Design of Experiment: Wear Indicators for Cutting Tools Estimate of Tool Remaining Useful Life

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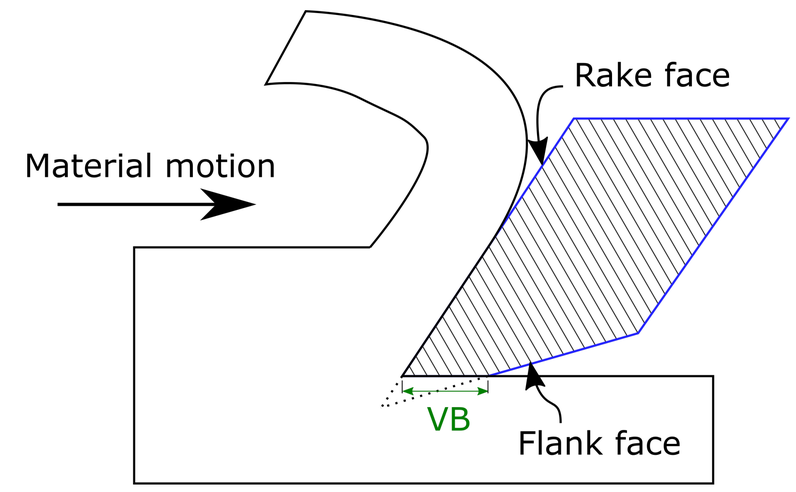
Résumé

- Remplacement optimal des outils coupants
- Simulation de la dégradation des outils de coupe par un procédé gamma [3]
- Utilisation et ajustement d'un modèle de Cox aux risques proportionnels pour prédire la durée de vie d'un outil coupant [1]
- Vérification de la prédiction face à une nouvelle campagne expérimentale
- **Conception de la campagne expérimentale**
- Analyse de la qualité de la prédiction et de ses facteurs d'influence

Context

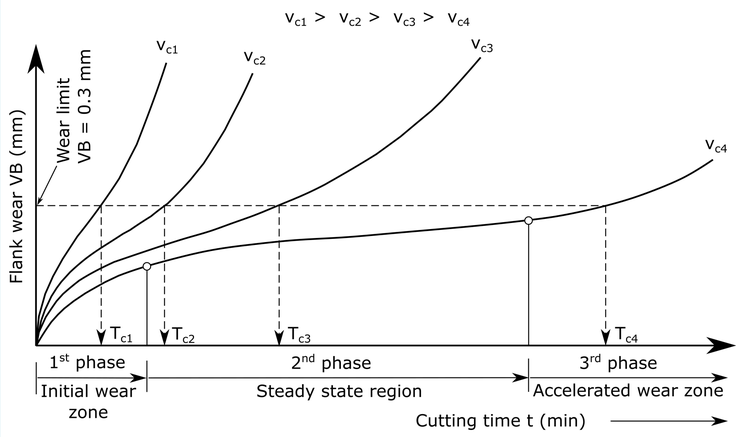
- Turning operations on iron alloys
- Wear of cutting tools
- **Remaining Useful Life assessment**

Flank wear of cutting tools



Wear evolution

Influence of cutting speed

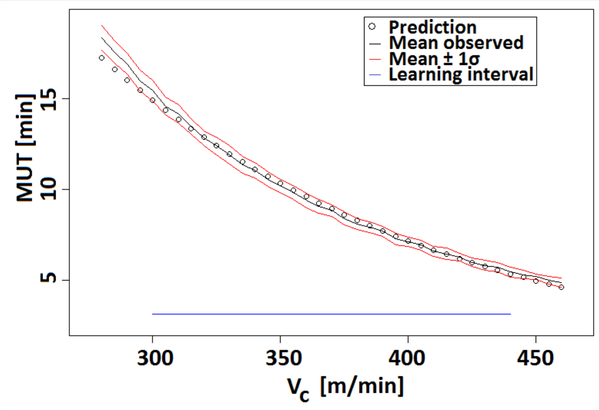


- 3 phases of wear
- **Influence of cutting parameters**
- Taylor's law $v_c T^n = C_T$
- Wear limit according to ISO 3685:1993

Tool lifetime prediction [1]

- Cox Proportional Hazards Model
- Covariates = cutting parameters, condition monitoring variables

Lifetime $MUT = f(v_c)$



- **Good prediction**
- Possible extrapolation

Experimental Inputs/Outputs

Wear indicators for condition monitoring: [2]

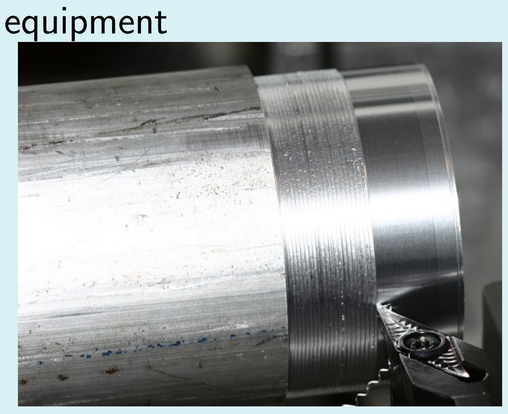
- Cutting forces
- Electrical power
- Vibrations

Parameters:

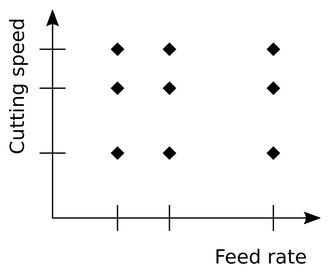
- **Cutting parameters** (depth of cut, feed rate, cutting speed)
- Tool material and shape
- Workpiece material machinability properties (**hardness**, adhesiveness, distribution of phases...)
- Machining operation (turning, facing...)
- Lubrication

Experimental setup and expected results

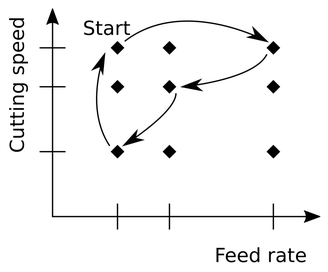
- 2 phases experiment
- 150 cutting inserts
- Online measurement of the selected wear indicators
- Proper choice of experimental equipment



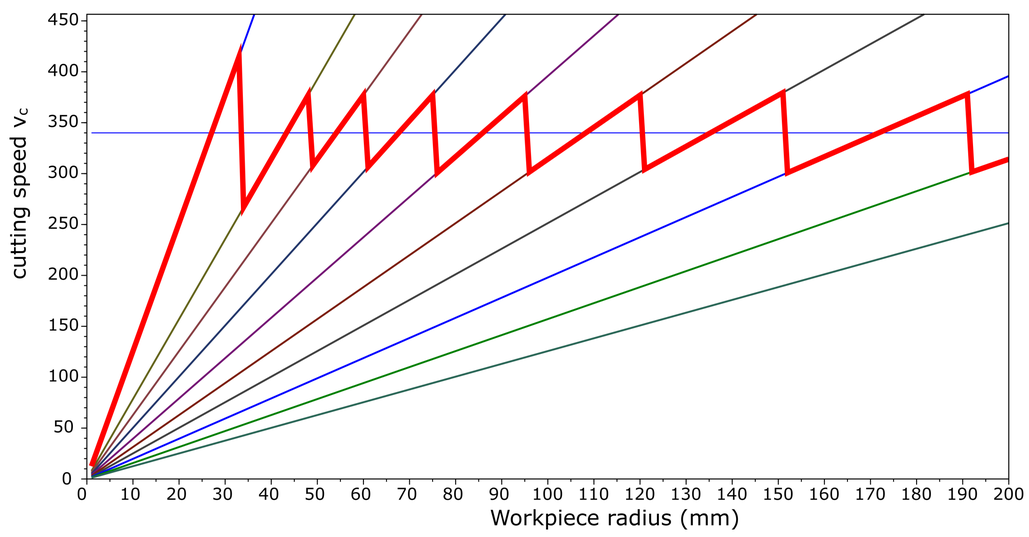
Constant parameters



Varying parameters



Traditional lathe cutting speed



- Traditional lathe gearboxes do not allow constant cutting parameters
- Necessity of using CNC machines

Keypoints and perspectives

- Essential experimental aspects defined
- Motivation for industrial applications
- Results are expected to match the statistical predictions
- Developments including condition monitoring as covariates
- Varying parameters matching industrial uses
- Essential logistics to be defined
- Time-dependent survival models
- Validation with key literature entries
- Limitations of traditional techniques

References

[1] Lucas Equeter, Christophe Letot, Roger Serra, and Pierre Dehombreux. Estimate of Cutting Tool Lifespan through Cox Proportional Hazards Model. *IFAC-PapersOnLine*, 49(28):238–243.

[2] Christophe Letot, Roger Serra, Maela Dossevi, and Pierre Dehombreux. Cutting tools reliability and residual life prediction from degradation indicators in turning process: a case study involving four approaches. *The International Journal of Advanced Manufacturing Technology*, 2015.

[3] Christophe Letot, Roger Serra, Lucas Equeter, and Pierre Dehombreux. Apport des modèles physiques de défaillance et des processus stochastiques pour la présiction de la durée de vie d'outils de coupe (Contribution of Physical Failure Models and Stochastic Processes for Cutting Tools Lifetimes Prediction). In *JFMS*, Nancy (France), 2016.

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