Simulation of the mechanical pickling of stainless steel coils

H. Hmaidouch [a], C. Hamdan [a], B. Latouche [b], E. Guyot [a], E. Rouhaud [a]
[a] Université de Technologie de Troyes, France, rouhaud@utt.fr; [b] APERAM, France, baptiste.latouche@aperam.com

Keywords: mechanical pickling, shot dynamics, simulation, coverage, shot blasting

Introduction

After hot rolling, stainless steel coils are covered by oxide which needs to be removed to ensure the quality of the subsequent steps of the manufacturing process. Mechanical pickling (or descaling) of the coils is thus performed on the first annealing and pickling line,. The oxide layer is generally removed by shot blasting and chemical pickling. For the shot blasting step, the shot is blasted on the steel by several turbines positioned on the line. This ensures the quality of subsequent cold rolling, improves surface quality, prevents corrosion and improves visual aspects.

Objectives

The understanding of shot blasting parameters and the resulting impacts on the material is critical to ensure the efficiency of chemical pickling and the final quality of the coils. In particular, it is important for the treatment to be sufficient and homogeneous in all directions. Figure 1 presents the shot peening line and the position of the turbine with respect to the coil. The objective of this study is to assess efficient and homogeneous treatments of the plates with simulation of the treatment and experimental validations for the industrial configurations.

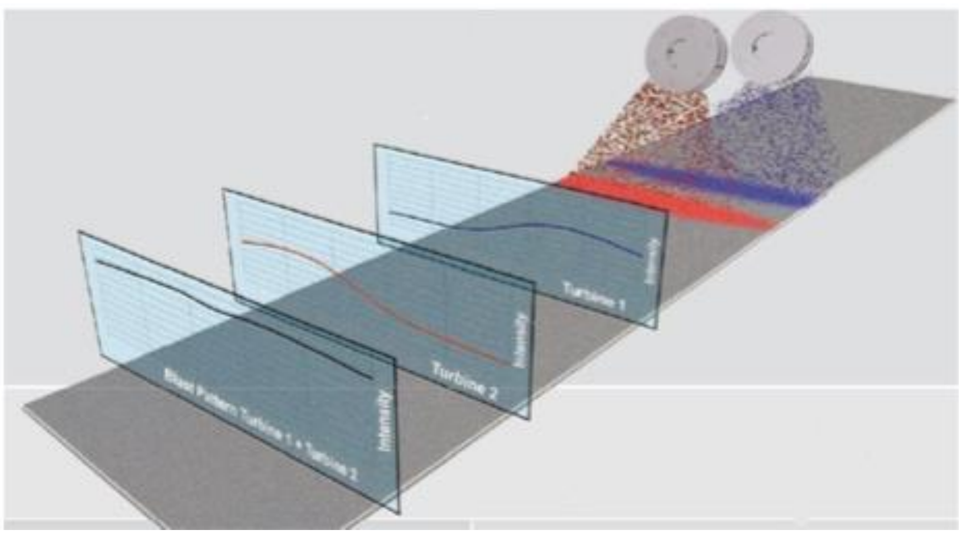

Figure 1: stainless steel coil in gray with the position of the turbines and the theoretical peening intensity, necessary to reach an optimal treatment.

Methodology

A software has already been proposed to model the dynamic of the shot in the case of ultrasonic shot-peening [1,2,3]. The software has been modified to model all type of shot peening. The code has been modified and now includes more general models to allow the creation of moving parts and targets (see Figure 2). It is thus now possible to model a moving turbine. A CAD model and surface meshing of the complete structure and the turbine has then been performed (see Figure 2), including the possibility of a moving coil.

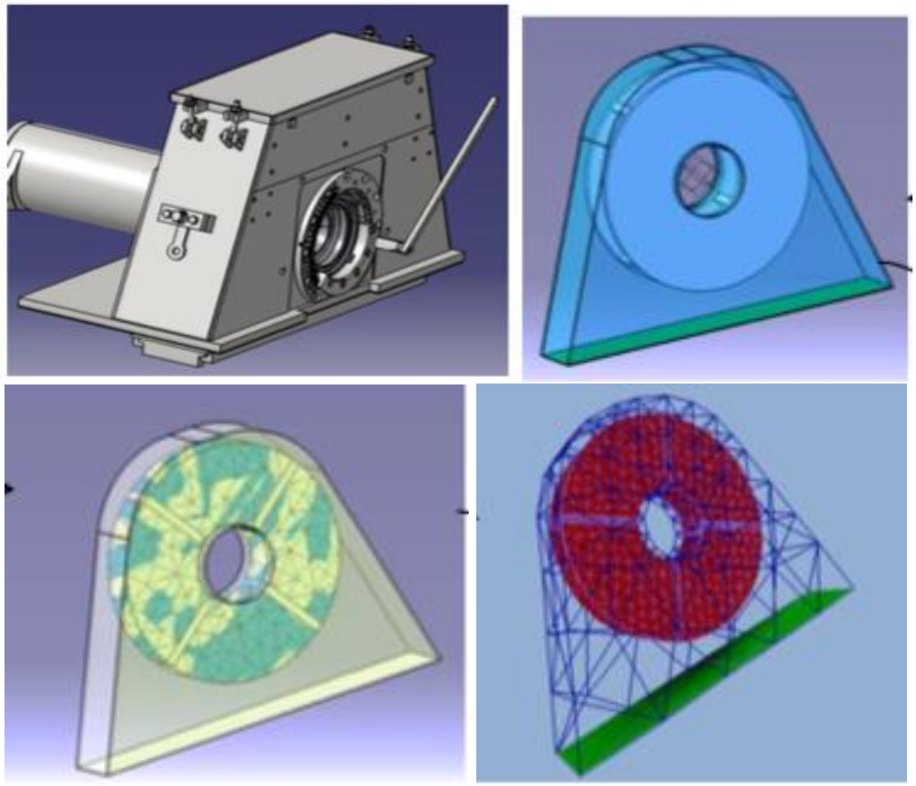

Figure 2: CAD model of the shot peening entity, a) the structure, b) the turbine, c) the meshing, d) the definition of the moving part (red) a target (green).

The software has been modified to compute the velocity that is transmitted to the shot by the rotating blades. Another difficulty has been to take into account the important amount of shot used in the process (several tons).
A simulation has been performed for the shot dynamics on the line. It includes the simulation of the projection of the shot by the rotating turbines. The industrial configuration has been simulated including the exact number of turbines, their position and inclination. A specific simulation has been performed with a fixed coil and a moving coil (see Figure 4). An experimental validation has been conducted. The velocity of the shot exiting the turbine has been successfully compared to measurements.

Results and analysis
Figure 3 presents a result of the simulations with the geometry of the turbine, the coil and the velocity field of the shot. The green lines represent the velocity of each particle. This software thus offers the possibility to visualize the dynamic of the shot. Figure 4 presents the impact density on the coil for a fixed and moving coil. The bottom Figures present the resulting impact density for a fixed (right) and moving (left) plate.

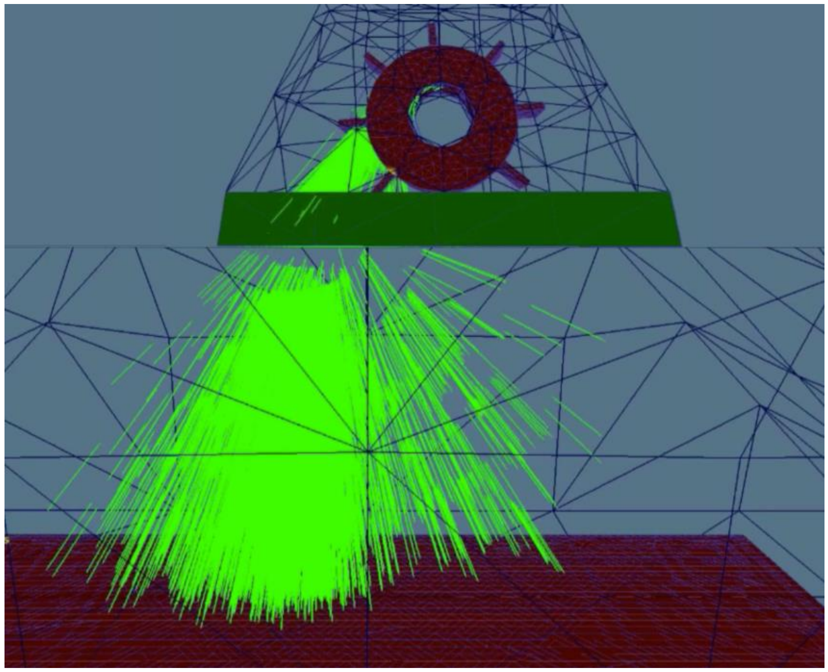

Figure 3: Example of visual possible with the software with the complete model of the shot dynamic in the structure. The green lines represent the velocity field of the shot. At the bottom, the treated coil is represented. The green structure represents the window to the turbine.

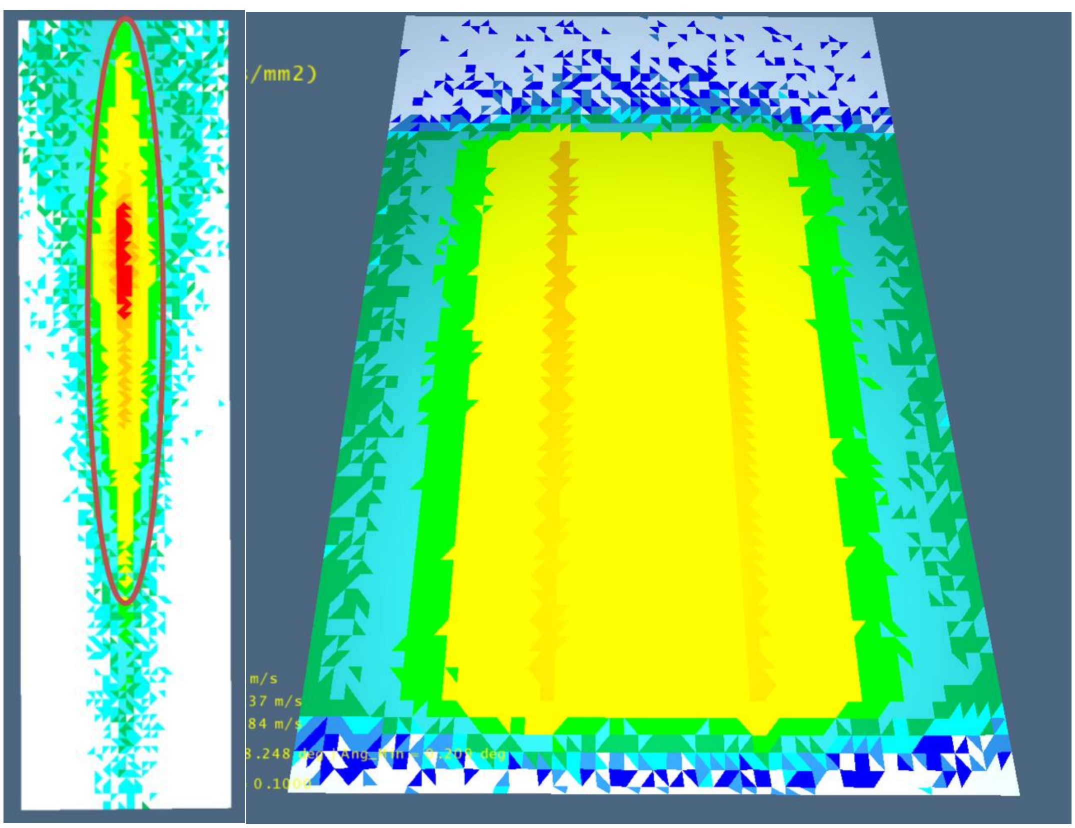

Figure 4: Impact density on a fixed coil (left) and a moving coil (right).

Conclusions

A software has been proposed to model the shot dynamic of any types of shot peening. It has been, in particular, adapted to model shot blasting with turbines. This specific case presents two difficulties. The first one is the fact that it is necessary to model rapidly moving parts. The second difficulty is that it is necessary to model an enormous amount of particles to model the shot. The simulation has been performed to reproduce the shot dynamics corresponding to the industrial case. The simulations have been successfully compared with experimental results.

References

[1] J. Badreddine, E. Rouhaud, M. Micoulaut, S. Remy, International Journal of Mechanical Sciences **82**, 179 (2014)

[2] J. Badreddine, S. Remy, M. Micoulaut, E. Rouhaud, V. Desfontaine, P. Renaud, Advances in Engineering Software **76**, 31 (2014).

[3] http://www.shotvisual.com