Sustainable manufacturing –
A German perspective on shaping global value creation

11th Global Conference on Sustainable Manufacturing -
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Prof. Dr.-Ing. Günther Seliger

CRC 1026 Sustainable Manufacturing – Shaping Global Value Creation
Funded by German Research Foundation (DFG)
Global Conference Series on Sustainable Manufacturing

- **GCSM 2013**: conference contributions from 34 countries (51 German, 72 international)

  Website visitors from all over the world

  ![Map showing conference locations and website visitors from around the world]
Agenda

- Challenge
- Architecture of global value creation
- Laboratory of sustainable manufacturing
- Dissemination
Agenda

- **Challenge**
- Architecture of global value creation
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Prosperity for everybody?

- How to design and manufacture products and services
  - opening up hungry markets,
  - avoiding bad investments in saturated markets,
  - increasing human wealth on global level within conditions of environmental resource availability

- Adapt existing process paradigms
  - between economies of scale and economies of scope,
  - to create more benefit for more people with less resources.
Quality of life and consumption of resources

Irresponsible development path: Wealth for all people relying on present technologies

Responsible consumption of resources

Emerging countries

Improving quality of life with a responsible consumption of resources

Acceptable living standard with responsible consumption of resources

Early industrialised countries

Maintaining the quality of life while reducing the resource consumption

Acceptable living standard

Consumption of resources

Quality of life
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- Challenge
- **Architecture of global value creation**
- Laboratory of sustainable manufacturing
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The dynamics of global competition and cooperation shall be utilized for lending wings to processes of innovation and mediation towards the reasonably demanded sustainability on our globe.
Global value creation

Areas of human living

- Energy
- Production
- Mobility

Development level

- Developing countries
- Emerging countries
- Developed countries

Network consisting of modules

Module consisting of value creation factors

Cooperation

Competition

Sustainability dimensions

Network consisting of modules

horizontal integration

vertical integration

Module consisting of value creation factors

- Product
- Process
- Organization

- What
- How
- When
- Where
- By what

Dimensions:

- Economic
- Social
- Ecological

Areas of human living

Development level

Developing countries

Emerging countries

Developed countries
B6 - Integration shop / laboratory of sustainable manufacturing

- Implementation of physical and virtual value creation modules (VCMs)
- Exemplarily connected to value creation networks (VCNs)

<table>
<thead>
<tr>
<th>VCM/VCN</th>
<th>Product</th>
<th>Process</th>
<th>Equipment</th>
<th>Organization</th>
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- Challenge
- Architecture of global value creation
- **Laboratory of sustainable manufacturing**
  - Area search and valuation
  - Area implementation
- Dissemination
Laboratory of sustainable manufacturing – Day 2, 14:30 – 16:30

A1/Demonstrator: “Pathways for sustainable technology development”
*Technology integration demonstration*

A5: “Multicriteria optimisation”
*Optimisation methods*

KAP: “KAP: Knowledge, awareness, and prediction of man, machine, material, and method in manufacturing; Volvo, Nissan, Intel, Infineon”
*Poster presentation*

B5: “Design of accuracy increasing systems for simple machine tools”
*Presentation and comparison of testing work pieces*

S: “Samara – energy efficient material handling”
*Robot and computer presentation*

SIM: “Integrated control system simulation for PLC-controlled material flow”
*Simulation and control system*

B4: “Development of microsystem enhanced machine tool structures for lightweight and accuracy optimised (LEG²O) frames”
*Presentation of LEG²O and sensor node prototype*

B2a: “Energy efficient dry ice cleaning”
*Presentation of rotational wheel blasting, geometries of accelerating parts*

B2b: “Energy efficient dry machining”
*Presentation of tool prototype (turning tool and cooling system)*

B3: “Sustainable welding production by combined application of numerical simulation and new process technologies”
*Test butt welds (thick metal plate)*

ST: “SmarTower” - System for wind turbines
*Miniaturized model and poster presentation*

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A1 - Exploiting technology for useful applications

Surrounding field scenarios

Technology scenarios

System creation

- Transfer technological potential into useful applications

- Problems
- Tasks
- Requirements

- Technological potentials/solutions
A2/A3 - Sustainability assessment & indicator development

- Development of a **new methodology and suitable indicators** for assessing **sustainability in specific value chains** within the manufacturing community

- Life Cycle Sustainability Assessment
  - environmental dimension
    - reduce environmental damage
    - identify environmental hotspots
  - social dimension
    - train & qualification of employees
    - consideration of (far) upstream supply chain
  - economic dimension
    - cost assessment and economic prosperity

- Measurement of sustainability impacts
  - practical case studies for products & processes
A4 - Manufacturing sector as key area for economic wealth

- Analysis of development paths by the use of worldwide Input-Output data
- Nodes refer to economic sectors

**Outcomes**
- There are only a few feasible development paths (links)
- The critical bottlenecks are dominated by (light) manufacturing sectors.

**Implications**
- The establishment of manufacturing industries is crucial for economic wealth
- The successful development of manufacturing sectors shapes human capital, institutions, natural stocks or society
- The access to sustainable manufacturing technology is the key for worldwide prosperity
Goal: Providing decision support tools

Requirements:
- Quantitative description and formalisation
- Finding algorithmic approaches to compute Pareto optimal solutions

Description in terms of mixed integer programs

\[
\begin{align*}
\text{max} & \quad Cx + Dy \\
\text{(i)} & \quad x_{\delta_v^+} = A_v x_{\delta_v^-} + b_v \quad \forall v \quad \text{production} \\
\text{(ii)} & \quad x_{\delta_v^-} \leq \sum_{q \in Q_v} y_q u_{q,\delta_v^-} \quad \forall v \quad \text{config limits} \\
\text{(iii)} & \quad 1 = \sum_{q \in Q_v} y_q \quad \forall v \quad \text{config choice} \\
\text{(iv)} & \quad y_q \in \{0,1\} \quad \forall q \quad \text{config choice} \\
\text{(v)} & \quad x \geq 0
\end{align*}
\]
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B1 - Virtual product creation in sustainable value creation networks

Enterprise and Society View

Trade-off between sustainability context areas and technical performance

Traditional Engineering View

Major Goal
Enable and qualify the engineer to develop products for sustainable value creation

Approach
Development of a Design Decision Support Assistant, embedded into designer’s IT environment

System design is based on the development of a pedelec and a turbo charger in a bottom-up analysis

Pedelec
Turbo charger
B2 - Energy efficient cleaning and dry machining

- Value creation module dry machining: Closed loop cooling
  - Design of LN2 cooling, control system and turning tool
  - Cutting trials with different cutting insert geometries (best stiffness to thickness ratio)
  - Evaluation of conventional turning tools (forces, temperatures, wear)

- Value creation module cleaning: Energy efficient cleaning
  - Development of a standard of comparison for cleaning capacity
  - Investigation of promising principles
  - Machining trials: High speed camera investigations
  - Fundamental investigation of principles to apply mechanical and thermal mechanism separately
B4 - Development of microsystem enhanced machine tool structures or lightweight and accuracy optimized (LEG²O) frames

- Modular machine tool structures (MT) provide the basis for higher degrees of adaptability, mobility and functionality
- Mechanical optimization of single structure, interconnects and assembly
- Microsystem technology (MST) enabling crucial functionalities in MT to foster sustainable value creation
- Wireless sensors considered on various functional and technological levels
C5 - Learnstruments in value creation modules

Goal: Increase in teaching and learning productivity for sustainable manufacturing through application of learnstruments

Learnstruments are artefacts which automatically mediate their functionality to the user

Learnstruments are designed for use in a combined working and learning environment

- Physical work place teach-in
- Work place optimization assistance
- Audio/ visual work description generation/ use
- Tele working support
- Planning assistance
- Assembly assistance
PSS: Product-Service Systems enabling for sustainable city mobility

- Bicycle for city mobility
- PSS-based maintenance, repair and overhaul (MRO)
- Win-win-win among the stakeholders customer, provider and society
- Implementation: E-Bike rental system
Sensitive areas
2.4 billion people do not have access to basic sanitation

- many deaths and disabilities are caused by improper sanitation
- on average, each middle-class person uses 60 liters of fresh water per day to flush their urine & feces down the drain
Stone paper - a rock solid alternative

Goldmine in Nevada, USA

80% limestone powder
(non usable material from e.g. goldmines)

20% polyethylene
(e.g. recycled plastic bottles)

NO tree cutting

NO water pollution

NO air pollution, bleach or strong acids

Water and grease proof

Flame retardant material

Tear resistant

Decomposes into limestone powder after 6 – 9 month under environmental influence

Unique surface feel
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Exemplary Global Research Cases

What? ICT as an enabling technology for sustainable manufacturing

How?

- 09:30 Keynote: European Vision for Horizon 2020 and ICT for Factories of the Future (Danuta Seredynska, European Research Programme Officer)
- 10:00 Keynote: Global research and new manufacturing technology projects (Thomas Messervey, Intelligently Manufacturing Systems Project Development Coach)
Capacity building for sustainable engineering – Day 3, 9:00 – 12:30, room 307

- Partner countries:
  - Jordan
  - Lebanon
  - Palestine
  - Syria

- Approaches:
  - Academic Exchange
  - New academic programs
  - Enhancing current programs

- Projects:
  - MeEng: Middle Eastern Partnership in Sustainable Engineering
  - MUREE: Modernizing Undergraduate Renewable Energy Education

- Target industries:
  - Quarrying and Stone
  - Textiles and Garments
  - Leather and Shoes
  - Furniture
  - Handicrafts
  - Chemical Industries
  - Pharmaceuticals
  - Food Processing
Theme: Networking for competitive remanufacturing

- Aim: allow the inclusion of remanufacturing in the processes of small and medium sized companies in Brazil and Germany.
- Solution: Provide a set of business models based on remanufacturing principles to companies by the mean of an online knowledge platform.
International partnership „Housing-Manufacturing-Water“ – Day 3, 9:00 – 12:30

- 2010 – Concepción, Chile „Recycling of construction materials after catastrophes“
- 2011 – Cape town area, South Africa „Brick minifactories in townships“
- 2012 – Vitoria Brazil „Mobile construction material factories“
International universities – Day 3, 9:00 – 12:30

New master program in „Global Production Engineering and Management” with a special focus on sustainable manufacturing

New Master Program in „Industrial Engineering” with a special focus on sustainable manufacturing

Fraunhofer Society founds a Turkey-based subsidiary to extend the outreach of research in promoting sustainable value creation with Turkish and Middle East partners.