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Experimental Research on Micro Structure And Mechanical Properties of Al Alloy Utilizing Sustainable Biomass As Quenching Medium

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Abstract— Quenching media, time, temperature are prime factors towards the enhancement of grain refinement structure and mechanical properties in metals. The present study reports the usage of novel quenching media that is cow urine to improve the mechanical properties that is tensile strength, yield strength and hardness of Al 2585 alloy. The ingredients such as (sodium, nitrogen, sulphur, Vitamin A, B, C, D, E, minerals, manganese, iron, silicon, chlorine, magnesium etc.,) present in cow urine are homogenously which help to improve micro structure and mechanical properties of Al alloy 2585. From the study, it is revealed that maximum tensile strength and yield strength is improved and grain refinement is exhibited at 50% blend. Likewise maximum hardness at 80% blends.

Keyboards— Al alloy, Cow urine, Mechanical properties, Micro structure, Water.

I. INTRODUCTION

The present scenario engineering materials are required to be light weight and corrosion resistant, coupled with high strength and hardness. Since no material in nature having all these properties, alloys and composites have been developed [1]. The existence of magnesium [2] better strain, harden ability and raises the material strength by solid solution. Aluminum-Magnesium alloys have outstanding resistance to corrosion in seawater. Heat treatment [3] at different temperature quenched in various media at 530^{0}C good mechanical properties finally chooses the cooling medium for effective mechanical properties. Properties [4] of 7075-T6 aluminum alloy improved toughness by (30%) when quenching in water and studied compression resistance, micro structure and the thermal stability for alloy. Polymer quench ants [5] result certainly ably in the lower of wear rate of the eutectic aluminum and silicon alloy over the standard quenching media. Aluminum alloy review, [6] adding of alloying elements like major and minor improve microstructure and mechanical properties.

Precipitation hardening [7] conducted aluminum alloy6061 samples were heat treated at different temperature quenched in water, cooling air and furnace.It was observed that the fast cooling grain refinement and mechanical properties changed as compared to lose of heat by annealing. Deliberated the impact [8]of petroleum and ecological quench ants on properties of medium carbon steels. The properties of microstructure of Al alloys and steels depend on the heat treatment and quenching process used. Petroleum and vegetable seed oils are commonly used quench ants which are biodegradable. [9], studied the effect of heat treatment process on the hardness and microstructure of medium carbon steels. It has also been reported in the literature that the chemical composition of AISI1050carbon steel with 20mm diameter were heated at 800^{0}c for 10 minutes to eliminate the residual stresses. Hence the present problem is chosen for research work. Lot of extensive work on thermal analysis of [10] piston using FEM. They made thermal analysis of conventional pistons and pistons coated with Zirconium material. Their FEM was based on ANSYS. They investigated the effect of coating on the thermal behavior of pistons. Mesh optimization was used by them for their analysis. The stress concentration effects were also studied by them. Worked on investigating[11] the effectiveness of quenching media to the required hardness and microstructure based on the application. The effectiveness of the quenching media depends on its cooling characteristics and its ability to harden the steel.

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II. EXPERIMENTAL PROCEDURE

The materials and equipments used during the experimental procedure include 2585 Aluminum alloy, lathe machine, electric furnace, UTM, Brinell Hardness tester and Scanned Electron Microscope. Nearly hundred test specimens are ordered from FENFE METALLURGICALS, India. The physical properties and chemical properties are shown in Table 1 and 2 and the machined standard specimen is shown in Figure 6. The experimental procedure involves the following steps.

1. Water is considered (0% Cow urine) and the specimen is heated to a temperature of 200^{0}C quenched in water for 15min.
2. For same 200^{0}C of specimen a quenching media of 10% cow urine and 90% water is used and the specimen is quenched for 15 min.
3. Similarly a quenching media of 20%,30%,40%,50%,60%,70%,80%,90%, and 100% of cow urine together with the different percentage of water are considered and quenched at same temperature namely 200^{0}C.
4. The same procedure as explained in the above step is carried out for a quenching temperature of 250, 300, 350, 400, 450, 500^{0}C.

5. The quenched specimens are cooled to room temperature and machined as per dimensions and finally tested for the mechanical and metallurgical properties as explained below.

Table. 1. Quenching Media Physical Properties

Quenching Media	Temp(°C)	Specific Gravity	Specific Heat Capacity	Density	Viscosity
Water	26	1.002	4.2 J/g° C	1.000 gm/m^3	0.8X10^{-3} Ns/m^2
Cow Urine	26	1.045	3.892 J/g^{-1}C	2.03gm/mol	0.002 Ns/m^2

Table. 2: Chemical Composition Al 2585 %by weight

Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Al
10	0.3	2	0.7	0.5	0.5	0.1	.01	.01	Rest

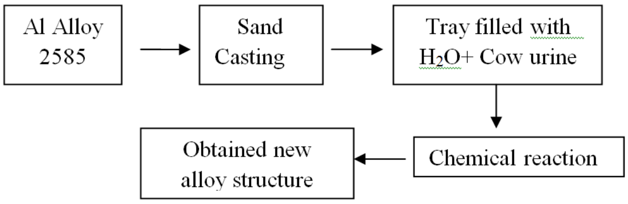

Figure. 1: Flow diagram for quenching operation

2.1 Mechanical Test

(a) Ultimate Tensile Strength and Yield Strength

MODEL: WDW-300 Max load :300KN the dimensions may be set as per ASTM18: 1962. A material response to the tensile load is determined by conducting tensile test on Universal Testing Machine (UTM). The machine is also used for compression and shear tests. To conduct a tensile test, one end of the standard specimen is attached to movable cross-head with other end fixed to a stationary member. The cross head is driven such that it stretch the specimen apart that is the specimen is subjected to tensile load. The specimen is stretched with a gradually increasing load that is applied along the axis of the specimen until it breaks. The loads and corresponding extensions are monitored to assess the tensile properties of the specimen.

(b) Hardness

HBN According to ASTM Specifications, lower load applied for measuring hardness of soft material. In a Brinell Hardness(Table.5) Test a hardened steel ball of diameter 10mm is forced into the surface for 15 -30 seconds with a suitable load(250 Kg) to form indentation. An optical measuring device is used to measure the diameter of resulting indentation.

(c) Microstructure

The changes in microstructure was observed(Figure.12 – Figure.19) by introducing the specimen through a series of processes where in specimens were cut in to small pieces in a bench vice; which are then machined through a grinding process in order to achieve required finish. The specimens were then polished with polishing powder to get mirror finish. After polishing etchant was (Aluminium paste) applied into the specimens. Which is termed as etching after etching, the specimens were ready for study Scanned Electron Microscope (SEI 25KV WD 10mm SS40 x 100 100 µm).

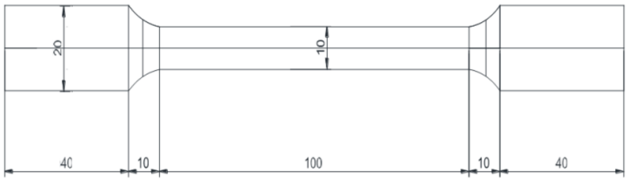

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Figure 2: Standard Test specimen

Figure 3: Cow urine blend with water

Figure 4: Cow urine at early hours

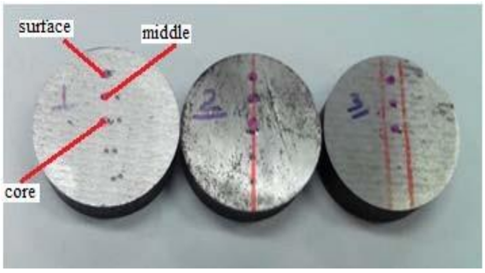

Figure 5: Specimens for Hardness testing

Figure 6: Fractured Specimens

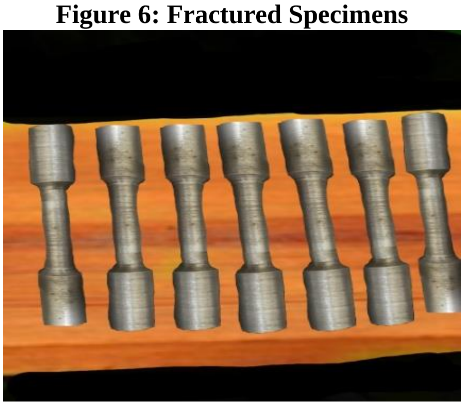

Figure 7: Specimens ready for testing

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Figure 8: Specimen Preparing on lathe

Table.3.Ultimate Tensile Strength in N/mm^2

% of CU	200°C	250°C	300°C	350°C	400°C	450°C	500°C
0	62	63	67	70	74	77	82
10	64	65	69	72	76	79	85
20	68	68	71	75	79	83	88
30	71	72	74	77	82	86	90
40	74	75	77	79	85	90	95
50	78	79	83	85	89	95	102
60	77	78	81	84	88	94	99
70	75	76	79	82	86	93	97
80	72	73	75	80	84	91	96
90	70	72	73	78	82	89	94
100	69	70	71	76	81	87	92

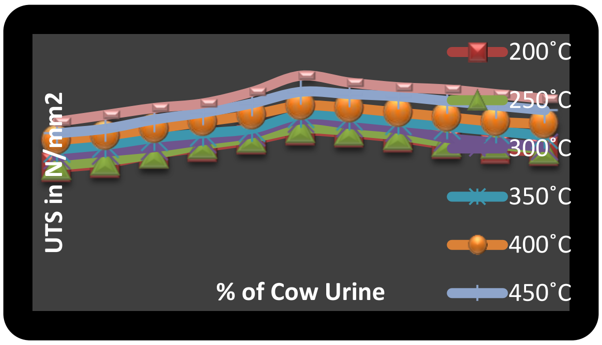

Figure 9: Change in strength property(UTS) at different temperatures and cow urine blend

Table .4. Yield Strength in N/mm^2

% of CU	200°C	250°C	300°C	350°C	400°C	450°C	500°C
0	49	50	52	55	57	60	65
10	50	51	53	57	58	62	69
20	55	56	54	59	60	66	70
30	59	60	62	64	65	68	75
40	62	63	65	67	67	71	77
50	65	66	69	69	70	75	82
60	63	64	68	62	74	74	81
70	59	63	64	61	72	72	79
80	51	58	62	59	70	71	77
90	46	55	60	57	69	70	75
100	44	53	60	56	68	69	74

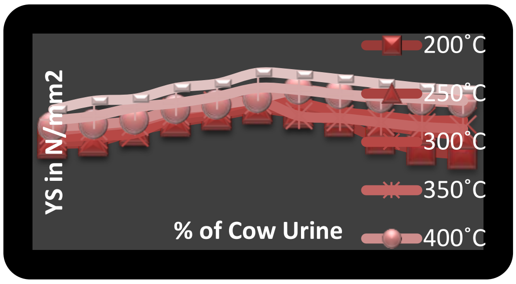

Figure 10: Change in strength property(YS) at different temperature and cow urine blend

Table .5. Hardness

% of CU	200°C	250°C	300°C	350°C	400°C	450°C	500°C
0	10	11	13	16	19	21	22
10	12	13	16	18	20	22	23
20	15	15	18	20	21	25	28
30	16	17	19	21	22	27	29
40	18	19	21	22	23	29	30
50	19	21	22	25	25	28	30
60	19	21	23	25	27	30	32
70	22	23	24	24	26	31	33
80	21	22	24	24	28	29	34
90	18	17	19	21	21	26	30
100	16	14	15	19	18	23	28

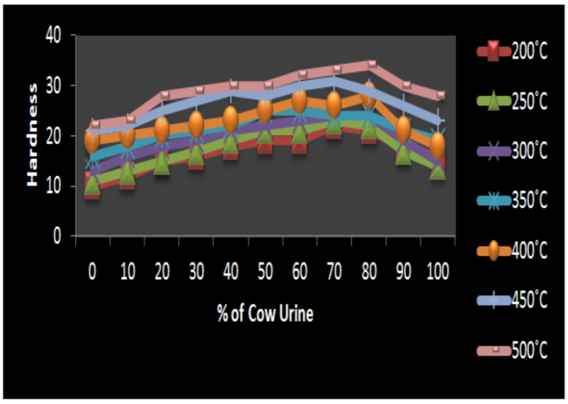

Figure 11: Change in Hardness at different temperatures and cow urine blend

Table .6. Elongation in mm

% of CU	200°C	250°C	300°C	350°C	400°C	450°C	500°C
0	6.5	6.8	7	7.5	7.9	8.1	8.5
10	6.7	7.1	7.5	7.8	8.2	8.3	8.8
20	6.9	7.3	7.9	8.1	8.6	8.7	9
30	7.1	7.7	8.2	8.5	8.8	9	9.4
40	7.3	8	8.4	8.9	9.2	9.4	9.7
50	7.8	8.2	8.6	9.1	9.5	9.7	10
60	7.6	7.9	8.3	9	9.3	9.5	9.8
70	7.5	7.6	8.1	8.8	9.1	9.3	9.6
80	7.3	7.5	8	8.6	8.9	9.1	9.4
90	7.1	7.3	7.9	8.3	8.6	8.9	9.2
100	6.9	7.2	7.7	8.1	8.4	8.5	9.1

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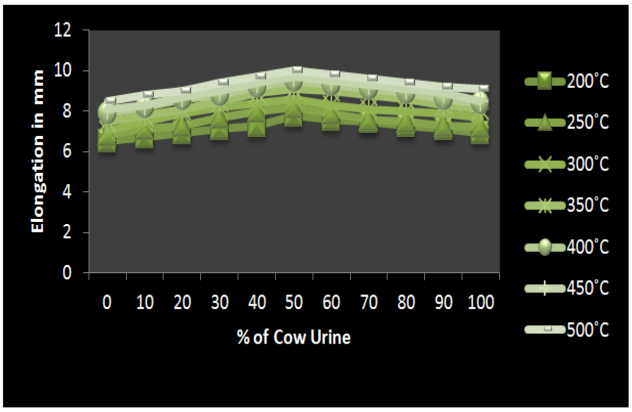

Figure12: Change in Elongation at different temperatures and cow urine blend Microstructures at different temperatures after quenched (SEI 25KV WD10mm SS40 x100 100µm)

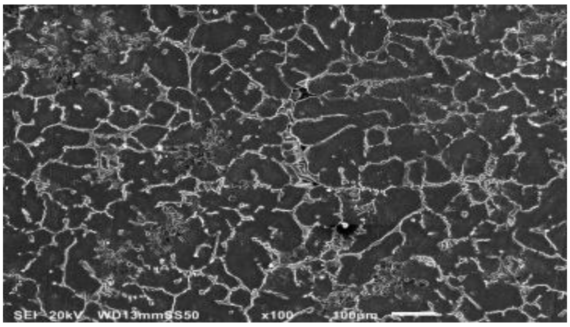

Figure 13:100% CU at 450^{0}C

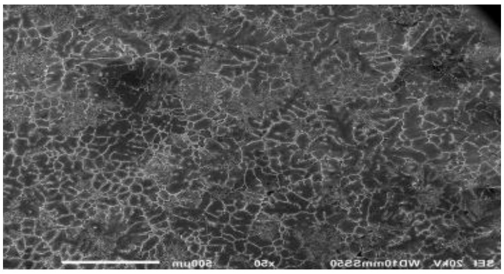

Figure 14: 100% CU at 500^{0}C

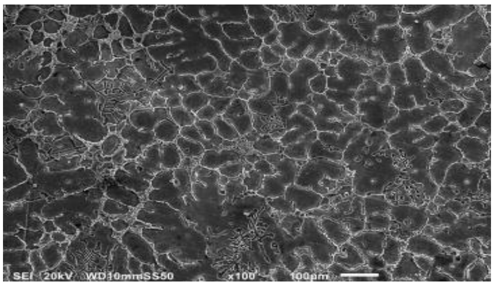

Figure 15:50% CU at 500^{0}C

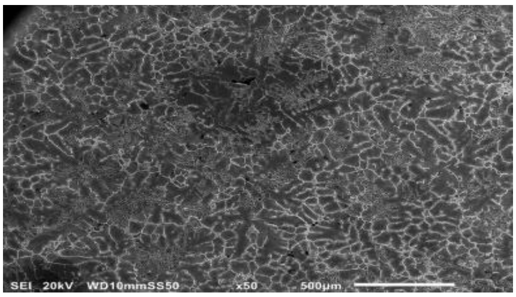

Figure 16 :40%CU at 450^{0}C

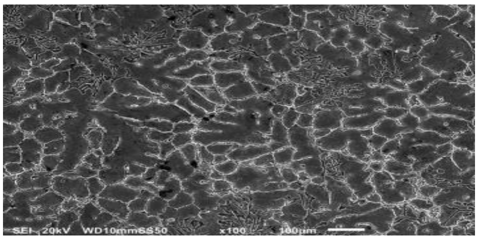

Figure 17: 40%CU at 350^{0}C

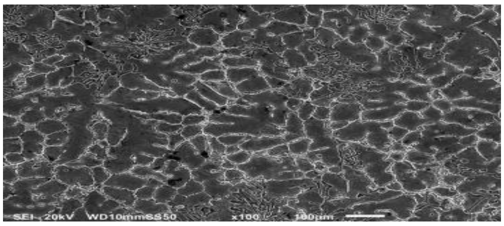

Figure 18: 30% CU at 250^{0}C

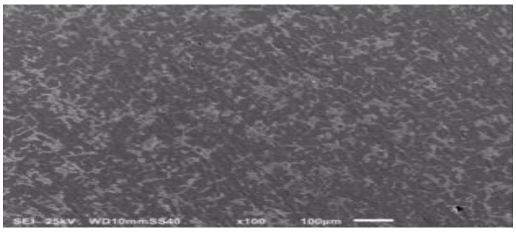

Figure 19:100% water at 200^{0}C

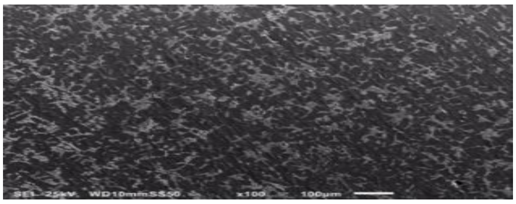

Figure 20: 30% CU at 400^{0}C

III. RESULTS & DISCUSSION

Based on tabulated values (Table.3) when the specimen was heated at 500^{0}C, Maximum tensile strength was obtained at 50% blend (50% water + 50% cow urine). Like wise the same blend the yield strength obtained(Table.4). The minerals present (sodium) in cow urine improved mechanical properties by refining grain boundaries. Further silicon present interlocking the grain boundaries and there by improved the mechanical properties. All these facts are very clearly seen in the photographs of microstructure.

IV. CONCLUSION

Al alloy 2585 containing the other impurities like Cu, Mg, Si. Sb, Fe and so on, when we added cow urine at different compositions, maintained temperature range 200^{0}C -500^{0}C. Al this temperature range of urine containing 95% water and other materials like NH_3, SO_4^{-2},PO_4^{-3}, Cl^-, Mg^{+2}, Ca^{+2} and so on reacts with impurities of Al 2585 to form compound like $FeCl_2$, $Mgcl_2$, $FeSO_4$, $MnSo_4$, $ZnSo_4$, $SnCl_4$, etc. By the effect of these compounds the properties of aluminum alloy might be changed which will be useful for metallurgical operations.

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As the composition of cow urine increased in base quenching media like water negative effect of metal.

V. ACKNOWLEDGEMENTS

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Nomenclature:

CU	Cow Urine
UTS	Ultimate tensile strength in N/mm^2
YS	Yield strength in N/mm^2
HBN	Brinell Hardness Number
QM	Quenching Media

VI.CONFLICT OF INTEREST

The authors have declared no conflict of interest

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