CHARACTERIZATION OF PRE-ALLOY FOR THE PRODUCTION OF ALLOYS AL-NI

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Abstract *Aluminum alloys have a wide applicability, especially in the automotive, aeronautical, naval, military and civil construction, because their properties acquired in accordance with each element added to aluminum and its low density, but most have a low mechanical strength. One solution for this problem is the addition of a second phase in the material, which according to the rule of mixture by combining several elements there are new properties. The Al-Ni alloy has a low density, high mechanical strength, corrosion resistance and in some cases has mechanical strength at increasing temperatures. The products manufactured from Al-Ni alloy are brittle and unsuitable for structural applications, today many scientists and engineers seeking a solution to combine high strength with low density from the combination of aluminum with nickel. The alloys are obtained by the solidification process, ie, the liquid metal is poured into an ingot which is cooled and thus solidified. Nickel is a chemical element that has a high melting point, higher than that of aluminum, just to obtain Al-Ni alloys, it requires that there be a pre-alloy. The pre-alloy, alloy or mother has a fundamental role in the manufacturing of the Al-Ni. This difference is due to high melting point of the elements involved Al - 660 ° C and Ni-1414 ° C. Therefore, it must be prepared in advance in order to be added to the final composition, otherwise there will be the solubility of Ni in increasing aluminum intermetallic compounds which are inherent in its manufacture. This study aims to characterize pre-Al-Ni alloys with the aim of discovering the percentages of each constituent, essential for the production of alloys of this system.*

Keywords*:* *Solidification, characterization, pre-alloy, Al-Ni*

1. INTRODUCTION

Aluminium is one of the most abundant metals in the Amazon region mainly for its industrial hub located in Barcarena. This metal has a range of applications in various industry sectors by being a light metal, having a good electrical conductivity, be resistant to corrosion and a has a low melting point.

Another metal of great importance among the sectors in the Nickel, being an excellent conductor of electricity and heat, being ductile, malleable and has a character ferromagnetic. Can be used in steel manufacturing, the production of nickel base superalloys or even more in the manufacture of metal alloys and other types of materials.

In the manufacture of nickel alloys can be used along with the aluminum resulting in a alloy with excellent properties. Aluminum has good corrosion resistance due the possibility of passivation in air or immersion in solution (Wang et al. 1998), while nickel is used mainly improvement mechanical strength at high temperatures corrosion resistance and other properties, for a wide range of ferrous and nonferrous (Costa, 2008). Other properties that stand out are: electrical and thermal properties (Gonzales et al. 2008).

Alloys Al-Ni when combined form intermetallic compounds, which are characterized due to its down density, good mechanical strength, high resistance to oxidation, but the disadvantage of these compounds to provide a down ductility material when subjected to down temperatures. Because of this these alloys are much used mainly in automotive and aerospace.

The metal alloys are made through the solidification process where two or more metal materials are fused, and the solute and the other one solvent are mixed and poured into an ingot which is coupled to a device and cooled, giving rise to an ingot. The study of solidification of metals and alloys in metal/mold systems aims to find ways to combine the best features you want, and at the same time, prevent the occurrence of defects during the solidification process (Costa, 2008).

When making an alloy of the item point fusion is extremely important, because of a discrepancy melting point among metals can result in serious problems in the alloy. The Al-Ni alloy, for example, where the elements involved in Al-Ni and 933,15 K – 1687,15 K have points different melting in the alloy is made with the conventional method is not solubilized in nickel increasing aluminum intermetallic compounds that are inherent in its manufacture. Therefore, for such a fact solutions is the manufacturing of pre-alloys, or mother alloy, is prepared in advance in order to be added to final composition.

Ways to assess the quality of materials microscopically to assess whether any failure techniques in manufacturing that can be seen with the naked eye are techniques for characterization of these materials. Soon, this work was carried out techniques characterization of the alloy, by means of microscopy Scanning Electron (SEM) and Atomic Absorption in production of AL-Ni alloys, in order to assess whether the preparation of pre-alloys is the most viable means to reach the manufacture of alloys Al-Ni.

2. MATERIALS AND METHODS

2.1. Fabrication of pre-alloy

The nickel and aluminum were weighed on a precision balance for a total of 0,04 Kg and 0,1 Kg respectively. Then the moisture was removed from the crucible in an electric oven BRASIMET, fig. 1, at a temperature of 373,15 K remained so far an hour, then increased the temperature to 473,15 K staying another hour and finally increased it the temperature to 273,15 K. This moisture has been removed in order prevent cracks due to sudden expansion of water in the crucible.

Figure 1.Electric muffle furnace

Then nickel was melted with a blowtorch and added to molten aluminum so that the first could be solubilized in the aluminum matrix (solvent) to form the pre-alloy.

2.2. Pre-alloy characterization

The pre-alloy was characterized by scanning electron microscopy (SEM) and atomic absorption model simultaraneans Vista Pro CCD ICP-OES Varian Brand, fig. 2.

Figure 2. Emission spectrometer simultaneous inductively coupled plasma

3. RESULTS AND DISCUSSION

The tab. 1 below presents the estimated percentage of nickel present in the pre-alloy. We made 7 sample pre-alloy resulting in a total mass of 0,05706 Kg of nickel obtained a total mass of all pre-alloy 1,035 Kg with a percentage of nickel 0,055371%. Therefore, the percentage of nickel in the alloy, corresponding to 5, 54%.

Table 1. Calculation of percentage of nickel in the pre-alloy

Sample	**Mass of nickel (Kg)**	**Mass of pre-alloy**	**% of nickel**
1	0,00412	1,035 Kg	0,055371
2	0,00533		
3	0,00418		
3	0,0043		
4	0,00629		
5	0,00484		
6	0,004		
7	0,024		
Total	0,05706	5,54% of Nickel	

In fig. 3 obtained by scanning electron microscopy (SEM) were analyzed six random points that show the presence of intermetallic compounds of Ag and Ni, which is not solubilized in the aluminum matrix. Taking into consideration that the sample did not suffer the metallographic preparation (sanding polishing and chemical attack).

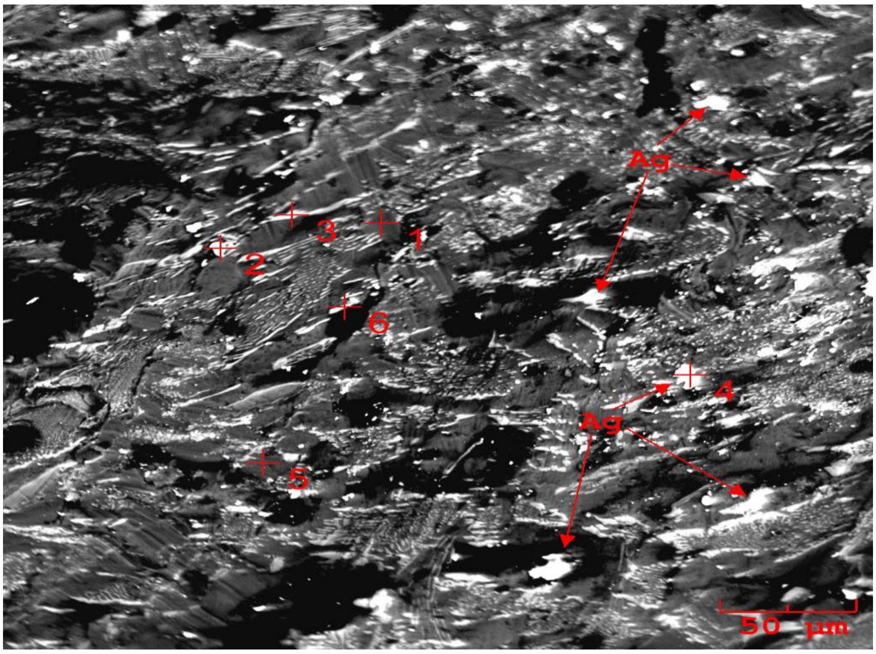

Figure 3. Image obtained by SEM

The presence of residual elements such as Cr, Co, Fe, Ag and Si, wich contribute to the formation of a third phase is not dissolved can be explained on the base of Al-Ni diagram that shows the difficulty of working the alloy, because the higher percentage of nickel is more conductive to the emergence of these compounds, so the alloy is usually crafted in percentages similar to to 7% nickel, or near the eutectic point. The figure 4 and 5 are diagrams of phase equilibrium of binary Al-Ni, respectively complete and partial.

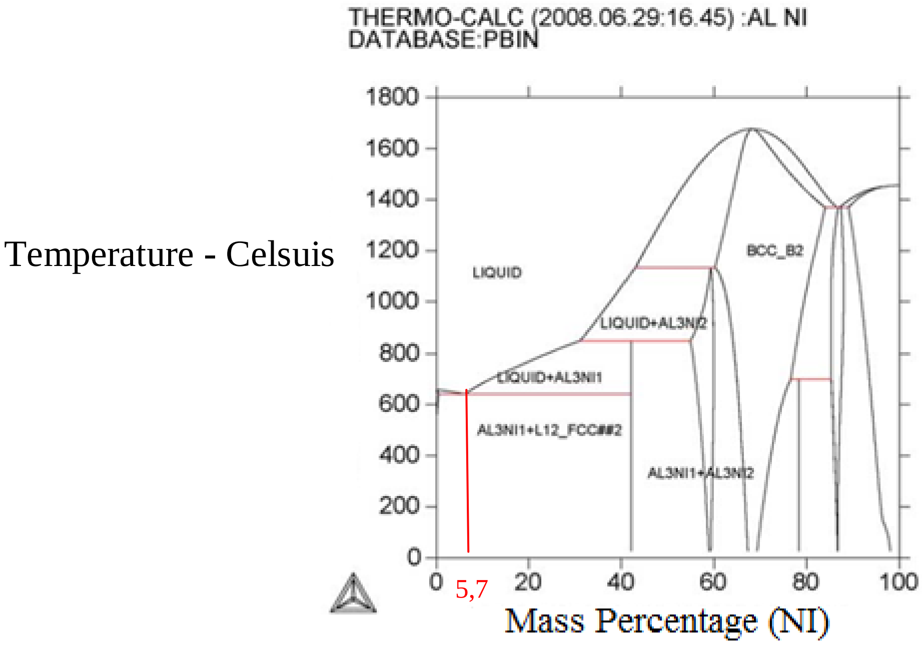

Figure 4. Equilibrium diagram of Al-Ni system (Thermo-Calc). Cante, 2009.

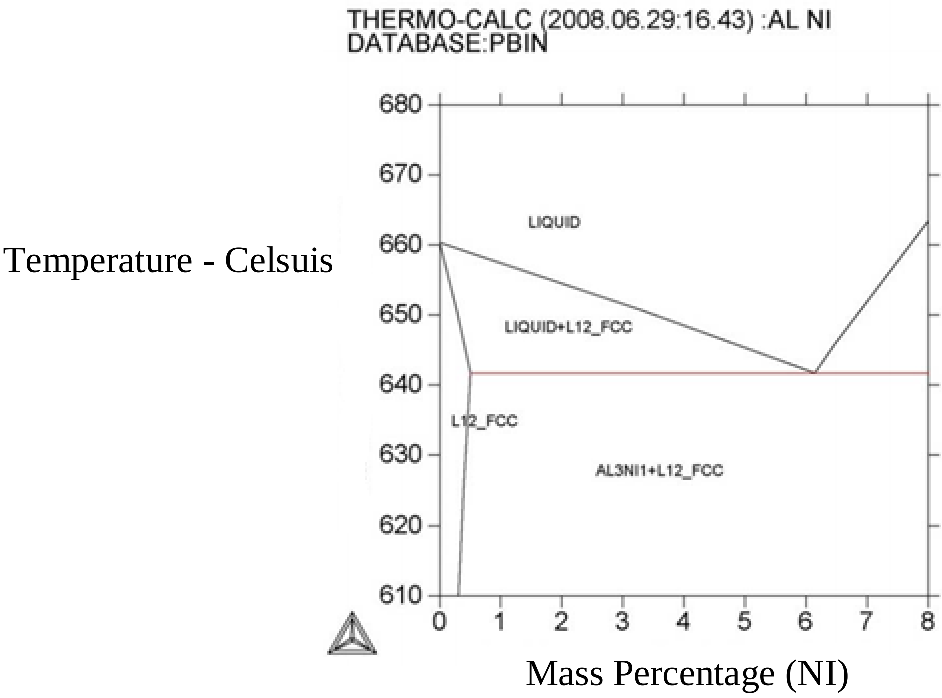

Figure 5. Partial equilibrium diagram Al-Ni system (Thermo-Calc) Cante, 2009.

3.1. Analyze of marked points on SEM

At points +1, +5 and +6 there is a large amount of aluminum and other elements that despite residual tend to accumulate in grain boundaries weaken the material already in the +2 and +4 points is observed a relatively high amount of silver in relation to the amount of aluminum, while the +3 point we find a high percentage of aluminum with a small amount of residual elements. Therefor, it can be concluded that this point was a satisfactory homogenization.

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
Al	Ka	4319,380	98,287	Wt.%	0,423
Cr	Ka	4,230	0,293	Wt.%	0,040
Fe	Ka	1,600	0,149	Wt.%	0,033
Co	Ka	1,070	0,121	Wt.%	0,033
Ni	Ka	2,390	0,315	Wt.%	0,058
Ag	La	5,080	0,836	Wt.%	0,105
TOTAL		4319,380	100,000	Wt.%	

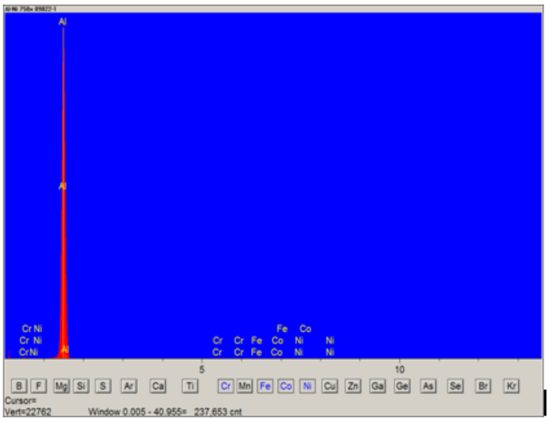

Figure 6. Semiquantitative analysis obtained at the point +1

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
Al	Ka	231,060	8,276	Wt.%	0,154
Cr	Ka	3,720	0,212	Wt.%	0,031
Fe	Ka	4,580	0,323	Wt.%	0,043
Co	Ka	1,330	0,110	Wt.%	0,027
Ni	Ka	9,280	0,875	Wt.%	0,081
Ag	La	927,230	90,203	Wt.%	0,838
TOTAL			100,000	Wt.%	

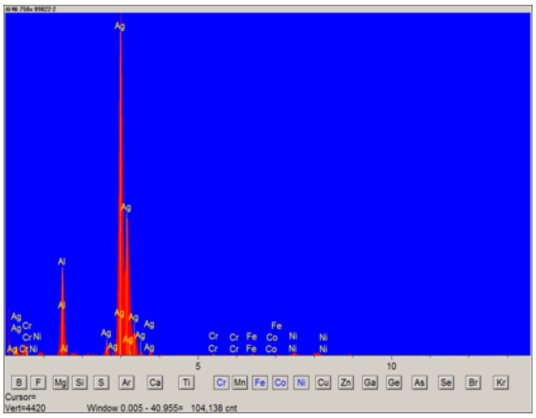

Figure 7. Analysis semiquantitative obtained at the pont +2

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
Al	Ka	1478,120	66,114	Wt.%	0,486
Cr	Ka	4,120	0,289	Wt.%	0,040
Fe	Ka	16,320	1,461	Wt.%	0,102
Co	Ka	0,810	0,096	Wt.%	0,030
Ni	Ka	222,460	31,604	Wt.%	0,599
Ag	La	2,630	0,436	Wt.%	0,076
TOTAL			100,000	Wt.%	

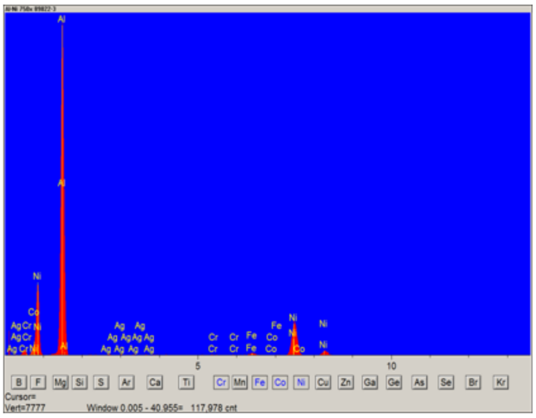

Figure 8. Analysis semiquantitative obtained at the pont +3.

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
O	Ka	74,310	4,643	Wt.%	0,152
Al	Ka	314,970	13,805	Wt.%	0,220
Si	Ka	66,370	2,897	Wt.%	0,101
Cr	Ka	9,790	0,704	Wt.%	0,064
Fe	Ka	32,100	2,908	Wt.%	0,145
Co	Ka	1,880	0,201	Wt.%	0,041
Ni	Ka	4,930	0,606	Wt.%	0,077
Ag	La	582,790	74,236	Wt.%	0,870
Totaç			100,000	Wt.%	

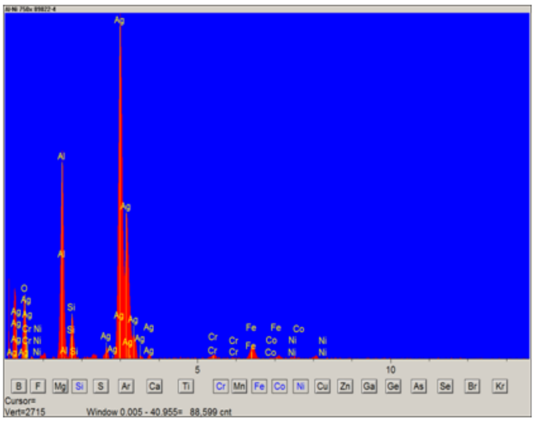

Figure 9. Analyse semiquantitative obtained at the pont +4.

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
Al	Ka	4231,280	98,013	Wt.%	0,426
Cr	Ka	5,270	0,371	Wt.%	0,046
Fe	Ka	1,640	0,155	Wt.%	0,034
Co	Ka	0,170	0,020	Wt.%	0,014
Ni	Ka	1,390	0,187	Wt.%	0,045
Ag	La	7,500	1,253	Wt.%	0,129
TOTAL			100,000	Wt.%	

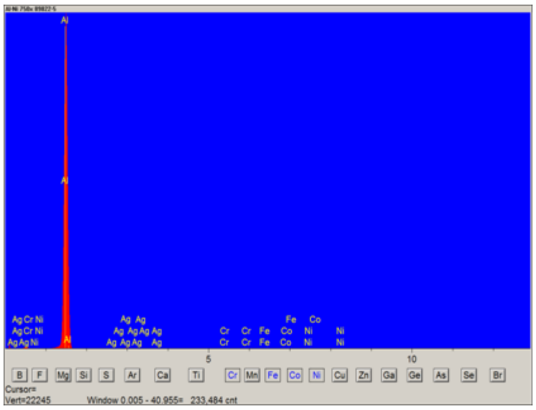

Figure 10. Analyse semiquantitative obtained at the pont +5.

Elt.	Line	Intensity (c/s)	Conc.	Units	Error 2-sig
Al	Ka	1296,040	64,525	Wt.%	0,507
Cr	Ka	1,560	0,118	Wt.%	0,027
Fe	Ka	5,000	0,478	Wt.%	0,060
Co	Ka	1,910	0,245	Wt.%	0,050
Ni	Ka	222,770	34,218	Wt.%	0,648
Ag	La	2,320	0,416	Wt.%	0,077
TOTAL			100,000	Wt.%	

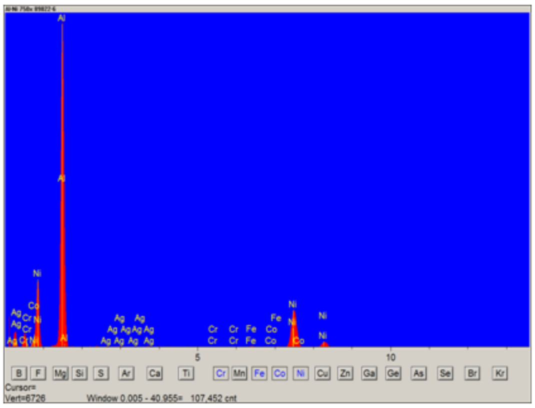

Figure 11. Analyse semiquantitative obtained at the pont +6.

3.2.Analysis of atomic absorption

In tab. 2 below observed the chemical analysis done by atomic absorption, where we note the presence of elements as cobalt, chromium and manganese, presenting itself as impurities or trace amounts of alloying elements. Already the nickel is presented with levels of agreement with the expected second the calculation of mass precedent it's foundry.

Table 2 - Results of atomic absorption analysis of the pre-alloy.

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	Sample mass	Co (228, 615 Kg/m^3)	Cr (205, 560 Kg/m^3)	Mn (259, 372 Kg/m^3)	Ni (221, 648 Kg/m^3)
Sample 1	0, 101 . 10^{-3} Kg	0, 136669	2, 543786	1, 25202	4, 604205
Sample 2	0, 1003 . 10^{-3} Kg	0, 121185	2, 822998	1, 42067	5, 272233
Sample 3	0, 1013 . 10^{-3} Kg	0, 142206	2, 889784	1, 40669	5, 261469
Mean	0, 1008 . 10^{-3} Kg	0, 133353	2, 752189	1, 35979	5, 045969

4.CONCLUSIONS

According to the analysis of the characterization performed, we conclude that the pre-alloy has undergone some contamination during the process of obtaining the same levels with undesirable elements relatively considerable. According to the SEM analysis it was found that the pre-alloy has not showed a good homogenization, because the element nickel didn't suffer in relation to total dissolved aluminum matrix, as well as the appearance of intermetallic compounds. Therefore, we conclude that this method is not the most effective for obtaining the Al-Ni alloys.

5. REFERENCES

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