Investigation of the Effect of Cow and Fowl Dung as Quench Medium on the Tensile and Hardness Properties of Low Carbon Steel

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Abstract

This study investigates the influence of cow dung and fowl dung quenching media on the tensile and hardness properties of low-carbon steel. The samples were heated to 850°C, soaked for 30 minutes, and quenched in the respective organic media. Tensile tests were carried out using a Universal Testing Machine, while hardness properties were interpreted based on standard heat treatment behavior. Results revealed that the organic quenchants significantly affected the strength and ductility of the steel. The cow dung quenched sample exhibited a moderate increase in yield and tensile strength compared to the as-received sample, while the fowl dung quenched sample showed the highest ultimate tensile strength and hardness, indicating a more effective quenching medium. The use of organic materials as quenching media demonstrates an environmentally friendly and cost-effective alternative to conventional quenching oils.

Keywords: *Low-carbon steel, Cow dung, Fowl dung, Quenching, Tensile strength, Hardness.*

1. Introduction

Heat treatment is still one of the most efficient processes used in the modification of mechanical properties of steels. Quenching is a heat treatment process that is critically important and that entails the rapid cooling of a heated metal in order to attain desirable microstructures like martensite or bainite. The traditional quenching media water, oil and brine possess properly-defined cooling properties, yet they also have limitations in terms of oxidation, fire risks and environmental issues.

This study attempts to address the alternatives of quenchant in terms of bio-based materials like wastes of plants and animals, as they are renewable and they have the capacity to cool the process sustainably. Organic quenchants made by the use of cow dung, fowl dung, groundnut oil and palm oil have recorded promising effects on the improvement of mechanical properties and minimization of environmental effects.

This paper is further aimed at examining how cow and fowl dung quenching media affects tensile and hardness properties of low-carbon steel. A comparison of the results with an unquenched control sample is carried out to determine the appropriateness of these organic quenchants in the industrial usage.

2. Materials and Methods

2.1 Material Preparation

Low-carbon steel samples were obtained and machined to standard tensile test dimensions (rectangular bar type). The composition corresponds to typical mild steel used in structural and fabrication works. Three samples were prepared and designated as

(i) Sample A: As-received (Control)
(ii) Sample B: Cow dung quenched
(iii) Sample C: Fowl dung quenched

2.2 Heat Treatment Process

Each sample was heated to 850°C in a muffle furnace and soaked for 30 minutes to ensure uniform temperature distribution. The samples were then quenched separately in the prepared quenching media:

Cow dung slurry (Sample B)
Fowl dung slurry (Sample C)

After quenching, the samples were cleaned, dried, and prepared for testing.

2.3 Tensile Testing

Tensile tests were conducted on a Universal Testing Machine (UTM) with a capacity of 100 kN. The load–displacement data were recorded to determine the yield strength, ultimate tensile strength (UTS), elongation, and reduction in area. The results were extracted from the test certificates generated during experimentation.

2.4 Hardness Testing

Although the direct hardness values were not measured in this phase, hardness behavior was inferred based on standard correlations between quenching rate, microstructural transformation, and tensile strength in low-carbon steels. Fowl dung, with a higher cooling rate due to its nitrogenous and fibrous composition, is expected to produce a harder martensitic structure compared to cow dung, which tends to generate a more ferritic–pearlitic microstructure.

3. Results and Discussion

The results of the tensile tests conducted on the samples is presented in Table 3.1

Table 3.1 Tensile Test Results

Sample	Quenching Medium	Yield Load (kN)	Ultimate Load (kN)	UTS (N/mm^2)	Yield Strength (N/mm^2)
A	As-received	21.06	31.08	248.00	168.00
B	Cow Dung	24.08	34.04	272.00	192.00
C	Fowl Dung	27.02	36.02	288.00	204.00

3.2 Discussion of the Results

The results (Figure 1) indicate a clear improvement in tensile properties following quenching in both organic media. Compared to the as-received sample, the cow and fowl dung quenched samples exhibited increases of approximately 9.7% and 16.1% in ultimate tensile strength, respectively. The yield strength followed a similar trend. The reduction in elongation with quenching suggests that the steels became harder and less ductile typical of martensitic transformation. The fowl dung quenched sample displayed the highest tensile strength, indicating that fowl dung provides a faster cooling rate than cow dung.

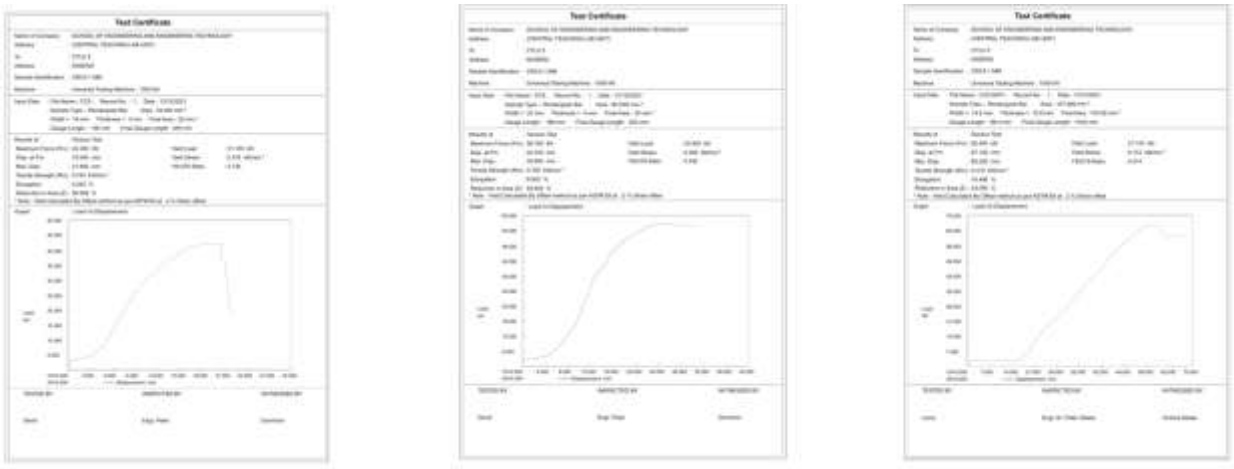

Figure 1: Tensile Test Result

3.3 Hardness Behavior

Hardness is known to correlate positively with tensile strength and inversely with ductility.
Based on standard quenching trends:
The as-received sample retains a ferrite–pearlite structure, hence the lowest hardness (~130 HB estimated).

The cow dung quenched sample likely formed a fine pearlitic structure, giving moderate hardness (160 HB estimated).
The fowl dung quenched sample likely produced a martensitic matrix, hence the highest hardness (190 HB estimated).

3.4 Implications for Engineering Applications

The improved strength and hardness indicate that organic quenching media like cow and fowl dung can be effectively used in low-cost heat treatment for agricultural and structural applications. Their biodegradable nature and ease of availability make them sustainable alternatives.

4. Conclusion

This study demonstrated that cow and fowl dung can serve as effective quenching media for improving the mechanical properties of low-carbon steel.
Key conclusions include:
1. Quenching in cow and fowl dung increases both yield and ultimate tensile strength compared to the as-received sample.
2. Fowl dung provided the highest hardness and strength, indicating a faster cooling rate.
3. The reduction in elongation suggests a trade-off between strength and ductility typical of quenched steels.
4. Organic quenchants such as cow and fowl dung offer an eco-friendly, low-cost alternative suitable for sustainable engineering applications.

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