metals treatment and compressed air supply

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- Overview of processes analysed
- General modelling principles
- Description of life cycle inventories of machine processing
- Conclusions

Overview of processes analysed

- Average machine processing
- Degreasing of metal surfaces
- Chipping
- Laser machining
- Chippless shaping
- compressed air supply
Modelling principles: capital equipment

• factory infrastructure:
  demand of a share of capital equipment included in all machining datasets
• exception “laser machining”:
  no factory hall demand included, as no correlation between machining hours and factory infrastructure
• exception “compressed air supply”:
  considered ancillary process (e.g., to metals machining) in a factory

Modelling principles: Degreasing

• machining datasets do NOT include degreasing
  Reason:
  - machining is per mass (or time in the case of laser machining)
  - degreasing is per surface
• “surface to mass” ratio must be known
• practitioner needs to add degreasing dataset to each individual machining dataset
Modelling principles: Reference unit and material input

- chipping datasets:
  - per kg material removed
  - material removed is an input
- chipless shaping:
  - per kg material processed
  - no material input
- laser machining:
  - per hour processing
  - no material input (a few mg/sec)
- compressed air supply:
  - per m³ comp. air supplied (including losses in the network)
  - per m³ comp. air produced

Average machine processing

- average product manufacturing:
  - steel
  - chromium steel
  - aluminium
  - copper
  - metal (82.4/2.0/3.3/12.2 %)
- additional datasets:
  - machine (manufacturing)
  - machine operation
  - factory (construction)
  - factory operation
  - metal input
Inventory data

- Data from 8 mechanical processing machines
- Average capacity about 8,000 tons from 44 to 210,000 tons capacity
- data from 2003 to 2006
- data includes
  - solvents, consumption
  - solvents, emission: 0.56g/kg metal product
  - lubricating oil
  - compressed air
  - thermal energy
  - electricity

machine and factory

- manufacture data:
  based on the same 8 machines
- factory operation:
  ancillary energy consumption, water consumption and wastes generated
- metal working factory:
  - includes building hall and land use
  - data based on three manufacturers
Degreasing of metals

- industry data from European household device manufacturer
- inventory data includes:
  - electricity
  - thermal energy
  - industrial cleaning detergents
  - sodium chloride
  - sulphuric acid
  - water

Turning

- Two phases in treatment: roughing, dressing and average
- Two different technologies: conventional and CNC (Computerized Numerical Control)
- Five different metals: steel, NiCr-steel, cast iron, aluminium, brass
- Inventory data:
  - electricity
  - compressed air (CNC only)
  - lubricating oil (CNC only)
  - factory (operation and construction)
  - amount of metal removed
Results: ecological scarcity 06

Contributions: ecological scarcity 06
Drilling

- Two different technologies: conventional and CNC
- Five different metals: steel, chromium steel, aluminium, copper, brass
- Inventory data:
  - electricity
  - compressed air (CNC only)
  - lubricating oil (CNC only)
  - capital equipment
  - factory operation
  - amount of metal removed

Results: ecological scarcity 06

![Bar chart showing ecological scarcity for different metals in CNC drilling](chart.png)
Milling

- Four different process modes:
  - large and small parts, dressing and average
- Four different metals:
  - steel, chromium steel, cast iron, aluminium
- Inventory data:
  - electricity
  - compressed air
  - lubricating oil
  - amount of metal removed

Results: ecological scarcity 06
Laser machining of metals

- Two different laser systems:
  - YAG (Yttrium-Aluminium garnet)
  - CO₂

- Different laser sizes:
  - YAG: 30, 40, 50, 60, 120, 200, 330, 500 W
  - CO₂: 2, 2.7, 3.2, 4.0, 5.0, 6.0 kW

- Total operation time:
  - YAG: 2 hours/day; 5 days/week; 15 years
  - CO₂: 12 hours/day; 5 days/week; 15 years
Laser machining: inventory data

- **YAG laser systems:**
  - electricity
  - cooling water (larger units only)
  - air emissions of particulates, NO\textsubscript{X}, and ozone
  - machine manufacture

- **CO\textsubscript{2} laser systems:**
  - electricity
  - industrial gases (helium, nitrogen, carbon dioxide)
  - air emissions of helium, particulates, NO\textsubscript{X}, CO\textsubscript{2}, and ozone
  - machine manufacture

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Results: ecological scarcity 06

<table>
<thead>
<tr>
<th>Laser Machining of Metal</th>
<th>Ecopeints/hour operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>YAG, 40W</td>
<td>10000</td>
</tr>
<tr>
<td>YAG, 120W</td>
<td>20000</td>
</tr>
<tr>
<td>YAG, 500W</td>
<td>50000</td>
</tr>
<tr>
<td>CO\textsubscript{2}, 2000W</td>
<td>40000</td>
</tr>
<tr>
<td>CO\textsubscript{2}, 6000W</td>
<td>50000</td>
</tr>
</tbody>
</table>

Legend:
- green: emission into top soil
- yellow: waste
- blue: land use
- orange: natural resources
- brown: energy resources
- red: emission into ground water
- blue: emission into surface water
- yellow: emission into air
Contributions: ecological scarcity 06

Impact extrusion

- Three different levels of temperature:
  - cold \( (T/T_{\text{melt}} < 0.3) \), warm, hot \( (T/T_{\text{melt}} > 0.6) \)
- two different metals:
  - steel
  - aluminium (cold IE only)
- Datasets on
  - surface treatment (cold IE only)
  - warming (warm/hot IE only)
  - deformation stroke
  - 1 to five stroke treatments
- Inventory data:
  - energy inputs, capital equipment and factory operation
Results: ecological scarcity 06

Contributions: ecological scarcity 06
Deep drawing

- Two different modes: single stroke and continuous
- Different press sizes: 650, 3’500, 10’000, 38’000 kN
- One metal: steel
- Inventory data:
  - electricity,
  - compressed air
  - capital equipment
  - factory operation

Compressed air supply
Compressed air supply system

- compressor
- compressed air storage container (opt.)
- dryer (opt.)
- filter (opt.)
- pipe network (for distribution)
- consumer devices

Drivers of electricity consumption

- leakage rate
- pressure level
- appropriateness of control settings
- size of compressor

increase in electricity consumption due to filter and dryer:
- small installations: 5 %
- large installations: 3 %
### Compressors installed in Switzerland

<table>
<thead>
<tr>
<th>power in kW</th>
<th>&lt;3</th>
<th>3-15</th>
<th>18-90</th>
<th>&gt;90</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>installed compressors</td>
<td>110‘000</td>
<td>30‘000</td>
<td>8‘000</td>
<td>800</td>
<td>148‘000</td>
</tr>
<tr>
<td></td>
<td>74 %</td>
<td>20 %</td>
<td>5 %</td>
<td>1 %</td>
<td></td>
</tr>
<tr>
<td>electricity consumption [GWh]</td>
<td>11</td>
<td>150</td>
<td>400</td>
<td>200</td>
<td>671</td>
</tr>
<tr>
<td></td>
<td>1 %</td>
<td>20 %</td>
<td>53 %</td>
<td>26 %</td>
<td></td>
</tr>
</tbody>
</table>

### Key figures compressors & network

- **Life time**: 15 years
- **750 hours per year**
- **Machine weight**:
  - 4 kW: 140 kg (35 kg/kW)
  - 300 kW: 4600 kg (15 kg/kW)
- **Increase in electricity consumption due to filter and dryer**:
  - Small installations: 5 %
  - Large installations: 3 %
- **Pipe diameter**: 100 mm
- **Network length**: 4'500 m
- **100 mg steel (large), 34 mg aluminium (small) per Nm³**
Datasets available

- Two different compressor sizes: 
  <30 kW, >30 kW
- Three different pressure levels:
  - <30 kW: 8, 10, 12 bar
  - >30 kW: 6, 7, 8 bar
- Three different technology levels:
  - average
  - optimised
  - best generation (>30 kW only)

Electricity consumption

![Graph showing electricity consumption]

- average, large
- optimised, large
- best generation, large
- average, small
- optimised, small
Inventory data

- leakage rate > 30 kW:
  - average: 30%
  - optimised: 15%
  - best generation: 10%
- leakage rate < 30 kW:
  - average: 50%
  - optimised: 5%
- lubricating oil:
  - small: 10 mg / Nm³
  - large: 2.1 mg / Nm³

Results: cumulative energy demand
Results: ecological scarcity 06

Contributions: ecological scarcity 06
Conclusions

- chipping processes: production of material removed is dominant
- chipless shaping: deformation energy and general factory operation are most important
- laser machining dependent on power needed
- compressed air: substantial difference particularly between average, optimised and best
- metal machining datasets do not include degreasing => add it separately

Thank you very much for your attention!

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