

## Chapter 9

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### Novel Contributions and Industrial Recommendations

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#### 9 Novel contributions of the current research

##### **Modelling and Simulation Study of Ultrasonic Vibration-Assisted Grinding of AISI D2 Tool Steel with Single Alumina Abrasive Grit**

- Developed a 2D finite element model (FEM) of single grit ultrasonic vibration assisted dry grinding (UVADG) and conventional dry grinding (CDG) of AISI D2 steel
- Evaluated the effects of ultrasonic vibration and downfeed on the chip formation mechanism, temperature field, grinding force and equivalent stress and strain
- Demonstrated that UVADG mode can improve chip morphology, reduce temperature field, and lower grinding force compared to CDG mode
- Identified the potential of UVADG mode for improving the surface integrity of AISI D2 tool steel

##### **Experimental Analyses into Ultrasonic Vibration-Assisted Grinding of AISI D2 Tool Steel with Alumina Wheel**

- Developed an indigenous ultrasonic vibration assisted dry grinding (UVADG) setup
- Compared the grinding productivity of UVADG mode to conventional dry grinding (CDG) and conventional wet grinding (CWG) modes
- Demonstrated that UVADG mode can achieve lesser grinding forces, better surface integrity, and higher BAC ratio compared to CDG and CWG modes
- Highlighted the potential of UVADG mode for improving the grindability of AISI D2 tool steel

## **Experimental Study into UVAMQL Grinding of AISI D2 Tool Steel with an Alumina Wheel Using Eco-friendly Cutting Fluids**

- Investigated the effectiveness of ultrasonic vibration assisted minimum quantity lubrication (UVAMQL) grinding on AISI D2 tool steel using four sustainable cutting fluids
- Demonstrated that UVAMQL grinding can simultaneously maximize production quality and reduce environmental concerns associated with the grinding process
- Identified soybean oil-deionized water (SO + DW) emulsion as a promising cutting fluid for UVAMQL grinding of AISI D2 tool steel

## **Surface Integrity Characterization of Ground Surface using Magnetic Barkhausen Noise Technique**

- Explored the application of novel non-destructive techniques like magnetic Barkhausen noise (MBN) and hysteresis loop (HL) in the grinding process to characterize the surface integrity and qualitatively assess the thermal damage of AISI D2 tool steel under dry, wet, MQL and UVAMQL grindings modes
- Demonstrated that MBN and HL can be used to effectively characterize the surface integrity of ground AISI D2 tool steel
- Developed a correlation between MBN and HL outcomes with surface property, i.e., microhardness under different environments
- Introduced the concept of UVAMQL grinding in combination with MBN or HL as a potential method for efficient grinding with a fast characterization of ground samples

## 9.1 Overall Novel Contributions of the current research

- Developed a comprehensive understanding of ultrasonic vibration-assisted grinding (UVAG) of AISI D2 tool steel through a combination of modelling, simulation, and experimental studies.
- Established the potential of UVAG mode for improving machining performance and surface integrity of AISI D2 tool steel, offering significant advantages over conventional grinding methods.
- Introduced the concept of ultrasonic vibration assisted minimum quantity lubrication (UVAMQL) grinding as a sustainable machining technique that simultaneously maximizes production quality and reduces environmental impact.
- Identified eco-friendly cutting fluids as a promising cutting fluid for UVAMQL grinding of AISI D2 tool steel, presenting a viable alternative to conventional mineral-based cutting fluids.
- Demonstrated the effectiveness of novel non-destructive techniques like magnetic Barkhausen noise (MBN) and hysteresis loop (HL) in characterizing the surface integrity of ground AISI D2 tool steel, providing a rapid and reliable method for assessing grinding-induced thermal damage.
- Developed a correlation between MBN and HL outcomes with surface property, i.e., microhardness under different environments, establishing a deeper understanding of the relationship between surface integrity parameters and grinding conditions.

## **9.2 Industrial recommendation of the new process for probable adoptability**

The new process of ultrasonic vibration assisted grinding (UVAG) has shown promising results in improving the machining performance and surface integrity of AISI D2 tool steel. This process offers several advantages over conventional grinding methods, including improved machining performance, surface integrity, and environmental friendliness.

UVAG is also an environmentally friendly process, as it can be used with eco-friendly cutting fluids. In addition, the use of novel non-destructive techniques like magnetic Barkhausen noise (MBN) and hysteresis loop (HL) can be used to characterize the surface integrity of ground AISI D2 tool steel and assess grinding-induced thermal damage.

Based on these findings, we recommend that UVAG be considered for use in industrial applications where high-quality surface integrity is required. UVAG is particularly well-suited for grinding AISI D2 tool steel, which is a "difficult-to-machine" material with a high tendency for thermal damage.

Some specific industrial recommendations for the new process:

- The new process should be standardized and made available to the wider machining community.
- The new process should be further studied to optimize its performance.
- The new process should be integrated into existing machining systems.
- The new process should be promoted to potential users.