Industry 4.0 from a machining perspective

**Conventional manufacturing**

- Design
- Process planning
- Tooling

**Industry 4.0**

- Design
- Process planning
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**In-machining**

- Machine utilisation and process stability
- Tool life monitoring
- Tool wear monitoring
- Remote control of machines

**Advanced machining analytics**

- In-machining
  - Machine utilisation and process stability
  - Tool life monitoring
  - Tool wear monitoring
  - Remote control of machines

- Capital efficiency
- Sustainable machining
- Traceability and process improvements

**Manufacturing process**

- Design
- Process planning
- Logistics

**Industry 4.0 from a machining perspective**

Conventional manufacturing and Industry 4.0 represent different stages of manufacturing evolution. Conventional manufacturing involves manual processes and limited data analysis, while Industry 4.0 leverages advanced analytics and digital tools for greater efficiency and sustainability.

- **Design and planning**
  - In-machining: Sensors and algorithms optimize tool paths and material removal.
  - Advanced machining analytics: Predictive maintenance and real-time data analysis.

- **Operation and maintenance**
  - In-machining: Digital twins for real-time monitoring and predictive maintenance.
  - Advanced machining analytics: Machine learning for predictive maintenance.

- **Logistics and supply chain**
  - In-machining: Streamlined supply chains with real-time data.
  - Advanced machining analytics: Predictive analytics for inventory management.

**Advantages of Industry 4.0**

- Increased efficiency
- Improved quality
- Reduced waste
- Enhanced safety

**Challenges of Industry 4.0**

- Investment costs
- Data security
- Skilled workforce
- Regulatory compliance

**Key factors**

- **Smart machines**
  - High precision
  - Low energy consumption

- **Data management**
  - Cloud computing
  - Big data analysis

- **Integration**
  - Interoperability
  - Modular systems

**Future trends**

- **Additive manufacturing**
  - 3D printing
  - Material optimization

- **Micro-factories**
  - Cost-effective production
  - Customized products

**Case study: Industry 4.0 application**

A leading manufacturer implemented Industry 4.0 strategies in its production lines, resulting in a 30% increase in efficiency and a 20% reduction in waste.

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*Figures are estimations based on results from ongoing R&D projects.*