



Investigating the influence of machining variables and defects on Machined components tensile properties.

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Introduction

- Tensile testing of EN8 steel specimens was utilised to reveal how machining variables shift yield strength, ultimate tensile strength (UTS) and Young’s modulus.
- Post-testing surface analysis was carried out using optical microscopy techniques.



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Project Aims

Assess how machining variables shape the tensile behaviour of EN8 specimens. Specific objectives were:

- Surface Finish** – Correlate surface roughness (6.4,3.2,1.6µm) with tensile response.
- Application of Coolant**– Compare tensile properties of 1.6µm sample after machining with 20 L/min vs 0 L/min.
- Surface Defect** – assess the effects of a single circumferential surface defect on tensile properties of EN8.

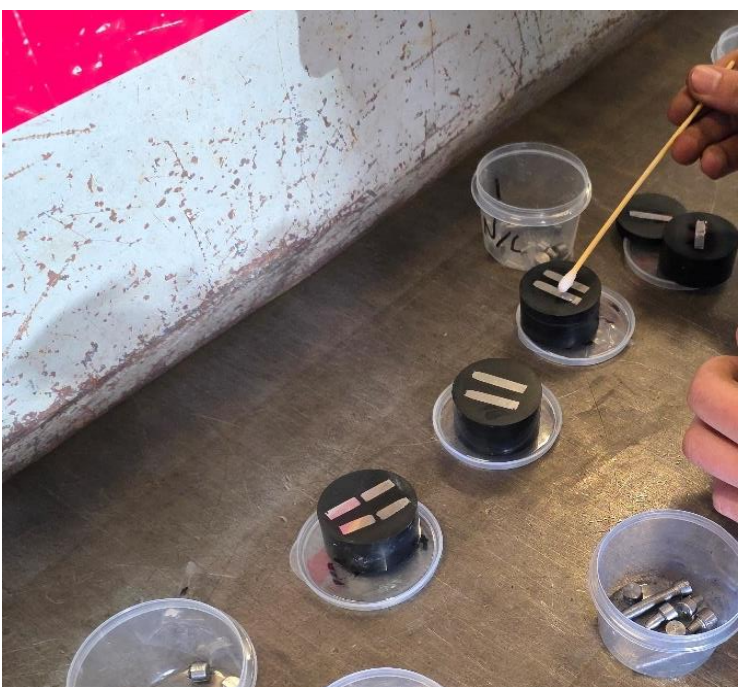
Methodology

A robust experimental methodology was devised:

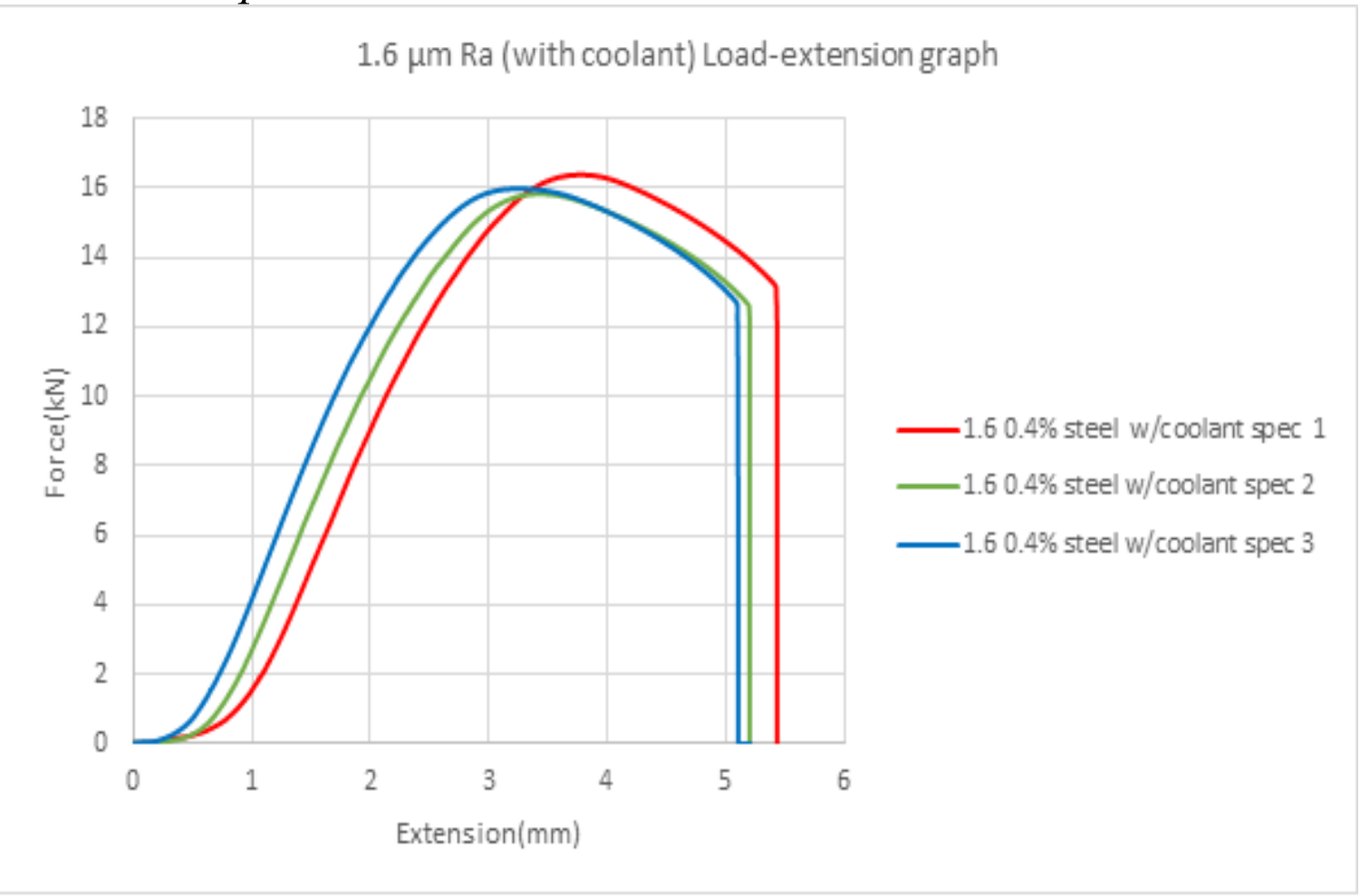
- Driven primarily from ISO 6892-1 Tensile testing standards (ISO,2019)
- 15 specimens were prepared and their quality assessed using metrological principles and tested to fracture.
- Microscopic analysis processes (cutting, mounting, polishing and acid etching) to reveal surface grain structure (Obondo and Nyangoye, 2019).



Image showing Tensile Testing specimens.



Etching of mounted samples using Nital.



A typical example of a load-extension chart derived from 1.6µm specimen tensile results.

Tensile Results

Surface Finish:

- Tensile properties improved up to 3.2 µm, gains level off beyond this point.
- UTS Increased by 4 % 3.2 vs 6.4µm. Yield strength Increased by ~15% 3.2 vs 6.4µm sample.

Application of Coolant:

- At a 1.6 µm finish, coolant rate had no meaningful effect on EN8 tensile strength.

Surface Defect:

- Surface defect cut UTS by 10–15 % and negated post-yield ductility.
- Highlights how even one surface defect can drive premature failure.

Experimental Limitations:

- Results were overshadowed by anomalous elastic modulus results.
- Likely caused by instrumental error of the extensometer.

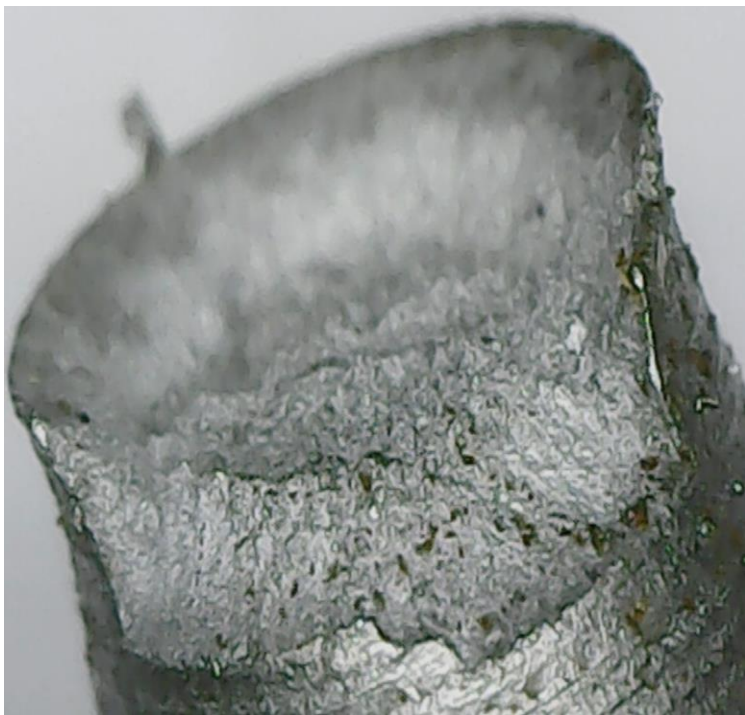


Image showing ductile failure of 3.2µm sample.



Image showing the tensile testing grip assembly.

References

ASTM (2010) ‘Test Methods for Determining Average Grain Size’.

Callister, W.D. and Rethwisch, D.G. (2020) Materials science and engineering: an introduction: SI Version. 10th edition, global edition. Hoboken: Wiley.

ISO (2019) ‘ISO 6892-1 Metallic materials - Tensile testing – Part 1: Method of test at room temperature.

Obondo, B.O. and Nyangoye, B.O. (2019) ‘Microscopy simple or advanced technique of material characterization’. *Open Science Journal* 4(1).

Womack, W. (2024) ‘Interpreting Common Verification Problems’. *Epsilon*

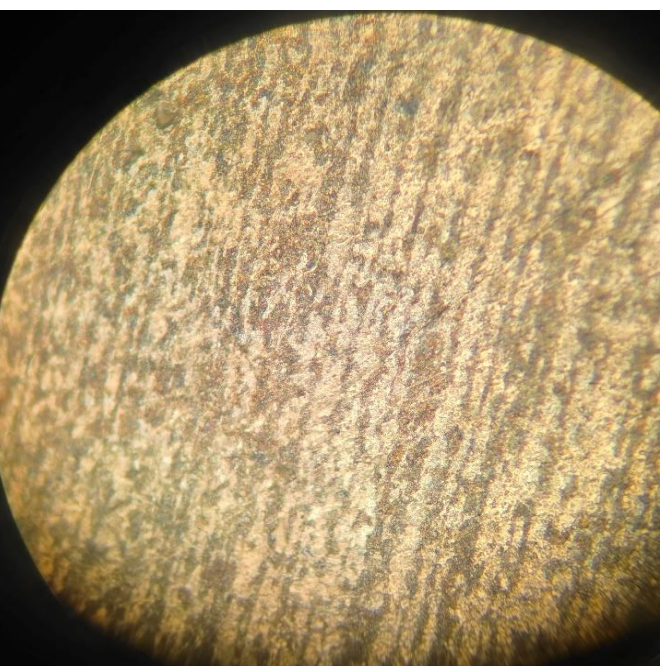
Microscopy Results

Microstructure & Composition:

- Specimens displayed a ferrite-pearlite microstructure.
- Evidence of Cold Drawing small elongated grains showing linear plastic deformation (Callister and Rethswick,2020).
- A lack of equiaxed grains suggests machining processes have not altered the grain structure (ASTM,2010).

Experimental Limitations:

- Limited magnification (60x)
- Improvised camera-over-eyepiece setup.



Columnar grain structure of 1.6µm specimen(0 L/min coolant).



Nikon optical microscope.

Future work

Tensile testing:

- Examine the effects and causes of the instrumental error.
- Evidence suggests a combination of slippage within the grips and instrumental error may be responsible (Womack,2024).

Microscopy:

- Optical microscopes of $\geq 100 \times$ magnification are recommended for grain sizing (ASTM,2010).
- A Scanning electron microscope could be used to capture sub-micron defects.
- Utilise a C-mount digital camera & live view software to eliminate the parallax and alignment errors.