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MACHINING SIMULATIONS AND THEIR USE IN INDUSTRY

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Summary. *Machining simulations is a challenge both with respect to demands on robust numerical methods as well as modelling issues. The paper outlines some of the challenges but also current use of simulations at Sandvik Coromant.*

1 INTRODUCTION

There is an industrial need for advanced simulation of manufacturing processes at companies developing machining processes as well as some of the advanced users. The paper shows the use of simulations at Sandvik Coromant, a world leading chip manufacturer, for developing and implementing the use of these tools in their development process.

2 CHALLENGES

The extremely large deformations and high strain rates and temperatures are the primary sources of problems for simulation and modelling. The chip formation process requires a capability for automatic remeshing. Distortion metrics to guide the remeshing and data transfer methods between the meshes are important ingredients[1]. There exist software that can handle this, as can be seen in Figure 1. However, the largest problem is on the modelling side. The material behaviour at these large strains and strain rates and high temperatures is quite uncertain in most models. This is believed to be a source of the discrepancy between measured and computed residual stresses in Table 1.

Specimen	Measured σ [MPa]	Calculated AdvantEdge σ [MPa]	Calculated SiMPle σ [MPa]
1	361 ± 17	640	130
2	130 ± 9	179	200
3	629 ± 28	550	630
4	138 ± 8	164	600
5	703 ± 31	240	680
6	500 ± 25	171	690

Table 1. Measured and computed residual stresses on machined surface.

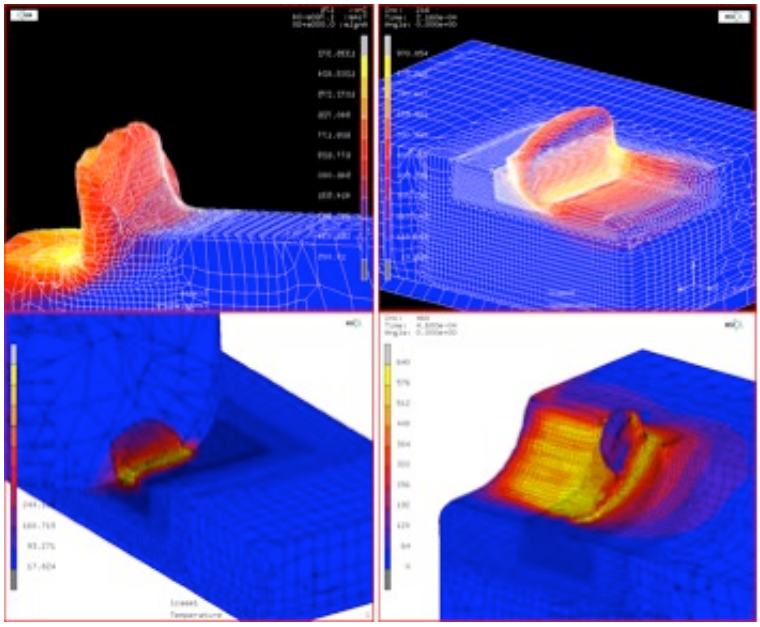

Figure 1. Examples of three-dimensional models of machining.

3 POSSIBILITIES

The use of simulations requires expertise but give also knowledge. The process can be studied in way that is not possible by means of experiments only and increase the understanding of the cutting process, Figure 2.

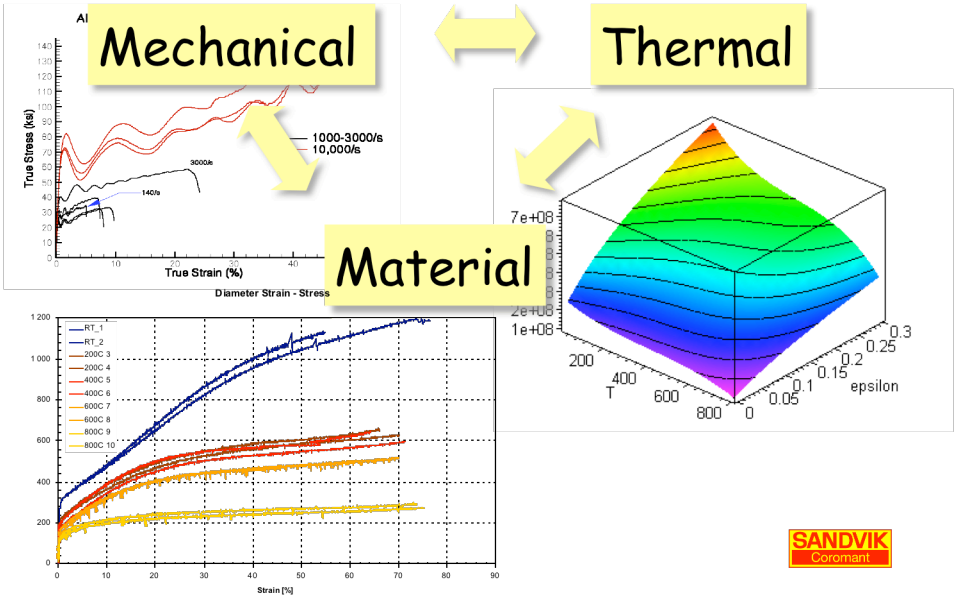

Figure 2. Understanding the interplay between mechanical and thermal fields with material properties in the machining process.

4 APPLICATIONS

The demands on the cutting process are *i*) high productivity – high speeds and feeds, *ii*) low cutting forces and power consumption, *iii*) low residual stresses beneath machined surface, and *iv*) long and predictable tool life.

Simulations can be used to investigate what influences these factors for new tool geometry without having to first manufacture them and then perform the testing. The latter is an expensive and time-consuming method, which is the common approach today. Examples of this kind of investigations are shown in the Figures 3 and 4 below. Wear can also be investigated by the use of simulations. Figure 5 shows an example where this is done. This pressure distribution in combination with temperature and relative sliding velocity affect the wear rate.

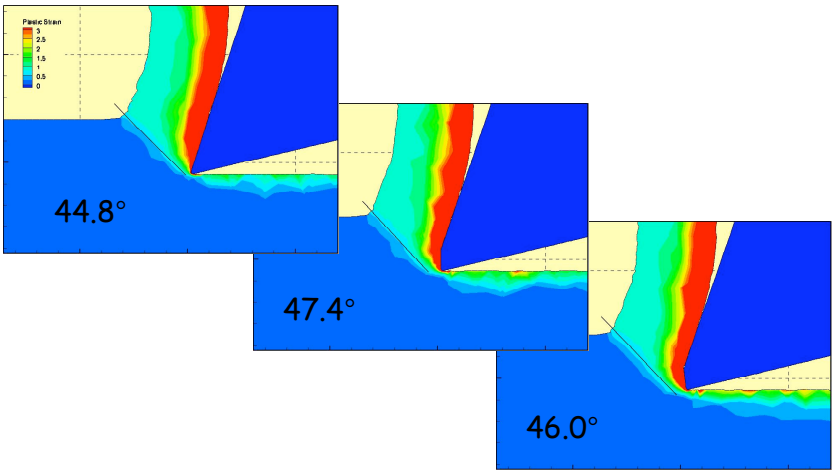

Figure 3. Effect of edge reinforcements on shear angle.

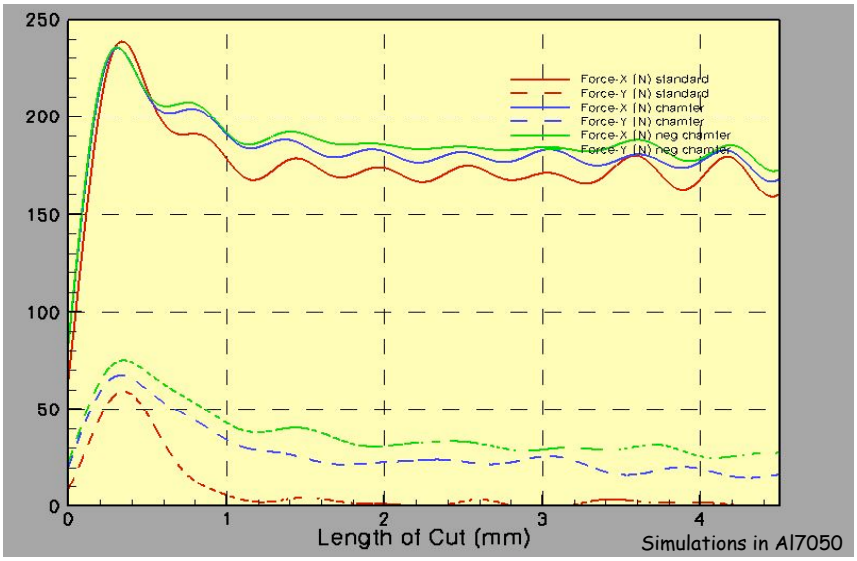

Figure 4. Effect on cutting forces for different reinforcements.

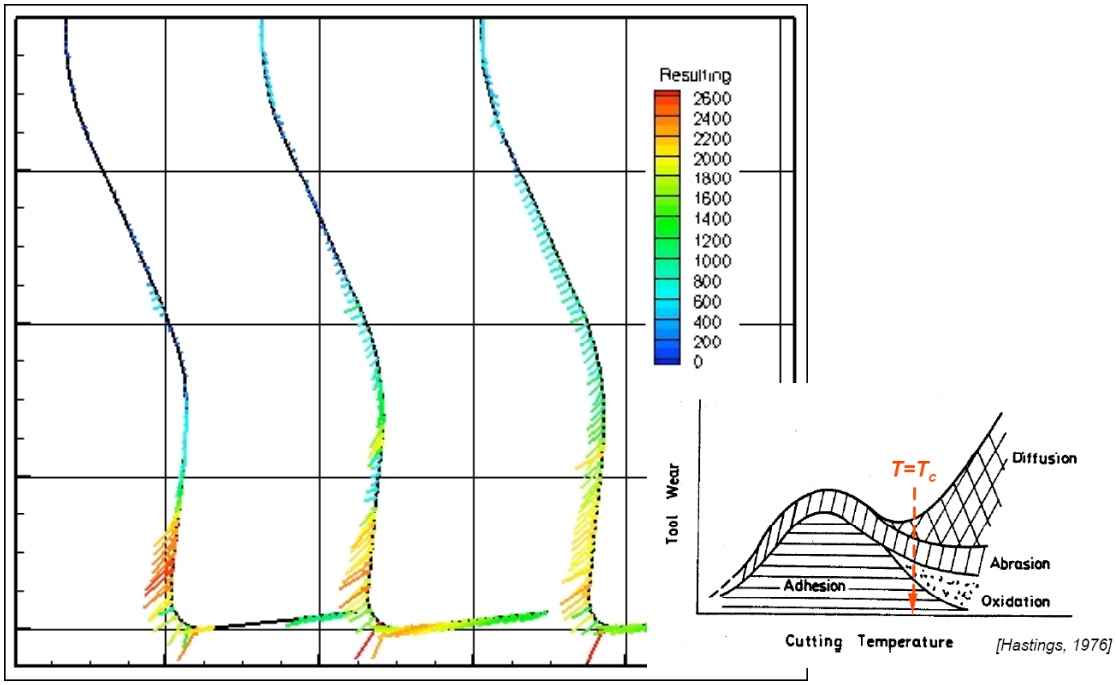

Figure 5. Pressure on surface of cutting tool.

12 CONCLUSIONS

Determination and a consistent implementation of a long-term strategy are important in technology transfer between university and industry. This, in combination with a mutual understanding of the perspective each partner has, is the basis for the long-term co-operation between Sandvik Coromant and Luleå University of Technology. The co-operation started ten years ago and is one example of the determination by Sandvik Coromant to use more computations and simulations in all aspects of their product design and to be at the forefront in research and development.

The conclusions in the current context are so far

- Finite element simulations can already today be used in design of cutting tools.
- The simulations can also be used to optimise cutting parameters like feed, cutting speed etc**.**
- Quantitative predictions are still difficult for some phenomena due to uncertain modeling of material behaviour.

13 REFERENCES

[1] V. Kalhori, *Modelling and Simulation of Mechanical Cutting*, PhD thesis 2001:28D at Luleå University of Technology, (2001). http://epubl.luth.se/1402-1544/2001/28/index.html