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Pack nitriding of aluminium using cassava waste

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Abstract

Pack Nitriding is a process analogous to pack carbonizing. In this work, cassava leaves were employed as a source of nitrogen. Upon heating, slow decomposition of the compound provides Nitrogen, the Nitrogen was allowed to interact with aluminium metal surfaces, which were packed nitrided at temperature of 350^0c. The time duration varied from 1 hour to 6 hours. It was observed that there was an increase in strength and hardness of aluminium. Therefore, a nitriding of aluminium using cassava leaf as a source of nitrogen is assessed possible.

Keywords
Diffusion, surface, nitriding, aluminium, cassava, strength.

1.0 Introduction

Aluminium is the most abundant metallic element in the earth's crust occurring in a variety of aluminium silicates such as clay, micas and feldspars. In contrast with other traditional metals such as iron and Copper, the tonnage use of which has remained fairly steady in recent times, aluminium use has been on the increase and it is now second only to plastics which have a faster rate of growth of production and use than aluminium. [1]. Since machine building is fundamental to industrialization, aluminium and its alloys needs to possess some properties that will make it an extremely useful engineering material [3]. The need to obtain high surface hardness of aluminium for designers and manufacturers of process machine components and spares cannot be over emphasized [4].

The main thrust of this project is to use dry cassava leaves as an alternative reagent for nitriding process to increase the surface hardness of aluminium by introducing Nitrogen into the surface (pack Nitriding), which is a process analogous to carbonizing [2]. The presence of cyanide in cassava have been emphasized. Studies have shown that the cyanide content of the cassava leaf is between 3 and 4% [4] with 100 times more cyanide content in its tubers. This method is an inexpensive source of nitrogen since the leaves and the peels are usually thrown away. This process therefore puts value on what is normally discarded as waste.

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2.0 Case depth with nitriding

Nitriding process impact nitrogen to the surface of aluminium. The amount of nitrogen passing through the slab increase with increasing areas and with increasing negative gradient of change in equilibrium number of vacancies with respect to change in distance (dc/dx). The coefficient of proportionality for this system is analogous to that of electrical conductivity.

$$J_x = -D(dc/d_X) \qquad (2.1)$$

when J_X = quantity of diffusing substance in unit time through a unit area perpendicular to the plane [1].

c = equilibrium number of vacancies
x = distance along x direction
d = diffusivity

The concentration of the diffusing C_X values with distance x, time t, and diffusivity D. If, D does not depend upon concentration, it gives rise to the equation

$$\frac{dc}{dt} = D(\partial^2 C_X / \partial x^2) \qquad (2.2)$$

known as Ficks second law of diffusion [3].

Nitrogen can penetrate the surface rapidly to the depth of about 0.50mm in the first 1 hour. This depends on the concentration and the type of the material, as well as on temperature.

3.0 Materials and method materials

The Al-Mg-Si alloy in form of rods of diameter 6mm was used in this work and it was obtained from NIGALEX Aluminium company in Oshodi, Lagos, Nigeria. It has chemical composition shown in table 1.1 below. Also, the cassava leaves used were obtained from a farm located in Owo, Ondo State of Nigeria.

Table 3.1 Chemical composition of aluminium alloy (%)

Elements	Al	Mg	Si	Fe	Mn	Cr	Ii	Ca	Sr
Composition (%)	98.6631	0.4321	0.3625	0.1516	0.0469	0.0076	0.0006	0.0011	0.0156

3.1 Method

Nitrizer was prepared by weighing 70% dried leaves of cassava grinded to 1µ with 30% energizer. The energizer used is sodium trioxo carbonate (IV) ($Naco_3$). It was added in order to reduce the hygroscopic nitrogen, which could lead to coarsening of the nitrogen mixture. Six aluminium alloy samples were prepared. The samples were packed with prepared Nitrizer inside a steel box and placed into the furnace maintained at 350^0C but kept there for times from 1 to 6hrs respectively. After the heat treatments, the samples were quenched into used engine oil. The micro hardness read was carried out on micro hardness tester manufactured by BRITISH LECO, model Lm, 700AT. The hardness reading was taking across the depth surface starting from the edge toward the centre of the samples.

The point of indentation is varied along the diameter of the specimen while the text load is maintained at l0*gf* and the indentation duration was kept at 15 seconds throughout.

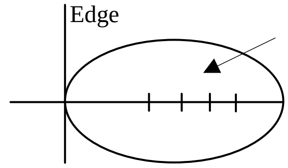

Figure 3.1: Micro hardness test across the samples surface

X-ray diffraction text was carried out on the sample before and after nitriding. The results from the *x*-ray diffraction was shown on figures 3.2 and 3.3.

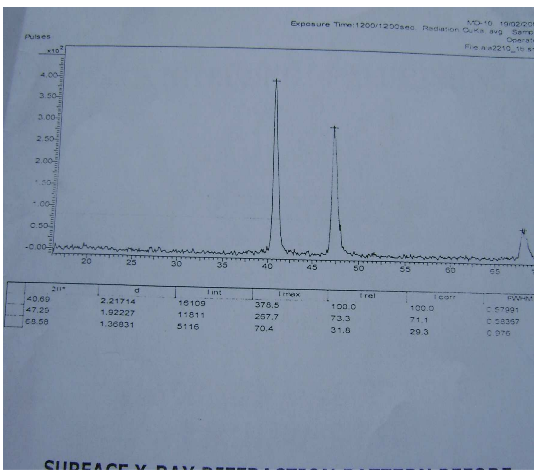

Figure 3.2: Surface X-ray diffraction patter before nitriding

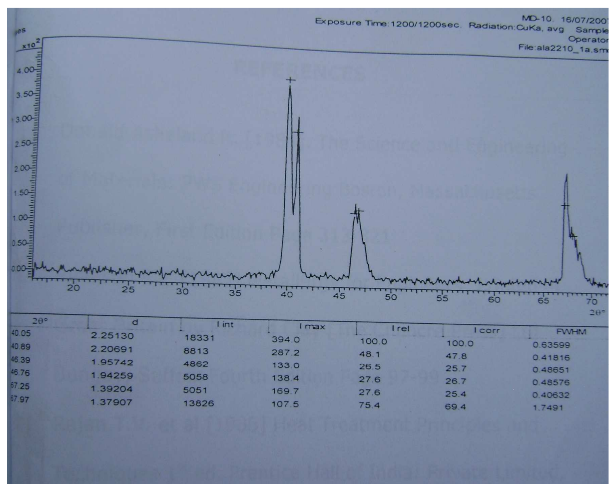

Figure 3.2: Surface X-ray diffraction patter after nitriding

4.0 Results and discussion

The result of hardness of aluminium across surface case depth of the sample are shown at Table 4.1

Table 4.1: Hardness of aluminium across surface case depth at 350^0C.

Distance/time	**0.50mm**	**1.00mm**	**1.50mm**	**2.00mm**	**2.50mm**	**3.00mm**
1hr	30.10Hv	28.70 Hv	26.70 Hv	16.50 Hv	15.50 Hv	15.50 Hv
2hrs	38.00 Hv	37.20 Hv	36.90 Hv	18.20 Hv	16.20 Hv	15.20 Hv
3hrs	48.70 Hv	40.00 Hv	38.00 Hv	20.00 Hv	18.20 Hv	18.20 Hv
4hrs	55.30 Hv	50.00 Hv	41.00 Hv	28.00 Hv	27.00 Hv	27.00 Hv
5hrs	65.50 Hv	55.00 Hv	45.20 Hv	31.00 Hv	28.00 Hv	28.00 Hv
6hrs	67.90 Hv	59.50 Hv	49.50 Hv	35.50 Hv	30.10 Hv	30.10 Hv

Slow decomposition of the reaction products at the Nitriding temperature provides Nitrogen. Diffusion transformations occur as a result of thermally activated movement of the atoms of the nitrogen across the interface of the aluminium. This will lead to precipitation in the sample with tendency to form aluminium nitride, silicon nitride, and magnesium nitride. The sizes of nitrogen, silicon, Aluminium and Magnesium are 0.7Å, 1.7Å, 1.40Å, and 1.60Å respectively. It means ALN have a better chance than other nitrides because of its size difference [4]. The results of the micro hardness test carried out on the samples that are nitrided are 350^0C across surface case depths shown that the micro hardness test value increase as the holding time increases and decreases as the case depth increases.

The results from the X-ray diffraction show that three order of angles were found on the sample 1b (Al-Mg-Si) at 40.67^0, 47.29^0 and 68.60^0 respectively. After nitriding, the profile changed as shown on sample 1a. We now have six angles 40.05^0, 40.89^0, 46.76^0, 67.25^0 and 67.97^0 visible. Likewise there is a change in inter-planer distance '*d*'. The change of the profile is as a result of the nitride formation in the aluminium. Precipitation increases the strength and hardness of the sample. The more nitrogen forming precipitates that are present, the harder and stronger will the alloy be as can seen in Table 4.1 and Figure 4.1.

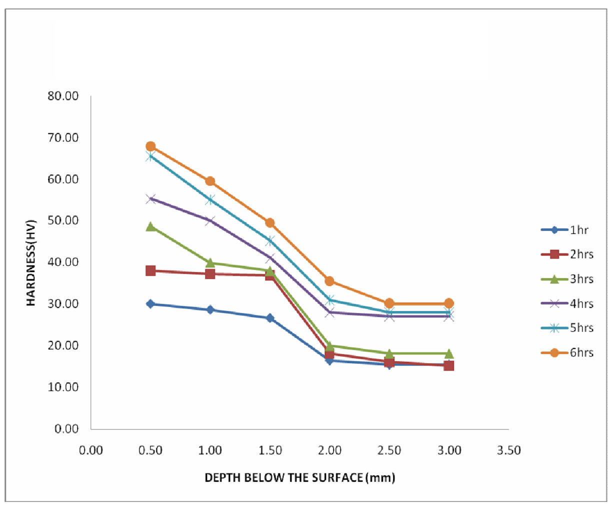

Figure 4.1: Plot of hardness against depth across the surface for the xperimental data at 350^0C

5.0 Conclusion

This investigation demonstrated the effect of nitriding in increasing the surface strength of aluminium. Therefore, time and temperature influence the hardness of the packed nitrided aluminium and it equally explain the possibility of using cassava leaf as a source of nitrogen in nitriding aluminium either metal or alloy.

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