Smart Manufacturing and Industry 4.0 - Opportunities and Challenges for SMEs

1st Industry 4.0 School & Industry Night

February 18, 2018
Kelonwa, Canada
Agenda

1. Smart Manufacturing
2. Smart Manufacturing Technologies
3. SmartMfg Survey of SMEs in West Virginia
4. Recommendations
“Manufacturing creates wealth”

Prof. Ronald G. Askin, Arizona State University (USA)
“Obama plans executive actions to strengthen U.S. manufacturing”

(http://www.reuters.com/article/2014/10/27/us-usa-obama-industrialoutput-idUSKBNOIGOUR20141027)

“Obama pushes for high-tech manufacturing”

(Pace, J., June, 24th 2011, NBC News)

“Obama confirms funding for manufacturing innovation hubs”

(Skiba, K., Chicago Tribune, Feb, 25th 2014)

“We’re building Ironman – Manufacturing Innovation”

(Obama, Feb, 2014)
Manufacturing today

• New technologies
• New global rules
• New opportunities
• New challenges…
You may have heard of

**Smart Manufacturing**

**Industrial Internet**

**Cyber-Physical (Production) Systems**

**Factory of the Future**

**Cloud Manufacturing**

**Intelligent Manufacturing**

**IMS**

**Industrie 4.0**

**Industry 4.0**

**Smart Factory**

**Manufacturing Intelligence**

... and many more!

*All these terms describe a similar development!*
Heading towards the 4th industrial revolution

Value from...

People

Process

Technology

Information

Source: https://www.i-scoop.eu/industry-4-0/
Automation

Physical vs. Cognitive
Industry 4.0 and employment

For workers in labor fields today, tomorrow may be a day off they hope will never come.

In an ever-changing job market, many workers are concerned about securing positions and artificial intelligence integration into their jobs may mean they are nothing but disposable.

A recent study by researchers at the University of Pittsburgh, Carnegie Mellon University, and the University of Pennsylvania found that nearly two-thirds of U.S. workers, up to six times higher than workers in Germany, now work with technologies that substitute for human labor.

However, according to Thomas H. Wooten, assistant professor of manufacturing at West Virginia University, while the types of jobs may change due to technological advancements, human innovativeness is still a vital part in the new market.

City needs more time to amend plan

Dr. Thorsten Wuest
thwuest@mail.wvu.edu

http://www.cbc.ca/radio/quirks/september-9-2017-1.4280509/will-you-have-to-become-a-cyborg-for-your-job-1.4280516
It is a global development

High-Tech Strategy
Projects for the future
• Industry 4.0 initiative
• Smart Services Program
• Smart Data Program for SME

Industry Revitalization Plan
Restructuring of industry
World’s leading IT society
Connected factory

Manufacturing Renaissance
• Industrial Internet Consortium
• Smart Manufacturing Leadership Coalition (SMLC)
• Manufacturing USA

China Manufacturing 2025
IT integration in industrial processes
High-end automatization & robotics

Source: Siemens Ltd. Seoul 2014
Advanced & **Smart Manufacturing**
Advanced vs. Smart Manufacturing
Two different ways of differentiation

**Advanced Manufacturing**
New technologies, products, materials and processes

**Smart Manufacturing**
Use of data throughout the product life cycle

**Advanced Manufacturing**
Focus on physical manufacturing technology

**Smart Manufacturing**
Focus on data and analytics

Source: Shipp et al. 2012

Source: Mittal, Khan & Wuest 2017

Dr. Thorsten Wuest
thwuest@mail.wvu.edu
"Smart Manufacturing is a data intensive application of information technology at the shop floor level and above to enable intelligent, efficient and responsive operations."

Wallace & Riddick, 2013
Smart Manufacturing

Smart manufacturing marries information, technology and human ingenuity to bring about a rapid revolution in the development and application of manufacturing intelligence to every aspect of business. It will fundamentally change how products are invented, manufactured, shipped and sold.

It will improve worker safety and protect the environment by making zero-emissions, zero-incident manufacturing possible.

It will help keep jobs in this country [USA] by keeping manufacturers competitive in the global marketplace despite the substantially higher cost of doing business in the United States.

Chand & Davis, 2010
Smart Manufacturing Opportunities
The Industrial IoT creates various improvement opportunities

+ 49% product quality

+ 80% efficiency

+ 25% productivity increase

- 30% production time

+ 1% GDP

+ 25% energy efficiency improvement

+ 40% customer satisfaction

- 25% safety incidents

- 25% safety incidents

Source: https://www.slideshare.net/solaircorporate/

Schmid & Wuest, 2017
Smart Manufacturing Vision
Fully Connected Smart Factory

Alerts monitor:
Problem with machine #2. Please check

Control center:
Aggregated data reveal improvement areas

Packing material is low. Please release order.

I need more materials

I'm customer order #312 and want to be red colored.

End of line test:
Machine #1, Please adjust machine parameters

Cogwheel will break in five days. I have ordered spare parts and scheduled external service provider.

Source: http://smartamerica.org/teams/smart-manufacturing/

Schmid & Wuest, 2017
IT/OT Integration enabling Smart Manufacturing
Convergence of the virtual and real world
Smart Manufacturing and (I)IoT

(I)IoT as an enabler of Smart Manufacturing

- Smart Manufacturing
  - Manufacturing industries
  - Systems, things, devices, on the shop floor
  - Products throughout their life cycle

Internet of Things
- All industries
- All things and devices

Source: https://www.youtube.com/watch?v=1Q5lyw8vll8

Schmid & Wuest, 2017
SMART MANUFACTURING MARRIES TECHNOLOGY, DATA AND HUMAN INGENUITY
Smart Manufacturing Technologies

- **Technology** is always a *key enabling factor*

- But what are **Smart Manufacturing** associated technologies?

- We created a comprehensive overview as a *basis for discussion* and a first step towards a Smart Manufacturing Ontology

<table>
<thead>
<tr>
<th>#</th>
<th>Technology</th>
<th>Definition</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Augmented Reality and Virtual Reality</td>
<td>Creating an artificial (virtual) environment of the real world using various innovative technologies like mobile devices, wearables, etc.</td>
<td>• Kolberg &amp; Zühlke (2015) • Tzong-Ming &amp; Tu (2009) • Rüßmann et al. (2015) • Wu et al. (2013)</td>
</tr>
<tr>
<td>2</td>
<td>Additive Manufacturing</td>
<td>Additive manufacturing creates complex parts from the ground up, mostly adding one layer at a time, based on a 3D CAD model.</td>
<td>• Huang et al. (2013)</td>
</tr>
<tr>
<td>3</td>
<td>Internet of Things (IoT)</td>
<td>IoT (also referred to as the Internet of Everything or Industrial Internet of Things) describes the connection and communication of physical ‘things’ over internet.</td>
<td>• Wu et al. (2013)</td>
</tr>
<tr>
<td>4</td>
<td>(Big) Data Analytics</td>
<td>Data sets (or data lakes) are now characterized by their high volume, velocity and variety nature (3Vs) plus veracity and value (5Vs). Specific technologies with new analytical methods and tools are required to transform big volumes of data effectively and efficiently into information and knowledge.</td>
<td>• De Mauro et al. (2015) • Addo-Tenkorang &amp; Helo (2016)</td>
</tr>
<tr>
<td>5</td>
<td>Autonomous and Collaborative Robots</td>
<td>Robots that are capable of autonomous decisions and are able to assist or work alongside humans in operations (i.e. CoBots).</td>
<td>• Beer et al. (2014) • Maurice et al. (2014)</td>
</tr>
<tr>
<td>6</td>
<td>Cyber-Physical Systems</td>
<td>CPS are systems of collaborating computational entities that are in intensive connection with their surrounding physical world and their on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet.</td>
<td>• Monostori et al. (2014) • Zhong &amp; Nof (2015)</td>
</tr>
</tbody>
</table>
38 technologies (27 char. / 7 enabl. factors)

We decided to **cluster**, resulting in:

1. 3-D Printing / Additive Manufacturing
2. Cloud Manufacturing
3. CPS (Cyber Physical Systems) / CPPS (Cyber Physical Production Systems)
4. Cyber Security
5. Data Analytics
6. Energy Saving / Energy Efficiency
7. Intelligent Control
8. IoT / IoS / IIoT
9. IT based Production System
10. Smart Product / Part / Material
11. Visual Technology

Mittal et al., 2017
Example: Visual Technologies

• Example Cluster: *Visual Technology*

• Comprised of three technologies:
  • *Hologram / Digital Twin*
  • *Augmented Reality*
  • *Virtual Reality*

Source: https://compass-ssl.surface.com/assets/d4/8d/d48dbc28-aec3-4417-b319-bed3aac91c81.jpg?n=Overview_Hero_1920_img_new.jpg
... But what does all that mean for manufacturing companies?

- **Continuous innovation**
  - Question current processes & practices!
- **Adaption** of new technologies, tools and frameworks
  - Data & Information driven!
- Skilled **workforce**
  - Lifelong learning!
Smart Manufacturing in
Small- and Medium-sized Enterprises (SMEs)
Status of Industry

Source: Jinwoo Park, 2015
Siemens Digital factory

- Siemens’ plant in Amberg, Germany
- *Products communicate* with manufacturing machines
- IT systems control and optimize all processes
- Production quality is at 99.99885 %
## SMEs vs MNEs – Different requirements

<table>
<thead>
<tr>
<th>#</th>
<th>Features</th>
<th>SMEs</th>
<th>MNEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of Advanced Manufacturing Technologies</td>
<td>Low</td>
<td>Very High</td>
</tr>
<tr>
<td>2</td>
<td>Financial Resources</td>
<td>Limited</td>
<td>Comparatively more</td>
</tr>
<tr>
<td>3</td>
<td>Organization Culture/Leadership</td>
<td>Conservative</td>
<td>Flexible</td>
</tr>
<tr>
<td>4</td>
<td>Company Strategy</td>
<td>Dictated by Gut Feeling of the Leader (Owner)</td>
<td>Market Research and Accurate Analyses</td>
</tr>
<tr>
<td>5</td>
<td>Decision Making</td>
<td>Restricted to Leader/ Few Knowledge Carriers</td>
<td>Board of Advisory</td>
</tr>
<tr>
<td>6</td>
<td>Human Resources</td>
<td>Engaged in Multiple Domains</td>
<td>Have Own Area of Specialization</td>
</tr>
<tr>
<td>7</td>
<td>Human Resource Development</td>
<td>Exposure</td>
<td>Training, Mentors, Workshops</td>
</tr>
<tr>
<td>8</td>
<td>Alliances with Universities/ Research Institutions</td>
<td>Not so Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>9</td>
<td>Important Activities</td>
<td>Outsourced Internal to the Organization</td>
<td></td>
</tr>
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<tr>
<td>10</td>
<td>Nature of Product</td>
<td>Highly</td>
<td>Little</td>
</tr>
<tr>
<td>11</td>
<td>Collaborative Network</td>
<td>High</td>
<td>Not so much</td>
</tr>
<tr>
<td>12</td>
<td>Customer/Supplier Relations (Partner Dependence)</td>
<td>Strong</td>
<td>Not so Strong</td>
</tr>
<tr>
<td>13</td>
<td>Standards</td>
<td>Not so</td>
<td>Strictly</td>
</tr>
<tr>
<td>14</td>
<td>Organizational Structure</td>
<td>Less Complex</td>
<td>Complex</td>
</tr>
<tr>
<td>15</td>
<td>Software</td>
<td>Provides Tailored Solutions to Problems</td>
<td>Standardized Solutions</td>
</tr>
<tr>
<td>16</td>
<td>Use of Resources/ Research &amp; Development</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>17</td>
<td>Knowledge and Experience</td>
<td>Focused in a Specific Area</td>
<td>Spread Around Different Areas</td>
</tr>
</tbody>
</table>
Upgrade existing systems

• Bosch upgraded *Lathe from 1887* to be Smart Manufacturing ready

• **New capabilities:**
  • process monitoring for constant quality assurance
  • another is condition monitoring in order to prevent unplanned downtimes

• Extreme example but *showcases the potential*

Project Scope

Background
- Internet of Things is **changing** the industrial landscape
- Manufacturing is undergoing a major **transition**
- Large corporations are dealing with this topic intensively

⇒ But how to apply Smart Manufacturing in small companies?
⇒ How can small manufacturers take advantage of it?

Objectives
- Examine the **current state** of manufacturing with a **survey**
- Understand the manufacturing landscape and its specific **challenges** and **concerns** by conducting **interviews** and plant visits
- Support **small** manufacturers in adopting Smart Manufacturing technologies by setting up a training **workshop**

Work Packages
1. Online survey
2. Interviews & plant visits
3. Analysis of results & report
4. Training workshop

Schmid & Wuest, 2017
Survey Method
Who participated in the survey?

53 Total # of respondents from manufacturing

Company size by #employees
- less that 20
- 100 - 499
- 20 - 99
- 500 and more

Bar chart showing the distribution of respondents from different industries:
- Machinery
- Metal Products
- Wood & Furniture Products
- Plastics & Rubber Products
- Electrical Equipment
- Food
- Chemical
- Transportation Equipment
- Nonmetallic-Mineral Products
- Nonmetallic-Mineral Product
- Textile & Apparel Products
- Miscellaneous
Survey Results

How aware are companies of the transition towards Smart Manufacturing?

I have already heard about...

- Industry 4.0: 30%
- Smart Manufacturing: 50%
- Industrial Internet: 40%
- Internet of Things (IoT): 30%
- Smart Factory: 40%
- Cyber-physical system: 20%

My company is dealing with...

- Industry 4.0: 10%
- Smart Manufacturing: 30%
- Industrial Internet: 40%
- Internet of Things (IoT): 30%
- Smart Factory: 10%
- Cyber-physical system: 10%
Survey Results
How prepared are companies for Smart Manufacturing?

How relevant is Smart Manufacturing for your company?

- Very relevant
- Moderately relevant
- Not relevant at all

To what extent is your company and your employees prepared?

- Very prepared
- Moderately prepared
- Slightly prepared

Schmid & Wuest, 2017
Survey Results

What are the needs of manufacturers when it comes to Smart Manufacturing?

What kind of support would be helpful for your company?

- Exchange of best practices: 60%
- Funding opportunities: 40%
- Further information: 20%
- Trainings & Workshops: 80%
- Collaboration with: 60%
- Employee engagement: 40%

My company is interested in...

- Results of the survey: 80%
- Further information on: 60%
- Trainings & Workshops in: 40%
- Assessment of company's: 20%
- None of them: 0%

Schmid & Wuest, 2017
Interview Method

Who participated in the interview sessions?

Manufacturers

9 Interviewees in manufacturing companies

Manufacturing Experts

5 Experts in academia, associations & state agencies
Selected insights from interviews

Lack of economic opportunities
- Decline of coal industry
- Decline in local markets
- Oversupply in global markets
- Global competition

Manufacturing reputation problem
- Mindset of ‘second-class’ jobs & low wages
- Misconception of dirty and dangerous work

Infrastructure challenges
- Telecommunication infrastructure
- Lack of investments in facilities/tech.
- Infrastructure of support systems

Perception of Smart Manufacturing value
- Lack of awareness of existing tech. & potential impact
- Hard to imagine value-add for discrete manufacturing
- Difficult to imagine in a small scale
- Lack of show cases & success stories / role models

Increasing cost
- Increasing utility rates
- Rapidly rising healthcare cost
- Lack of capital to ‘keep up’ w/ tech.

“It’s a different deal in small companies in many ways”
- Small companies could move faster
- Less resources reg. humans resources, money & time
Key challenges of Smart Manufacturing adoption for SMEs

Lack of opportunity

Resources & cost

Knowledge & awareness

Skilled workforce

Missing ‘success stories’
‘Capability creates Opportunity’

Craig Hartzell, Azimuth Inc., 2017
SMART MANUFACTURING IS NOT ONLY FOR THE BIG GUYS.
Opportunities for collaboration & entrepreneurs

Brave new world

‘Low’ initial investment

Dedicated ‘Apps’ (Platform solution)

Scalable solutions (interoperable & extensible)

Fast deployment
Recommendations (1/2) for Smart Manufacturing in SMEs

• Provide **educational resources** on Smart Manufacturing and Industry 4.0 (‘spread the word’ in an accessible way) for industrial partners.

• Jointly develop **curriculum for 1) professionals** to equip them with required knowledge to innovate and operate within a Smart Manufacturing environment, and 2) include Smart Manufacturing in **existing engineering curricula** across institutions (‘high school to masters/Ph.D.’), departments and majors.

• **Communicate successes** broadly and encourage peer-to-peer exchange (across industries) of best practices and lessons learned.
Recommendations (2/2) for Smart Manufacturing in SMEs

- Build **strong and sustainable partnerships** between companies, academia and industry associations. For example, leverage (local) technology start-ups to team-up with established manufacturers and academia.

- Start with small **‘lighthouse’ projects** targeting specific pain points to learn and achieve quick wins.

- **Leverage state and federal funding** to complement the limited recourses available to manufacturing SMEs.
SMART MANUFACTURING CANNOT BE BOUGHT. THE SUCCESS HAS TO BE EARNED.
My take on this issue:

- Solutions must be tailored to SMEs’ (real!) needs & requirements!
- Create real value (short AND long term)!
- Fit the strategy / vision!

To do so SMEs need to:
- Assess their current processes critically
- Identify their core competencies
- Build on those and
- Develop a roadmap with specific milestones / objectives
- (keep 80/20 rule in mind!)
Thank You!

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