Integration of RFID-based “Industrial Internet of Things (IoT)” concepts along the textile value chain

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Outline

• RFID – State of the Art
  • How does it work?
  • Solutions for internal value chain
  • RFID in textile supply chain
• Opportunities and challenges
• Examples from research
• Critical review on utilization of RFID
• Ecological and socio–technological view
4 reasons for using RFID technology

- Data need to be transmitted wirelessly
- Data need to be stored
- Simultaneously identification of several objects
- Direct contact or visual connection are not necessary
Operating principles of RFID-based solutions
Embedding RFID-based solutions in overall system
State-of-the-art – RFID systems in laundry industry

- Production Control
- Material Flow Control
- Supply Chain Management
- Asset Management
- Tracking & Tracing
<table>
<thead>
<tr>
<th>Primary activities</th>
<th>Secondary activities</th>
<th>Firm Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inbound Logistics</strong></td>
<td><strong>Firm Infrastructure</strong></td>
<td>Storage and relocation processes, pool management</td>
</tr>
<tr>
<td>• Inbound posting of laundry and containers</td>
<td><strong>Human resource management</strong></td>
<td>Time recording, back-up plans, personnel planning, focused (qualification-based) engagement of personnel</td>
</tr>
<tr>
<td>• Digital order processing</td>
<td><strong>Technology</strong></td>
<td>Automation through individualization</td>
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<tr>
<td>• Process planning</td>
<td><strong>Procurement</strong></td>
<td>Focused procurement, small inventory</td>
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<tr>
<td>• Sorting processes</td>
<td><strong>Operations</strong></td>
<td>• Control of machines and laundry items</td>
</tr>
<tr>
<td><strong>Outbound Logistics</strong></td>
<td><strong>Outbound logistics</strong></td>
<td>• Outbound posting of laundry and containers</td>
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<tr>
<td>• Control of machines and laundry items</td>
<td>• Route planning</td>
<td></td>
</tr>
<tr>
<td><strong>Marketing &amp; Sales</strong></td>
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<td>• The base for marketing campaign/services</td>
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<tr>
<td>• Advertising for tailor-made services</td>
<td>• Development of business models</td>
<td></td>
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<tr>
<td>• Customer loyalty through transparency</td>
<td><strong>Service</strong></td>
<td>• Web applications</td>
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<tr>
<td>• Web applications</td>
<td></td>
<td>• Simplified complaints processing</td>
</tr>
<tr>
<td>• Simplified complaints processing</td>
<td><strong>Service</strong></td>
<td></td>
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</tbody>
</table>
### Examples of supply chain management

<table>
<thead>
<tr>
<th>Transparency of processes</th>
<th>Optimizing logistics</th>
<th>Resource efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tracking of laundry along the whole textile supply chain:</td>
<td>• Tracking of containers e.g. for simplified collection of laundry articles at the arrival process</td>
<td>• Tracking of used resources e.g. containers with washing chemicals</td>
</tr>
<tr>
<td>- Proof of origin</td>
<td></td>
<td>• Establishing of consumption-oriented ordering system (Kanban)</td>
</tr>
<tr>
<td>- Product protection</td>
<td></td>
<td></td>
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<tr>
<td>- Batch traceability e.g. in the case of complaint management</td>
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</tbody>
</table>

View into the future – Trends of RFID usage

- Combination of different frequencies
  - Dual reading devices for bridging the transformation of HF in UHF systems
  - Dual transponders for connection of manufacturing and end-user applications

- Combination of different technologies
  - Barcode/RFID (state-of-the-art)
  - RFID and sensor systems
Benefits of RFID Solutions

Financial (and personal) benefits through

➢ More transparency
➢ More efficiency
➢ Optimization of processes
➢ Savings of resources
➢ Increase in process safety
➢ Establishing novel digital services/business models
➢ Reducing downtimes e.g. through predictive maintenance

Success!
Cost savings
Increase in turn over
Simplified decision-making
Benefits of RFID Solutions – Localization

RFID is not a locating technology, but combination with other technologies is possible e.g. GPS

→ **Example:**
Loading of truck with containers (RFID identification) coupled with GPS localization

→ **Benefits:**
automated planning of tours and reducing/avoiding misleading; further benefits could arise after a launch of autonomous driving

Synergetic effects with other technologies e.g. VR/AR and AI

- Automatic processing of data via Artificial Intelligence (AI) algorithms allows the optimization of logistic processes
  → agile logistic workflow

- The usage of Augmented Reality (AR) coupled with RFID improve quality assurance in laundries e.g. distance maintenance and support, Ginters, E. et al. Low cost augmented reality and RFID application for logistics items visualization, *Procedia Computer Science* 2013, 26, 3-13.
**Examples from research**

- Combination of textile-based sensor system with passive RFID technology:
  - textile moisture sensor (electrically conductive sensor fibers in a textile matrix), RFID chip and monitor antenna for energy and data transfer

- Textile-based RFID sensors (embracing the read range from UHF to NFC) for optimizing the manufacturing and user comfort of compressions stockings

Gera-Ident GmbH/Hohenstein, project RFIDMEDTEX, unpublished results, 2019
Critical review on utilization of RFID

Potential risks of RFID usage:

• Fail of transponder or the RFID tag is not located on garment e.g. after laundering processes
• Transponder could significantly lose their performance
• Transponder from different suppliers exhibit different performance
• The external environment may influence the electromagnetic field
• Lack of standards may lead to duplicates
Critical review on utilization of RFID

Which consequences may occur?

• Transponder will be not identified in the process
• Wrong transponder will be identified (e.g. because of overreach)
• Transponder transmit wrong codes
  → wrong data basis for further processing
Critical review on utilization of RFID

Examples of solutions

- Prior bringing the transponder into the process, a quality check in accordance with standardized guidelines should be done.
- Defining which kind of performance is necessary.
- Establishing of standards.
- Self-testing systems should be established, check of logic and completeness.
- Misreading of RFID should be taken into account in the risk assessment.
Standards

Technology
- NFC
- HF
- UHF

Data
- EPC, UID
- Rain
- GTIN
- Own sectoral standards

Quality
- performance
- materials
- wash resistance

IIOT
smart devices
smart objects
machine control
process safety
...
## Relevant standards for laundries

<table>
<thead>
<tr>
<th></th>
<th>LF – Low Frequency – 125kHz – 135kHz</th>
<th>HF – High Frequency – 13.56 MHz</th>
<th>UHF – Ultra High Frequency – 860 MHz – 960 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy supply</td>
<td>passive</td>
<td>passive</td>
<td>passive</td>
</tr>
<tr>
<td>Reading range</td>
<td>less than 1 m</td>
<td>max. 1.7 m</td>
<td>approx. 6 m</td>
</tr>
<tr>
<td>Transmission rates</td>
<td>low</td>
<td>middle</td>
<td>high</td>
</tr>
<tr>
<td>Influence through fluids</td>
<td>no influence</td>
<td>small influence</td>
<td>strong influence</td>
</tr>
<tr>
<td>Influence through metal</td>
<td>strong influence</td>
<td>strong influence</td>
<td>very strong influence</td>
</tr>
<tr>
<td>Alignment of transponder</td>
<td>not necessary</td>
<td>not necessary</td>
<td>sometimes necessary</td>
</tr>
</tbody>
</table>

### Trends in industrial laundries
Comparison of RFID with other communication technologies
Ecological and socio-technological view on RFID

- More process efficiency allow a more focused usage of resources

- On the other hand: New challenges may occur through the integration of electronics (and thus maybe novel materials e.g. battery systems) in clothing during the recycling process