Ecodesign - sustainable material and manufacturing concepts

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The Giants Playing the Field…

- China and India (picture): at par in 1970, today India 2x while China 7x increase in per capita material consumption
- China: resource consumption slashes 15% material efficiency (Wang et al 2012)

Role of secondary markets in Cu

Growing uses

- Wind energy - In large turbines one tonne of copper
- Solar energy - technology that uses copper in the manufacture of solar cells developed
- Copper motors in hybrid electric vehicles
- In motors and cables of light rail vehicles
- Use in data transmission growing

World production and demand 2011-2035
(‘000t contained copper in concentrates, SXEW cathode and secondary materials)
Global flow of primary Ni into fabrication

- World nickel consumption is dominated by stainless steel sector and market in China (40% of consumption and production) and India
- A 5% growth estimated during next 5 years
- Growth in battery industry (electric hybrid vehicles)
Future change factors to business logic

- New fees, restrictions and possibilities to emerge through legislation and regulation (e.g. removing waste status of side streams).
- Price fluctuation of raw materials will become more radical. Raw materials are interdependent, e.g. the price of nickel has an impact on the price of steel.
- Sustainable acquisition of raw materials legitimates operations. Environmental actions directed to raw material industry are seen as business potential rather than a disadvantage or PR.
Typical material life cycle

- **Raw material**
- **Primary production**
- **(Semi-) fabrication**
- **Product manufacture**
- **Recycling**
- **Use**
- **Waste**
- **Energy, resources**
- **CO₂**
- **Water**
Ecoefficiency

Material and structure designed for
- Substitution
- Performance
- Recycling

Optimal material streams
- New recycling technologies
- Industrial symbiosis
- 0-waste communities

Energy, resources

Primary production

(Semi-) fabrication

Product manufact.

Use

Recycling

Raw material

Waste

Product manufacturing
- Production systems and automation
- New production concepts
- Digital manufacturing
VTT’s Ecodesign concept

- Toolbox under development to bridge the gaps in the whole cycle
  - Modelling assisted material design
  - New materials and processing to “digital format”
  - Platform for digital interaction of whole product and production chain including product life cycle analysis
  - Additive manufacturing, manufacturing for design
  - Optimum performance, simulation, related in-built service strategy (predictive maintenance vs cost)
  - (On-line) lifetime evaluation, process guiding feedback
  - New recycling technologies, disassembly design
  - € PROFIT
VTT Tools under development in the frame of materials and manufacturing
Additive manufacturing

- Paradigm change in manufacturing
- Higher added value, custom made, eco-efficient and sustainable products
- Less side streams
- New freedom to design
  - Ecodesign – more flexible variations in raw materials
  - Smartdesign – localized performance, IPR in product,
  - In-situ sensors
- Digital manufacturing
  - New logistics and distribution models for manufacturing
  - New lean and agile supply chains
Multiscale modelling for material design

MODELLING ASSISTED ROUTE

Raw materials
Constructional design

Process P
Structure S
Properties P
Performance P

E.G controlled wear

Life time control of component
Maintenance strategy

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Life time control of component
Maintenance strategy
Production and Industrial systems

- Smart machines
- Prognostic maintenance
- Production systems and automation
- New production concepts
New recycling methods

System Analysis
- System modelling
- Design for disassembly
- Sustainability analysis

Sorting
- Smart crushing and sieving
- High sensitivity sensors
- Machine vision

Processing
- Smart crushing
- Hydrometallurgical processes
- Bioleaching
- Biotechnical processing
Ecodesign concept

COMPONENT

Raw material

Primary production

(Semi-) fabrication

Product manufact.

Use

Recycling

Waste

SIDE STREAMS

Energy, resources
Ecodesign concept

COMPONENT

Raw material

Powders, pastes

Additive manufact.

Recycling

Use

Waste

Energy, resources

CO₂

Water
Ecodesign concept

COMPONENT

Raw material

Recycling

Use

Additive manufact.

(Csemi-)
fabrication

Bio

Mineral

Powders, pastes

CO₂

Water
Ecodesign concept

COMPONENT & SYSTEM

Raw material

Bio

Mineral

Powders, pastes

(Semi-) fabrication

Additive manufact.

Product manufact.

Use

Recycling

Energy, resources

CO₂

Water
Energy, resources

COMPONENT & SYSTEM & INDUSTRIAL

Raw material

Bio Mineral

Powders, pastes

(Semi-) fabrication

Additive manufact.

Recycling

Use

CO₂

Water

Automation

Condition monitoring

Industrial symbiosis

Operative ICT

Industrial services

Global networks

Production

Ecodesign concept
Cases
Case 1: Copper flow in electric vehicle

- Need:
  - Towards energy efficient transportation
  - Enough available Cu
    - Cu amount per electric car 100-200 kg
    - 1 billion passenger car globally (2010)
  - Additionally Nd, Co, Sm, Li for permanent magnets and batteries

- Solution
  - Replacement of Cu, e.g.,
    - carbon fibre, nanotechnology (motor)
    - wireless data transfer (cables)
  - Light material solutions in chassis
  - Compact, light weight power line
  - Battery materials

- Benefits:
  - Better transportation specific energy efficiency [kg/W]
  - Energy is used for transportation itself, not for moving heavy vehicle
  - Nd, Co, Sm, Li usage reduced

Ecodesign Solution by VTT:
- Modelling assisted design & optimization of new motor and other concepts
- Systematic link between performance, life-cycle, maintenance strategies and system level
- New recycling methods based on the bioleaching
Case 2: Nickel flow in combustion boiler

- **Need:**
  - More demanding fuels is used (waste, biomass…) making environment harsher for materials
  - Also higher process temperatures are desired to increase boiler efficiency

- Currently thick over welded coatings are used with high amount of Ni. Also Nb and Ta are present.

- **Solution**
  - Thermally sprayed Cl-trap coating

- **Benefits:**
  - Decrease in Ni xx%, Nb 100%, Ta 100%
  - Manufacturing costs (raw materials, manufacturing, maintenance)

**Ecodesign Solution by VTT:**
- Modelling assisted material and structure design
- Systematic link between performance, life time, maintenance strategies and finally energy efficiency in system level operation
Case 3: Printed Intelligence

- Organic photovoltaics – a multilayer structure with organic and inorganic thin – and thick films – manufactured using roll-to-roll printing processes

- Challenges:
  - Electron contact – typically silver paste which is expensive and environmentally not sustainable
  - Hole contact – TCO typically ITO, In is a rare metal and expensive, patterning by etching

VTT’s Aluminum based electron contact paste provides cheaper and more sustainable OPV structures

ITO patterning process developed such a way that etching waste can be circulated via normal liquid waste, In can be recovered from the waste
Summary

- New design and manufacturing concepts will be in decisive role in competitiveness of industry. They offer new opportunities to SMEs. Additive manufacturing provides a possibility to create new types of products, business, business models and jobs.

- Materials, processing and manufacturing technologies are one of the critical parts of the chain and bringing them as part of the digital manufacturing chain is a precondition for getting the cycle function in the industrial sense.

- New agile design tools help respond to the global challenges caused by quantity, location, and price of raw materials.

- Future society is based on sustainable development, where the re-use is of central importance. Materials reuse, efficient use of secondary flows as well as more efficient recovery technologies provide the basis for the sustainable exploitation of natural resources.
VTT - 70 years of technology for business and society