Influence of Processing Variables on the Mechanical Properties of Worked Al-Mn Alloy.

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ABSTRACT

This study investigated the influence of processing variables on the mechanical properties of worked Al-Mn alloy. Standard methods were adopted for tensile test using extensometer while metallography was carried out using the standard technique. Results obtained from the test showed that the tensile strength (58N/mm^2, 73 N/mm^2, and 97N/mm^2) for as-cast, hot rolled, and cold rolled, respectively, were recorded. As-cast and hot rolled samples recorded appreciable ductility of 12.50% and 20.33%, while poor ductility value of 8.45% was recorded by cold rolled sample. However, a good correlation was established between the microstructure and mechanical properties of the samples examined.

(Keywords: processing variables, mechanical properties, as-cast, hot rolling, cold rolling)

INTRODUCTION

Recently, the demand for aluminum and its alloys are on the increase. This has been attributed to a lot of reasons which include its attractive physical and mechanical properties; and partly by virtue of the shortage and high cost of steel. Studies [3,6] reported that aluminum and its alloys have relatively low density (2.7g/cm^3) compared to (7.9g/cm^3) for steel. Another study [5] reported that aluminum is used in five major areas namely building and construction, containers and packaging, transportation, electrical conductors, machinery and equipment. A recent survey has shown progressive increase in the world consumption of aluminum and its alloys. In Nigeria today, it has been observed that one out of every three houses erected within the last five years are roofed with aluminum sheet against the conventional and out-of-favor zinc sheet.

Al-Mn alloys are used mostly in producing roofing sheets mainly because of its high corrosion resistance and strength. Being a lightweight alloy, the aim of this work is to study the influence of the processing variables on the mechanical properties of this material considering its high demand in the building industry.

MATERIALS AND METHODS

Samples used in this work were collected from First Aluminium Plc., Port Harcourt. This alloy is known and referred to as 3SR in this company. The processing history of the alloy consists of melting in reveboratory furnace, casting using D.C. machine, preheating (homogenization), hot rolling at 2High mill, annealing, cold rolling, intermediate finishing like embossing, etc., and coiling.

The chemical composition of the sample was conducted using an Atomic Absorption Spectrophotometer (AAS). The samples were subjected to tensile and micrographic test following standard procedures as stipulated by [1-2]. Standard specimens were prepared according to the requirement of each test [4]

RESULTS AND DISCUSSION

Results of the chemical composition of the 3SR alloy used in this study are shown in Table 1.

As expected, the chemical composition shown in Table 1 revealed that the alloy contains 98.90 wt % Al, 0.251 wt % Mn and 0.21 wt % of Fe. Furthermore, results confirmed a well-known fact that the presence of iron reduces the solid solubility of manganese, thereby increasing the danger of large primary particles of $MnAl_6$ formation.

Table 1: Chemical Composition of 3SR Alloy.

Alloy	Composition wt %										
3SR	Al	Mn	Si	Fe	Cu	Mg	Cr	Ti	Zn	Ni	V
	98.90	0.251	0.153	0.21	0.05	0.011	0.007	0.008	0.05	0.002	0.006

Manganese addition strengthens aluminum mainly by solid solution strengthening [6] and by fine dispersion of precipitates.

Table 2 shows that the tensile strength of the as-cast and hot rolled samples are significantly lower than the cold rolled sample. For cold rolled sample 40.21% and 42.05% increase in the tensile strength and yield strength were obtained, respectively. However, for the hot rolled sample, a 38.50% increase in ductility was obtained, while the cold rolled sample recorded a 32.40% reduction in ductility.

Table 2: Mechanical Properties of 3SR Alloy.

Test	As-Cast	Hot Rolled	Cold Rolled
Tensile strength	UTS(N/mm^2)		
	58	73	97
Yield strength	51	56	88
	Ductility (%)		
Elongation	12.50	20.33	8.45

The higher tensile strength recorded by both hot rolled and cold rolled samples may be explained by the elimination of solute concentration gradient during homogenization of the as-cast sample. Furthermore, working operations are accompanied by strain hardening effects. In hot working operation, strain hardening and distorted grain structure produced by deformations are rapidly eliminated by the formation of new strain-free grains as a result of recrystallization.

Conversely, strain hardening effects are not eliminated in cold working operation thereby justifying the higher tensile strength and lower ductility recorded. From the AAS result, high composition of iron may have restricted the amount of manganese taken into solid solution resulting in the formation of large primary particles of $MnAl_6$ which is known to affect ductility negatively. This is evidenced in the low percentage elongation (ductility) recorded by the as-cast sample when compared to that of the hot rolled sample.

The micrographs of as-cast, hot rolled, and cold rolled samples are displayed in Plates1-3. Plate 1 revealed columnar grains distributed randomly in the matrix. Plate 2 showed equiaxed non-uniform and small grains. Plate 3 showed highly elongated grains containing relatively equiaxed dislocation cell structure due to strain hardening.

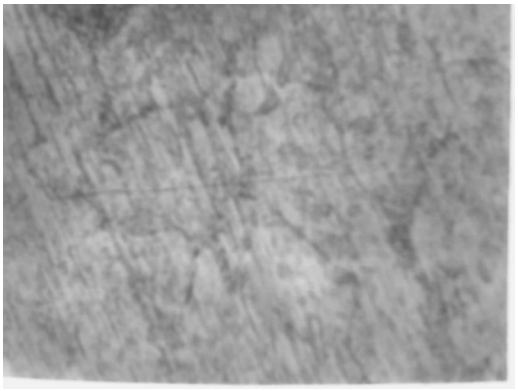

Plate 1: As-Cast Sample

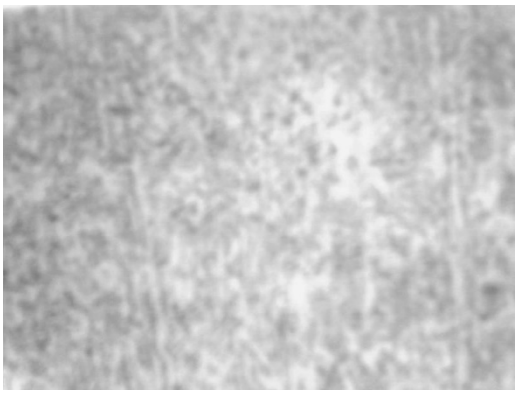

Plate 2: Hot Rolled Sample

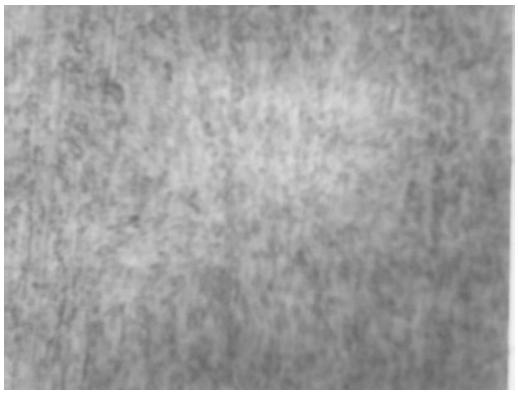

Plate 3: Cold Rolled Sample

CONCLUSION

It can be concluded that processing variable like alloy compositions, casting, homogenization, rolling affect to a large extent the mechanical properties of worked 3SR alloy. When ductility is the most desired property, the iron composition should be reduced drastically.

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