Machine Cutting Tool Vibration Monitoring Strategies for Prevention of Tool Chatter - Pat Lenihan

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Aim of the Project

- **Aim:** To investigate machine cutting tool vibration monitoring strategies for prevention of tool chatter
- **Objectives:**

1. Review existing literature on machine cutting tool vibration monitoring, tool chatter, and preventive strategies.
2. Explore and evaluate current strategies for preventing tool chatter based on real-time vibration monitoring.
3. Complete the CNC Machining course provided by ACE Machining & Dr Tony Schmitz.
4. Review several Case Studies in relation to machine cutting tool vibration monitoring strategies for prevention of tool chatter.

Background

- **What is Tool Chatter?**

Tool chatter is the unwanted vibration of a cutting tool during machining operations, typically caused by improper machining parameters or tool/workpiece setup.

- **Effects of Tool Chatter**
- Poor Surface Finish
- Dimensional Inaccuracies
- Reduced Tool Life
- Noise & Vibrations

Fig 1 below shows a part that has been machined. Evidence of chatter can be seen on the left whereas on the right, where no chatter occurred, a smooth surface, free of defects, can be seen

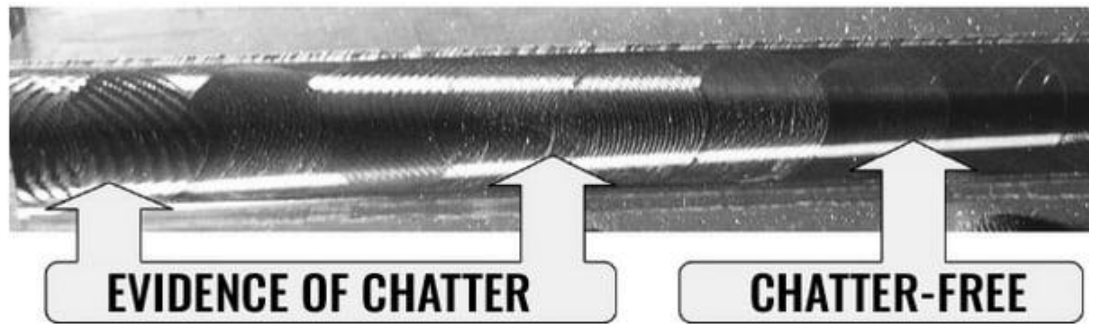

Figure 1: Evidence of Chatter

- **Causes of Tool Chatter:**
- **Incorrect Machining Parameters:** Excessive cutting speed, improper feed rate, inappropriate depth of cut, can lead to tool chatter during machining processes
- **Excessive Cutting Forces:** High cutting forces, often caused by inappropriate cutting parameters, can induce vibrations.
- **Improper Tool Geometry:** Incorrect tool geometry, such as an unsuitable rake angle or cutting-edge design, can contribute to tool chatter.

Methodology

- ACE Machining 6-hour CNC Machining course was completed and below shows a sample experiment for monitoring machining behaviour and monitoring tool chatter.
- Machining parameters were input to the CAM + Software, developed by Dr Tony Schmitz, such as axial and radial depth of cut, tool diameter, number of flutes, flute length, feed per tooth, spindle speed and whether it was up-cut or down-cut milling.
- Aluminium 6061 T6 is the material being machined.
- CAD model of the part is shown below in Fig 2.
- Tap Test is performed, and the data is fed back to the CAM + App.

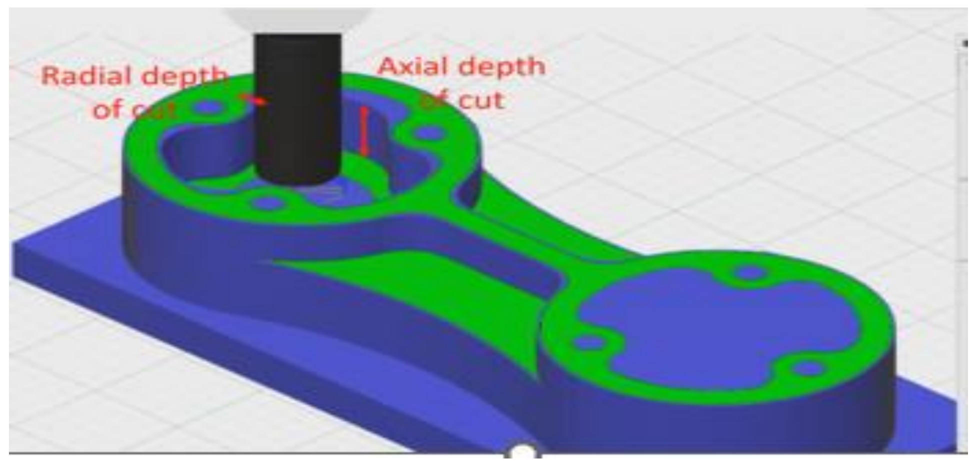

Figure 2: CAD Model

Results

- Frequency Response Function is formed, as seen below in Fig 3.

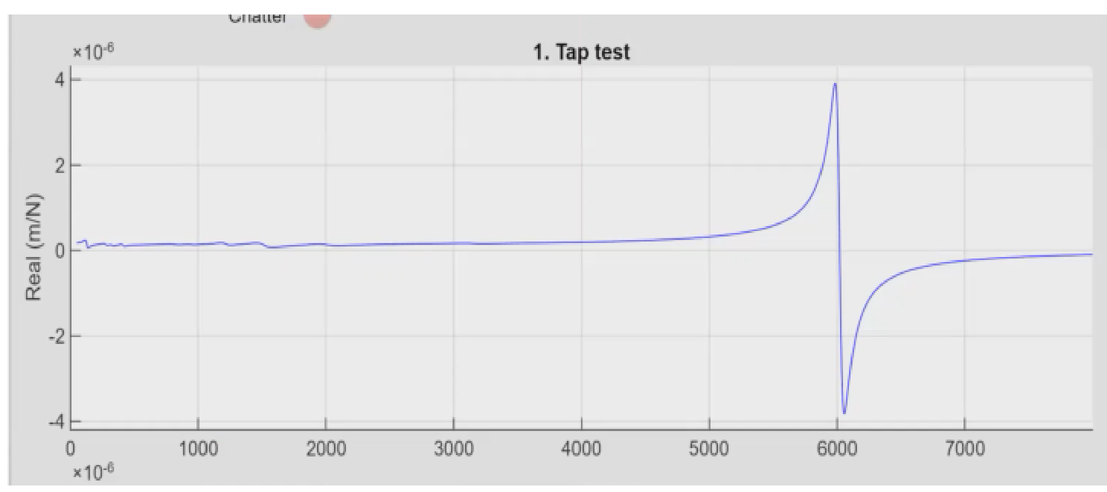

Figure 3: Frequency Response Function (FRF)

- The FRF curve has a very tall narrow peak, which shows this tool has damping and stiffness values which are low. This also means it is hard to apply high axial and radial depths of cut without getting chatter.
- The Stability Lobe Map for the tool set up is shown in Fig 4. A problem can be seen. There is no spindle speed that is stable for the 15.88mm axial depth. This is due to the low stiffness of the tool used and needs to be addressed i.e. Multiple Cuts instead of 1

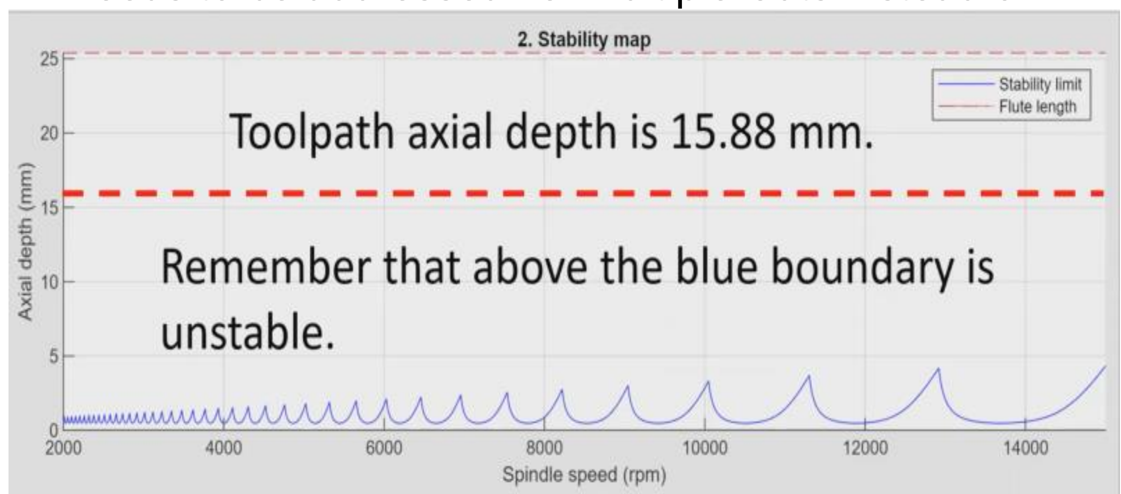

Figure 4: Stability Lobe Diagram

- Fig 5 shows a zoomed in version of the previous Stability Map. An area where no chatter is present can be seen at 12900 RPM and 3mm depth of cut.

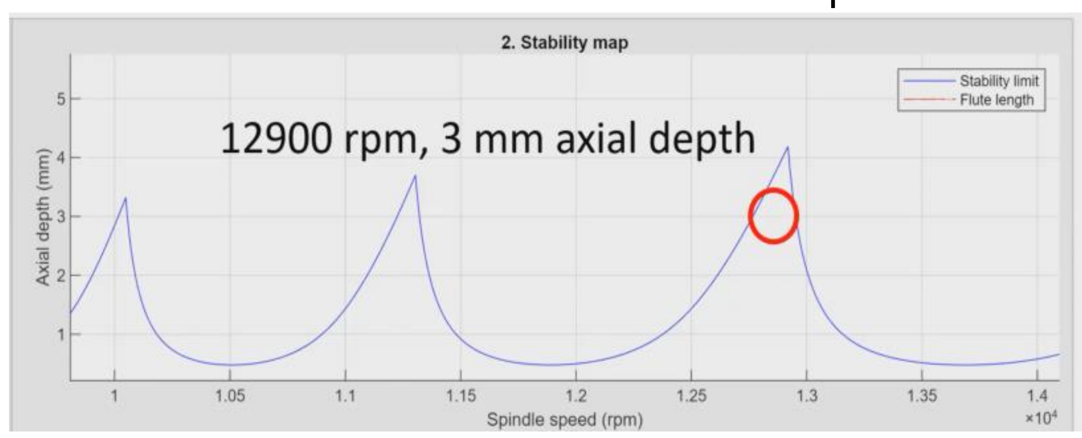

Figure 5: Zoomed Stability Lobe Diagram

- Fig 6 shows in the simulation section that there is a stable cut present due to the small forces and small vibrations. The vibrations repeat from one tooth passage to the next, shown by the red circles all lined up. No chatter is present.

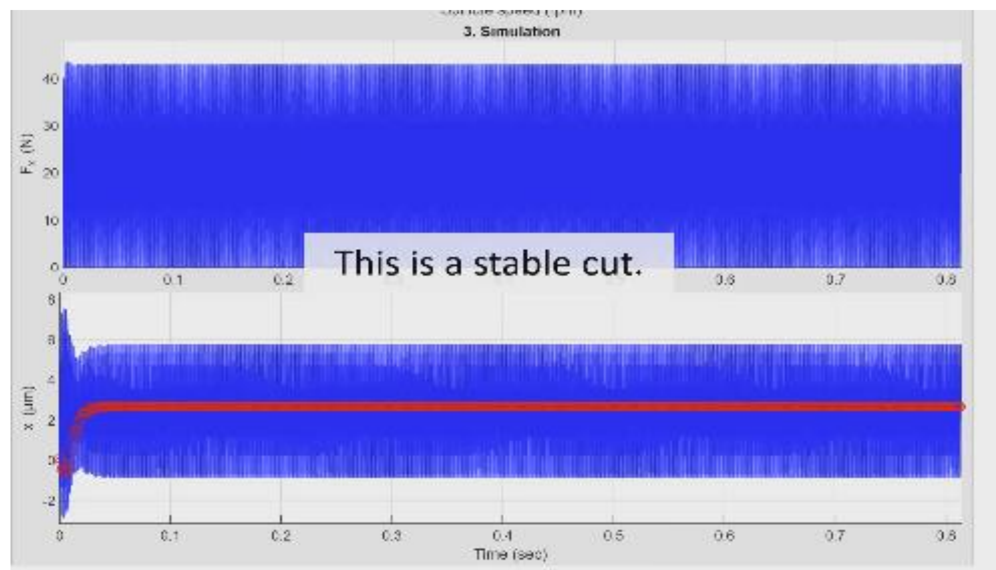

Figure 6: Simulation Graph (No Chatter)

- For reference, the Spindle Speed was changed to 13000 RPM.
- With a difference of only 100 RPM, chatter is present. Larger nonrepeating forces, and much larger vibrations are present, as seen in Fig 7.

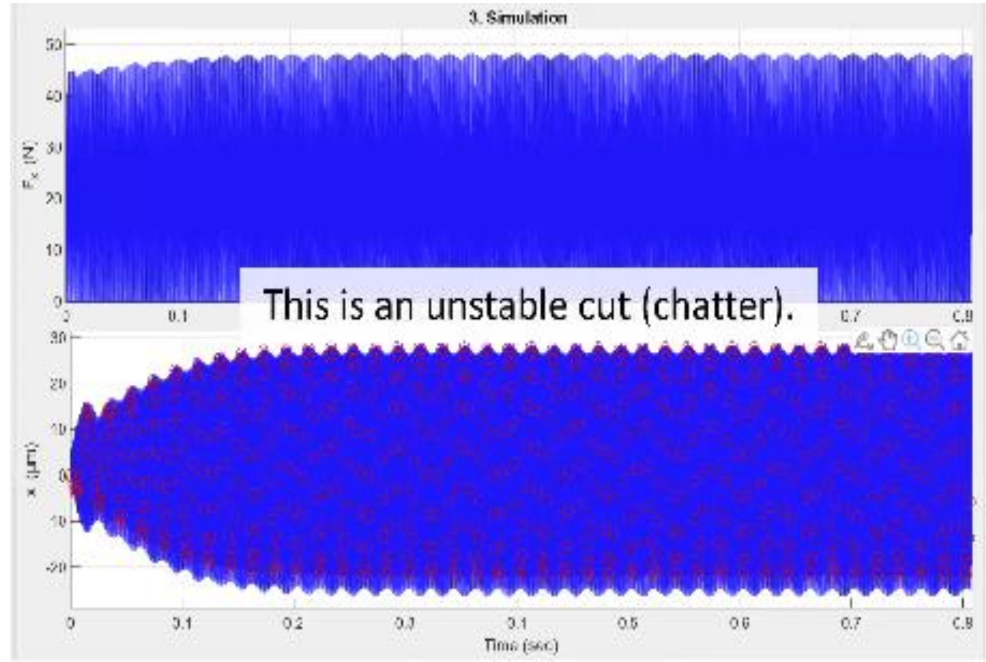

Figure 7: Unstable Cut (Chatter)

Conclusion

- **Dr Tony Schmitz CAM + Software**
- Provided valuable insights into machining behaviour for chatter in milling operations.
- Revealed critical aspects of tool performance and stability.
- Offered opportunities for optimization to reduce chatter and enhance machining efficiency.
- **Overall Conclusion**
- Demonstrated significance of adjusting machining parameters to achieve stability and minimize chatter.
- Highlighted why reducing chatter is important - it improves surface finish, extends tool life, ensures dimensional accuracy, increases productivity, and prevents machine damage.

References

https://mabe.utk.edu/people/tony-schmitz/
https://waykenrm.com/blogs/chatter-in-machining/

Acknowledgments

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