



Smarter machines through adaptive intelligence

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From data capture to autonomous process control in the manufacturing industry

The manufacturing industry is under increasing pressure to produce more efficiently, sustainably and flexibly. Smart machines are playing an ever greater role in this. Automation used to consist mainly of fixed rules and pre-set parameters, but today the focus is shifting to systems that adapt their behaviour based on context, data and real-time feedback.

This development is consistent with the vision of Industry 4.0, which sees adaptivity as an important step towards future-proof production environments. Machines no longer just execute commands, but interpret their environment and adjust processes independently. This applies not only to production planning or logistics, but also to the heart of production, such as machining processes.

Adaptive systems as the next stage of maturity

In conventional production systems, machines follow their preprogrammed instructions exactly. This works well as long as processes remain predictable. However, as soon as conditions change,

for example due to varying material conditions, tool wear or changing load, inefficiencies quickly arise.

Adaptive production systems take a different approach. They combine:

- Continuous data capture by means of sensors
- Process models and simulations
- Automatic control based on up-to-date process information

According to Acatech's Industry 4.0 vision, full adaptivity constitutes the highest level of maturity. In this phase, the system makes decisions independently, within predefined limits: people set the goals and the system optimises the execution.

This approach is also becoming increasingly relevant within machining processes.

Cooling lubricant as a lever for efficiency

Cooling lubricant is an essential part of machining, affecting process stability, tool life and surface quality. In many production environments, though, it is still supplied on a fixed and often conservative basis, leading to excessive use of lubricant and unnecessarily high energy consumption.

Researchers at IFW Hannover, together with industrial partners, investigated how this could be done more efficiently. Their focus was on adaptive volume control of cooling lubricant, driven by data from CAM planning.

From CAM planning to adaptive control

At the heart of this approach lies the link between digital preparation and process execution. Within the CAM software hyperMILL, the machining volume is accurately calculated per processing step. This information forms the basis for a model that determines how much cooling lubricant is needed at any given time.

The adapted volume flow is then:

- Automatically integrated into the NC code
- Forwarded to the machine control system
- Applied dynamically during processing

As a result, cooling lubricant is no longer continuously supplied in the same quantity, but adapted to the actual process demand.

Impact on energy consumption and process reliability

Demonstrations show that this approach can lead to substantial energy savings of 80 percent or more for the cooling system, without any negative impact on:

- Surface quality
- Tool life

- Process stability

Although this technology is still mainly in a research and demonstration phase at present, it clearly illustrates how CAM data, process models and automatic control can come together in a practical application. Rather than being employed blindly, cooling lubricant is now supplied on a targeted and adaptive basis.

AI-controlled chip and cooling lubricant management in CNC machinery

Besides academic research, there are also industrial applications in which adaptive intelligence is already being used today. Modern CNC machinery is increasingly integrating sensors, cameras and artificial intelligence to optimise processes autonomously.

One example is AI-driven chip management in the machine room. The system uses image processing to detect chip build-ups during machining. Based on this analysis, the machine makes automatic adjustments, for example by:

- Adapting the direction of coolant flow
- Actively flushing away chips
- Avoiding unplanned downtimes

These applications show how real-time observation and automatic decision-making lead to more robust and autonomous machinery without additional manual intervention.

Flemish research into data-driven machining

Further development of adaptive production processes is also being actively pursued in Flanders. Within the VLAIO-supported [project COOCK+ 4.0 Maturity Enhancement](#), Sirris and VIVES University of Applied Sciences are investigating how combinations of data capture, simulations, modelling and AI can make better use of machining processes.

The research is focusing on, among other things:

- Linking measurement data to process models
- Monitoring and predicting energy consumption
- Identifying measures to reduce this consumption effectively

Gaining a better understanding of where and why energy is consumed creates scope for targeted process optimisation.

From data to decision-making power in production

The various examples show a clear common thread. Smart manufacturing isn't just about collecting data: above all, it means translating that data into actual decisions within the process itself.

Adaptive systems:

- Respond faster than manual interventions
- Reduce the wasting of energy and resources

- Make production environments more robust

The next step is to further scale up these concepts, from research set-ups to broad industrial applications. This requires technological expertise, but also an understanding of processes and integration into existing production environments.

Want to know more about adaptive machining and smart manufacturing?

Would you like to gain insight into how adaptive intelligence, CAM data and AI can contribute to more efficient machining processes within your organisation? Or would you like to know more about ongoing research and possible next steps?

Contact our expert, Tom Jacobs. He will be happy to discuss adaptive manufacturing, data-driven process control and energy efficiency in machining.

[Contact us](#)

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