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Supported by the federal Swiss Innovation Promotion Agency

TORNOS

Process Parameters Optimization for Energy Efficiency in Swiss-Type Machining

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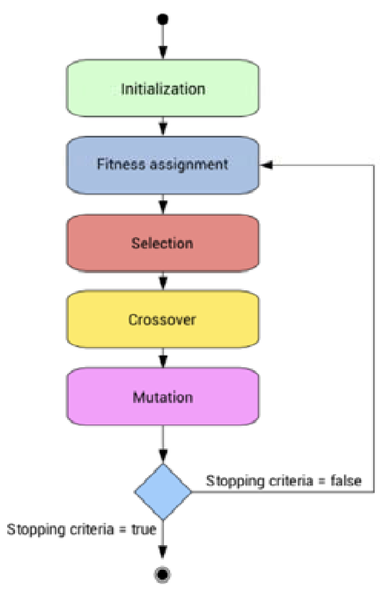
Introduction

The energy efficiency is a critical issue economically and ecologically, this is why in this project we aim to reduce the energy consumption of the machining by optimizing the process parameters : material feed rate, spindle rotation speed and the depth of cut.

We employ a genetic algorithm for which we investigated and compared four different fitness method which approximate experiments done on a Swiss DT13 of Tornos.

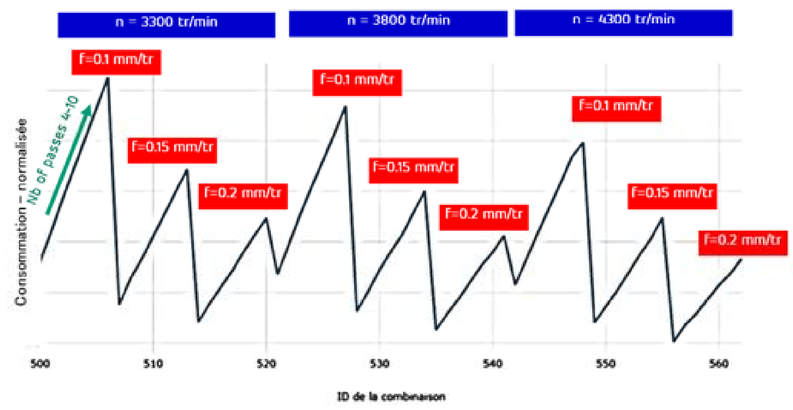
Genetic algorithm

- The genetic algorithm finds solutions based on the principe of evolution.
- We create an initial population of parameters combinations.
- We evaluate each individual based on a fitness method.
- We select the best one.
- We crossover the individuals we kept to create a new population.
- We mutate some individuals to create which may find another local optimum.



Finding a good fitness method is primordial to obtain parameters combination suited to our need.

Experiments



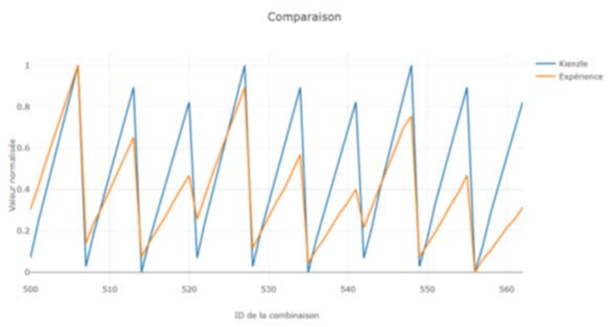
- Piece : We chose a piece from which we are almost always removing the material to maximise the use of the parameters.

- Experiments : We did 63 different experiments with for each a different combination of parameters.
- We took the minimum, median and maximum value recommended by the tool supplier for each parameter.

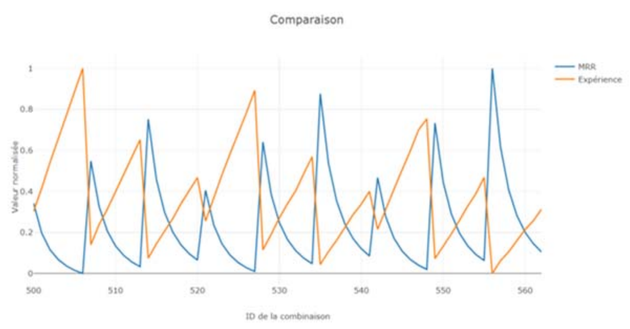
- The number of passes goes from 4 to 10 (depth of 2.5mm to 1mm)
- The feed rate from 0.1 mm/rev to 0.2mm/rev
- The spindle rotation speed from 3300 rev/min to 4300 rev/min

Fitness methods

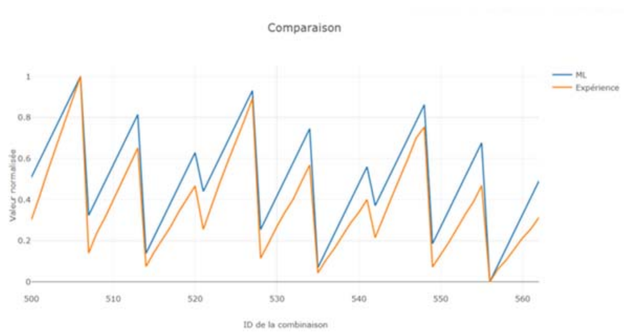
- Kienzle : Formula that estimates the cutting force needed based on the cutting parameters, the material, the tool, etc.
- We obtained a correlation of 80% compared with the experiments



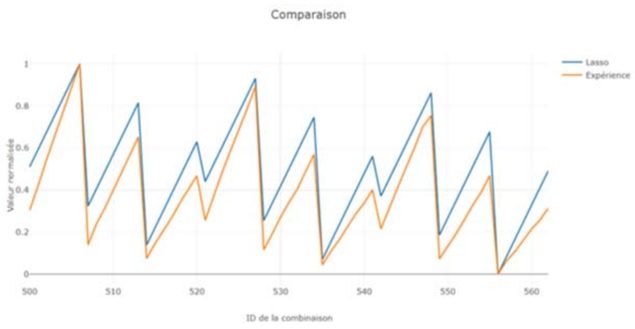
- MRR : Formula estimating the volume of material removed by second with the given parameters
- We obtained a correlation of -90% compared with the experiments



- Machine Learning Regressor: Regressor that learn based on experiments already done.
- We obtained a correlation of 97% compared with the experiments



- Lasso: Mathematical regressor model based on experiments already done
- We obtained a correlation of 97% compared with the experiments



Conclusions and perspectives

- The fitness methods based on regression have the best results but it add the cost of doing experiments for the learning phase.
- The machining parameters optimizing the energy consumption are the same as the ones who lowers the time needed to machine a piece.
- We still need to investigated the other machining phases, e.g. milling.
- The energy consumption is not the only important part of the machining, we have to take into account the tool life and the surface quality, the Multi-Objective Genetic algorithm is the next step.

2019 3rd International Conference on Industrial Automation, Robotics and Control Engineering