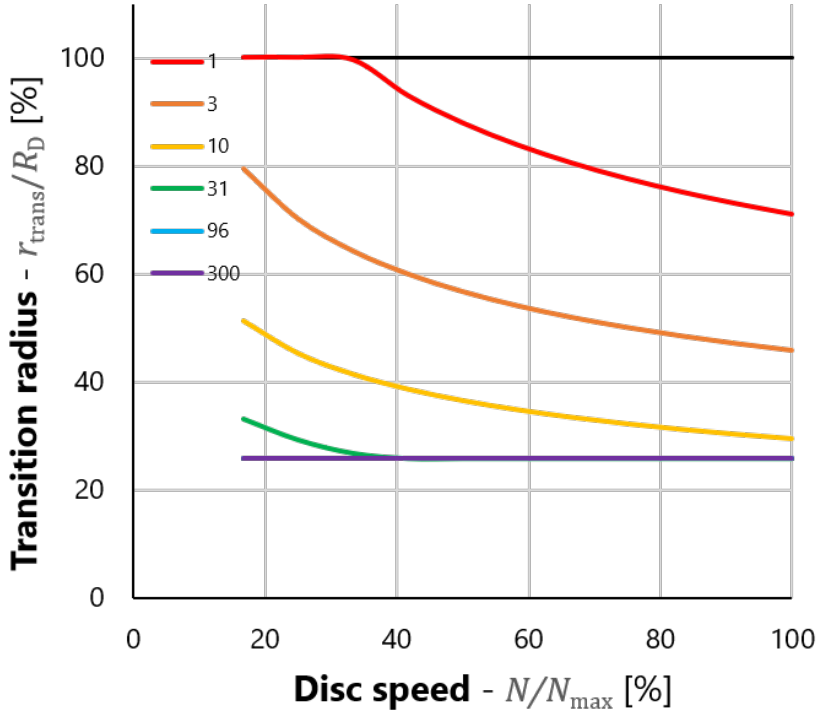
R_D = rotor radius (0.035 m)

ν = kinematic viscosity of the fluid [m²/s]

h = rotor-stator gap (0.0005 m)

4.3 Transition Radius

The transition radius, r_{trans}, marks the radial position at which the imposed throughflow becomes comparable to the rotation-driven motion. Inside this radius, throughflow is dominant and the flow is more plug-flow-like; outside it, rotation increasingly dominates and recirculation becomes more important. Increasing process flow shifts the transition radius outward, whereas increasing disc speed shifts it inward. The resulting change in the relative PFR-like and CSTR-like volumes provides the physical link between operating conditions and the residence time distribution.



Graph with selected transition radii as a function of disc speed for the SpinPro R2.

4.4 Residence Time Distribution (RTD)

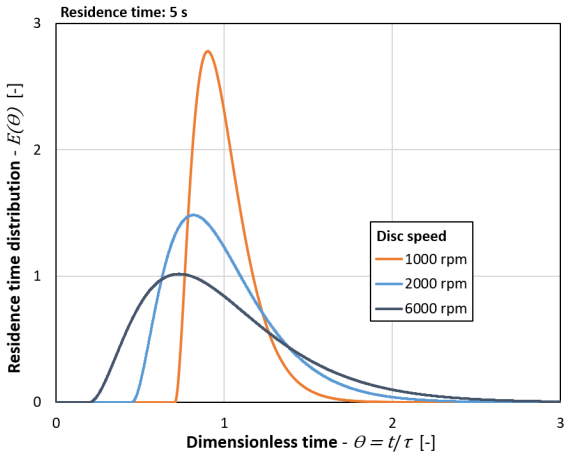
The residence time distribution, E(θ), describes the distribution of fluid residence times relative to the mean residence time, using the dimensionless time θ = t/τ. It provides insight into axial dispersion and backmixing inside the SpinPro R2. A narrow distribution indicates more plug-flow-like behaviour, whereas a broader distribution with a pronounced tail reflects a larger contribution from mixed regions.

For a residence time of 1 s or less, the RTD is essentially identical for all investigated disc speeds. Under these conditions, the hydrodynamic behavior is dominated by the imposed throughflow, and the relative distribution between plug-flow-like and mixed regions remains effectively unchanged. The resulting RTD is narrow and sharply peaked, indicating limited backmixing.

For a residence time of 5 s, the RTD becomes increasingly broader with increasing disc speed. At higher rotational speeds, the contribution of the rotation-dominated region becomes more pronounced, leading to increased backmixing and a broader residence time distribution with a longer tail. This behavior is consistent with the increase in transition radius and the larger effective fraction of CSTR-like volume at higher disc speeds.



Dimensionless residence time distribution at a mean residence time of 1 s for water.



Dimensionless residence time distribution at a mean residence time of 5 s for different disc speeds.

4.5 Residence Time and Equilibration

Because the SpinPro R2 operates continuously, a change in inlet composition or operating conditions requires time to propagate through the reactor before the new condition is fully reflected at the outlet. The response is governed by both the mean residence time and the residence time distribution described above.

The mean residence time is defined as:

$\tau = V / Fv,tot$

where τ is the mean residence time [s], V is the internal process volume [mL], and Fv,tot is the total volumetric process flow rate [mL/s]. For the three-stage configuration, the nominal internal volume is 15 mL. In practice, sufficient equilibration time should be allowed after a process change, particularly under operating conditions that produce a broader RTD and longer tailing.

4.6 Multiphase Mixing and Mass Transfer

Mass transfer in multiphase processes is enhanced by two complementary mechanisms. Turbulent motion reduces transport resistance around dispersed phases, while the high shear in the rotor-stator gap produces fine droplets or bubbles and therefore a large interfacial area. Together, these effects make the SpinPro particularly suitable for gas-liquid and liquid-liquid processes in which conventional equipment is limited by mass transfer.

5. Hydraulic Performance

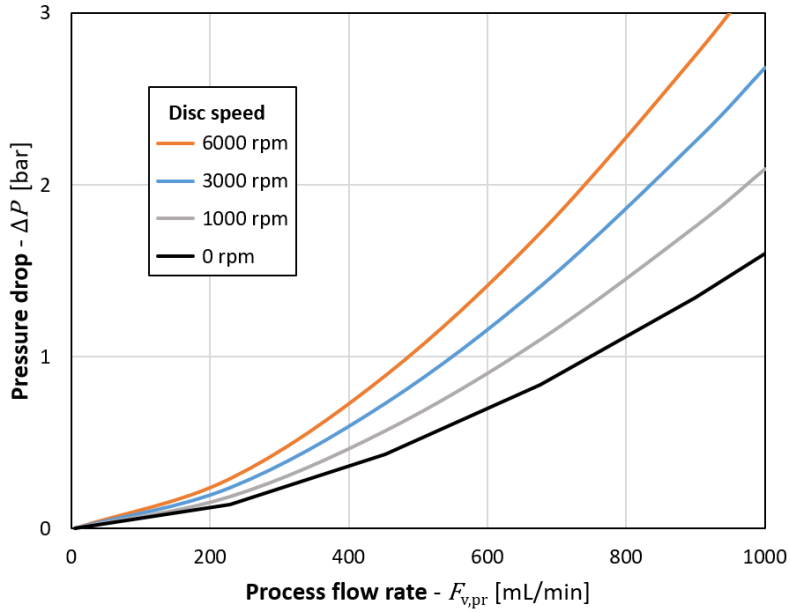
Unless stated otherwise, the performance curves in Sections 5 and 6 are based on water. Values should be interpreted within the operating range shown in each figure.

5.1 Process-Side Pressure Drop

The pressure drop across the SpinPro R2 reactor depends on both the volumetric flow rate and the rotational speed, as illustrated in the graph below. Increasing the flow rate increases the hydraulic resistance, while increasing the rotational speed introduces an additional pressure drop due to centrifugal effects.

The rotational contribution arises from the different pressure gradients in the outward- and inward-flowing regions. As fluid moves radially inward, its tangential velocity tends to increase as angular momentum is redistributed, producing a figure-skater or “ballerina” effect. The resulting centrifugal pressure gradient differs from that in the outward-flowing region, creating an additional net pressure requirement across the reactor. This contribution becomes increasingly important at higher disc speeds.

The presented data are based on water as the process medium. For other fluids, the pressure drop will also depend on their physical properties, particularly density and viscosity.

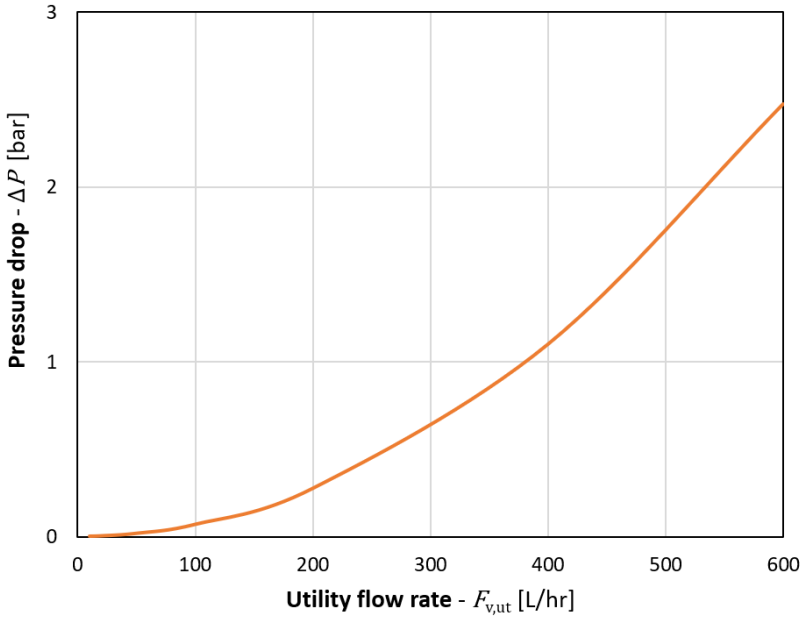


Process-side pressure drop for water as a function of process flow rate and disc speed.

5.2 Utility-Side Pressure Drop

The pressure drop across the utility channels of the SpinPro R2 increases with increasing utility flow rate, as illustrated in the graph below. The pressure drop exhibits an approximately quadratic relationship with the volumetric flow rate, characteristic of a flow resistance dominated by inertial effects.

The presented data are based on water as the utility medium. For other fluids, the pressure drop will depend on their density and viscosity. The graph can be used to determine the required pumping capacity and to select a suitable temperature control unit for the desired utility flow rate.



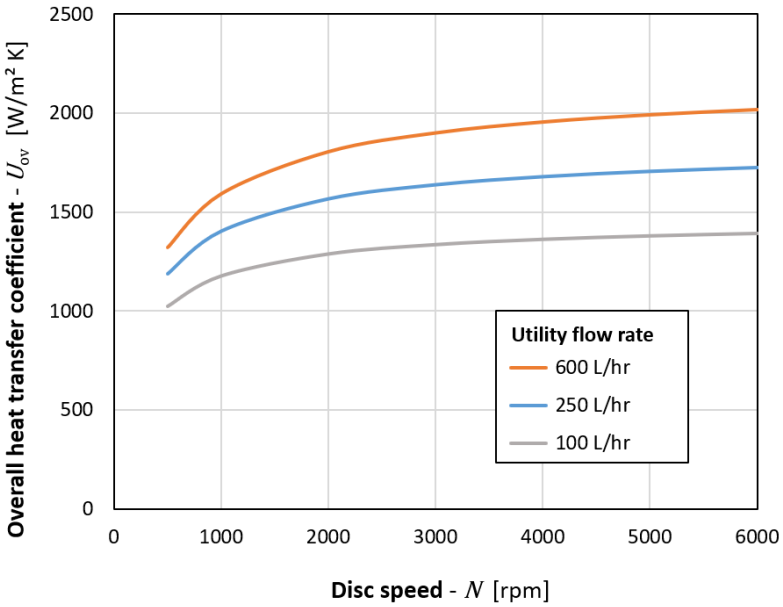
Utility-side pressure drop for water as a function of utility flow rate.

6. Thermal Performance

6.1 Heat Transfer Mechanism

Heat is transferred from the process fluid to the utility side through three principal resistances in series: convection from the process fluid to the reactor wall, conduction through the reactor material, and convection from the wall to the utility fluid. Increasing disc speed intensifies process-side mixing and reduces the process-side convective resistance. Increasing utility flow similarly improves the utility-side contribution until further increases provide diminishing benefit.

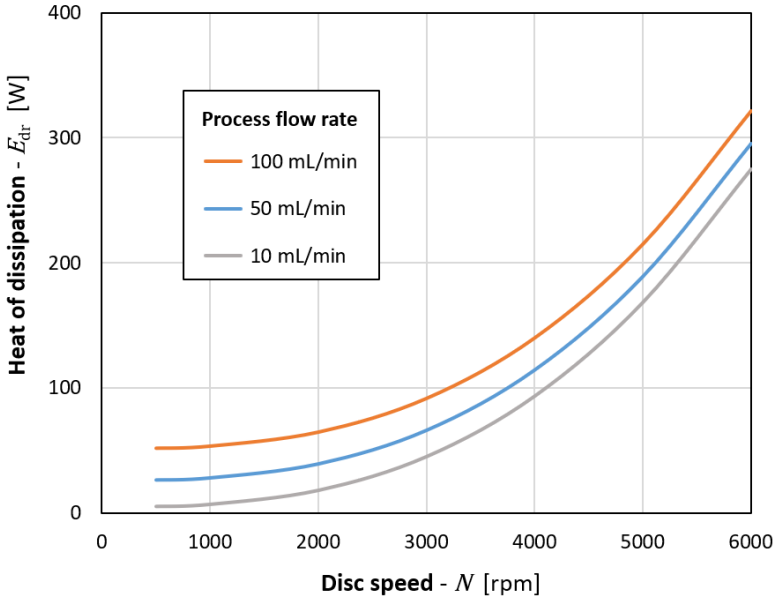
6.2 Overall Heat Transfer Coefficient



Overall heat transfer coefficient for water as a function of disc speed and utility flow rate.

6.3 Heat Generation by Viscous Dissipation

Mechanical energy introduced by the rotating discs is ultimately dissipated as heat through viscous shear in the process fluid. For water, the resulting heat generation increases strongly with disc speed and also depends on process flow rate, as shown in the figure below. This internally generated heat load should be included when sizing the temperature-control system and establishing the process heat balance.



Heat generation by viscous dissipation in water as a function of disc speed and process flow rate.

7. Contact

If you have any questions, please do not hesitate to contact us.

Kevin van Eeten: Director Development

Phone: +31 (0) 85 401 5025
Email: info@flowid.nl
Visitor Address: Flowid
Valeton 2A
5301 LW Zaltbommel
The Netherlands