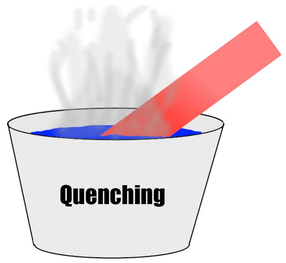

Heat of the Moment: Quenching Temperature's Effect on Steels

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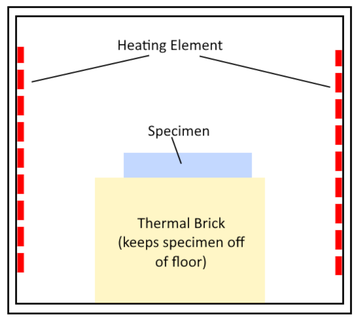
Abstract

Steels in their natural state lack the hardness and corresponding strength to be practically useful in many potential applications. To overcome this deficit, a hardening process is employed, which involves heating and then rapidly cooling (quenching) the steel, thereby altering its molecular structure and thus mechanical properties. To investigate the effect of quenching temperature and carbon content on hardness increase after quenching, three different variations of steel (1018, 1045, and O1) with 0.18%, 0.45%, and 0.85% carbon content respectively, were hardened at 5 distinct temperature set points. The samples were then analyzed through a Rockwell Hardness tester. Hardness after quenching increased with carbon content at all temperatures tested, with maximum increase from 1018 steel (0.18%C) to O1 steel (0.85%C) of about 15 HRA at 800°C. 1045 and 1018 steel both exhibited inverted parabolic behavior with respect to temperature with a maximum hardness increase at a temperature of 880-920°C. O1 steel exhibited no change in hardness increase with temperature.

Experimental Design

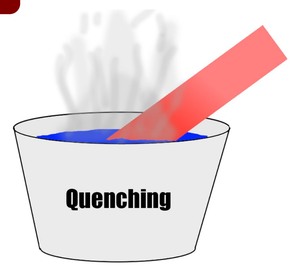
Quenching Temperature

800°C
850°C
900°C
950°C
1000°C

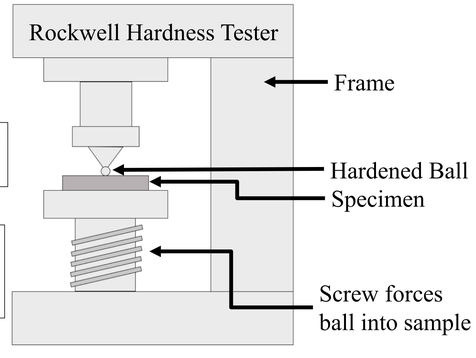


Heated to quenching temperature for 10 minutes

Quenched directly into water

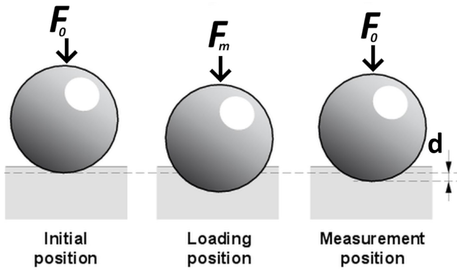


Once sample cools, placed into Rockwell Hardness Tester for measurement



Tester directly outputs HRA measurement

Four measurements are taken per sample, one per side



Hardness Equation

$$H = N - hd$$

N & h: standardized scaling factors
d: depression depth in mm to force F_m

HRA scale:

$$N = 100, h = 500, F_m = 60N$$

$$\Delta H = H_{quenched} - H_{unhardened}$$

Carbon Contents of Tested Steels

Steel Type	Carbon %	HRA Unhardened
O1 Steel	0.85%	57.08
1045 Steel	0.45%	60.60
1018 Steel	0.18%	58.45

Acknowledgements

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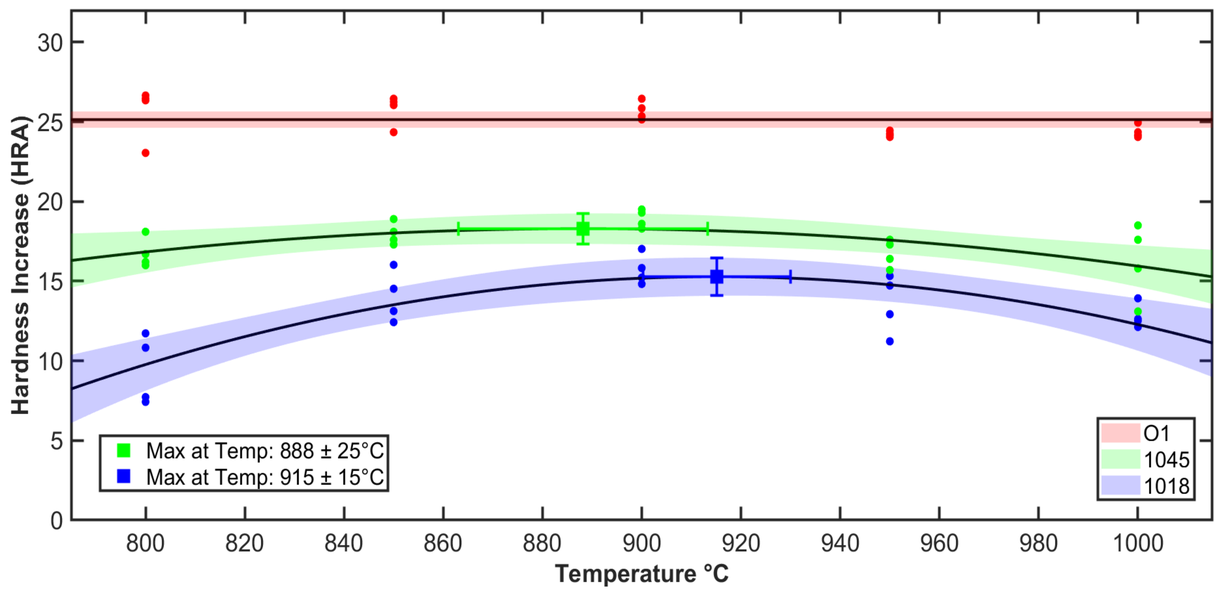
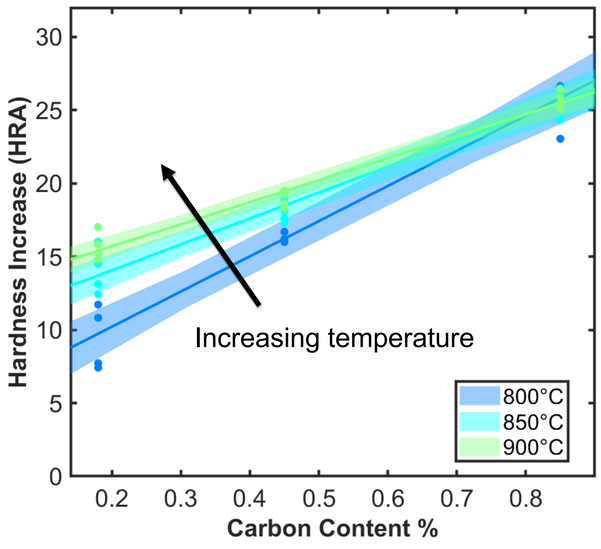
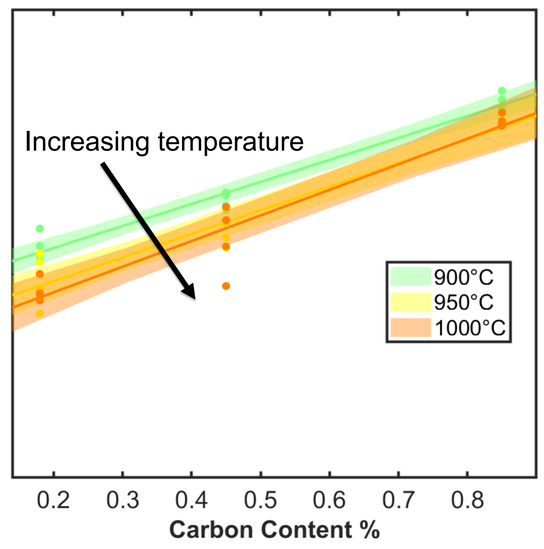
Quenching Effects on Hardness







Conclusions

- The highest carbon content steel, O1, (0.85% C) exhibited a constant increase in hardness of 25 ± 1 HRA, independent of quenching temperature
- 1045 and 1018 steel exhibited inverted parabolic hardness behavior with respect to temperature, with hardness increasing to a maximum and then decreasing. The temperature at maximum hardness was 888 ± 25 °C for 1045 Steel (0.45% C) and 915 ± 15 °C for 1018 Steel (0.18% C). The maximum hardness increase for the two steels was 18 ± 1 HRA and 15 ± 1 HRA, respectively.
- An increase in carbon content in steel led to a linear increase in hardness after quenching.

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