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EFFECTS OF HUMAN AND ANIMAL URINE ON NITRIDING FOR IMPROVED HARDNESS PROPERTY OF ALUMINIUM ALLOY MATERIALS

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ABSTRACT: *The study was carried out to determine the effect of human and animal urine on nitriding for improved mechanical properties of aluminium alloy material. The study adopted a 2x3 factorial design. The population comprised alloy materials that contain aluminium as elemental metal in its content. The specimens of 24 pieces of aluminium alloy materials were cut from 70mm diameter aluminium alloy machined to 50mm diameter. Human urine was obtained from urine houses built in Port Harcourt while animal urine was got from cattle butchers also in Port Harcourt. Twelve specimens were heated to a temperature of 500^0C in a cylinder containing human urine for 4, 5, and 6 hours respectively while another 12 specimens were also heated to the same temperature in a cylinder containing animal urine for 4, 5 and 6 hours respectively. In either case, no quenching was applied, rather the materials were allowed to cool naturally. Direct testing and measurement of nitrided specimens were carried out using Brinell testing machine. The research question that guided the study was answered using mean while the null hypothesis was tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. It was found from the study that human and animal urine as local ammonia increased the hardness of aluminium alloy material. Animal urine is more effective than human urine on nitriding, nitriding time showed significant effect on hardness of aluminium alloy material.*

KEYWORDS: Nitriding, Ammonia, Urine, Aluminium Alloy, Hardness.

INTRODUCTION

Most of the engineering components like pistons, shafts, gears, cams and pinions made of nitralloys or aluminium alloy materials wear away very rapidly when put into use. The reason for the rapid wearing is that the materials lack basic mechanical properties due to the fact that they are mostly not nitrided.

The reason for not nitriding aluminium alloy materials is as a result of non-availability of industrial gas ammonia. Another reason for not nitriding aluminium alloy is that industrial gas ammonia is very expensive and capital intensive. Adjei, Quesenbery and Chamblish (2002), Bibikov and Chiachuck (2005) stated that urine (human and animal) contain ammonia, and can be a local source of ammonia. Ammonia is inorganic compound, a gaseous compound of hydrogen and nitrogen (NH3) with a pungent smell.

Nitriding

Nitriding is a heat-treatment process for hardening and making materials wear resistant thereby improving the mechanical properties. Nitriding is a highly specialized surface hardening treatment that produces a thin but high hardness case on a wide variety of steel (Bestow, 2000). The significant advantages of nitriding over other surface hardening processes according to Powers (2002) are:

1. The case hardness is developed without quenching and the attendant distortion problems.
2. Nitriding surfaces are highly wear resistant and provides anti – galling properties (anti-irritation, exasperation or discomfort.
3. The fatique life is improved.
4. The process improves the corrosion –resistant property
5. The surface hardness is resistant to softening by temperatures up to the process temperature.

This implies that the mechanical property of hardness of aluminium alloy which is nitrided is improved and conditioned for more durability.

Urine

Urine is an aqueous solution of approximately 95% water, with the remaining percentages being metabolic wastes such as urea, dissolved salts and organic compounds. Fluids and materials filtered by the kidneys to become urine come from the blood or intestinal fluid (Ababio, 2005). Except in cases of kidney or urinary tract infection (UTI), urine is virtually sterile and nearly odourless on leaving the body.

Subsequent to elimination from the body, urine can acquire strong odour due to bacterial action most noticeably, the asphyxiating (suffocating) ammonia is produced by the breakdown of urea. Ammonia can harden and improve the mechanical properties of aluminium alloy materials.

Properties are the qualities that describe the specific characteristics of a material. Mechanical properties of a metallic material therefore are the properties that reveal their elastic and inelastic behaviour where external load or force is applied, thereby indicating their suitability for mechanical applications (Raghavan, 2006). The mechanical properties of hardness, not only influence the service life of aluminium alloy material but also the choice of manufacturing process.

Aluminium

Aluminium is a white metal produced by electrical processes from the oxide alumina, a clayey mineral called bauxite (Khurmi and Gapta, 2008). Aluminium is light, weak and soft for most engineering uses, but has engineering applications due to its light weight and corrosion free quality. It is due to its lightness and corrosion free properties that made it possible for aluminium to be alloyed (mixed with other materials) to improve the mechanical properties and make it resistant to indentations, weal and tear that are associated with mating parts. When

aluminium is alloyed with small amount of other metals, it is most widely used because the mechanical properties of hardness, is improved.

Hardness

Hardness is the ability of a material to resist tear, wear, indentation and penetration when external forces are applied on it. Rajput (2008) stated that hardness, is part of mechanical properties of a material.

Statement of the Problem

Industrial gas ammonia used for nitriding is very expensive and can only be afforded by large industrial set-ups. The capital intensiveness of nitriding with industrial gas ammonia makes it impossible for small and medium scale manufacturers to engage in the process of case-hardening their products. Aluminium alloy parts produced by these local small and medium manufactures are not nitrided (case hardened). The parts produced with aluminium alloy that are not nitrided are prone to fast wear and tear hence failure becomes imminent (Amadi, 2013).The study is to find a cheaper and easier means of hardening aluminium alloy materials to make it durable.

Purpose of the Study

The purpose of the study is to determine the effect of human and animal urine on nitriding for improved mechanical properties of aluminium alloy materials.

Specifically, the study sought to determine:

1. The effect on the hardness of aluminium alloy materials nitrided using human and animal urine as ammonia.

Research Questions

1. What is the effect on hardness of aluminium alloy materials nitrided using human and animal urine as ammonia?

Hypotheses

The following null hypothesis was postulated to guide the study:

$H0_1$ There is no significant difference in the hardness of aluminium alloy materials nitrided using human and animal urine as ammonia.

METHODOLOGY

Design of the Study

The study adopted 2 x 3 factorial design. According to Gray (1991), Ali (2006), factorial designs are basically elaborations of true experimental designs and permit investigations of two or more variables individually and in interaction with each other. This design is suitable for the study because it has human and animal urine as two independent variables, nitriding time of 4, 5 and 6 hours as moderator variables while hardness, as dependent variable.

Area of the Study

The study was carried out in South-south geopolitical zone of Nigeria.

Population

The population comprised alloy materials that contain aluminium as elemental metal in its content (which is reactive to ammonia gas) as follows: 0.50% silicon, 0.7% ferrum, 0.13% copper, 1.20 manganese, 0.10% magnesium, 0.03% chromium, 0.03% Nickel, 0.15% zinc, 0.20% Titanium, 0.03% vanadium and the remainder as Aluminium (Source: First Aluminium Nigeria Plc, Port Harcourt).

Specimen

Hardness Test Specimens

The specimens were 24 pieces of aluminium alloy material for hardness. The specimens were cut from 70mm diameter aluminium alloy obtained from first Aluminium Company Nigeria Ltd, Port Harcourt. The 70mm diameter was used so that 50mm diameter for hardness testing can be machined conveniently.

Specimen Distribution

For hardness test, 12 specimen nitrided with human urine for four hours were marked H4, those nitrided for five hours were marked H5 and those nitrided for six hours were marked H6. Similarly, specimen nitrided with animal urine for four hours were marked A4, those nitrided for five hours were marked A5 and those nitrided for six hours marked A6 in accordance with nitriding time.

Data for hardness were obtained using Brinell/Rockwell hardness testing machine. Brinell/Rockwell hardness testing machine is a conventional instrument used to measure hardness. The instrument is a standardized industrial machine used for specific purpose.

Experimental Procedures

Urinary houses were built in Port Harcourt, Rivers State where human urine was collected in large quantity. Also, 200 litres of animal urine were obtained from butchers at slaughter houses in Port Harcourt.

Heating Cylinders

Two heating cylinders were procured. Each of the cylinders was attached with temperature gauge regulators to regulate the temperature of 480^0C to 540^oC (Rajput, 2008). The heating cylinders are 50 litres in volume and are provided with air vent to allow the escape of vapourized urine. Each of the packed heating cylinders was loaded to the furnace, heated to a temperature of 500^0C and allowed to remain at that temperature for four hours for the first experiment, five hours for the second experiment and six hours for the third experiment.

Nitriding

Human urine was used to fill one of the cylinders to 40 – litre level while animal urine was used to fill another cylinder to the same level. Twelve specimens were put into each of the cylinders for the hardness test for human and animal urine. Each of the cylinders was heated

simultaneously up to 500^0C for four hours. After four hours, the heating was stopped and the specimens removed after the cylinders are cooled. The hating operation was repeated for five hours and six hours and labelled accordingly. The specimens heated with human urine were coded H4, H5 and H6 while those heated with animal urine were coded A4, A5 and A6 respectively. The specimen, when cool, were taken out of the heating cylinders to the machine for testing.

Method of Data Collection

Direct testing and measuring of hardness of the specimens were done on the testing machine. The testing machine used is at SGS Inspection Service Nigeria Ltd, Port Harcourt. Data on hardness were measured in Brineel (HB).

Method of Data Analysis

Data obtained for the research question were analysed using mean while the hypothesis was tested with Analysis of Covariance ANCOVA at 0.05 level of significance.

Results

Table 1: Mean Hardness of Nitrided Aluinium Alloy using Human and Animal Urine

Type of Urine	4 Hours	5 Hours	6 Hours	Mean	SD
Human Urine	31.67	33.33	38	34.33	3.49
Animal Urine	32.00	34.33	43	36.44	5.14

Data presented in Table 1 show that animal urine produced higher mean hardness of 36.44RC while human urine produced a mean hardness of 34.33 RC. Therefore, animal urine is superior to human urine in hardness of nitrided aluminium alloy materials.

Table 2: Analysis of Covariance of Hardness of Aluminium Alloy Materials Nitrided with Human and Animal Urine

Sources of variation	Sum of squares	df	Mean square	F	Sig
Corrected model	379.567[a]	5	75.913	18.757	0.000
Intercept	30077.964	1	30077.964	7431.696	0.000
Urine	27.413	1	27.413	6.773	0.018
Hours	327.180	2	613.590	40.420	0.000
Urine time (hrs)	24.973	2	12.486	3.085	0.70
Error	72.851	18	4.047		
Total	30530.381	24			
Corrected total	452.417	23			

Data presented in Tale 2 show a statistical significant mean effect for urine $F(1, 24) = 6.773$, $P < 0.018$. The null hypothesis was therefore rejected indicating that there was significant difference in the mean hardness of aluminium alloy materials nitrided with human and animal urine.

Discussion

It was found in the study that human and animal urine were effective in hardening aluminium alloy material over time. The range of 21RC to 23RC was obtained for the control specimens whereas a range of 31.67RC to 43.00RC was obtained for the experimental specimens. These ranges of hardness were obtained within four to six hours of nitriding time. Higher hardness may be obtained with longer time.

The results obtained with the aluminium alloy materials that were investigated compared with the findings of Ohize (2007), with values of 51.177HRC to 61.660HRC for mild steel carburized and quenched from 900^0C. Moreover, mild steel pack carburized each with coal, wood charcoal and bone charcoal and hardened increased considerably in hardness. Powers (2002), Kazuo, (2005) reported Brinell hardness number range of 400BHN to 700BHN. These values were found to contain energizers to the local materials used in this study, better results may be obtained in shorter times.

CONCLUSION

The mean hardness of control specimens was 22.0RC while the mean hardness of the experimental specimens was 36.44 RC for animal urine and 34.33RC for human urine. The mean hardness for each of human and animal urine as local ammonia showed considerable higher values than the control specimen. It was therefore concluded that human and animal urine are good for nitriding for case hardening aluminium alloy materials for improved mechanical properties.

RECOMMENDATIONS

The following recommendations are made based on the findings of the study:

1. Human and animal urine should be used to increase the hardness strength of aluminium alloy materials.
2. Workshops should be organized on the processes involved in the nitriding of aluminium alloy materials using human and animal urine.
3. Nitriding aluminium alloy materials using human and animal urine should be infused into the curriculum of metalwork technology of institutions in Nigeria.

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