International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 1, Issue 9, ISSN No. 2455-2143, Pages 107-111
Published Online July – August 2016 in IJEAST (http://www.ijeast.com)

EXPERIMENTATION ON STRUCTURAL AND MECHANICAL PROPERTIES CHANGE OF Al-ALLOYS USING BIOLOGICAL QUENCHING MEDIUM

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Abstract—**Huge data base is available on the failure criteria of I C engine piston heads. The analysis focused on the strength criteria of failure. However, in some cases the failure of piston heads occurred within the safe stress levels. Discrete references were available in the literature on such failure cases. The irregularities in micro structure of the piston head material may be one of the reasons for such failure. However an in depth study is required to analyse the micro structure, densification during cooling, quenching methods etc. To address the above issue an attempt is made in this paper to study the strength properties, micro structure etc in relation to the quenching methods and parameters used while manufacturing the piston heads. The current work is a simulation of the piston head material and varying the quenching parameters used for manufacture of the piston heads. The composition of the quenching media with additives needs an in depth study. An attempt is also made in this paper to add different percentages of sheep urine in the base quenching media and to study its effect on the micro structural and mechanical properties of the cast Al Alloy materials used for piston heads. Sheep urine is supposed to contain rich percentages of sodium, nitrogen, sulphur, manganese, silicon etc, homogeneously present and the elements have a remarkable effect on the micro structure in the areas of grain refinement and interlocking of grain boundaries and consequent improvement in mechanical properties. It has been concluded that the sheep urine mixed with base quenching media has an overall marginal improvement in the micro structure and mechanical properties of Al alloy materials used in the manufacturing of piston heads.**

Keywords— **Piston heads, Mechanical properties, Micro structure, Grain Refinement, Failure analysis.**

I. INTRODUCTION

Normally different additives are added separately in the quenching media to improve the mechanical properties. However the sheep urine which contains many elements mixed homogeneously when mixed with base quenching media improves the micro structure and mechanical properties marginally. In fact the sodium present in the sheep urine results in grain refinement and silicon with other elements helps in interlocking the grain boundaries. The above enhances the mechanical properties.

II. LITERATURE REVIEW

Ali rafaAltaweel etal [1], did extensive work on Effect of quenching media, specimen size and shape on the hardenability 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 etal [2], 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 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 250^0C for well balanced mechanical properties.

T. Akor etal [3], did extensive work on Investigation of the potential of jatropha seed oil as Austempering quenchant for Medium Carbon Steel. They investigated the suitability of jatropha seed oil as quenching medium for austempering

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medium carbon steel the samples were austenited at 950^0C and socked for 1,2,3,4,5 hours. They concluded that a significant increase in tensile strength and impact energy can be achieved by using jatropha seed for quenching medium.

M. Maruthi rao [4], made Experimental Studies on effect of Biological quenching media on micro structural and mechanical properties of Al alloy materials sued 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.

Adebiyi, K.A etal [5], worked on effect of brine solution on grain size formations in AISI1080 low carbon steel. They investigated on the influence of carbon steel samples quenched in brine solution of concentrations 3.5, 5.5 & 8.0 mol/dm^3 under conditions of constant bath temperature the grain sizes in micro structure were analysed using fractal samples. They concluded that an increase in brine concentration above 5.5 reduces the fractal dimensions of the steel from attaining the perfect shape and size.

Soundhar. J etal [6], did extensive work on evaluation of surface hardness behaviour of heat treated 35Mn6Mo3 and C35MN75 Steel. They examined samples of medium carbon steel after heating them between 900^0C to 980^0C in a vertical force air circulating furnace and the tempering temperature was 250^0C. They concluded that the hardness values of quenched samples were relatively higher than those of the as cast samples.

Saigeeta etal[7], 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.

Shivaprakash etal [8], did extensive work on the comparative study on mechanical properties of AISI 4340 High-Strength steel alloy steel 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 etal [9], 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. The compare 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 etal [10], used clay/water media as quenchant for Hardening and Characterisation of 0.45%C steel. Different weight percentage of clay were added to water to form clay/water quenching media. The steel specimen were heated to austenizing temperature and quenched in the 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.

III. Issues and Challenges Related to Present Work

1. Extensive literature reviewed is to be made to ascertain the as on today technology on quenching methods.
2. A scientific method is to be developed for studying the metallurgical micro structure of the fractured specimens.
3. Standard test specimens for estimating various strength properties are to be designed and machines.
4. Suitable strength measuring equipments are to be selected.
5. What is being done in the current work is a simulation work. The results are to be transformed for real time piston head Al alloys.

IV. Scope and Objectives of Present Work

The scope of present work is to study the effect of carrying quenching parameters with special reference to adding different percentages of sheep urine in the base quenching media, on the micro structure and mechanical properties of Al alloy with an objective of obtaining improved mechanical properties of Al alloy used for manufacture of piston heads.

V. Formulation of Problem

Since piston heads form the critical components of IC engine and are subjected to extreme stress conditions, any research through 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 sheep urine in base quenching media and conduct quenching. The micro structure and mechanical properties are investigated.

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VI. EXPERIMENTAL WORK

Material chosen for present work is cast Al alloy with IS designation 2585 (Al 2585) with specimen having dimensions of 150mm length and 10mm diameter. The experimental work consists of adding different percentages of sheep urine along with base quenching media namely water the percent of sheep urine consists of 0%, 10%, 20%, 30%----------100% sheep urine. The quenching temperatures considered were 350^0C, 400^0C & 450^0C and quenching time was 90 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 1,2,3 and the same was graphically presented in figures 1,2. The specimen micro structures of the different percentage quenching media is **shown through figures 3 to 12.**

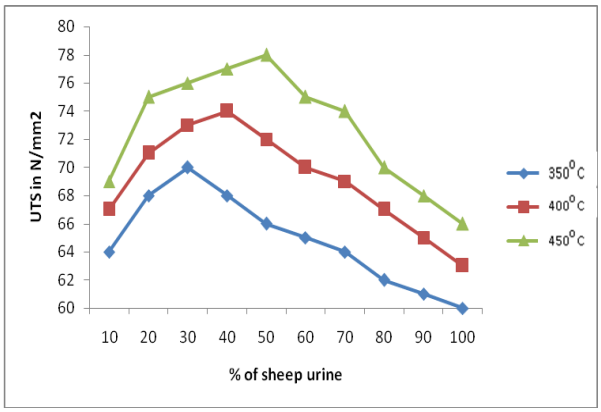

Fig.1. (% of Sheep urine Vs UTS of Al 2585)

Table-1 Ultimate tensile strength (UTS in N/mm^2), Yield stress (YS in N/mm^2) and Hardness number at 450^0C temperature in sheep urine & water is 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	--	
%sheep Urine	00	10	20	30	40	50	60	70	80	90	100	
U.T.S	69	69	75	76	77	78	75	74	70	68	66	
Y.S	46	46	53	57	59	60	58	57	55	51	49	
Hardness	34	26	29	31	33	35	36	34	32	30	28	

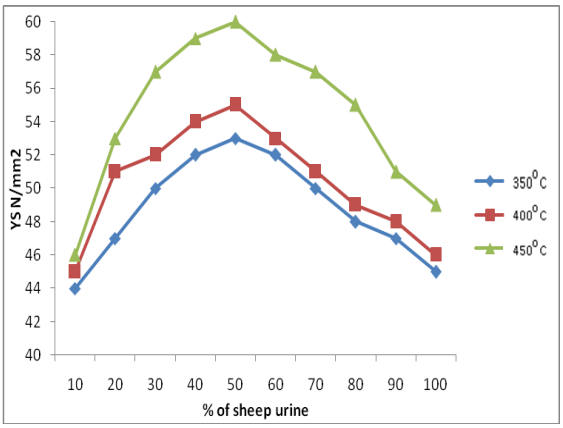

Fig.2. (% of Sheep urine Vs YS of Al 2585)

Table-2 Ultimate tensile strength (UTS in N/mm^2), Yield stress (YS in N/mm^2) and Hardness number at 400^0C temperature in sheep urine & water is 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	--
% Sheep urine	00	10	20	30	40	50	60	70	80	90	100
U.T.S	67	67	71	73	74	72	70	69	67	65	63
Y.S	45	45	51	52	54	55	53	51	49	48	46
Hardness	30	23	25	27	29	31	32	30	28	26	25

Table-3 Ultimate tensile strength (UTS in N/mm^2), Yield stress (YS in N/mm^2) and Hardness number at 350^0C temperature in sheep urine & water is 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	--
% Sheep urine	00	10	20	30	40	50	60	70	80	90	100
U.T.S	64	64	68	70	68	66	65	64	62	61	60
Y.S	44	44	47	50	52	53	52	50	48	47	45
Hardness	28	21	23	25	26	28	30	29	27	24	22

Microstructure of material having 450^0C after quenching in the difference **water** and **sheep urine** composition.

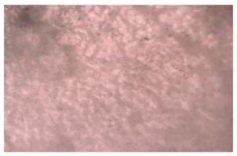

Fig.3. 90 % water+10 %sheep urine

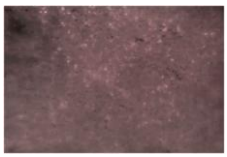

Fig.4. 80% water +20% sheep urine

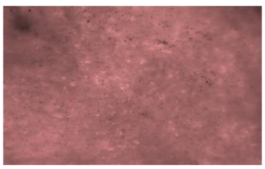

Fig. 5. 70 % water + 30 %sheep urine

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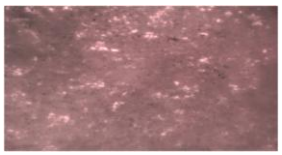
Fig.6. 60%water +40% sheep urine

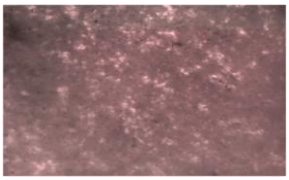
Fig.7. 50%water +50% sheep urine

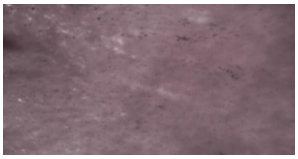
Fig.8. 40%water + 60%sheep urine

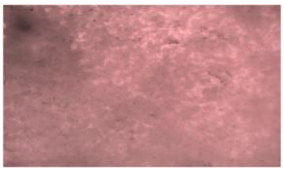
Fig.9. 30%water + 70% sheep urine


Fig.10. 20%water + 80% sheep urine


Fig. 11. 10% water + 90% sheep urine

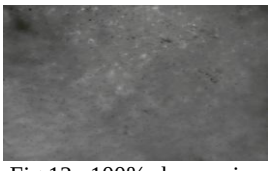
Fig.12. 100% sheep urine

VII. RESULTS AND DISCUSSIONS

- It has been found that with pure water, the Ultimate Tensile strength increases along with temperature of quenching of quenching media thereby at minimum temperature of 350^0C the UTS was 64 N/mm^2 and at 450^0C it was 69 N/mm^2. Similarly a similar behaviour was observed for Yield stress.
- From the experimental results it is observed that, there is gradual increase in strength values from 64 N/mm^2 to 69 N/mm^2 for 10% sheep urine. This increase is up to 50% and there after the strength values appear to decrease. This may be because, as the % of sheep urine increases beyond a certain value, the sodium present in the sheep urine which has a property of refining a grain boundary may show a negative effect and hence a reduction in strength values is observed.
- From the experiments results it is found that regarding hardness, which is reported in BHN, pure water exhibits the lowest hardness value number namely 28, for 350^0C, 30 for 400^0C and 34 for 450^0C.
- From the experiments it is observed that as the % of sheep urine increases, there is a gradual increase in hardness and some where near 60 to 70% sheep 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 programme can be written to arrive at the optimum strength values and corresponding % sheep 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 3 to 12)

VIII. CONCLUSION

- 10% of sheep urine, the grain refinement as seen from microstructure revealed that the grain refinement is slightly improved compared with pure water and strength values also.
- It was observed that, 20% sheep urine the grain refinement and improved the microstructure compared with 10% of sheep urine.
- It continues up to 40% of sheep urine.
- From 50% sheep urine grain refinement slight decrease. However at 450^0C there is slight improvement grain refinement and strength values also.
- From 60% sheep urine grain refinement is getting poorer and even in the case of 450^0C the grain refinement is decreased and this fact is seen from strength values.
- 70% sheep urine the behaviour of microstructure and strength values show the same pattern namely decrease in grain refinement and decrease grain boundary interlocking and decrease in strength

values. Sodium present in sheep urine it shows the negative effect on grain refinement, this continues up to 100% sheep urine.

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