Real-Time Process Optimization with In-Mold Sensors and Machine Learning

SPE Webinar | May 25, 2023
WHO IS BEHIND sensXPERT?

As a recognised *industry expert* with *50+ years of experience* in material science and sensor technology, it is the *NETZSCH Group* that transforms industries with next-level intelligence for increased efficiency, quality assurance and process reliability for the *plastics industry*.

Corporate Venture:
NETZSCH Process Intelligence GmbH

Enhancing productivity through advanced process analysis technology for the industry 4.0

Parent Company:
NETZSCH

Family-owned global technology leader with 4100+ employees present in 36 countries
physically within your company
physically within your company

Full visibility and in-mold quality control

Access real-time transparency & production control on the factory floor

Fully integrated mold sensors

Edge device

Plastics process control in real-time

Harness the ubiquity & flexibility of cloud computing

Customizable dashboards

Retrains the AI core

sensXPERT® Cloud
cloud storage
THE sensXPERT PRODUCT

Equipment-As-A-Service Technology

• integrated sensor hardware to measure critical process parameters

• edge device to evaluate machine and material data for automated data analytics to increase overall equipment efficiency in real-time

• monthly subscription model with low initial setup cost
MATERIAL KNOWLEDGE AT THE HEART OF PROCESS ENHANCEMENT

Real-Time Material Characterization with Dielectric Sensors

- Measuring material behavior
  - resin viscosity, degree of cure, glass-transition, material condition (mixing ratio, ageing, shrinkage, contamination)
- Combined with third-party measurement devices (pressure transducers, thermocouples, and more)

MATERIALS
- Thermosets and thermoplastics
- Fiber reinforced polymers
- Sands or natural stones bonded with resin

PROCESSES
- (Reaction) Injection Molding
- Thermoforming & Compression Molding
- Transfer Moulding Processes
- Vacuum infusion & Autoclave Curing
Electronics Encapsulation Industry

Use Case
sensXPERT USE CASE:
OPTIMIZING ELECTRONICS ENCAPSULATION FOR E-MOBILITY

Component: High-power electronics circuit board

Material: Epoxy molding compound

Quality criterion: Degree of cure > 90%

Initial cycle time: 3 minutes
sensXPERT USE CASE: OPTIMIZING ELECTRONICS ENCAPSULATION FOR E-MOBILITY

**Component:** High-power electronics circuit board

**Material:** Epoxy molding compound

**Quality criterion:** Degree of cure > 90%

**Initial cycle time:** 3 minutes

[Graph showing laboratory based material behavior]
ROI Calculator - single machine

Productivity
Number of parts produced annually
Without sensXPERT
4,617,000
With sensXPERT
4,860,000
5.26% increase in production throughput

Efficiency
Waste reduction with sensXPERT installed
50% potential to avoid an imperfect cure

Calculate return
With sensXPERT installed

- €75,000 Savings from reduced failure & downtime
- €145,800 Savings from reduced wastage
- €0 Savings from reduced cycle times

Return on investment
With sensXPERT installed
Total economic value generated per year (Savings + Added Revenue)
€257,250

Total cost of sensXPERT per year
€29,880

Costs recovered
1.73 months
Let us dive deep into the material behavior during production
Variation in injection time affects the cure behavior

Thick gate

![Graph showing the effect of injection time on cure behavior](image)

- Log ion visc. / Ohm*cm
- Time / min
- Curves for different injection speeds:
  - 2.1s inj. speed
  - 3.7s inj. speed
  - 6.6s inj. speed
Small series production in collaboration with Schwarz Plastic Solutions

influence of shearing on the curing

PF highly filled
Variation in gate and injection time

fixed injection time: 2

fixed injection time: 4

fixed injection time: 8
Consolidated summary of process variations and cure behavior
Small series production in collaboration with Schwarz Plastic Solutions

influence of shearing on the curing

PF highly filled (isotropic)
Variation in gate and injection time

**fixed injection time: 2**

**fixed injection time: 4**

**fixed injection time: 8**
Consolidated summary of process variations and cure behavior
Aviation Industry

Use Case
sensXPERT USE CASE: COMPOSITE AEROSPACE STRUCTURES

Component: Composite structures

Material: Infusion epoxy / carbon fiber

Quality criterion: Degree of cure > 90%

Initial cycle time: 400 minutes
sensXPERT USE CASE: COMPOSITE AEROSPACE STRUCTURES

30% Cycle Time Reduction

- Shows Process Step 3 is stable before 300 minutes
- Reduce cycle time by over 1.5 hours
ROI Calculator - single machine

**Productivity**
Number of parts produced annually

<table>
<thead>
<tr>
<th>Without sensXPERT</th>
<th>With sensXPERT</th>
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<tbody>
<tr>
<td>500</td>
<td>667</td>
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33.4% ↑
increase in production throughput

**Efficiency**
Waste reduction with sensXPERT installed

0% potential to avoid an imperfect cure

**Calculate return**
With sensXPERT installed

- €75,000
  Savings from reduced failure & downtime
- €158,000
  Savings from reduced wastage
- €0
  Savings from reduced cycle times

**Return on investment**
With sensXPERT installed
Total economic value generated per year (Savings + Added Revenue)

€83,733,000

Total cost of sensXPERT per year

€29,880

**Costs recovered**
0 months
How does it work?
sensXPERT® process data

1. Introduction of the material
2. Minimum resin viscosity
3. Progression of cure / gelation / crystallization
4. Completion of cure / crystallization
MACHINE LEARNING AND PROCESS OPTIMIZATION

Data Preprocessing

- Dielectric Measurements
- Kinetic Model
  - Degree of Cure
  - Glass Transition Temperature
  -...

Data Generation → Training & Testing → ML Model → Prediction & Optimization
Simulation and Optimization

A data driven solution.

- AI model calculates and predicts material properties
- Dynamically control and adapt the process to ensure constant quality
CLOUD SERVICE

- Process data transparency
- 24/7 access on any device
- Customizable dashboards
- OpenAPI: flexible data handling
RESULTS OF sensXPERT®

Up to 50% of existing scrap reduction

Up to 23% energy savings

Up to 30% cycle time reduction

Reduce (re)-commissioning time
sensXPERT Pipe

NO-DIG Sewer Renovation
Trenchless sewer rehabilitation with UV sensor & analyzing equipment
Sensors measure the curing process to determine the required velocity of the UV Light Source.
We are looking forward to welcoming you into the sensXPERT community!

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