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COMPARATIVE ANALYSIS OF IMPORTED, CAST LM14 ALUMINIUM ALLOYS FOR RECIPROCATING FREON COMPRESSORS

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ABSTRACT

This paper presents the comparative analysis of the imported LM14 piston with locally cast ones for a reciprocating Freon compressor. The approach adopted in producing the pistons is that of copy technology in which the imported piston was subjected to composition and mechanical tests to discover the elements presents and its mechanical properties. The tests revealed that the important piston made is from LM14 aluminum allow having low magnesium and zinc content. Scraps of imported compressor piston were melted for casting in a permanent mould using local crucible furnace. The cast piston was equally subjected to composition and mechanical property tests. Heat treatment was carried out on the cast pistons to improve the mechanical properties. The cast pistons compare favorably with the imported one.

Key Words: *Permanent mould, scraps, ultimate tensile strength, yields strength, hardness, chemical composition.*

INTRODUCTION

The acquisition of appropriate skills, abilities and competencies both mental, materials and equipment is indispensable for the individual to live in and contribute to the development of his society, National Policy on Education (1997). The National Policy on Education (NPE), which the National Education Research Council (NERC) describe as the most eloquent indicator of how the nation planned to improve or bring about those necessary developmental changes in the society through forma,, non formal man power training and development for elevating the social, spiritual and economical well being of Nigerians. The educational policy consequently had as it major objectives for the improvement of the productive capacity of the nation, in such away that it will gradually consolidate the nation's independence, while reducing its dependence on out side sources for most of her needs. One of the major impediments to Nigeria technological advancement is her weak production capability caused by non-availability of appropriate equipment and material. However, where equipment is available, the standard and appropriate production techniques are not followed for parts and machines production (Sunmonu, 2004). Sunmonu, (1996) advanced passive participation of highly trained man power such as Technologist and Engineers in machines and spare parts fabrication and recognize the dominant role of craftsmen and Technicians, which training did not include complex engineering considerations in machines design and production, as being responsible for the low quality of spare parts and machines fabricated locally in Nigeria. Budinsks (1979), concluded that the mechanical properties are those that describe the behavior of material when an external force is applied e.g. tensile, yield and compressive strength, hardness, toughness, impact, creep and fatigue. Almost all known casting processes are used in producing aluminum alloy casting. The casting processes are die casting, permanent mould casting, sand casting, shell mould casting, plaster casing, investment casting, composite mould casting, premium quality casting, squeeze casting, centrifugal casting and continuous casting. Many factors affect the selection of a casting process for producing a specific part, in many cases the decision is influenced strongly by geometric configuration and design features, quality factors, quality requirements, unit cost, availability and delivery factor (Mitra and Prasad, 1986). One many casting operations, moulds are preheated to their approximated operating temperatures before the operation begins to prevent premature solidification and minimize casting defects (Tailor, 1970). The selection of materials for the charge depends on melting equipment and capacity, composition and quality of the alloy needed, cost and availability of analytical equipment. The charge may be in form of purchased crap, clean scrap, machining scrap, foundry scrap, and virgin maggots. A suitable furnace for melting the charge materials is selected accordingly (Wright, 1987). In all internal combustion engines and reciprocating compresors, the piston is invariably the most vulnerable single member which serves three main functions: namely: provides the means whereby gas loads are transmitted to the connecting rod/ cranks shaft mechanism and vice versa, incase of compressor; acts as a carrier for the gas and oil sealing elements- the piston rings; and also act as a crosshead to react on cylinder wall side loads in the connecting rod/ crankshaft system (Lilly, 1986).*

MATERIALS AND METHODS

Materials

Scraps of imported LM14 and cast aluminum alloys were sourced locally and collected together as charge materials for the production of piston to be used in reciprocating Freon compressor.

METHODS

Mould Production

The permanent mould consists of the split dies, the accessories and the sprue. The dies were made from Grey cast iron material, while the accessories, which include the lifting, and ejection mechanisms were produced from medium carbon steel. The various parts were coupled together with the aid of screw and bolts after the mechanizing to the stipulated dimensions.

Core production

Sand core was used in this casting process due to the simplicity of production, cheapness, availability and ease of removal. A wooden core box containing the required cavity that gives the shape and size of the core was rammed full with silica sand mixed with vegetable oil, bentonite and water. After ramming, the core box was removed from the formed sand core, which was mounted on a support plate for the purpose of drying.

Piston production

Scraps of imported, cast and LM14 aluminum alloy were melted in a blower type coke fired crucible furnace. The mould surface was coated with graphite powdered, preheated and the molt on metal took an average of 32 seconds. The cast piston was ejected from the mould, the core removed and the piston machined to the required size. The pistons were strengthened in boiling w2ater for three hours and aged at room temperature for five days. This procedure agrees with Sunmonu (2004) and Dangyara (2002) method of piston production.

Mechanical Test

Two tests were conducted on the imported, cast and LM14 pitons namely, tensile test and hardness test.

Tensile test

The specimen for the tensile test was taken from each of the pistons under investigation, heats treated and machinist to the standard size. The tensile test was conducted with the aide of house field tens meter and the load applied axially on the test piece. The indenter is a steel ball of 1mm dosimeter forced in to the surface of the test piece under the action of 5kg load applied for 115 seconds. The results obtained are as indicated in table 3.2.

Brinell Hardness test

The Brinell hardness test was carried out on each of the test pieces using the universal hardness testing machine. The indenter is a steel ball of 1mm diameter forced in to the surface of the test piece under the action of 5kg load applied for 15 seconds. The results obtained are as indicatwed in table 3.2.

Results and discussion

Table 3.1 shows the chemical composition of the alloying elements present in the imported, cast LM14 aluminum pistons. The composition of imported and cast aluminium alloy pistons compare favorably with LM14 aluminium alloy which is noted to have tremendous strength at elevated temperature that made it suitable for piston production for heavy duty diesel engine and afire cooled cylinder head, (polmear, 1995). The most probable reason for choosing this type of casting alloy by the manufacturer is to eliminate the possibility of the Freon 12 gases reacting with magnesium and zince if their. Concentration is very high. Table 3.2. indicate the result of the mechanical properties of the imported, cast and LM14 aluminum alloy pistons. The ultimate tensile strength values of the imported and cast piston full within the acceptable range of 260-295 M/m2 for LM 14 aluminum alloy piston. Furthermore, the yield strength values of the cast piston fall within the acceptable range of 195-3230 MN/m2 and 90-120HB. Respectively as found I LM14 piston. The ultimate tensile strength, yield strength and hardness values. Increased appreciably, after the heat treatment operation of the cast piston. The improved mechanical properties may be attributed to refinement of grain sizes and eliminate of porosity in the cat piston during Heat treatment (sunmonu, 2004).

In addition, increase in the mechanical properties could also be as a result of work hardening, which the piston has been subjected to during the period of operation.

CONCLUSION

Research investigation has been conducted on the imported, locally cast aluminium alloy pistons in comparison with the standard LM14 aluminum piston. The mechanical properties test conducted on the finished pistons indicate that the pistons have adequate strength, hardness and resistance against corrosion. Chemical composition and mechanical properties of the piston produced compare favourably with the standard LM14 piston. The performance tests conducted on the piston by first coupling them in to a compressor and running it up to 30MN/m2 and later mounting them in the refrigerating system indicate good product functionality since there was no overheating in the compressor. The cast pistons could therefore be used as substitutes for imported ones in the reciprocating Freon compressors.

Table 3.1 Chemical composition of imported and locally cast pistons.

Alloying Element	Ai	Si	Cu	Fe	Mn	Mg	Cr	Ni	Zn	Ti	Sn
Imported Piston (%)	90.8	0.65	3.95	0.80	0.35	0.25	0.25	2.24	0.32	0.35	0.05
Cast Piston(%)	90.75	0.65	3.93	0.96	0.34	0.24	0.24	2.19	0.30	0.34	0.04
Lm 14 Piston(%)	89.15 91.65	0.70	3.50 4.50	1.0	0.35	0.150-0.35	0.25	1.70-2.30	0.35	0.35	-

Table 3.2 Mechanical properties of imported and locally cast pistons.

Mechanical Properties	Ultimate Tensile Strength(Mn/M2)	Yield Strength (Mn/m2)	Elongation (%)	Reduction In area (%)	Hardness HB
Imported Piston	292.0	264.2	0.95	1.37	95.4
Cast Piston	260.9	230.0	1.15	1.59	75.0
Lm 14 Piston	260-295	195-230	1.0-4.0	-	90-120
Heat Treated Cast piston	275	2600	1.0	1.40	90

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