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Metallurgical Characterisation of Recovered Aluminium Alloys in Cameroon

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ABSTRACT: This article is a comparative study of metallurgical characteristics of the different aluminium alloys gotten through recycling of recovered aluminium in Cameroon. A simple experimental device for the foundry of secondary aluminium blend, of very good quality built around a movable charcoal furnace is presented. It enables better energy efficiency, a better distribution of the heat around the crucible and indirectly assures good quality of the products obtained, while respecting the economic constraints and users' safety. Six refining methods are proposed by the addition of polyvinyl chloride (method A), coke rich in carbon CH_S (method C), ammonium chloride NH_4Cl (method E), manganese dioxide MnO (method T), acrylic nitrite $(C_2H_3Cl)_n$ (method P) and sodium chloride NaCl (method S). A critical analysis of the different recycling techniques is presented as well as a proposed process of melting and refining that enables the obtaining products with high degrees of purity. The results are then compared to the results obtained from the industrial methods of aluminium refining such as fractional crystallization (FC), granular filtration (GF) and dissolution in a metal solvent (DS). The later (DS) gives the rate of 6.540% of accumulated alloy elements and enables the best purification (93.460%), while the NaCl gives the lowest global rate of additive elements (9.478%), with the best purity index (90.522%) amount the proposed methods. Results obtained show that this method of refining improves the metallurgical properties of secondary aluminium alloy blends and guarantees better safety, as well as reducing the risks of environmental pollution.

KEYWORDS: Aluminium, Foundry, Recycling, Recovery, Refining.

1 INTRODUCTION

Recycling is the process of treatment which enables the reintroduction of some used objects through recovery, in the production cycle of a product. In Sub Saharan Africa, the methods of recycling used by aluminium artisanal casters to manufacture some kitchens utensils and various tools are misleading. According to M. Fogue and *al*, 1987 [1] impurities that can affect the quality of the product, affect the health of artisanal casters and that of those using the products. It therefore becomes important to find a method of refining that can limit these intrusions while improving the quality of products.

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This paper proposes a method of refining of the recovered aluminium based on the reduction of the intrusion of impurities by the modification of the microstructure of the recovered aluminium alloys with the help of the molten salts and makes a comparative study of the results gotten with those from the traditional methods used by artisanal casters.

On the basis of models of heated metal furnace studied by Jean Perron, 1987 [2] and concerning the problems of efficiency and safety with respect to the rudimentary state of materials for manufacturing traditional smelting furnaces, a prototype of a mobile fusion oven, that is more detailed and better adapted to the Cameroonian context has been designed in 2005 by Theodore Tchotang [3].

The mobile fusion oven designed [3] is composed of two main parts notably the fireplace and the crucible. The fireplace built with refractory bricks is made up of a cylindrical section consisting of a combustion chamber of about 100 litres in capacity and a lid composed of two parts fitting together one in the other. The crucible is made of refractory steel in which the liquid is melted, with a capacity of nearly 32 litres. The oven prototype enables the assurance of a good thermal insulation, because temperatures can reach 1800°C while functioning for 150min on its own. This oven offers efficiency of 65.28%, a value close to that gotten by P. Lailler, 1983 [4], ranging from 60% to 70% and is better in relation to the one used in traditional fusion oven by artisanal casters that is only about 12.21% [3].

The determination of the content of the constituent elements of the products manufactured based on aluminium alloy recovery has been done on the electronic ionisation impact mass spectrometer used in the ultramodern chemical analysis laboratory belonging Alucam-Socatral company in Edea, Cameroon.

2 Classical Processes of recycling of the recovered aluminium alloys

2.1 Industrial processes of recycling of the recovered aluminium alloys

2.1.1 Description of the Processes

Industrial recycling of recovered aluminium alloys takes place in general, according to M. Samuel, 2003 [6] in four main stages notably the collection of scrap, preparation of the materials collected by cooling and heating after grinding and sorting, the smelting and the refining of the liquid. Three techniques of refining of recovered aluminium alloys that enable the production of aluminium of high purity exist according to Bao of Sun and *al*, 2004 [7].

Gaston Riverin, 1993 [8] presents the method of purification of alloys of recovered aluminium by fractional crystallization (FC), that has as advantage the separation of the constituents at low temperatures leading to energy saving. The inconvenience of this method is its low rate of production for a relatively long time of treatment. Its functioning implies high investments and a very expensive maintenance for a low rate of production. According to Harald Gorner, 2009 [9], the method of purification by granular filtration of tabular alumina (GF) is efficient when the concentration in inclusions is weaker and it is recommended when the diameter of inclusions is small. It is costly and reserved for productions on a large scale. In fact the process of purification by dissolution in a noble metal solvent (DS) invented by Paul, R. Kruesi, 2007 [10], remains very efficient for the recovery and the refining of the aluminium. Its principal disadvantage is the very high current density used that implies an increased energy cost and the difficulty to dispose of the noble metals.

2.1.2 Comparative study of the metallurgical characteristic of recovered aluminium alloys gotten from the different industrial refinement

By optimal content comparison [3] of additives and the degree purity of the recovered aluminium alloys gotten by the three industrial techniques of refinement notably the purification by fractional crystallization (FC) [8]; by granular filtration of tabular alumina (GF) [9] and by dissolution in a noble metal solvent (DS) [10], the later (DS) gives the weakest rate (6.540%) of accumulated alloy elements and enables the best purification (93.460%) of aluminium alloys from non refined alloys composed of 85.387% aluminium; and thus a better reduction of the rate of additives (-123.385%) and an increase of the degree of relative purity of 8.634%.

2.2 Traditional processes of refining of the recovered aluminium alloys

2.2.1 Traditional methods of refining of recovered aluminium alloys

According to studies led by M. Fogue and *al*, 1998 [1], processes of the recovery and recycling of the aluminium in units of traditional foundry include the stages of collection, sorting and compacting, smelting and refining, milling and flow and the polishing. After collection, material to be melted is introduced in the crucible, starting with the light scrap, followed by the heavy scrap. When the smelting liquid has the required consistence of a paste, the polyvinyl chloride (PVC) with chemical formula $(C_2H_3CL)_n$ is added for the refining. In the presence of free oxygen combustion according to equation (1) leads to the formation of carbon monoxide (CO), hydrochloric acid (HCl) and steam (H_2O).

$$(C_2H_3Cl)_n + \frac{3}{2}nO_2 \rightarrow nH_2O + nHCl + 2nCO \tag{1}$$

From the present metallic oxide reaction in the liquid with the hydrochloric acid (HCl), it forms the metallic chlorides that can be cleared at the surface of the liquid before pouring.

Table 1. Chemical compositions and purities of recovered aluminium alloys produced by the traditional process of refining by the old artisanal-casters , 1998 [1]

Elements of alloys (%)		Si	Fe	Cu	Mg	Mn	Sn	Cr	Ti	Ni	Zn	Pb	Ga	Elements of alloy accumulated	Al*(%)
Sources	**Samples**														
Old samples cast by artisanal - casters of Douala and analysed on the high power electronic microscope (MEB) at Insa in Lyons (Art)	**Art1**	06,750	0,770	0,350	0,515	-	0,030	0,007	0,012	0,025	0,205	0,019	0,015	08,697	91,303
	Art2	16,530	0,940	0,450	0,690	-	0,040	0,007	0,011	0,035	0,235	0,023	0,015	18,975	81,025
	Art3	12,150	1,490	0,560	0,505	-	0,030	0,007	0,013	0,020	0,190	0,014	0,020	14,998	85,002
	Art4	18,960	0,740	0,480	0,350	-	0,110	0,019	0,016	0,040	0,260	0,024	0,015	21,013	78,987
	Art5	08,226	0,700	0,280	0,490	-	0,025	0,007	0,014	0,020	0,170	0,012	0,010	09,953	90,047
	Art6	15,430	0,830	0,360	0,325	-	0,110	0,019	0,015	0,035	0,245	0,020	0,010	17,399	82,602

- **(*) Stands for an estimated value**
- **Numbers put in to show that the composition of the alloyed element is in excess with respect to values of the standard NFA50-105 [11]**

Table 2. Chemical compositions and purities of recovered aluminium alloys produced by the traditional process of refining by the new artisanal-casters, 2008, [3]

Elements of alloys (%)			Si	Fe	Cu	Mg	Mn	Sn	Cr	Ti	Ni	Zn	Pb	Ga	Elements of alloy accumulated	Al*(%)
Refining	**Samples and% of refining**															
A	**A000**	**0**	14,861	1,847	0,832	0, 556	0,278	0,200	0,448	0,025	0,255	0,527	0,126	0,028	19,427	80,573
	A050	**0,2**	15,431	0,898	0,356	0,236	0,025	0,024	0,181	0,008	0,156	0,425	0,145	0,002	17,887	82,113
	A100	**0,4**	13,248	0,785	0,359	0,256	0,056	0,001	0,012	0,012	0,004	0,325	0,062	0,002	15,122	84,878
	A150	**0,6**	12,155	1,494	0,565	0,482	0,039	0,002	0,024	0,023	0,052	0,268	0,087	0,003	15,194	84,806
	A200	**0,8**	13,754	0,836	0,485	0,362	0,045	0,001	0,032	0,008	0,002	0,241	0,074	0,001	15,841	84,159
	A250	**1**	16,354	0,987	0,545	0,458	0,016	0,003	0,426	0,007	0,25	0,189	0,121	0,002	19,358	80,642

- **(*) Stands for an estimated value**
- **Numbers put in to show that the composition of the alloyed element is in excess with respect to values of the standard NFA50-105 [11]**

2.2.2 COMPARATIVE STUDY OF THE METALLURGICAL CHARACTERISTIC OF RECOVERED ALUMINIUM ALLOYS GOTTEN FROM TRADITIONAL REFINING PROCESSES

Table 1 shows the only existing metallurgic data on recovered aluminium alloys melted by artisanal casters in the city of Douala in Cameroon and analysed with a high power electronic microscope (PEM) [1]. These metallurgical characteristics being insufficient, it was necessary to repeat the analysis in order to have some more complete information on the traditional process of refining of recovered aluminium alloys. Six (6) samples (Table 2), of recovered aluminium alloys have been cast by artisanal casters in the city of Yaounde. Each specimen has been tested five times and the final measurement considered for each sample is the arithmetic mean of results of all the specimens.

The analysis of results (Table 2) shows that all the six (6) samples of aluminium alloys recovered by artisanal casters has an excessive rate of Fe+Si, Cu, Mg, Zn and Pb (0.062 to 0.145%> 0.05) in accordance with the NFA50-105 standard [11]. Most specimens contain an excess of chromium and nickel. For each of these two metals an excessive content in 3 samples of the 6 considered can be noticed. The content of the Sn is only greater than the recommended value for the non refined sample. On the other hand the Ti and the Ga are in acceptable proportions. By comparison of the chemical compositions and degree of purity, the traditional refining [3], at 0.4% of $(C_2H_3Cl)_n$ gives the lowest overall rate (15.122%) and thus a relative (-28.468%) reduction of additive element in recovered aluminium alloys produced by artisanal casters in the city of Yaoundé and enables better purification to be done (84.878%) for the recovered aluminium alloys gotten from a non refined alloy composed initially of 80.573% aluminium; and thus an increase in the degree of purity of 5.072% in relative terms.

3 Proposed processes of refining of recovered aluminium

3.1 Description of the method

The beneficial effect of salt-oxides interactions during the recovery of aluminium raised in J.A.S. Tenorio and *al*, 2002 [12], permitted the putting in place of a purification process of recovered aluminium alloys [3], by the use of melted regular salts to remove the metallic oxides contained in molten aluminium alloys. In the operations of this progress, while following similar manufacturing steps as those of the traditional processes of recovering of salvaged aluminium alloys by the addition of polyvinyl chloride (method A) (PVC or PET), coke rich in carbon CH_S (method C), ammonium chloride NH_4Cl (method E), manganese dioxide MnO (method T), acrylic nitrite $(C_2H_3Cl)_n$ (method P), and sodium chloride NaCl (method S). So, the initial C, E, T, P, S and A are according to the source of the samples and to the nature of refining used in the purification of the fusion liquid as specified above. The contents of the refining elements vary from 0.2% to 1% of the molten aluminium mass; that corresponds to codes ranging from 000 to 250, in steps of 50 assigned to every initial.

3.2 Undertaken chemical reactions

The compounds CO_2, CO, SO_2, H_2S, NOx, C_nH_m and MO occur according to combustion formulas (2) to (5) and oxidation of $CH_S(C)$ in presence of the oxygen (6) [6], [12]. The combustion of compounds of CH_S of general formula C_xH_yO is shown in equation (2):

$$C_xH_yO + \left(x + \frac{y}{4} - \frac{1}{2}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O \tag{2}$$

Equation (3), shows combustion of compounds of CH_S of general formula CH_yO_x written as follow:

$$CH_yO_x + (1 + \frac{y-2x}{4})(O_2 + 3,76N_2) \rightarrow CO_2 + \frac{y}{2}H_2O + 3,76(1 + \frac{y-2x}{4})N_2 \tag{3}$$

To obtain NO_x , the combustion equation (4) is used:

$$N_2\,(air) + O_X \rightarrow NO_X + N \text{, when the temperature exceeds 1400°C (thermal NO)} \tag{4}$$

If the combustion is carried out at higher temperatures (over 1000°C), metallic oxides MO are reduced by the carbon and to form carbon monoxide according to equation (5):

$$MO + C \rightarrow M + CO \tag{5}$$

The following oxidation equation (6) in the presence of additive elements is gotten:

$$2nCH_S + Al_2S_3 + MS + mH_2O \xrightarrow{Oxidation} 2C_nH_m + 2nH_S + MO + 2SO_2 + 2Al(OH)_3 + 2H_2S \tag{6}$$

CH_S represents the macromolecules of coke rich in carbon;

C_nH_m represents the heavy hydrocarbons (gaseous)

MO and $Al(OH)_3$ represent oxides and metallic hydroxides

Al_2S_3 represents aluminium sulphides, easy combination of sulphur and aluminium.

In the presence of hydrochloric acid (HCl) produced according to equation (7) from ammonia salt NH_4Cl and oxygen (O_2), there is a reaction with the additive elements in the alloy according to the reaction (8) below and impurities can be released at the surface of the bath as chlorides and metallic hydroxides when the molten metal is mixed :

$$2NH_4Cl + \frac{7}{2}O_2 + 3C \rightarrow 2NO_2 + 2HCl + 3H_2 + 3CO \tag{7}$$

$$2NH_4Cl + Al_2S_3 + 2HCl + 6H_2O + 2Mg \rightarrow 2H_2 + 2Al(OH)_3 + 3H_2S + 2NH_3 + 2MgCl_2 \tag{8}$$

The gases given out are namely hydrogen (H_2), hydrochloric acid (HCl), ammonia (NH_3), carbon monoxide (CO), hydrogen sulphide (H_2S) and other gas traces.

The manganese dioxide MnO_2 and the added elements present in the bath of metal favour the chemical reaction (9), with the production of hydrochloric acid according to equation (7). This enables the impurities that are found at the surface of the bath as chlorides and metallic hydroxides to be removed when molten metal is mixed at the end to refine the metallic mixture.

$$MnO_2 + 2HCl + Al_2S_3 + 6H_2O + Mg \rightarrow Mn(OH)_2 + 2Al(OH)_3 + 3H_2S + MgCl_2 \tag{9}$$

The gases emitted are namely hydrogen (H_2), hydrochloric acid (HCl), carbon monoxide (CO), hydrogen sulphide (H_2S) and other gases like nitrogen dioxide NO_2 and traces of some metals.

After proper cleaning and compacting of the aluminium alloy trash, the combustion of the polyvinyl chloride $(C_2H_3Cl)_n$ is resumed in the bath in the presence of oxygen according to the reaction (1) as seen in the case of traditional refining, to produce carbon monoxide (CO), hydrochloric acid (HCl) and steam (H_2O) :

$$(C_2H_3Cl)_n + \frac{3}{2}nO_2 \rightarrow nH_2O + nHCl + 2nCO \tag{1}$$

According to equation (10), additive elements and the metallic oxides present in the metal in fusion react with the hydrochloric acid, to produce chlorides and metallic hydroxides that are formed at the surface of the vessel:

$$2HCl + MgO + Al_2S_3 + 5H_2O \rightarrow MgCl_2 + 2Al(OH)_3 + 3H_2S \tag{10}$$

The gases formed remain as previously mentioned as carbon monoxide (CO), hydrochloric acid (HCl), hydrogen sulphide (H_2S), traces of other gases and volatile organic compounds (COV).

The sodium chloride NaCl added in presence of oxygen is decomposed according to equation (11) and the dichloride formed immediately reacts with the Mg, Mn, Si and Fe metals, and reduces the additive elements content in the vessel of the aluminium alloy according to equation (12) to eliminate sodium peroxides, chlorides and the metallic hydroxides:

$$2NaCl + O_2 \rightarrow Na_2O_2 + Cl_2 \tag{11}$$

$$MgCl_2 + Al_2S_3 + 6H_2O \rightarrow 3H_2 + 2Al(OH)_3 + Cl_2S_3 + Mg \tag{12}$$

Gases given out at the time of the fusion of the recovered aluminium while using NaCl in refining are essentially hydrogen (H_2) and some traces of other gases and heavy metals..

Table 3. Chemical composition and purities indices of recovered aluminium alloys gotten according to the refining method by the addition of regular molten salts in the metal vessel in fusion in the Solid Mechanics Laboratory at ENSP, Yaoundé Cameroon [3]

Alloyed Elements (%)			Si	Fe	Cu	Mg	Mn	Sn	Cr	Ti	Ni	Zn	Pb	Ga	accumulated alloyed elements	Al*(%)
Refining	Samples and % of refining															
C	C000	0	12,799	0,714	0,368	0,045	0,287	0,002	0,055	0,063	0,101	0,113	0,002	0,057	14,606	85,394
	C050	0,2	09,830	0,662	2,590	0,327	0,192	0,028	0,018	0,049	0,019	0,313	0,012	0,021	14,061	85,939
	C100	0,4	09,019	0,724	2,573	0,315	0,206	0,003	0,026	0,061	0,024	0,254	0,013	0,025	13,243	86,757
	C150	0,6	09,499	0,742	2,387	0,245	0,252	0,014	0,007	0,017	0,017	0,195	0,017	0,020	13,412	86,588
	C200	0,8	09,777	0,747	2,39	0,280	0,205	0,018	0,060	0,014	0,020	0,109	0,020	0,020	13,660	86,340
	C250	1	10,681	0,645	2,364	0,184	0,245	0,023	0,061	0,015	0,015	0,189	0,017	0,025	14,464	85,536
E	E000	0	12,817	0,712	0,364	0,047	0,278	0,002	0,055	0,063	0,101	0,113	0,002	0,057	14,611	85,389
	E050	0,2	10,815	0,352	0,009	0,184	0,012	0,001	0,002	0,012	0,003	0,118	0,008	0,011	11,527	88,473
	E100	0,4	09,947	0,353	0,009	0,221	0,011	0,002	0,002	0,011	0,003	0,129	0,007	0,026	10,721	89,279
	E150	0,6	10,260	0,355	0,016	0,172	0,011	0,002	0,002	0,011	0,003	0,130	0,008	0,020	10,990	89,010
	E200	0,8	10,564	0,352	0,054	0,122	0,020	0,003	0,021	0,030	0,007	0,118	0,005	0,024	11,320	88,680
	E250	1	11,322	0,308	0,061	0,075	0,018	0,002	0,018	0,050	0,021	0,164	0,008	0,015	12,062	87,938
T	T000	0	12,808	0,717	0,363	0,044	0,282	0,002	0,055	0,063	0,101	0,113	0,002	0,057	14,607	85,393
	T050	0,2	11,991	0,693	0,409	0,09	0,066	0,023	0,007	0,015	0,017	0,099	0,018	0,002	13,430	86,570
	T100	0,4	11,133	0,702	0,402	0,099	0,062	0,019	0,006	0,014	0,017	0,103	0,019	0,025	12,601	87,399
	T150	0,6	11,343	0,740	0,387	0,097	0,061	0,025	0,006	0,015	0,015	0,099	0,018	0,025	12,831	87,169
	T200	0,8	11,243	0,708	0,284	0,449	0,207	0,003	0,023	0,059	0,023	0,251	0,009	0,002	13,261	86,739
	T250	1	12,207	0,761	0,404	0,089	0,071	0,014	0,007	0,014	0,018	0,099	0,019	0,026	13,729	86,271
P	P000	0	12,811	0,716	0,366	0,040	0,284	0,002	0,055	0,063	0,101	0,113	0,002	0,057	14,610	85,390
	P050	0,2	11,390	0,705	1,786	0,039	0,200	0,004	0,019	0,057	0,023	0,242	0,009	0,019	14,493	85,507
	P100	0,4	09,774	0,671	2,638	0,068	0,189	0,007	0,018	0,060	0,045	0,222	0,008	0,019	13,719	86,281
	P150	0,6	10,824	0,705	2,196	0,063	0,204	0,010	0,021	0,015	0,016	0,200	0,015	0,020	14,289	85,711
	P200	0,8	10,927	0,732	2,123	0,063	0,245	0,017	0,004	0,014	0,007	0,157	0,016	0,002	14,307	85,693
	P250	1	10,501	0,685	2,747	0,073	0,205	0,003	0,017	0,048	0,019	0,244	0,008	0,027	14,577	85,423
S	S000	0	12,822	0,715	0,365	0,043	0,275	0,002	0,055	0,063	0,101	0,113	0,002	0,057	14,613	85,387
	S050	0,2	10,044	0,529	0,031	0,252	0,027	0,001	0,003	0,012	0,004	0,017	0,012	0,013	10,945	89,055
	S100	0,4	08,641	0,358	0,009	0,355	0,014	0,002	0,025	0,011	0,003	0,030	0,008	0,022	09,478	90,522
	S150	0,6	09,469	0,423	0,030	0,292	0,018	0,001	0,030	0,013	0,004	0,028	0,012	0,017	10,337	89,663
	S200	0,8	09,652	0,347	0,009	0,254	0,014	0,002	0,002	0,011	0,003	0,017	0,008	0,023	10,342	89,658
	S250	1	10,630	0,318	0,030	0,389	0,015	0,002	0,020	0,016	0,001	0,019	0,010	0,017	11,467	88,533

3.3 PRESENTATION AND DISCUSSION OF RESULTS OF SPECTROMETRIC ANALYSIS OF RECOVERED ALUMINIUM ALLOYS GOTTEN ACCORDING TO THE METHOD OF REFINING THE MOLTEN SALT ADDED IN THE METAL VESSEL

Table 3 represents contents for which every refining element is given for maximum reduction of impurities and an increase in the degree of purity in a population of 150 specimens of recovered aluminium alloys purified by molten salt addition.

A comparison of spectrometric analysis results done on samples, with excerpts of the French Standard NFA50-105 [11], has been made and slots in gray are those of which contents of allied elements are more than the recommended values. Furthermore, addition of the contents of Fe+Si elements whose values are greater than the recommended ones according to the standard for all tested samples, those of the other elements namely copper (20 out of 30 samples), magnesium (15 out of 30 samples), zinc (22 out of 30 samples) are superior to the Standard. The high content of manganese is observed in samples (16 out of 30 samples). Nevertheless, the behavior of copper in alloys depends on the different methods of refining. Indeed, the refining CHs and $(C_2H_3Cl)_n$ increases the content of copper alloy after refining as compared to the non refined alloy . The MnO_2 enables the copper content of the alloys to remain almost unaltered. And at the end NH_4Cl and NaCl give the aluminium alloys a copper content that decreases greatly after refining and permits them to respect the norm. On the whole, contents in Sn, Cr, Ti, Ni, Pb and Ga are distinctly lower than the values of the norm. The refining with NaCl is favours a big increase of the Mg content, to the detriment of the other elements of which contents after refining with NaCl are lower than the norm, except Fe+Si. It is also observed that there are less additive elements in excess when NaCl is used in refining. The metallurgic characteristics (table 3) of the refining of recovered aluminium alloys by the molten salt addition shows that refining with NaCl is the most efficient because of its lowest rate of impurities (9.478%) and a reduction in relative value of -54.178%. It enables the best purification (90.522%) of aluminium gotten from a non refined aluminium alloy (85.387%) to be done; thus an increase in purity index; indicated by the relative value (5.673%). Data of the refining of the metal vessel NaCl is as the values of as the reference values for comparison with the other techniques of refining [3].

4 GENERAL COMPARISON OF THE OPTIMAL METALLURGICAL CHARACTERISTIC OF RECOVERED ALUMINIUM ALLOYS GOTTEN FROM DIFFERENT PROCESSES OF REFINING STUDIED

By comparing of results gotten from the different processes of purification of recovered aluminium alloys studied, the performance of the refining method with NaCl has been investigated and lies (Fig. 1) between that of the industrial purification by dissolution in a noble metal solvent (DS) which is more efficient, and the one of the traditional refining with $(C_2H_3Cl)_n$ whose values are not good enough. It would be necessary for a more reliable use of refining of aluminium alloys with NaCl(S100) at the industrial scale, to consider less use of resources in relation to the industrial refinement by DS, however enormous efforts are to be made extensively in relation to alloys of traditional refining as it is limited in efficiency .

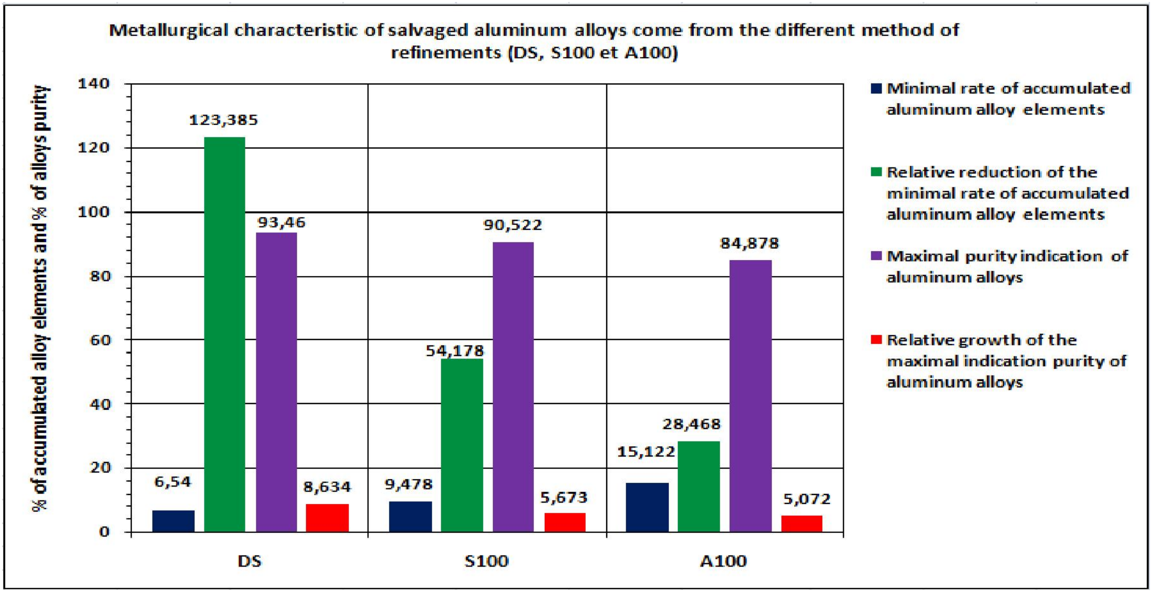

Fig. 1. Metallurgic characteristic according to refining techniques (DS, S100 et A100)

5 CONCLUSIONS AND PERSPECTIVES

Among all the molten salt refining methods proposed, the refining with NaCl gives the lowest global rate of additive elements (9.478%), with the best purity index (90.522%) for aluminium gotten from a non refined alloy initially at 85.387% of aluminium and makes it more suitable to minimize the poisonous effects of alloys tested, for health and to reduce risks of environmental pollution. In addition to the satisfactory result, due to the inconsistency of the gas proportion given out during combustion and fusion, it has proven in addition to be the best alternative in relation to the industrial processes of refining, inaccessible and thus difficult to put place, implying the more energy costs and very high investment cost for a production in small scale.

With the detection of the effective presence of poisonous heavy metals, tests of change of state shall be considered in the future, to deduct in order to foresee the degree of their harmfulness and to contribute to the standardisation of the recovery process and the recycling of aluminium in Cameroon as well as in other countries of sub-Saharan Africa.

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