Sensor-Based and Data-Driven Thermoset Manufacturing Optimization

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SPE TOPCON - 2023
sensXPERT Introduction

Parent Company: NETZSCH

Founded: 1962 (Analyzing and Testing)

Global scientific instrument and thermal analysis leader with 3700+ employees present in 36 countries

Corporate Venture: NETZSCH Process Intelligence GmbH

Founded: 2019

Technology startup developing intelligent manufacturing solutions
sensXPERT Introduction

Supplier
- Incoming Raw Materials
- Raw Materials In-House Quality Control
- In-House Part Manufacturing
- Post-Process Part Quality Assurance
Customer
Equipment-As-A-Service Technology

- integrated sensor hardware to measure critical process parameters
- edge device to evaluate machine and material data for automated process optimization
- cloud service for customizable dashboards
Process data collection and visibility

Plastics process control in real-time

Fully integrated mold sensors

Edge device
at a glance

Process data collection and visibility

sensXPERT® Cloud

Plastics process control in real-time

Fully integrated mold sensors

Edge device

Customizable dashboards

Predictions and optimization
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
- Mineral casting

PROCESSES

- (Reaction) Injection Molding
- Compression Molding
- Resin Transfer Moulding Processes
- Autoclave Curing
Dielectric Analysis

- Observes the behavior of material under the application of an electric field
- Molecules in the material sample have a net electric charge
- Interact with the electric field
- **Ion viscosity** – An analog to mechanical viscosity

Behavior of ions and dipoles inside an external electrical field
Dielectric Analysis

Traditional parallel plate electrodes

Interdigitated “comb” electrodes

sensXPERT in-mold sensor
Dielectric Analysis: Ion Viscosity

RTM / Infusion Epoxy

180 °C / 350 °F mono-component epoxy system

Standard process data

- Temperature ramp
- Holding time
- No viscosity or cure information
Dielectric Analysis: Ion Viscosity

RTM / Infusion Epoxy

180 °C / 350 °F mono-component epoxy system

sensXPERT process data

1. Introduction of the material
2. Minimum resin viscosity
3. Progression of cure / gelation
4. Completion of cure
Dielectric Analysis: Ion Viscosity

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180 °C / 350 °F mono-component epoxy system

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Predictions and optimization
Process Predictions and Optimization
MACHINE LEARNING AND PROCESS OPTIMIZATION

Data Preprocessing

- In-Mold Measurements
- Thermal Analysis
  - Degree of Cure
  - Glass Transition Temperature
- Machine Data
- Dielectric Measurement
- Temperature
- Kinetic Model

Data

Training & Testing

ML Model

Prediction & Optimization
A data driven solution.

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

- Process data transparency
- 24/7 access on any device
- Customizable dashboards
- OpenAPI: flexible data handling
<table>
<thead>
<tr>
<th>INDUSTRIES WE WORK WITH</th>
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<tbody>
<tr>
<td>Automotive</td>
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<td>Aerospace</td>
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<td>Building &amp; Construction</td>
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<td>Renewable Energy</td>
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<td>Consumer Goods</td>
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<tr>
<td>Electronics Encapsulation</td>
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<tr>
<td>Result</td>
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<td>-----------------------------------------------------------------------</td>
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<tr>
<td>Up to 50% of existing scrap reduction</td>
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<td>Up to 23% energy savings</td>
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<td>Up to 30% cycle time reduction</td>
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<td>Up to 15 days p.a. installation &amp; downtime reduction</td>
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