- **Oleg Nikitashin**
- **Lab Time** Apr 28, 2025 , Monday 12.45
- **Lab Group Number**: GGOY
- **Course & Lab Number**: ENGR270 Material Science Lab “Jominy End-Quench Test”

Lab Report: Jominy End-Quench Test

Objective: This experiment aims to examine how the cooling rate influences hardness in two steels (1040 and 4140) and highlights why adding alloying elements enhances uniformity and depth of heat treatment.

Background: The hardness and microstructure of steel depend on its cooling rate from the austenite region. Slow cooling produces ferrite and pearlite, whereas rapid cooling leads to martensite formation, significantly enhancing hardness. Alloying elements like chromium, molybdenum, and nickel increase the steel's ability to form martensite, improving hardenability.

Experimental Procedure: Two steels (1040 and 4140) were subjected to the Jominy end-quench test. Samples were heated to roughly 800°C for 45 minutes and quenched by directing water onto one end. Hardness was measured along the bar's length at specific intervals using Rockwell C scale.



Discussion:

The 4140 alloy steel exhibited higher hardness values and retained higher hardness further from the quenched end compared to the 1040 steel. This indicates superior hardenability due to

its alloying elements (chromium and molybdenum), which delay pearlite formation and facilitate deeper martensite formation.

The 1040 steel, with fewer alloying elements, showed a rapid decrease in hardness from the quenched end due to quicker pearlite formation, suggesting lower hardenability.

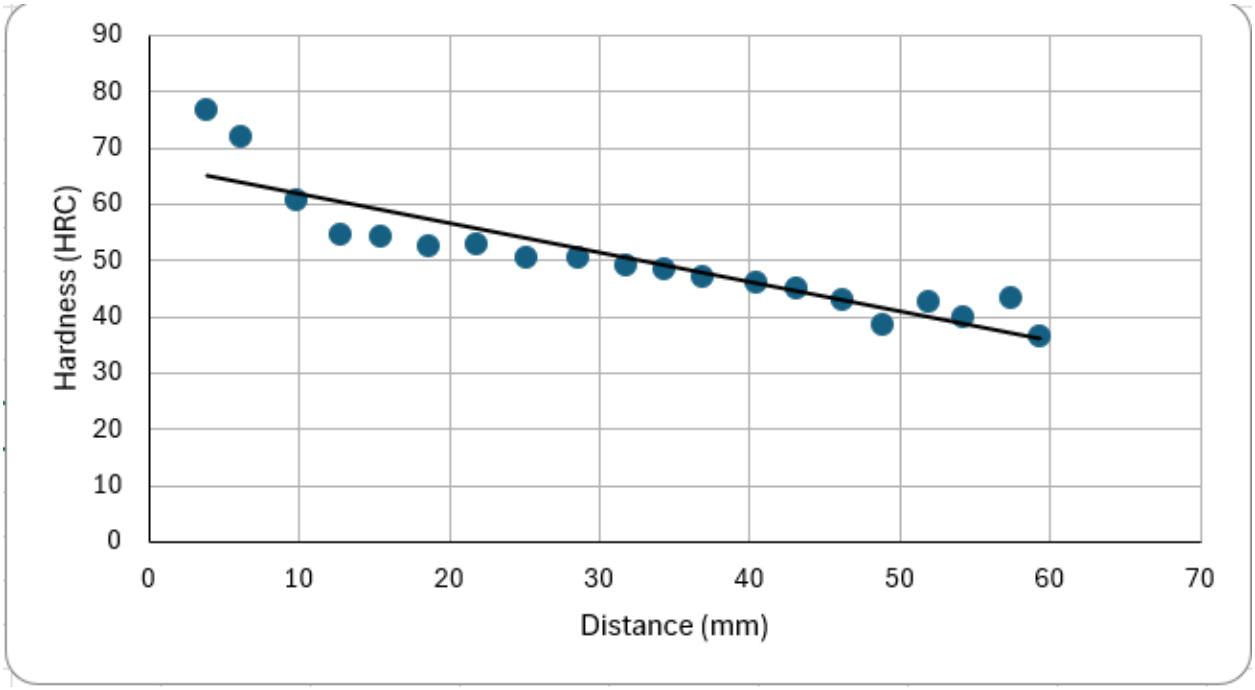
Comparing our data to typical hardenability curves (Figure 6 from the experiment guide), our results align with expected trends. Variations observed may stem from slight experimental inconsistencies, such as variations in quenching rate, specimen preparation, or hardness measurement accuracy.

Radial Hardness Profile:

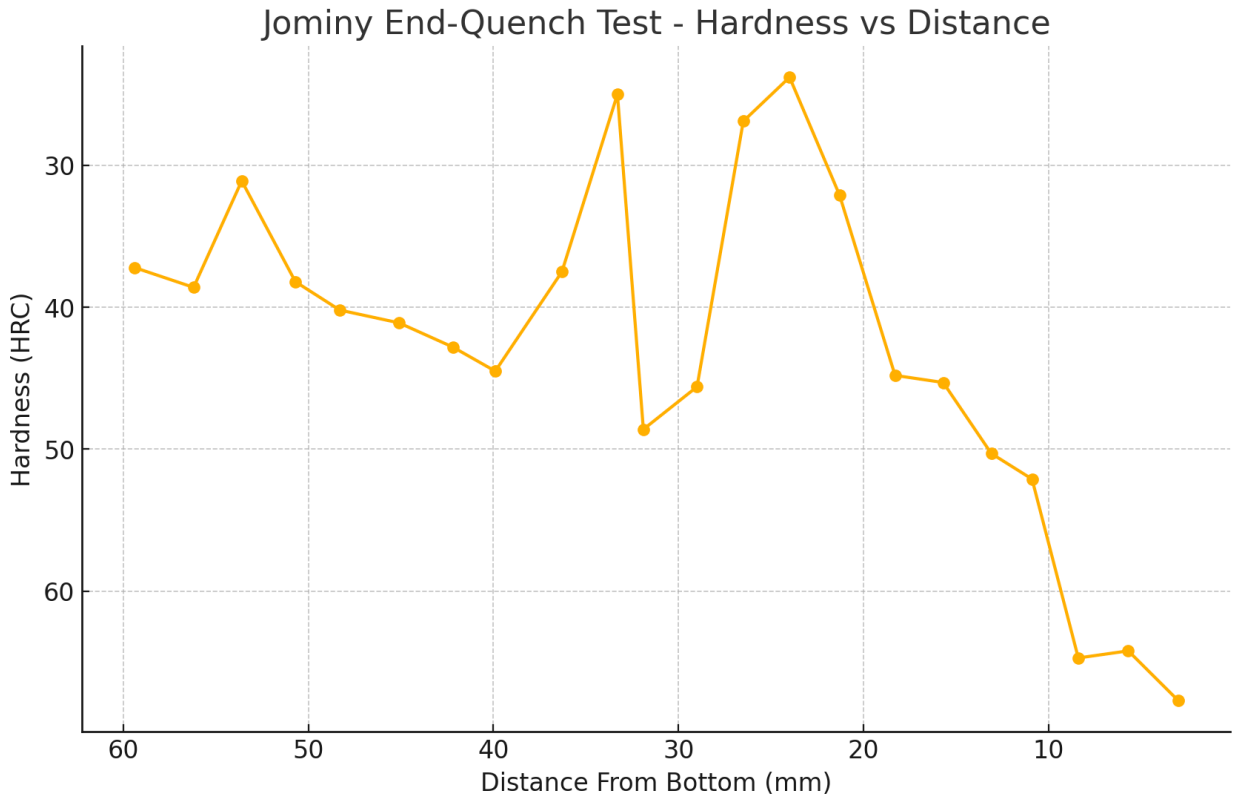
Based on obtained curves, cylindrical bars (2-in diameter, 4-in length) quenched in mildly agitated water would have significantly hardened surface layers with rapidly decreasing hardness towards the center, especially noticeable in the 1040 steel. In contrast, 4140 steel would display a relatively uniform hardness distribution towards the center, beneficial for applications requiring deeper uniform strength.

Conclusion: Alloying significantly improves steel's hardenability, with 4140 steel demonstrating superior depth and uniformity in martensite formation compared to the 1040 steel. This knowledge is critical for selecting appropriate steel alloys and heat-treatment processes in engineering applications.

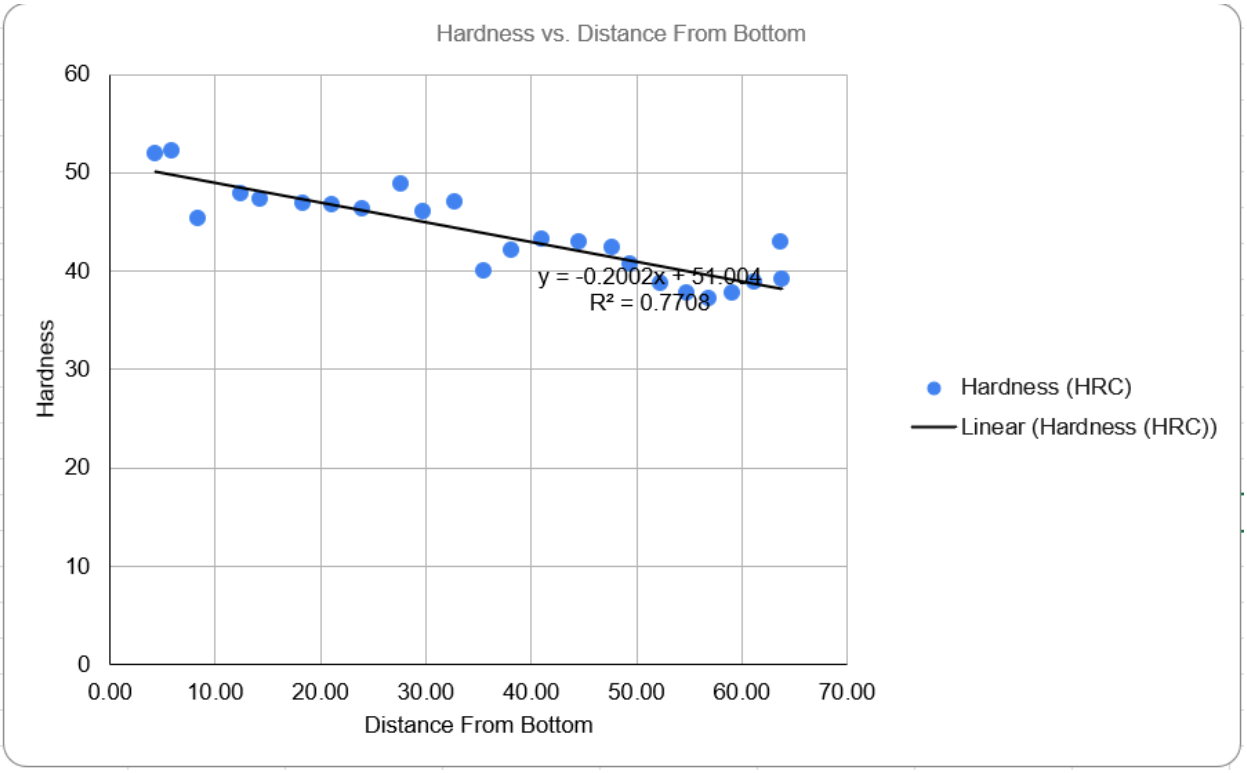
Team ADJ 1040 Steel:



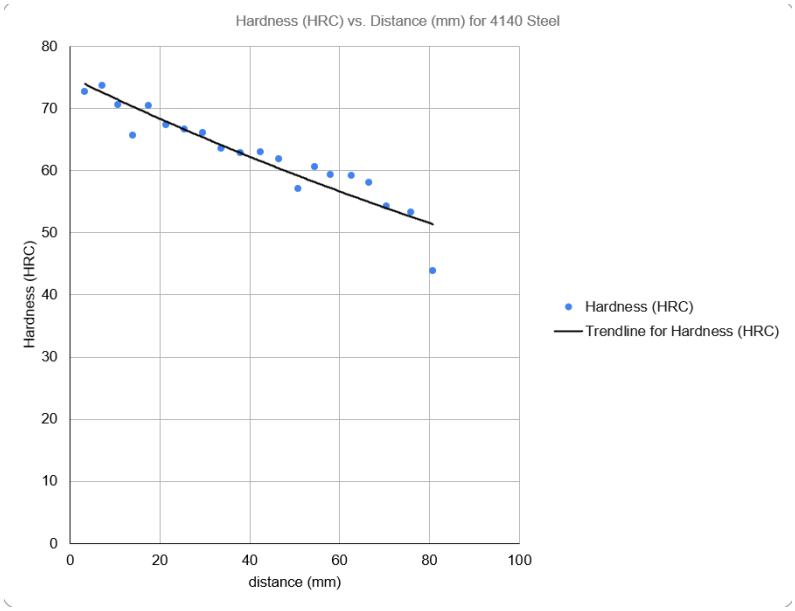
Team JAM 1040 Steel:



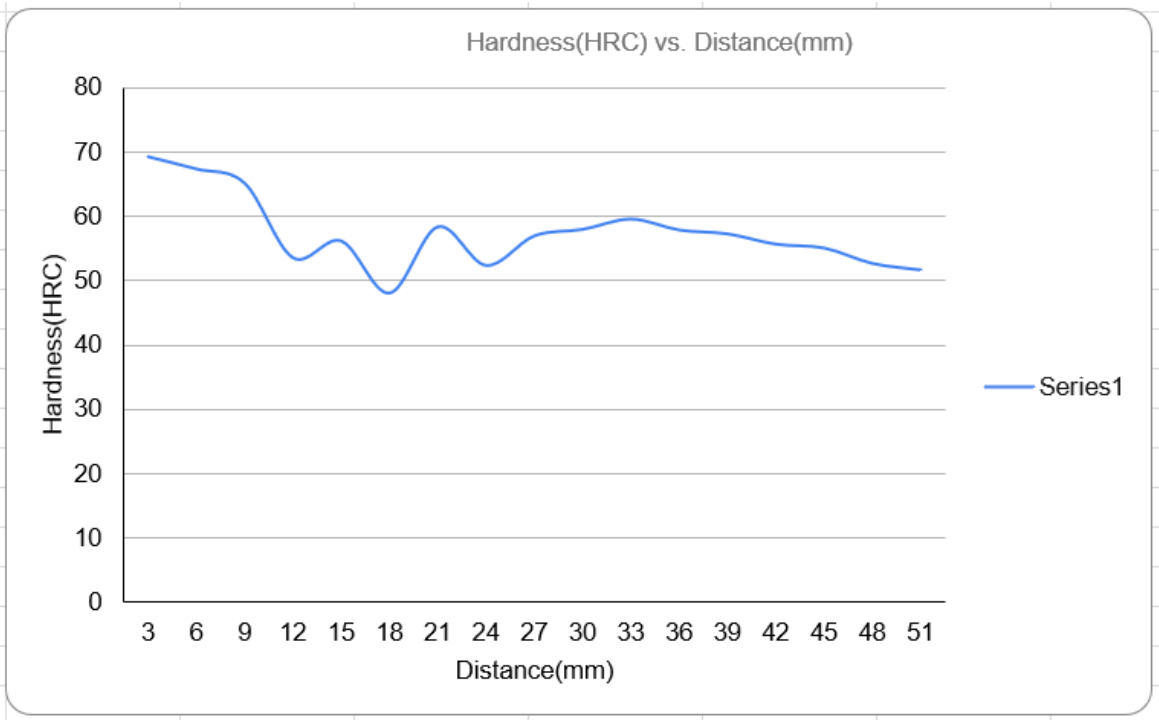
Team LRS 1040 Steel:



Team GGOY 4140 Steel



Team BTZD 4140 Steel


Hardness(HRC) vs. Distance(mm)
Hardness(HRC)
80
70
60
50
40
30
20
10
0
3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51
Distance(mm)
Series1

Team AMR 4140 Steel: