



Smart tool wear management

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From Taylor formula to AI-driven monitoring

Tools wear out. This is inevitable. The question is not whether a tool will wear out, but when you should replace it. Changing it too early increases costs. Changing it too late causes quality problems or even tool breakage.

On many production floors, tool management is still done on the basis of experience, supplier advice or fixed rules of thumb. This works as long as the same operator is present and production remains stable. When there's a change of production run or machinery starts running autonomously, the need for a more systematic approach arises.

In the Flemish machining industry, tools are often replaced 20 to 40% too early out of caution. In other cases, the changeover happens just too late, resulting in loss of quality or production downtime. Both situations can be avoided with a better understanding of wear and tear behaviour.

Within the VLAIO COOCK+ [4.0 Maturity Acceleration project](#), these issues have been described in detail a technical guidance document, which contains an overview of the full wear analysis, model descriptions, threshold values, standard architecture and implementation paths. This is free on request for companies.

[Download the whitepaper \(in Dutch only\)](#)

Wear is not a single phenomenon

Tool wear can take different forms. Each type of wear has its own cause and requires a different approach.

The most common wear forms are:

- Flank wear: wear on the flywheel surface
- Crater wear on the rake face
- Cutting edge chipping due to mechanical stress
- Built-up edge, where material from the workpiece adheres to the cutting edge
- Notch wear, often in hard-to-chip materials

Recognising these wear patterns is essential. When you understand why a tool wears out, you can take more targeted action. Consider a different cutting strategy, modified cutting speeds or an adjusted cut depth.

Industrial standard ISO 3685 defines concrete tool changing criteria. For general applications, for example, the maximum flank wear is about 0.3 millimetres. This is an important reference point for monitoring systems.

Three phases in each wear curve

Tool wear rarely occurs linearly. Three phases are visible in almost every machining process.

1. Running-in phase

A new tool wears out a little faster at first. The cutting edge stabilises during initial use. This phase usually lasts for a short time.

2. Steady-state wear phase

This is the longest and most predictable phase. Wear increases gradually. The well-known Taylor formula describes this phase well.

Monitoring is particularly valuable here. Trends become visible and the right changeover moment can be predicted.

3. Wear-out

At a certain point, wear accelerates sharply. Degradation proceeds exponentially.

In this phase, there is increasing risk of:

- Tool breakage
- Quality loss
- Damage to workpiece or machine

Many simple monitoring systems fail to take into account this non-linearity, working with fixed intervals. More advanced systems dynamically adjust the remaining lifetime when signals indicate the onset of this third stage.

Which strategy suits your business?

Strategy	Main advantages
Taylor model	Free, directly available data
Historical averages	Company-specific data
Operator inspection	Wear type and location
Vision (camera + AI)	Accurate, type-specific
Sensor (indirect)	Real-time, automatic
Hybrid / combined	Learning and adaptation

There is no universal method of tool wear management. The right approach depends on the type of production, degree of automation and available data.

Taylor model

The Taylor formula provides an initial estimate of tool life. The method is simple and immediately applicable.

- Limitation: the model does not take account of current process variations

Historical production data

Companies can record tool changes and calculate average lifespans.

- Advantage: based on own production data
- Limitation: conservative when variation is high

Operator inspection

Operators visually inspect tools and decide when a change is needed.

- Advantage: wear patterns are visible
- Limitation: highly dependent on experience

Vision with camera and AI

Cameras analyse the cutting edge and recognise wear patterns automatically.

- Advantage: high accuracy
- Limitation: inspection often takes place outside the process

Sensor-based monitoring

Sensors measure indirect signals such as vibrations, forces or acoustic emission.

- Advantage: real-time monitoring possible
- Limitation: models are difficult to generalise

Hybrid systems

The most advanced approach combines different data streams.

- Advantage: robust and learning system
- Limitation: requires investment and integration

It is important to build these strategies incrementally. Start with simple models and add sensor data or AI analysis when sufficient process data is available.

The challenge of generalisability

Sensor and AI systems offer great potential, but also present significant challenges. Models trained on one specific combination of material, tool and process parameters often work less well as soon

as one variable changes.

This problem is common in companies with small production runs and a lot of variation.

Recent studies show that so-called transfer learning is a possible solution. This involves training a basic model on a broad dataset. The model can then be adapted to a specific application with a limited amount of new data.

Companies recording process data today are laying the foundation for future AI applications.

Research within the COOCK+ project

Within the [VLAIO COOCK+ 4.0 Maturity Acceleration project](#), Sirris and VIVES University of Applied Sciences are investigating how companies can improve wear management.

Testing infrastructure

Test rigs at Sirris in Genk and at VIVES in Kortrijk are evaluating various technologies, including:

- Sensor measurements such as forces, vibrations and acoustic emissions
- Visual inspection with cameras
- Industrial solutions such as the Schunk iTendo²

Mobile test platform

Companies can temporarily deploy a mobile test platform in their own production environment. This platform combines:

- Taylor-based tool life estimation
- Sensor monitoring
- Visual inspection

Individual guidance

Sirris and VIVES guide companies from initial feasibility analysis to full implementation of monitoring systems.

Want to know more about tool wear?

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Wondering what this means for your production?

Do you want to gain a better understanding of how to monitor and predict tool wear in your machining processes? Discover how models, sensors and data help optimise tool changes.

[Contact Tom Jacobs](#)

Authors



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