An Integrative Approach for Estimating Cutting Tools Wear in Turning

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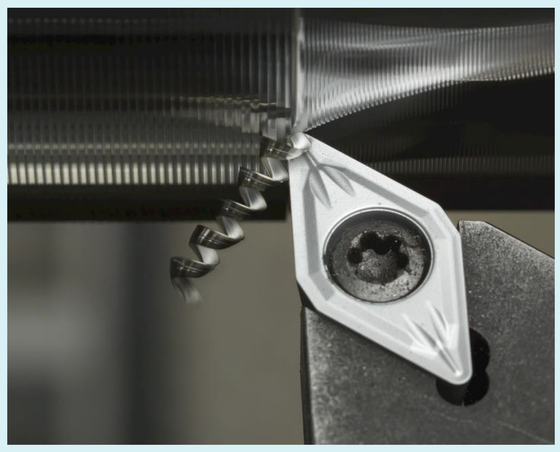
Abstract

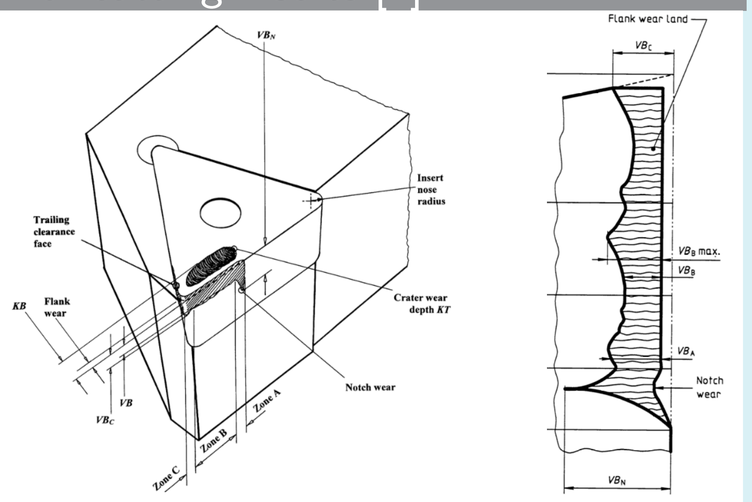
- Objective : Optimal replacement of cutting inserts
- **Large costs** linked with tools:
  - Early replacement ⇒ tool waste, maintenance additional charge
  - Late replacement ⇒ scrap
- Industrial need: estimation of tool residual lifetime
- **Choice of condition monitoring variables** to assess the tool degradation
- Estimate of the tool remaining useful life
- Probabilistic approach to the evolution of tool wear, based on data obtained through finite elements models

Turning

- Machining operation
- Material : AISI 1045 steel ; coated WC cutting insert

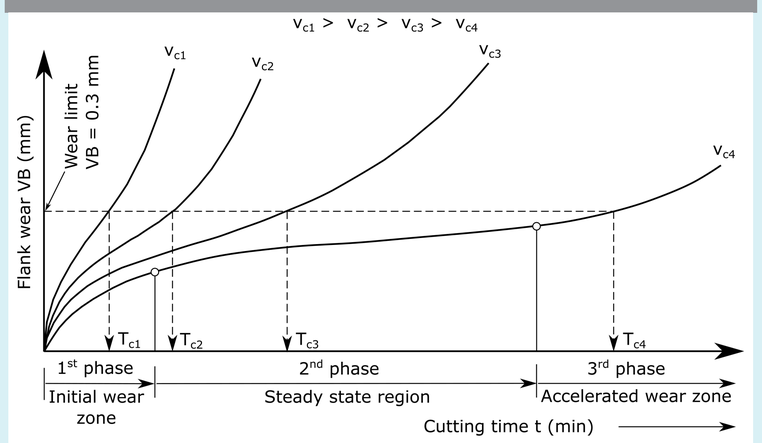


Wear of cutting inserts [1]



Wear Evolution

Influence of cutting speed

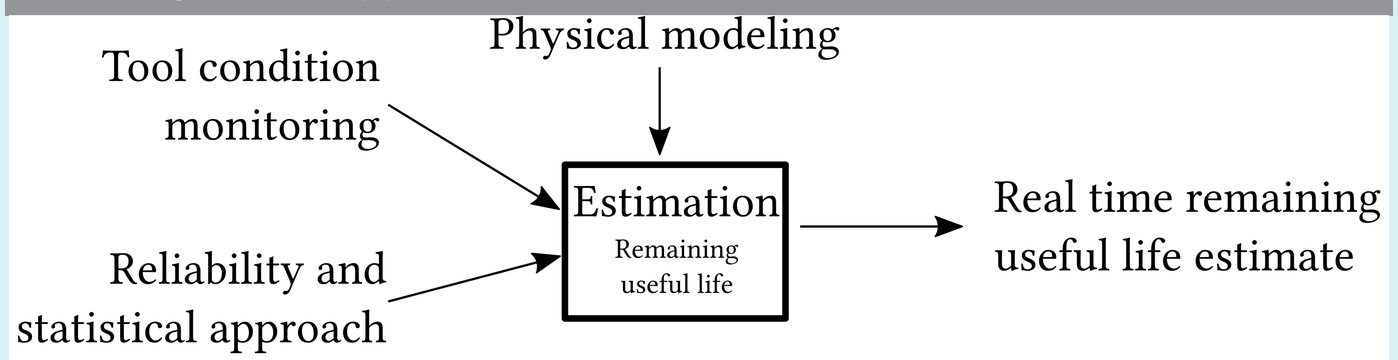


- 3 wear phases
- **Influence of cutting parameters**
- Taylor's law $v_c T^n = C_T$
- End-of-life criterion given by ISO 3685:1993

Integrated approach for Tool Wear Estimate

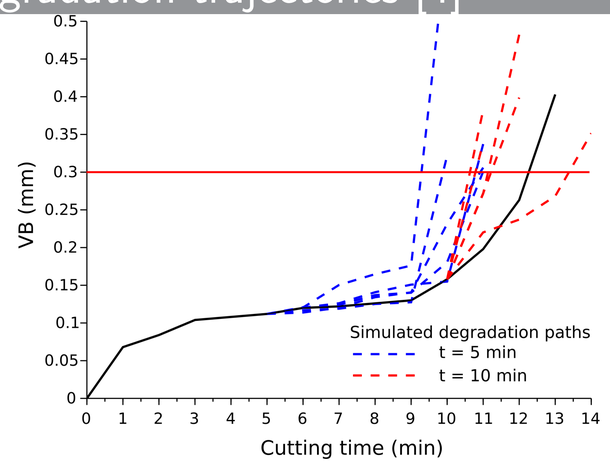
- Statistical methods using the evolution of the tool wear (survival analysis, degradation trajectories simulation)
- Tool condition monitoring using adequate variables (dimensions, machining environment)
- Physical modeling of the consequences of tool wear influence on other variables (finite elements method)

Summary of the approach



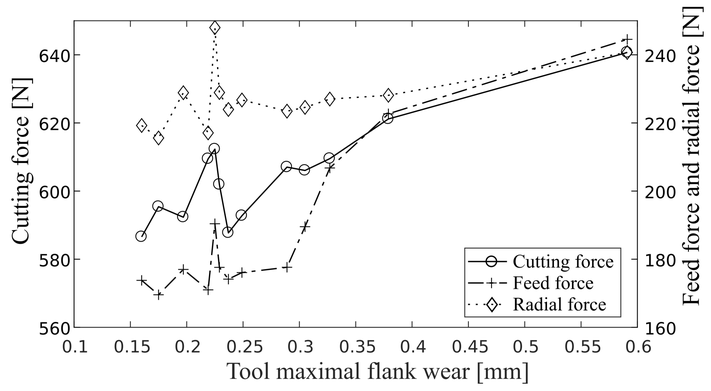
Results

Degradation trajectories [4]



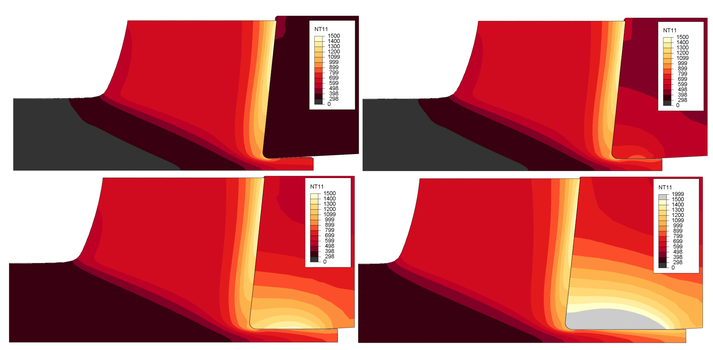
- Updated simulations (based on few observations)
- Each observation allows a new simulation

Tool condition monitoring [2]



- Experimental assessment of wear influence on cutting forces
- Significant cutting forces increase with tool wear
- Feed force is most significantly affected (40 % increase)

Wear influence modeling [3]



- Increase of temperature with tool wear
- Modeling of flank wear only
- VB measurements : 0; 0.1; 0.2; 0.3 mm
- Cutting speed 150 m/s ; depth of cut 0,2 mm
- Displaced maximal temperature area

Conclusions and Perspectives

- Strong financial impact and industrial interest
- Multiple approaches in a common framework methodology
- Degradation trajectories of cutting tools can be simulated
- Condition monitoring (cutting forces) may yield important information on wear evolution
- Tool degradation consequences on condition monitoring variables can be simulated
- These approach may lead to the estimate of current tool wear
- Current tool wear leads to the estimate of residual useful life
- Ongoing experimental work should confirm these approaches

References

[1] ISO 3685:1993 - Tool-life testing with single-point turning tools., 1993.

[2] Robin Devlamincq. *Experimental investigation of the cutting tool flank wear in longitudinal turning of C45 steel.* Master's thesis, University of Mons, 2018.

[3] Lucas Equeter, François Ducobu, Edouard Rivière-Lorphèvre, Mustapha Abouridouane, Fritz Klocke, and Pierre Dehombreux. Estimation of the Influence of Tool Wear on Force Signals: a Finite Element Approach in AISI 1045 Orthogonal Cutting. *AIP Conference Proceedings*, 1960:070012, 2018.

[4] Lucas Equeter, Christophe Letot, Clément Dutoit, Pierre Dehombreux, and Roger Serra. Cutting tool life management in turning process : a new approach based on a stochastic wear process and the Cox model. In *Qualita*, Bourges, France, 2017.

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