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# Energy Efficient High Performance Cutting of Grey Cast Iron

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## Introduction

High Performance Cutting (HPC) is a concept which seeks to minimize production cycle times while maximizing product quality. HPC has gained considerable momentum in recent years and embodies such synergistic concepts as high speed machining, dry machining and minimal quantity lubrication (MQL). [1]

The development of ultra-hard cutting tool materials such as CBN (Cubic Boron Nitride) and ceramics exhibiting excellent wear resistance, chemical stability and hardness at high temperatures have enabled much higher cutting speeds and dry machining. [1-3]

The aim of this project is to determine the optimum strategy for high performance cutting of grey cast iron. The project will involve finite element modelling of the machining process, experimentally validated using state-of-the-art force analysis, temperature measurement and surface characterisation equipment. Machining performance in terms of material removal rates and product quality are presented here.

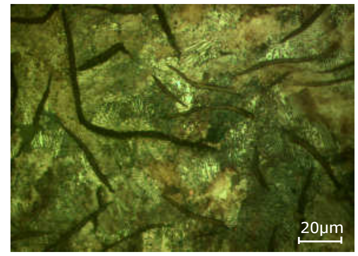


Fig.1: Microstructure of Grey Cast Iron; dark graphite flakes in a predominantly pearlitic matrix

## Experimental Setup

Annular workpieces are machined with an 18kW CNC lathe. The workpiece was faced-off, as shown in Figure 2, for continuous and interrupted cutting trials. This was carried out for dry machining and with flood cooling (12litres/min).

Four slots (12mm wide) were milled into the face of the workpiece prior to interrupted cutting trials.

Solid annular workpieces are used for continuous cutting.

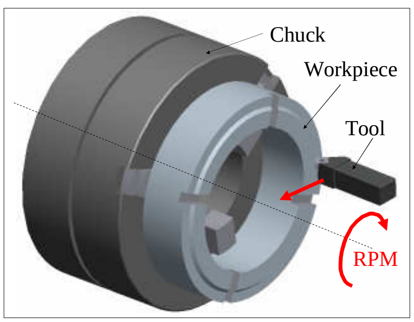


Fig.2: Interrupted facing of Grey Cast iron workpieces

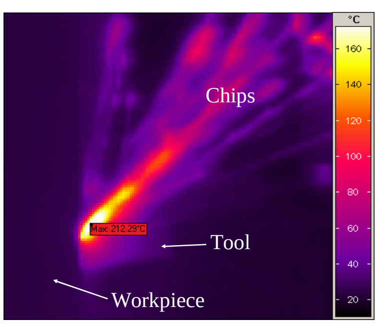


Fig.3: A low magnification thermograph of dry machining of Grey Cast Iron

Thermal imaging of the cutting process has shown that the maximum cutting temperature is established and maintained within the first second of tool engagement.

High magnification thermography will be implemented for the full experimental programme.

## Results

Material removal rate capabilities are mapped for continuous and interrupted cutting for carbide, ceramic and CBN cutting inserts, see Figure 4.

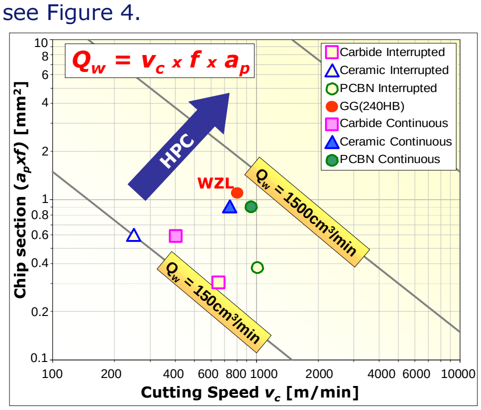


Fig.4: Removal rate diagram for turning of Grey Cast Iron

Adequate surface roughness (Ra < 3.2µm), and dimensional stability was achieved for all data presented. Cutting fluid was not found to have a significant effect on product quality.

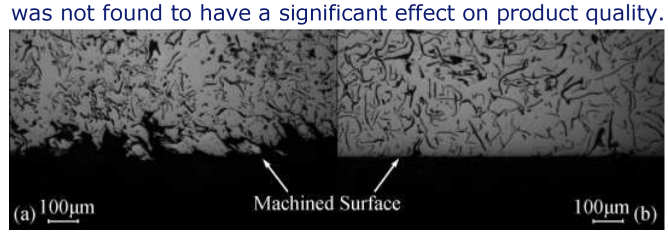


Fig.5: Improved surface finish achieved in (b) by optimizing the tool nose radius to 0.8mm resulting in the surface roughness reduced from Ra > 10µm (a) to Ra < 3.2µm (b).

## Conclusion

1. Grey cast iron is a good candidate for dry machining (for cutting speeds in the range 200 – 1000 m/min).
2. High Speed Machining (defined in [4]) has been successful in terms of surface finish and dimensional stability.
3. Material removal rates comparable with that achieved at WZL Aachen [1] have been demonstrated.
4. Cutting fluid was not found to have a significant effect on product quality presenting the potential for significant savings.
5. A potential reduction in throughput time of 22% has also been demonstrated by this work to date.

**References:** [1] Byrne, G. *et al.* (2003) **Ann. CIRP**, 52/2;483-507 [2] Liu, Z.Q. *et al.* (2002) **J. Mater. Process Tech**, 129;222-226 [3] Tlusty, J. (1993) **Ann. CIRP**, 42/2;733-738. [4] Schulz, H., Moriwaki, T., (1992) **Ann. CIRP**, 41/2;637-645.

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