An analytical study of wheel regeneration in surface grinding

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Grinding is the oldest machining operation invented by mankind, and has been used for thousands of years in different shapes and forms. Being an abrasive process, grinding relies on a wheel consisting of many small and hard particles called grains or grits to remove material from the workpiece. As with conventional machining operations (e.g. turning), grinding can be negatively affected by unstable self-excited vibrations known as chatter. However, due to the geometric uncertainty and significant wear of grinding wheels, assessing the stability of grinding processes has particular difficulties. The randomness of individual grains makes it especially complicated to accurately characterise the geometry of the grinding wheel, and the excessive wheel wear allows for regeneration to occur not only on the surface of the workpiece but on the surface of the grinding wheel as well. Much research has been done in the past decades in order to gain a deeper understanding of grinding chatter, including the above-mentioned complexities. However, analytical studies are still lagging behind numerical ones due to their inherent difficulties and limitations. The present study describes an analytical investigation of grinding stability, aiming to explore the intricate nature of grinding wheel regeneration in surface grinding operations. Contrary to most previous studies, this work relies on the circumferential variation of a fundamental physical quantity called the specific grinding energy for instability to occur. The main idea is that a blunt or more worn grain produces a greater grinding force, whereas a sharp or less worn grain produces a smaller grinding force. By characterising the grit wear as a function of the material removal (which itself depends on the vibration of the grinding wheel), a mathematical model governing stability can be established. The current stage of this research does not include a full and final assessment of stability, but shows consistent and promising results.