

Evaluation of Mechanical Properties of Aluminum alloy Quenched in Natural Biological Fluid

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Abstract : The atharvaveda says the cow's body represents various devas and other divine beings the Mahabharata, Harivamsapurana, Manusmriti and other literature eulogies the cow. Cow dung is one of the main fuel in rural India and also served as a fertilizer. Cow dung and cow urine are also thought to be an disinfectant among ancient Indians, and used to clean up home. This paper attempts to investigate the influence of biological quenching media on aluminum alloy its properties(Tensile strength, Yield stress, Hardness) and microstructure. The test samples temperature was 450⁰C, 500⁰C, 550⁰C quenched in two different quenching media (water & cow urine). It has been concluded that the cow urine mixed with base quenching media has an overall improvement in the micro structure and mechanical properties of Aluminum alloy material.

Keywords : Aluminum alloy , Hardness, Tensile strength, Yield stress, quenching media.

1. Introduction

Normally different additives are added separately in the quenching media to improve the mechanical properties. The biological estimation of cow urine has shown that it contains sodium, nitrogen, sulphur, minerals, manganese, iron, silicon and vitamin A, B, C, D, E etc., these elements are homogeneously present in cow urine and will remarkably alter the microstructure in the areas namely, grain refinement, interlocking of grain boundaries and improved mechanical properties UTS (Ultimate tensile strength), yield strength (YS) and hardness of Aluminum alloy. In fact the sodium present in the cow urine results in grain refinement and silicon with other elements helps in interlocking the grain boundaries. An attempt is made in this paper to experimentally verify above statements.

2. Literature Review

Shivaprakash et al [1], did extensive work on the comparative study on mechanical properties of AISI 4340 High-Strength steel alloy under time-quenched and austempered conditions. The hardness, micro structure and impact test were conducted and experimental results were compared with timed quenched specimens. It was found that the grain size of the austempered specimen was higher than the time quenched specimen.

M. Dauda et al [2], worked on effect of various quenching media on mechanical properties of annealed steel. They have used palm kernel oil, cotton seed oil and olive oil as quenching media. They compared the effectiveness of the oils. The samples were quenched to room temperature in the quenching media. They concluded that the hardness of steel when quenched in water was higher than the hardness when

quenched in kernel oil. They also concluded that olive oil can be used where the cooling severity is less than that of water.

Joseph et al [3], used clay/water media as quenchant for Hardening and Characterisation of 0.45%C steel. Different weight percentages of clay were added to water to form clay/water quenching media. The steel specimens were heated to austenizing temperature and quenched in above media. The mechanical properties of steel were investigated. They concluded that the addition of 2 to 4% of clay water gave the best mechanical properties.

M. Maruthirao [4], made Experimental Studies on effect of Biological quenching media on micro structural and mechanical properties of Al alloy materials used for manufacturing IC engine piston heads. The author tried with cow urine along with base quenching media of water and sheep urine along with base quenching media water separately and found that the mechanical and micro structural properties al Al piston head materials improved. The author concluded that there is marginal improvement in the micro structure and mechanical properties of Al piston head material.

Dr. B.N. Sarada et al [5], studied the effect of quenching media on the mechanical properties of Al 6061-TiO₂ metal matrix composites. They subjected specimens to heat treatment at temperature 530⁰C for 1.5 hours followed by quenching in different media like air, water, aqueous polymer solutions. The hardness, tensile strength values were evaluated. They concluded that the quenching has significant effect on the hardness and tensile strength values exhibiting significant improvement as compared to cast composites.

Wijanarko et al [6], made experimental study on the influence of quenching temperature variation on retained austenite fraction in AISI 4140 steel. According to them quenching has three major steps namely austenizing, premier and partitioning . They arrived at an optimum quenching and partitioning temperature and partitioning time so that maximum fraction of austenite is retained.

Ali rafaAltaweel et al [7], did extensive work on Effect of quenching media, specimen size and shape on the harden ability of AISI4140 Steel. The purpose of their study was to investigate the influence of different quenching media on the hardened depth of AISI steel they demonstrated as to how these parameters can effect the hardness from the surface to the core of samples they concluded that the hardness of the quenched samples at certain depths can be estimated on the basis of heat transfer equations.

S.A. Takur et al [8], worked on effect of tempering temperature of mechanical properties of Medium Carbon Steel. Most of the applications require that the quenched part be tempered so as to impact same toughness and further improve ductility. Their work reports and analysis results of mechanical testing on various heat treated medium carbon steel and to arrive at an optimum heat treatment strategy. They concluded that the optimum heat treatment strategy was found to be at a tempering temperature of 250⁰C for well balanced mechanical properties.

Saigeeta et al [9], did extensive work on effect of quenching medium on hardness of three grades of steel – AISI 1040, 1050 and 4340. They concluded that hardness of medium carbon steel can be improved by quenching through different quenching mediums. Their investigations emphasized on improving the hardness property of three different types of steel as mentioned above.

Soundhar. J et al [10], did extensive work on evaluation of surface hardness behavior of heat treated 35Mn6Mo3 and C35MN75 Steel. They examined samples of medium carbon steel after heating them between 900⁰C to 980⁰C in a vertical force air circulating furnace and the tempering temperature was 250⁰C. They concluded that the hardness values of quenched samples were relatively higher than those of the as cast samples.

3. Issues and Challenges Related to Present work

- Extensive literature review is to be made to ascertain the “as on today technology” on quenching methods.
- A scientific method is to be developed for studying the metallurgical micro structure of the fractured specimens.
- Standard test specimens for estimating various strength properties are to be designed and machined.
- Suitable strength measuring equipments are to be selected.

- What is being done in the current work is a simulation work. The results are to be transferred for real time piston head Al alloy.

4. Formulation of Problem

Since piston heads form the critical components of IC engines and are subjected to extreme stress conditions, any research on improved micro structure goes a long way in the life of piston heads. The methods of casting, heat treatment and quenching play a major role in deciding the strength of the Al alloys used for manufacture of piston heads. Hence the current problem consists of using different percentages of cow urine in base quenching media and conduct quenching. The micro structure and mechanical properties are investigated.

5. Experimental work

Table 1: Chemical Composition of Al 2585 (wt%)

| %Cu | %Mg | %Si | %Fe | %Mn | %Ni | %Zn | %Pb | %Sn | %Al |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------|
| 10 | 0.3 | 2 | 0.7 | 0.5 | 0.5 | 0.1 | .01 | .01 | Remaining |

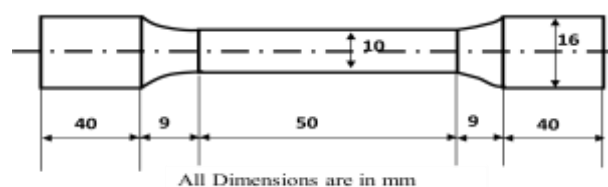


Figure 1. Tensile test specimen from Al2585

Material chosen for present work is cast Al alloy with IS designation 2585 (Al 2585) with specimen having dimensions of as below. The experimental work consists of adding different percentages of cow urine along with base quenching media namely water. The percent of cow urine consists of 0%, 10%, 20%, 30%-----100%. The quenching temperatures considered were 450°C, 500°C & 550°C and quenching time was 60 minutes. Al material test specimen were prepared and quenched as per the above plan. The UTS, YS and hardness values are noted down and presented in table 2,3,4 and the same was graphically presented in figures 2,3,4. The specimen micro structures of different percentage quenching media is shown through figures 8 to 18.

Table 2: Ultimate tensile strength (UTS in N/mm²), Yield stress (YS in N/mm²) and Hardness number at 450°C temperature in Cow urine & water as quenching medium.

| S.No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|-------------|-----|----|----|----|----|----|----|----|----|----|-----|
| % water | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | -- |
| % Cow urine | 00 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| UTS | 69 | 70 | 75 | 76 | 77 | 78 | 74 | 72 | 69 | 67 | 65 |
| YS | 46 | 48 | 53 | 58 | 60 | 61 | 59 | 57 | 55 | 53 | 51 |
| Hardness | 34 | 35 | 38 | 40 | 42 | 43 | 45 | 43 | 41 | 38 | 34 |

Table 3: Ultimate tensile strength(UTS in N/mm²),Yield stress(YS N/mm²) and Hardness number at 500°C temp; cow urine & water as quenching medium.

| S.No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|-------------|-----|----|----|----|----|----|----|----|----|----|-----|
| % water | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | -- |
| % Cow urine | 00 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| UTS | 71 | 72 | 77 | 78 | 79 | 80 | 76 | 74 | 71 | 68 | 65 |
| YS | 48 | 50 | 55 | 60 | 62 | 63 | 60 | 58 | 56 | 54 | 52 |
| Hardness | 26 | 28 | 31 | 35 | 32 | 38 | 40 | 38 | 36 | 34 | 32 |

Table 4: Ultimate tensile strength(UTS in N/mm²),Yield stress(YS N/mm²) and Hardness number at 550°C temp; cow urine & water as quenching medium.

| S.No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|-------------|-----|----|----|----|----|----|----|----|----|----|-----|
| % water | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 20 | 10 | -- |
| % Cow urine | 00 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| UTS | 73 | 74 | 79 | 80 | 81 | 82 | 65 | 78 | 73 | 70 | 67 |
| YS | 50 | 52 | 57 | 62 | 63 | 64 | 63 | 61 | 59 | 57 | 55 |
| Hardness | 28 | 30 | 33 | 37 | 39 | 41 | 43 | 41 | 39 | 37 | 35 |

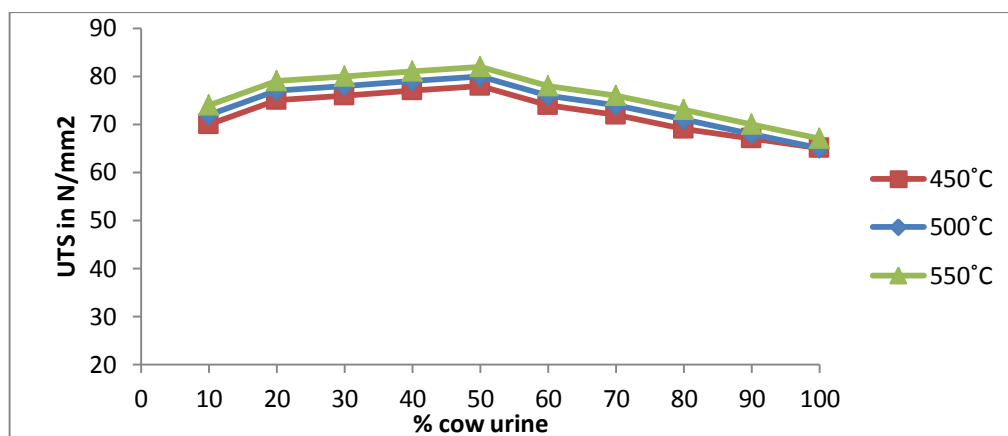
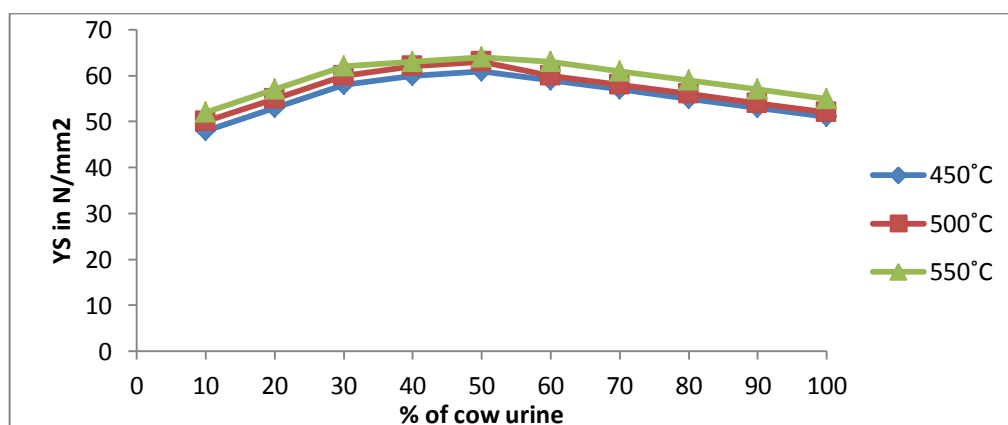
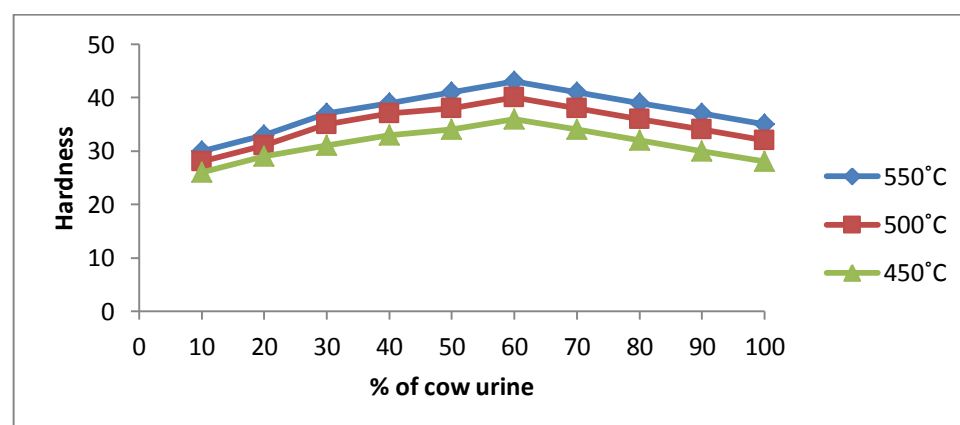
**Figure 2. Strength values and % cow urine****Figure3. Yield strength and % cow urine****Figure4. Hardness and % cow urine**



Figure 5. The photos show fracture shape experienced Specimens.



Figure 6. 100% water + 0% cow urine



Figure 7. 90% water + 10% cow urine



Figure 8. 80% water + 20 % cow urine



Figure 9. 70% water + 30% cow urine



Figure 10. 60% water + 40% cow urine



Figure 11. 50% water + 50% cow urine



Figure 12. 40% water + 60% cow urine

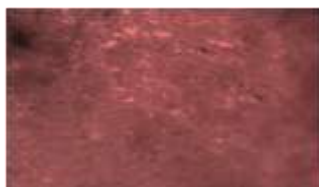


Figure 13. 30% water + 70% cow urine



Figure 14. 20% water + 80% cow urine



Figure 15. 10% water + 90% cow urine



Figure 16. 100% cow urine

6. Results and Discussion

- It has been found that with pure water, the Ultimate Tensile strength increases along with temperature of quenching thereby at minimum temperature of 450⁰C the UTS was 69 N/mm² and at 550⁰C it was 73 N/mm². A similar behaviour was observed for Yield stress.
- From the experimental results it is observed that, there is gradual increase in strength values from 70 N/mm² to 72 N/mm² for 10% cow urine. This increase is up to 50% and there after the strength values appear to decrease. This may be because, as the % of cow urine increases beyond a certain value, the sodium present in the cow urine which has a property of refining a grain boundary may show a negative effect and hence a reduction in strength values is observed.
- For 450⁰C and 500⁰C the increase in strength starts with 50% cow urine, whereas at 550⁰C the reduction starts at 60% of cow urine. This may be because the negative effect of sodium is delayed as the temperature is increased.
- From the experiments it is found that regarding hardness, which is reported in BHN, pure water exhibits the lowest hardness value number namely 24, for 450⁰C, 26 for 500⁰C and 28 for 550⁰C.
- From the experiments it is observed that as the % of cow urine increases, there is a gradual increase in hardness and some where near 60 to 70% cow urine the hardness values appear to slightly reduce. However the reduction is only very marginal.
- The above experimental work is expected to generate huge data base and suitable computer program can be written to arrive at the optimum strength values and corresponding % cow urine, time of curing etc.
- It is also proposed to study the metallurgical microstructure with special reference to refinement of grain boundaries and interlocking grain boundaries. A few metallurgical microstructure photos are presented.(Fig: 6 to 16)

7. Conclusion

It is observed that in pure water grain refinement is not satisfactory. In case of 10% cow urine, grain refinement as seen from microstructure revealed that it is slightly improved compared to water. In case of 50% of cow urine, grain refinement slightly decreases (450 to 500⁰C), and at 550⁰C, grain refinement still continues and this fact is confirmed through the strength values. From 60% to 100 % the grain refinement is poorer due to sodium present in cow urine has negative effect on interlocking the grain boundaries.

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