

SMART REACTOR™ SYSTEMS

Next-Generation Intelligent Reactor Solutions

A Joint Engineering & Innovation Initiative



In
collaboration



Engineering intelligent, scalable, and execution-ready reactor systems through automation, digital intelligence, and research-driven design.



Reactor
Systems



Process
Engineering



Industrial
Automation



Digital
Intelligence



Site
Execution



Design • Automation • Manufacturing • Research • Execution

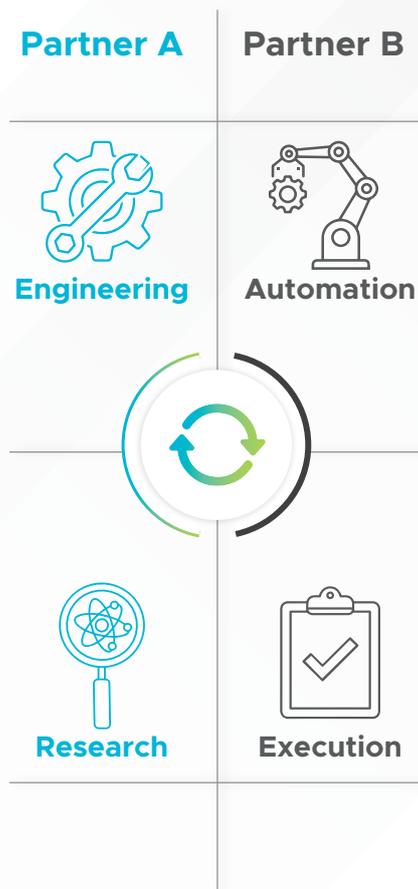
The Collaboration

Specx Technologies Pvt. Ltd. and **Arrhenius India Pvt. Ltd.** have formed a strategic engineering collaboration to develop **next-generation Smart Reactor Systems** for the evolving needs of modern process industries.

As industries move toward higher efficiency, improved safety, and data-driven operations, conventional reactor systems face limitations due to manual control, low visibility, and scale-up challenges. This collaboration bridges that gap by combining strong execution capability with research-backed reactor design and digital intelligence.

Specx Technologies leads with expertise in reactor system design, mechanical and process engineering, automation, industrial IoT, digital twins, and turnkey on-premises execution. Arrhenius India complements this with strengths in reactor hardware, mixing technologies, photobioreactors, additive manufacturing, and applied research, supported by academic and laboratory ecosystems.

Together, the partnership delivers intelligent, scalable, and execution-ready reactor systems for industrial production, R&D, and pilot-scale applications.



From reactor concept and pilot studies to automation, manufacturing coordination, and on-site commissioning, delivered as one integrated solution.

Specx Technologies
Lead Execution & Automation Partner

Arrhenius India
Reactor Technology & Research Partner

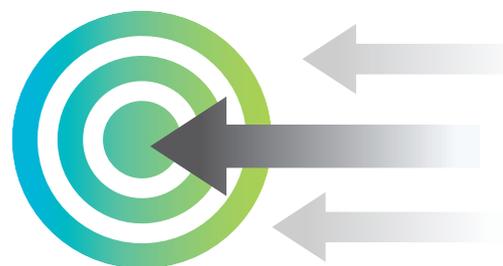
- ➔ Reactor system design and engineering
- ➔ Mechanical and process design
- ➔ Automation architecture (PLC, SCADA, DCS)
- ➔ Industrial IoT and digital twin integration
- ➔ Manufacturing coordination and site execution
- ➔ Commissioning, validation, and handover



- Reaction vessels, agitators, and impeller systems ←
- Advanced mixing and mass transfer solutions ←
- Photobioreactors and sustainability-driven reactors ←
- Additive manufacturing and rapid prototyping ←
- Research-driven validation and testing ←
- Academic and laboratory collaboration (BITS Pilani Goa) ←

OUR VISION

To engineer smart, safe, and scalable reactor systems that seamlessly integrate mechanical robustness, advanced automation, and digital intelligence, enabling industries to operate more efficiently, sustainably, and predictably.



Why Smart Reactors?

Reactor systems are at the heart of most chemical, pharmaceutical, and process industries. While mechanical designs have evolved over time, many reactors still operate with limited process visibility, manual control strategies, and reactive decision-making.

As product quality requirements tighten, energy costs rise, and safety and compliance expectations increase, conventional reactor operation increasingly results in inefficiencies, variability, and scale-up risks. Smart Reactors address these limitations by embedding intelligence, automation, and data-driven control directly into the reactor system.

Problem vs Solution Section

Limitations of Conventional Reactors

- ⚠ Limited real-time insight into reaction behavior
- ⚠ Manual or semi-automatic operation
- ⚠ Reactive maintenance and unplanned downtime
- ⚠ Difficulty in reproducing lab/pilot results at plant scale
- ⚠ High dependence on operator experience
- ⚠ Energy inefficiencies and inconsistent product quality



Advantages of Smart Reactor Systems

- ✔ Continuous, real-time monitoring of critical parameters
- ✔ Automated and optimized control of reaction conditions
- ✔ Predictive maintenance and early fault detection
- ✔ Faster and safer scale-up from lab to pilot to production
- ✔ Reduced batch variability and improved yield
- ✔ Enhanced safety, traceability, and regulatory compliance

Smart Reactors convert reactor operation from operator-dependent control to data-driven, predictive, and optimized performance.

What Makes a Reactor “Smart?”

A Smart Reactor integrates:

- 1 Intelligent instrumentation and sensor networks
- 2 Automated control systems and safety interlocks
- 3 Real-time data acquisition and visualization
- 4 Digital twin models for simulation and optimization
- 5 Predictive analytics for maintenance and performance
- 6 Seamless integration with plant and enterprise systems



Industries & Applications

Smart Reactor Systems are applicable across:

- Chemical and specialty chemicals
- Pharmaceuticals and biotech
- Sustainability and carbon capture processes
- R&D centers and pilot plants
- Scale-up and process intensification applications

TRADITIONAL	SMART
<p>Sensors Limited manual sensing</p>	<p>Sensors Comprehensive sensor network</p>
<p>Automation Manual control systems</p>	<p>Automation Integrated adaptive automation</p>
<p>Analytics Manual control systems</p>	<p>Analytics Real-time analytics</p>
<p>Safety Basic safety interlocks</p>	<p>Safety Predictive safety systems</p>

Specx Technologies –

Lead Execution Partner

Specx Technologies Pvt. Ltd. leads the Smart Reactor Systems initiative with strong expertise in process engineering, mechanical design, automation, and industrial digitalization. Its approach is grounded in real plant challenges, ensuring every solution is engineered for reliability, execution, and long-term performance.

Unlike conventional providers, Specx integrates reactor design, automation, digital intelligence, and on-site execution into one accountable workflow. This ensures seamless continuity from concept and pilot studies to installation, commissioning, and handover.

Specx Technologies serves as a single-point engineering and execution partner, ensuring that design intent translates into actual plant performance.

Core Responsibilities of Specx Technologies

1. Reactor System Design & Engineering

- Design and engineering of reactor systems for batch, semi-batch, and continuous processes
- Mechanical design aligned with process requirements and safety standards
- Support for pilot plant studies and scale-up programs

2. Mechanical & Process Design

- Process modeling and mass-energy balance development
- Equipment sizing, selection, and layout integration
- Design for operability, maintainability, and safety

3. Automation & Control Systems

- PLC, SCADA, and DCS-based automation architecture
- Recipe management, batch control, and sequencing
- Safety interlocks, alarms, and compliance logic

4. Industrial IoT & Digital Twins

- Sensor integration and real-time data acquisition
- Digital twin development for reactors and mixers
- Predictive analytics and performance optimization

On-Premises Execution Ownership

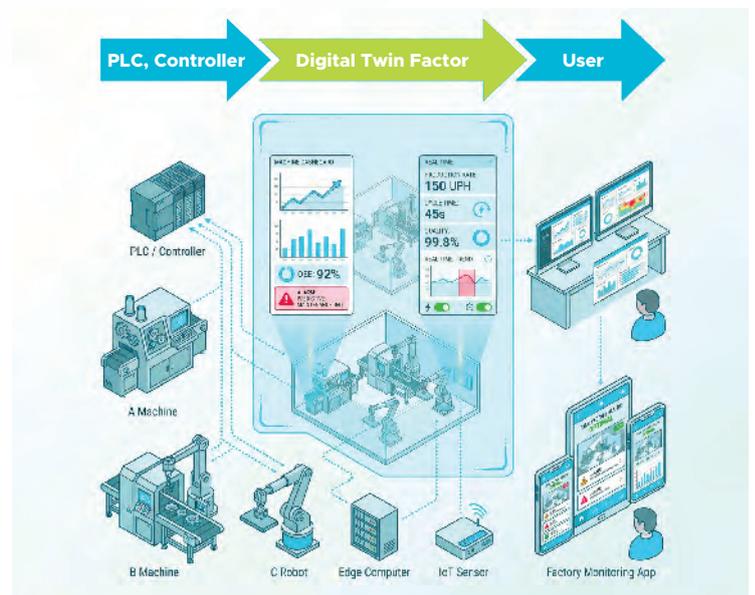
Specx Technologies executes Smart Reactor Systems directly at client premises, taking full responsibility for engineering coordination, manufacturing interface, installation, testing, and commissioning.

Execution Scope Includes:

- ➔ Front-end and detailed engineering
- ➔ Manufacturing coordination and vendor management
- ➔ Automation panels, instrumentation, and cabling
- ➔ Site installation, integration, and commissioning
- ➔ Performance validation and handover

The Economics of Intelligence

Investing in intelligence pays for itself. By reducing batch variability and optimizing energy consumption, our Smart Reactor systems typically achieve ROI within the initial years primarily driven by yield improvement and operational efficiency.



Smart Automation, Digital Intelligence & Execution

Smart Reactor Systems integrate advanced automation, intelligent data architecture, and real-time digital intelligence for reliable industrial operation. At Specx, automation and digital tools are core engineering elements, tightly aligned with reactor design, control logic, and process behavior.

1. Smart Automation & Control Systems

Specx designs and implements robust automation systems tailored to reactor operation and safety.

Key elements include:

- PLC, SCADA, and DCS-based control architecture
- Automated control of temperature, pressure, agitation and utilities
- Batch and recipe management systems
- Alarm management, safety interlocks and fail-safe logic
- Integration with plant-wide control and safety systems

Stable, repeatable, and safe reactor operation with minimal operator dependency.

3. Digital Twins & Advanced Analytics

Specx develops digital twins, virtual replicas of reactors and mixers for deeper analysis.

Key elements include:

- Real-time digital twins synced with live plant data
- Simulation of reactions, heat transfer, and mixing
- Predictive maintenance for critical rotating parts
- Performance optimization and energy efficiency analysis

Improved predictability, reduced downtime, and optimized reactor performance.

Advanced Reactor Configurations & Process Intensification:

Depending on reaction kinetics, heat release, and selectivity requirements, Smart Reactor Systems are also being developed for continuous and hybrid configurations, including plug flow reactors (PFRs), recirculating reactors with external heat exchangers, and process-intensification techniques such as cavitation.

Execution Scope Includes:

- ➔ Automation panel design and build
- ➔ Instrumentation supply and calibration
- ➔ Control logic development and testing
- ➔ Site commissioning and performance validation
- ➔ Operator training and documentation

2. Industrial IoT & Data Architecture

Specx builds secure, scalable systems connecting reactors to digital intelligence.

Key elements include:

- Integration of sensors for temperature, pressure, torque, vibration, flow, pH, ORP, and energy
- Edge computing and industrial IoT gateways
- Secure on-premises or hybrid data architectures
- Real-time dashboards and historical data analysis

Complete process visibility and actionable insights for operators and engineers.

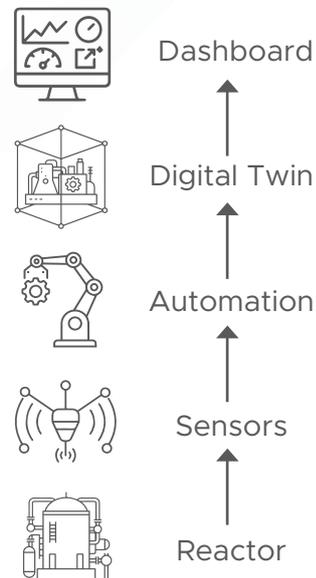
4. On-Premises Execution & System Integration

All automation, instrumentation, and digital systems are engineered and commissioned on-site by Specx.

Specx ensures seamless coordination between:

- Reactor hardware and instrumentation
- Automation panels and control systems
- Digital platforms and analytics layers

This integrated approach eliminates gaps between design intent and actual plant performance.



Arrhenius India

Reactor Technology & Research Partner

Arrhenius India Pvt. Ltd. contributes specialized expertise in reactor systems, mixing technologies, and applied research, forming a critical pillar of the Smart Reactor collaboration.

With strong roots in chemical engineering research and close association with academic laboratories, Arrhenius bridges the gap between fundamental reaction science and practical reactor hardware design. Their involvement ensures that reactor concepts are not only mechanically sound, but also validated through experimental insights and research-driven understanding.

By integrating Arrhenius's research-led reactor development with Specx's engineering, automation, and execution capabilities, the collaboration delivers solutions that are scientifically robust, industrially feasible, and scalable.

Core Capabilities of Arrhenius India

1. Reactor Systems & Hardware

- Reactor vessel design
- Batch & special configurations
- Safety & reliability

2. Mixing Technology & Internals

- Agitator & impeller design
- Flow optimization
- Scale-up support

3. Photobioreactors & Sustainability

- Light-driven reactors
- Algae & carbon capture
- Energy-efficient processes

4. Additive Manufacturing & Prototyping

- Rapid prototyping
- Custom geometries
- Faster validation

5. Digital Twin Validation

- Experimental support
- Data-based validation
- Physical-digital link

Academic & Laboratory Ecosystem

Arrhenius operates in close association with the Water-Energy-Food Nexus Lab, Department of Chemical Engineering, BITS Pilani Goa.

Execution Scope Includes:

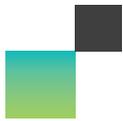
- ➔ Access to advanced laboratory infrastructure
- ➔ Research-driven testing and validation
- ➔ Industry-academia collaboration for Innovation and scale-up

Value to the Smart Reactor Program:

Arrhenius India strengthens the collaboration by ensuring:

- ✔ Scientific rigor behind reactor design
- ✔ Research-backed scale-up confidence
- ✔ Faster validation of new reactor concepts
- ✔ Reduced technical risk during industrial deployment





Infrastructure, Research & Leadership

1. Research & Innovation Infrastructure (Specx Technologies)

Specx is establishing a dedicated R&D and innovation facility at:
C-40/2, GIDC Saykha, Chemical Zone, Dist. Bharuch,
396160 Gujarat, India



Proposed R&D & Innovation Facility

- + Pilot-scale reactor studies and validation
- + Smart equipment testing and instrumentation trials
- + Automation and digital twin development
- + Performance optimization and process innovation

The R&D facility will act as a bridge between concept development, pilot testing, and full-scale industrial deployment.

2. Engineering & Execution Offices

Specx operates through strategically located offices to ensure fast response and strong execution:

- Bharuch (Head Office):** Process engineering, industrial solutions, project management
- Vadodara:** Mechanical design, automation, and project execution support
- Mumbai (Upcoming):** Client engagement, business development, partnerships

This geographic presence enables rapid response, effective execution, and long-term client support.

3. Leadership & Core Team (Smart Reactors)

The Smart Reactor initiative is led by a multidisciplinary leadership team combining industrial execution experience and advanced research expertise.

Arun Yadav

Co-Founder & Executive Director,

Leads reactor systems engineering, automation strategy, and turnkey execution.

Dr. Anirban Roy

Director (Research),

Provides leadership in reactor science, digital twins, modeling, and safety engineering.

Harmin Chodvadia

Director, (Business Development)

Oversees business operations, compliance, and organizational growth.

Rupesh Kumar

Director (Production),

Leads production planning, manufacturing coordination, and quality delivery.

Rohit Ganti

Director (Marketing),

Leads marketing strategy, business development, and client engagement.

Dhananjay Vyas

Director (Automation)

Leads automation, digital platforms, and advanced control systems.

Connect With Us

Engineering intelligent, scalable, and execution-ready
Smart Reactor Systems from concept to commissioning.



Lead Execution & Engineering Partner

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R&D & Innovation Facility: C-40/2, GIDC Saykha, Chemical Zone, Dist. Bharuch – 396160, Gujarat, India



Arrhenius
India Pvt. Ltd

Reactor Technology & Research Partner

www.arrhenius.co.in

Water–Energy–Food Nexus Lab, Department of Chemical Engineering, BITS Pilani Goa – 403726

Engagement Areas



Smart reactor
design & engineering



Pilot studies and
scale-up programs



Automation, digital
twins and IIoT



On-premises execution and
commissioning



Research and
industry collaboration



Process Intensification:
More Output. Less Equipment.
Smarter Processes.

Let's build the next generation of intelligent reactor systems.