GREAT DESIGNS IN STEEL

TWENTY YEARS

ADVANCED LASER HARDENING TECHNOLOGY FOR TOOLS AND DIE STEELS

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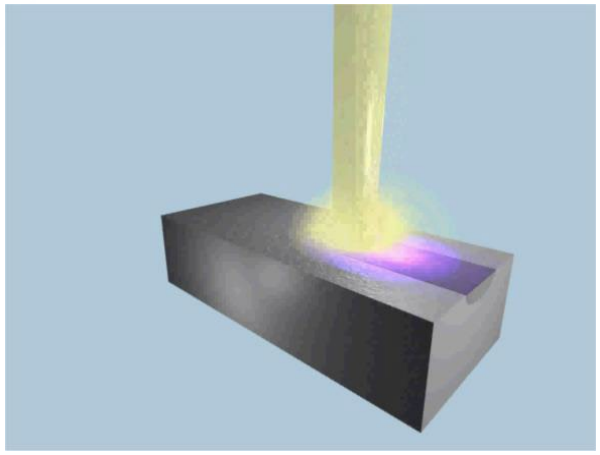
On Behalf of Auto/Steel Partnership

LASER HARDENING BACKGROUND

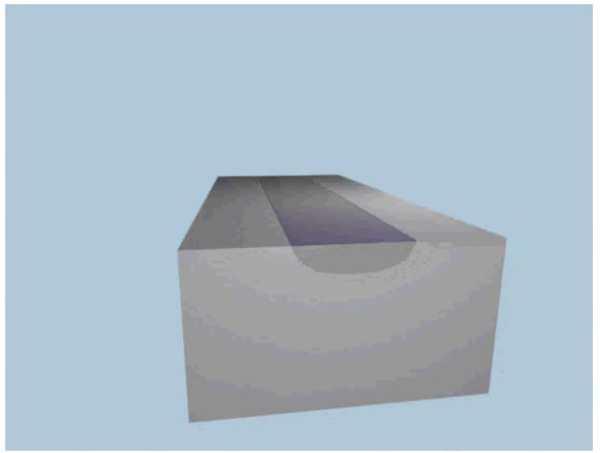
Laser Hardening Background

- NIR laser energy absorbed at material surface, transformed to heat
- Austenitizing of thin surface layer through diffusion
- Self quenching process

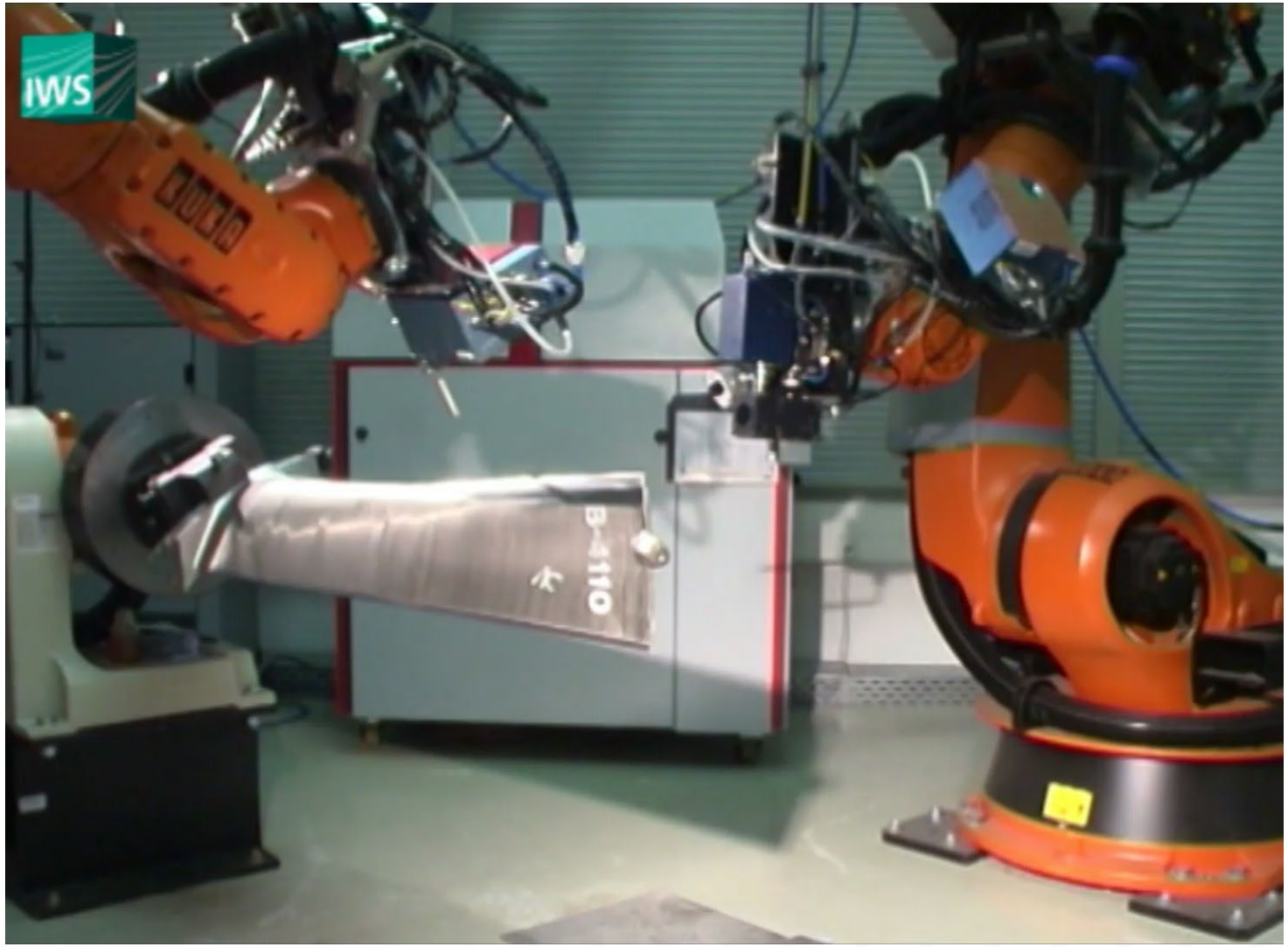


Advantages of Laser Hardening

- Low material distortion
- High geometrical precision
- Achieves maximum hardness values

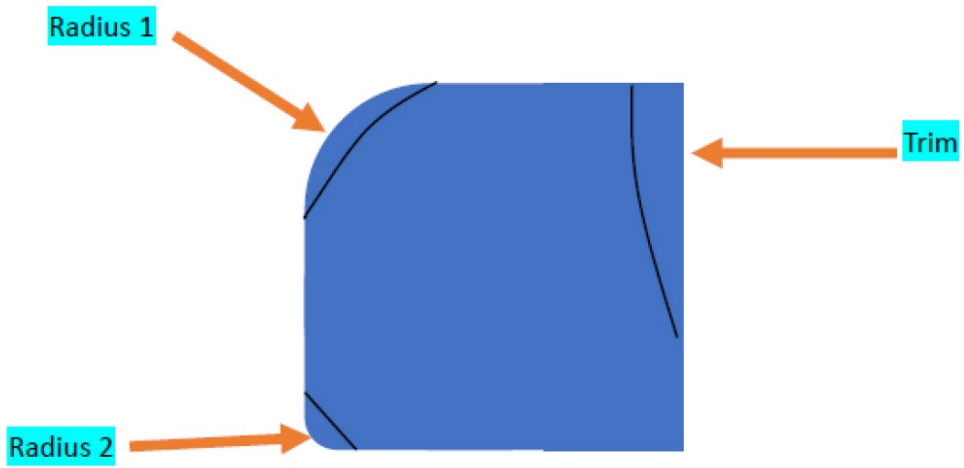


LASER HARDENING PROCESS DEMO FRAUNHOFER IWS TURBINE BLADE



PROJECT INTRODUCTION

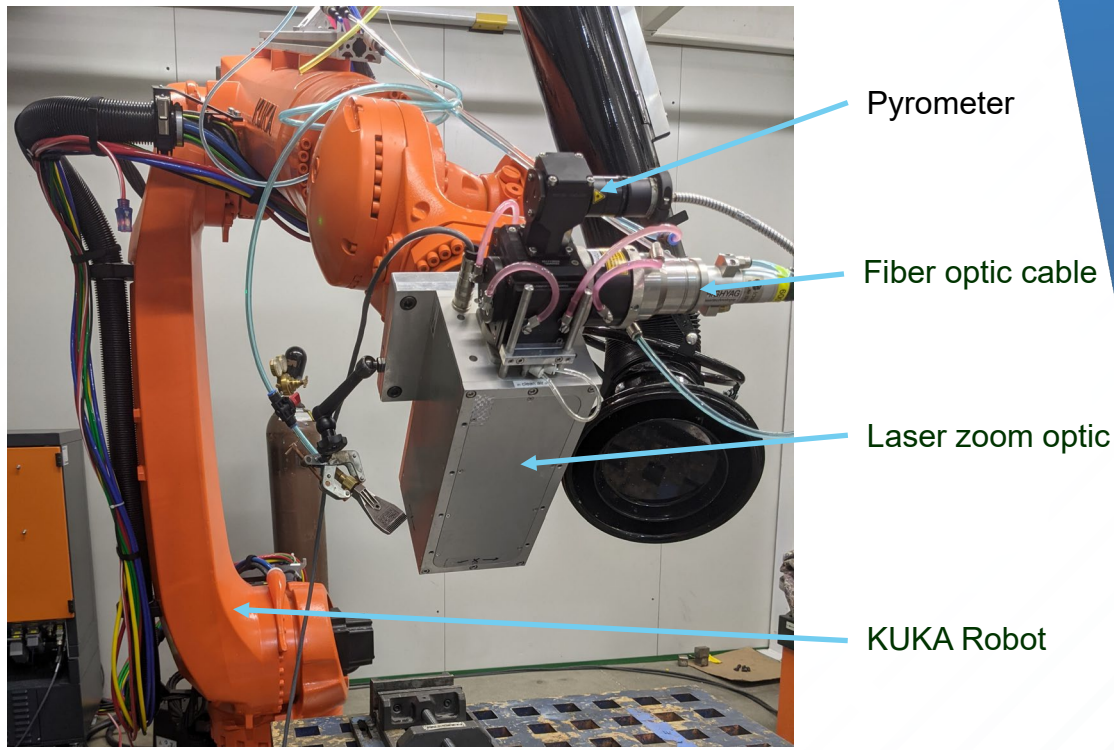
- Collaboration between **Auto/Steel Partnership** and **Fraunhofer USA** - Laser Applications Division
- S2333, S7, and D2 tool steels trialed
- Trim edge, 12mm radius, 3mm radius laser hardening features
- Test process for laser power control and temperature control



Cross section of hardening features

EXPERIMENTAL SETUP – LASER HARDENING

Laser	10kW Laserline diode laser LDF 10.000-60
Optic setup	Laserline zoom optic, spot size range 6x6mm to 56x56mm
Fiber	600µm
Workstation	KUKA KR120HA
Temperature Control	LASCON 600µm Pyrometer SN00126

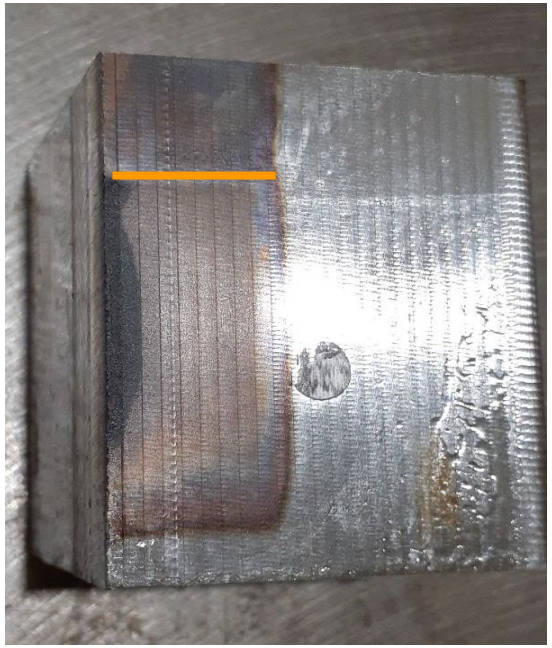


Note: Temperature control was only utilized for the radii features. The trim edge hardening process was controlled for laser power.

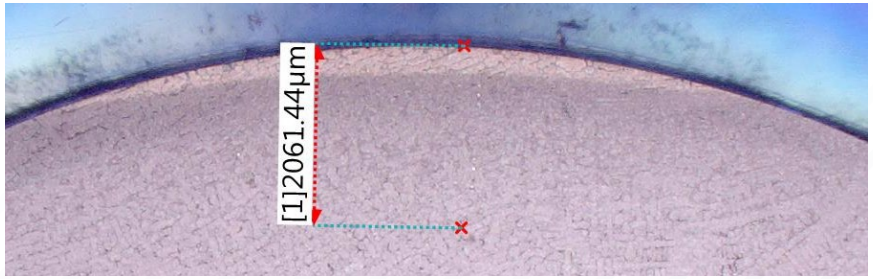
APPROACH AND METHODOLOGY

Process parameters: laser power, workpiece temperature, feed rate, spot size

- Identify borderline laser power or workpiece temperature where surface melting occurred
- Vary feed rate and spot size for multiple trials
- Cut cross sections and measure HAZ depth
- Vickers microhardness testing to identify optimal parameters

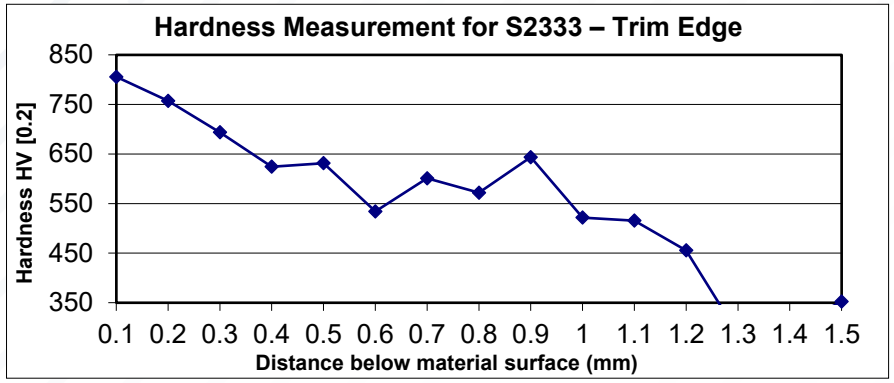


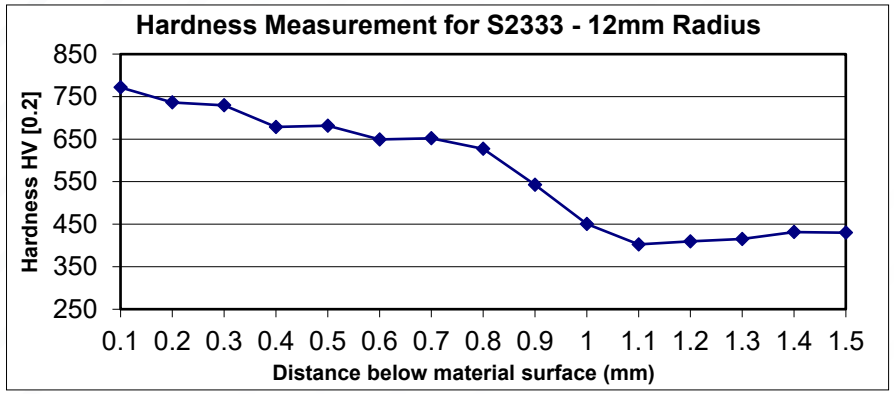
Example of surface melting on trim edge

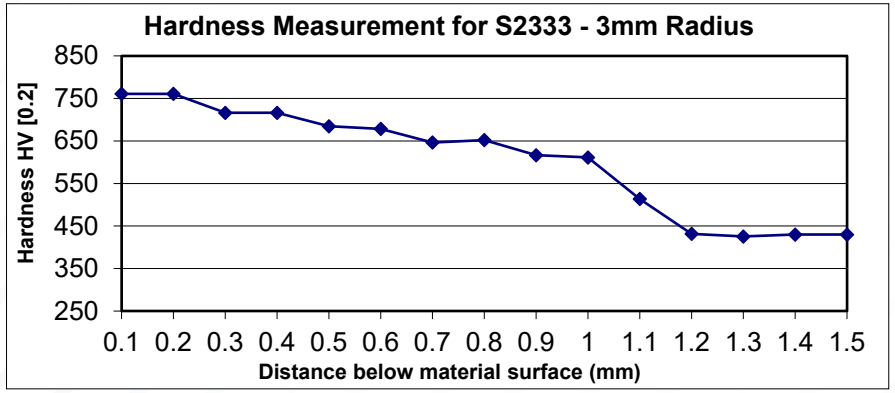


Cross section of surface melting on 12mm radius

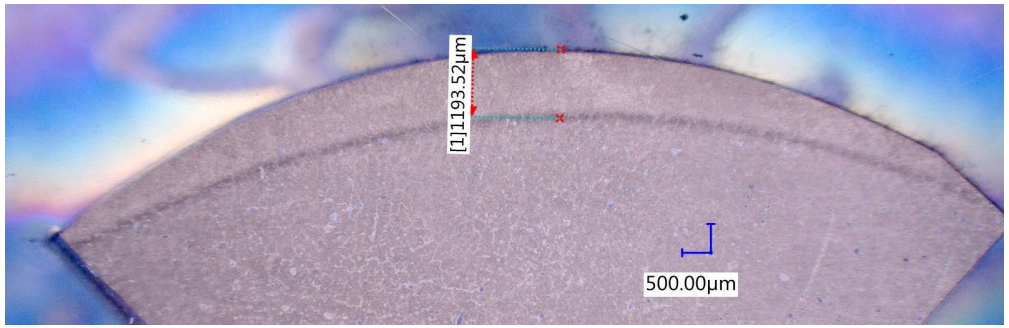
LASER HARDENING RESULTS – S2333 STEEL



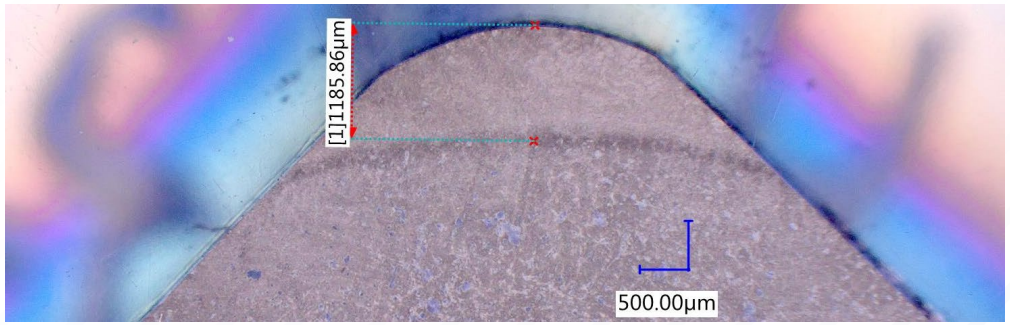




Cross section of S2333 - trim edge

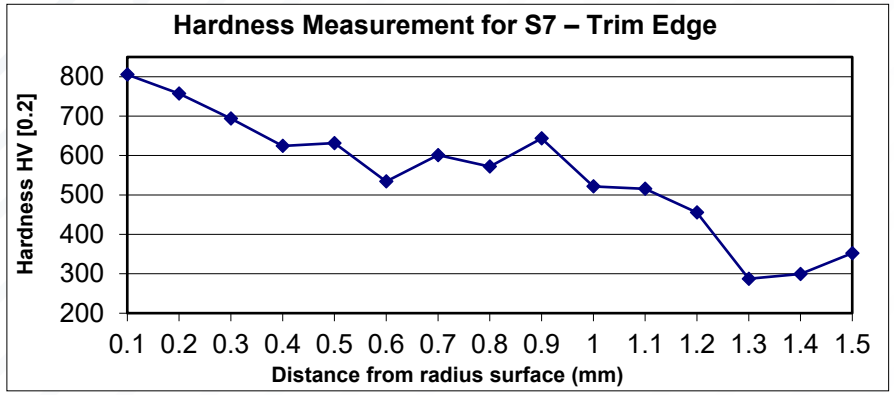


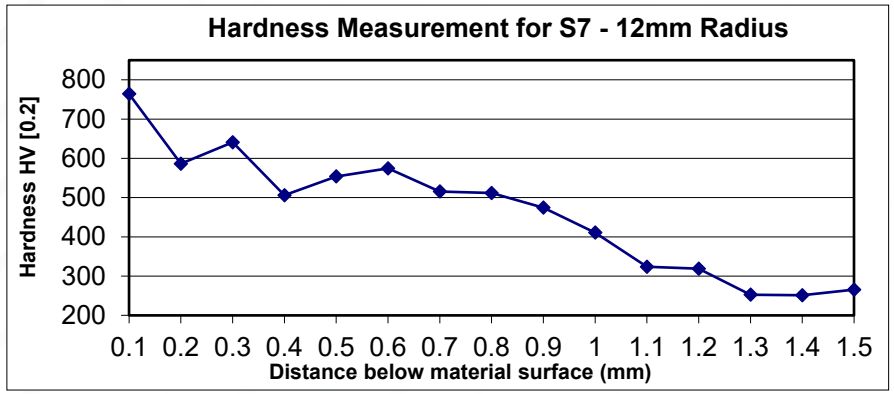
Cross section of S2333 - 12mm radius

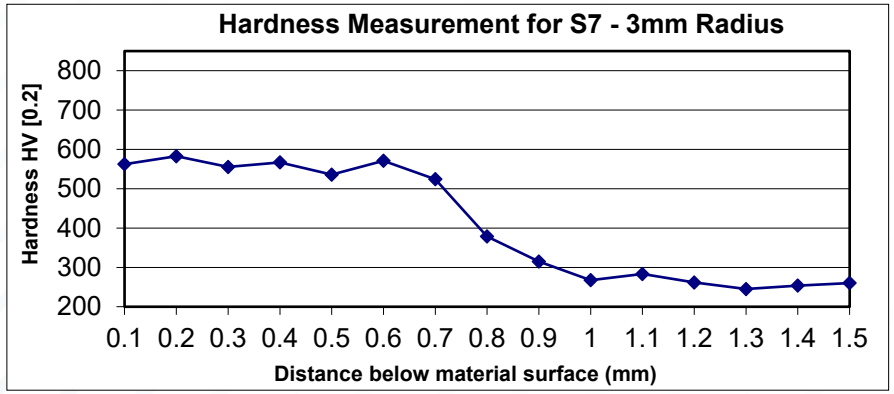


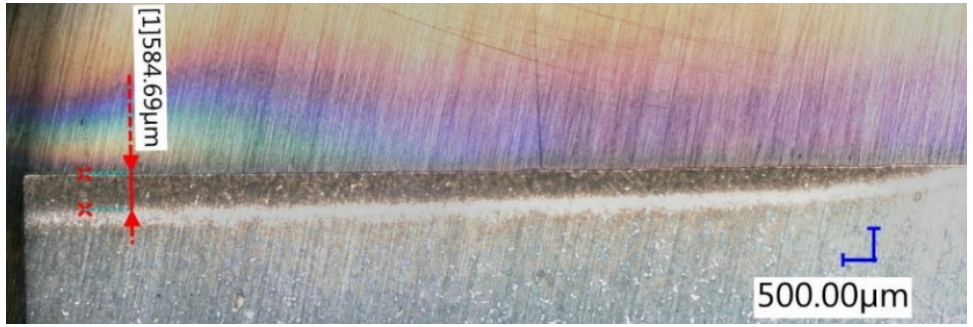
Cross section of S2333 - 3mm radius

LASER HARDENING RESULTS – S7 STEEL

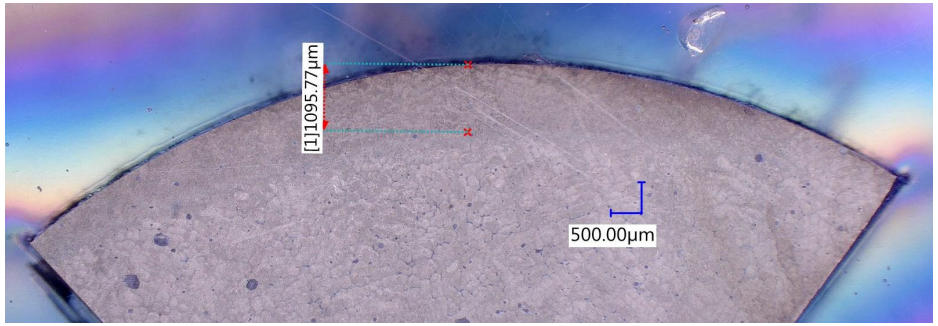




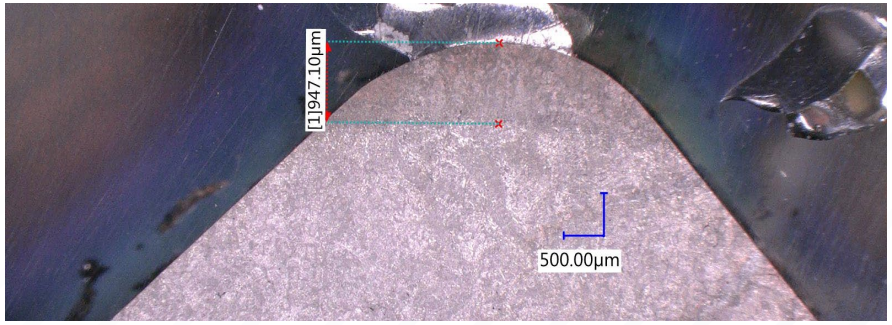




Cross section of S7 - trim edge

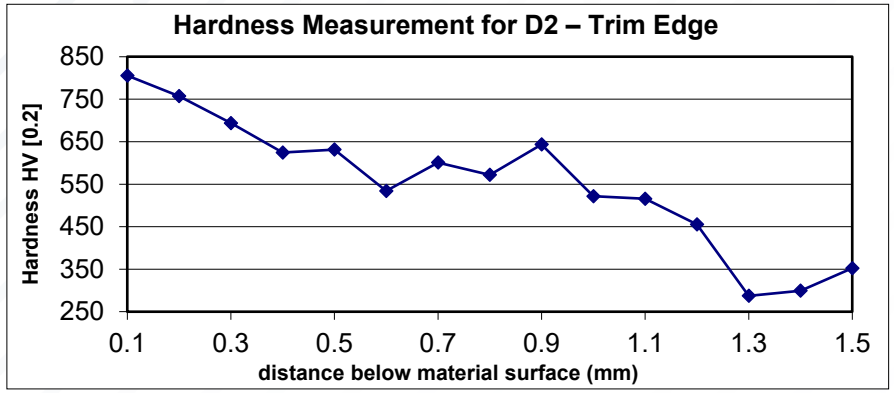


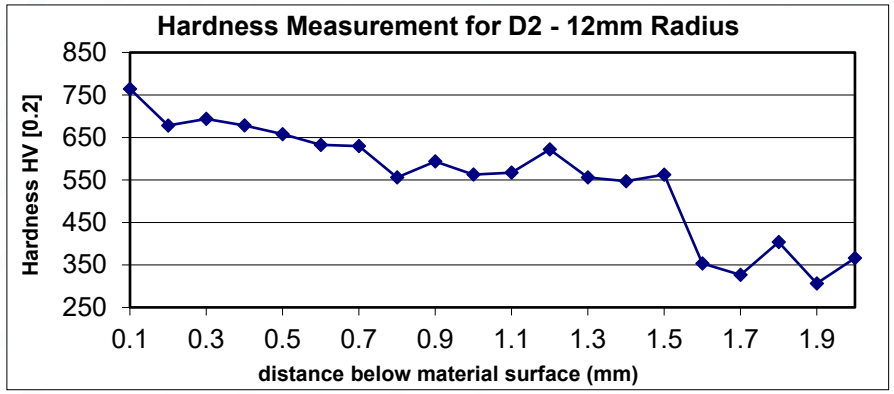
Cross section of S7 - 12mm radius

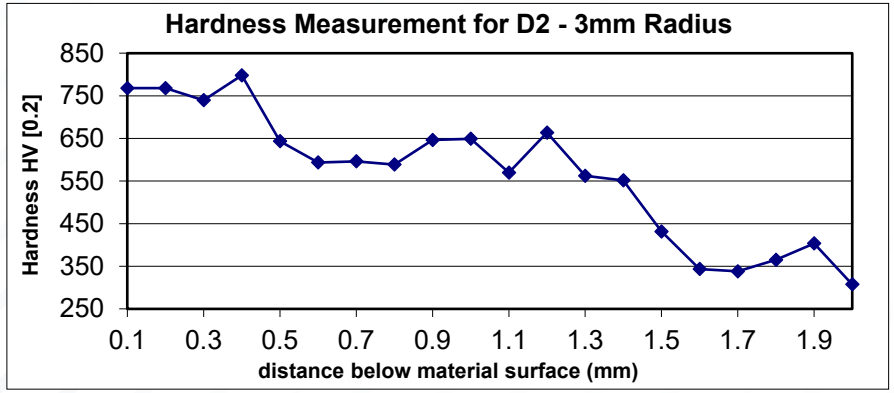


Cross section of S7 - 3mm radius

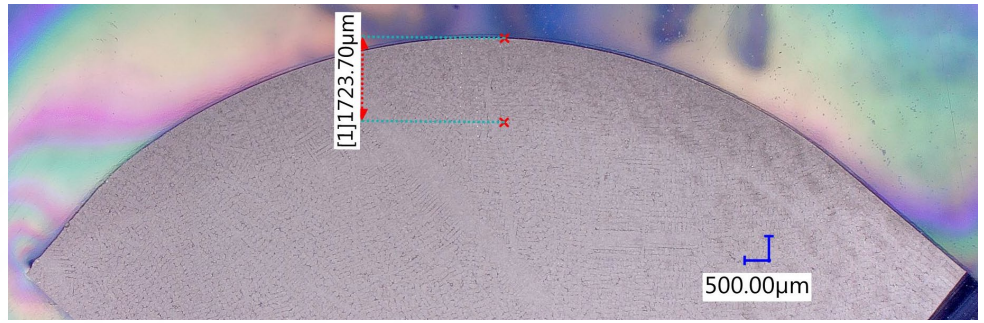
LASER HARDENING RESULTS – D2 STEEL



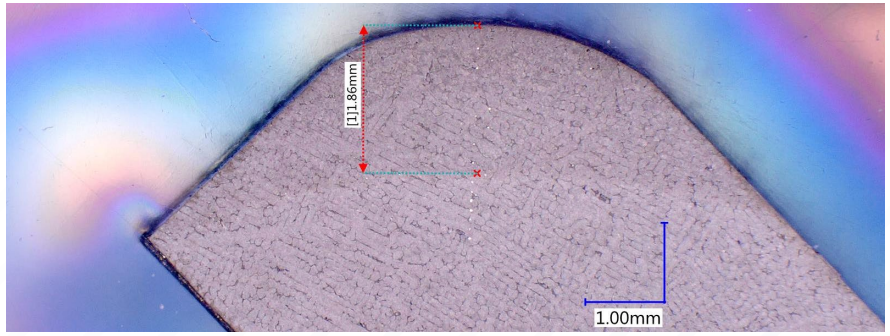




Cross section of D2 - trim edge



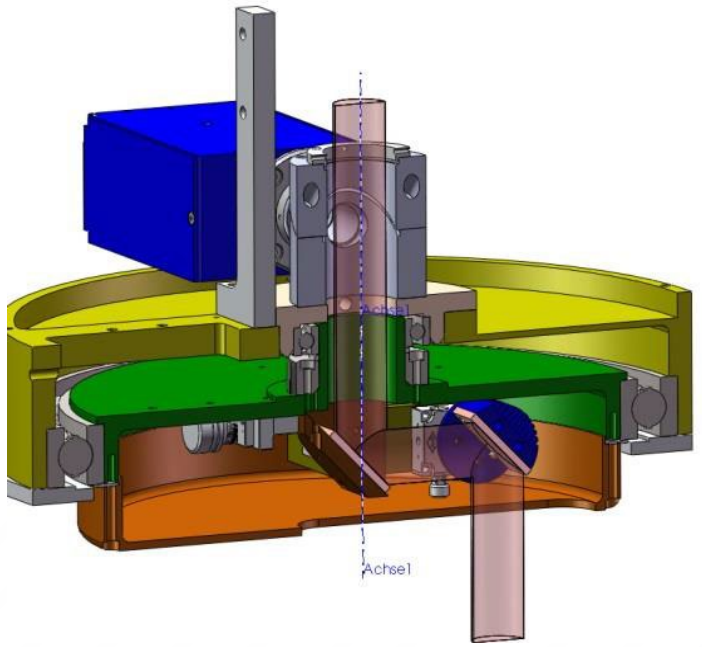
Cross section of D2 - 12mm radius



Cross section of D2 - 3mm radius

SCANNING OPTICS IN LASER HARDENING

- **Fixed optics**
  - Constant beam characteristics during process
  - Circular or rectangular spot shape
  - Beam positioned with robot or NC movement
- **Scanning optics**
  - Varies beam characteristics during process
  - Beam shaping/positioning with mirrors in optic
  - Opportunities for closed loop control (temperature)
  - Adapts to changes in part geometry real-time



3D drawing of sample scanning optic

THERMAL FIELD CONTROL (TFC) LASER SCANNING SYSTEM

- Developed by Fraunhofer IWS in Dresden, Germany
- Allows for uniform hardening of complex geometries

- **Multiple control parameters**
  - Laser beam shape and intensity profile
  - Scanning pattern and speed
  - Laser power output
- **Measurement methods**
  - Beam intensity profile (LASMON camera)
  - Temperature (NIR camera or pyrometer)

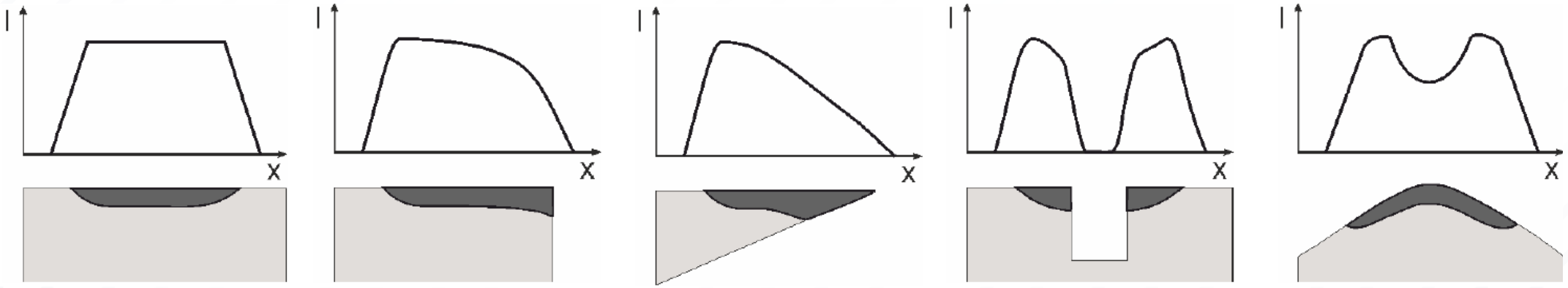
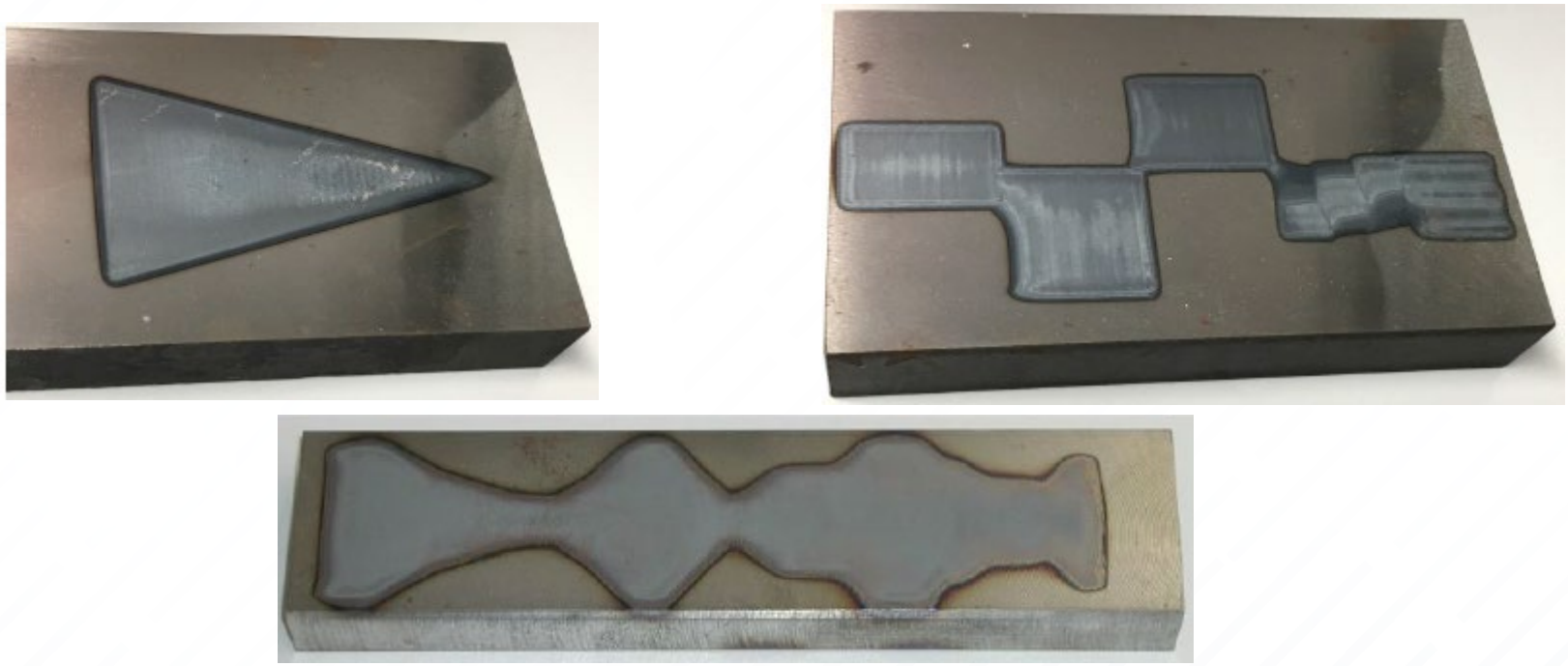


Illustration of optimal beam intensity profile for various hardening features

CONTROL OF BEAM SIZE AND POSITION

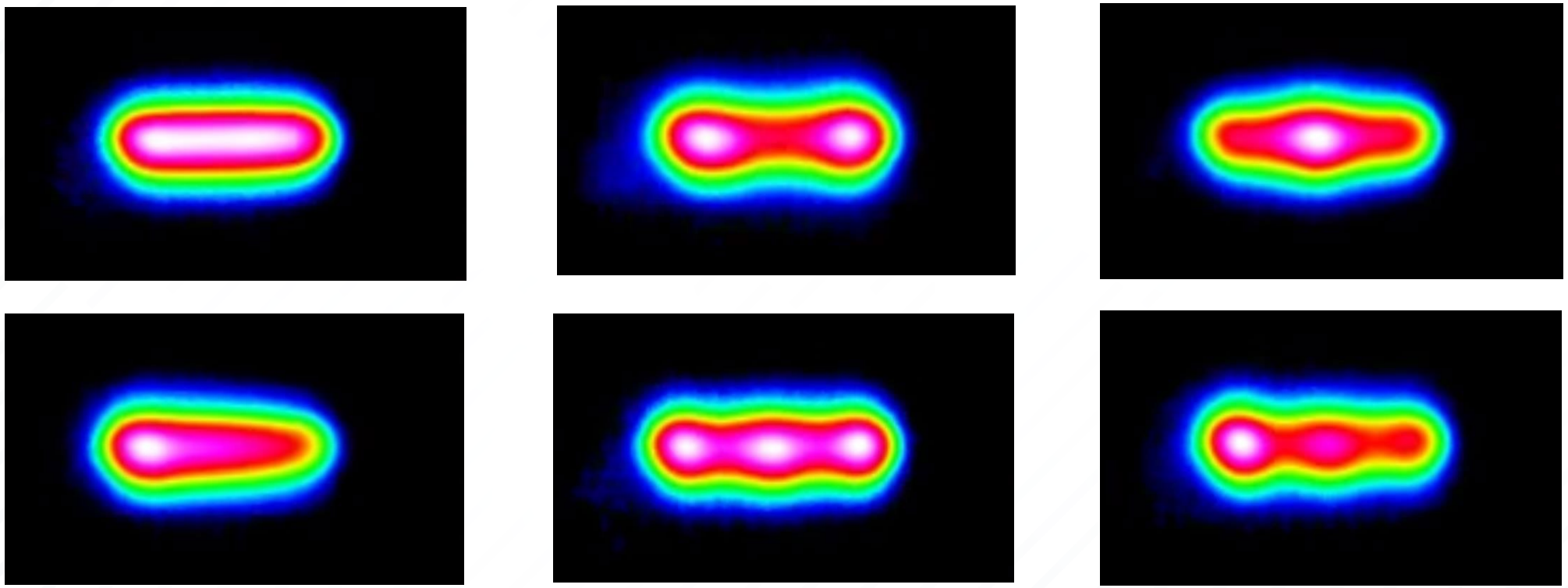
- Fast and continuous changes during running process
- Stabilized by temperature controller
- Maximum width depends on laser power (50-90 mm at 9 kW)
- Working field limited by optical focal length



Examples of possible hardening profiles with TFC system, scanner head feed direction to left/right

CONTROL OF TEMPERATURE PROFILE

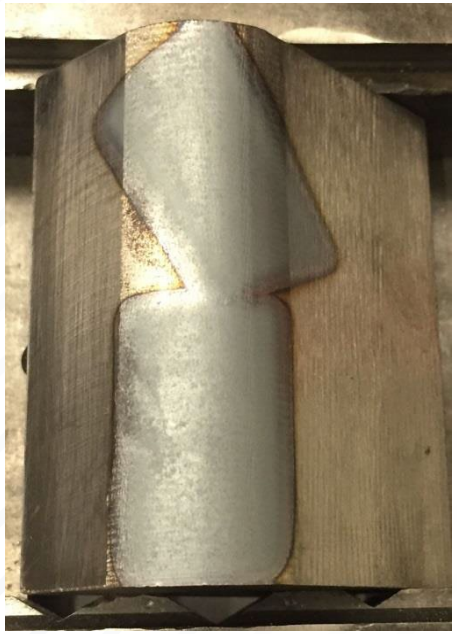
- Temperature profile given by operator (7 segments of control)
- Real-time 2D temperature measurement with NIR camera (E-MAqS)
- Heat condition effects limit time interval for temperature field stabilization

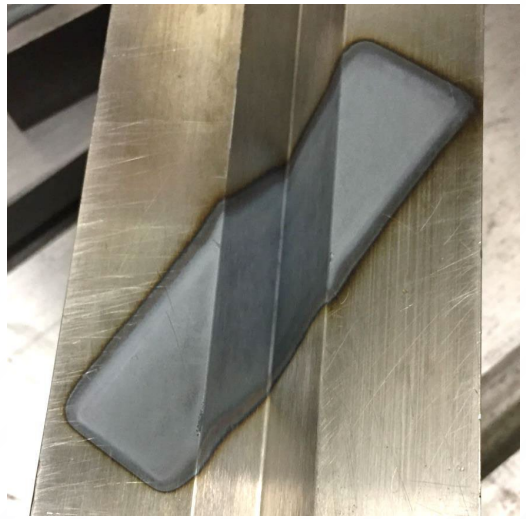


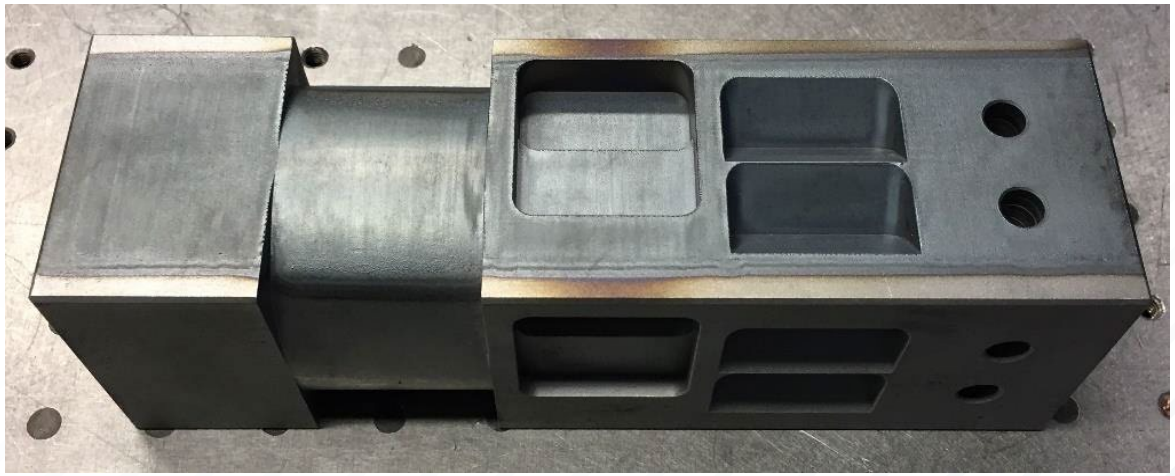
Sample temperature profiles attainable with Thermal Field Control system

TFC SYSTEM READY FOR INDUSTRIAL USE

- TFC system allows for hardening of complex geometries
- Particularly well-suited to automotive applications
  - **Dies**
  - **Tools**
  - **Pistons**
  - **Gears**
  - **Crankshafts**
  - **Etc.**







FOR MORE INFORMATION

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More Questions? Meet Brandyn at the Auto/Steel Partnership booth after this presentation.

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