Metallographic analysis of the 7G-Tronic automatic gearbox housing

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***Abstract*—**The paper consists on the metallographic analysis of the 7G Tronic automatic gearbox material housing in order to establish the materials that are included in the housing and their percentage. This helps to improve the housing characteristics and also the molding process and its advantages and disadvantages.

***Keywords*—**automatic gearbox, 7G Tronic, Magnesium, analysis, diffraction.

I. INTRODUCTION

BECAUSE of the high temperatures in some areas of the automatic gearbox 7G Tronic observed with the thermographic method in which are found the main brakes and couplings, it is recommended that the optimization of the shape of the housing to be made by adding cooling ribs and optimizing the chemical structure of the housing material. This ribs can achieve more efficient cooling in areas where located, because of their geometry, during the running of the vehicle. To identify the metallographic structure of the material and any material failures, we'll use two chemical structural analysis methods (X-ray diffraction and X-ray scanning electron microscopy).

To carry out these studies were collected samples of material from three different areas of the 7 g-Tronic automatic gearbox fig (1):

• area 1-highlighted with red color (corresponding to the portion of the converter and the gearbox, formerly upper area);

• area 2-highlighted with blue color (median-posterior portion corresponding to the gearbox, gross Kevlar coupling);

• area 3-highlighted with green (belonging to the inferior portion of the 7 g-Tronic gearbox, hydraulic control block).

These samples consist of pieces of wool board sized 5 mm long and 2 mm thick.

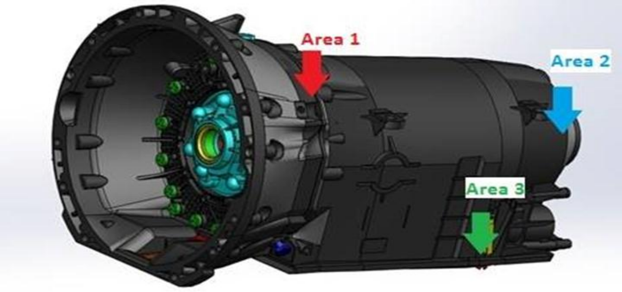

Fig 1. Sample areas

II. COMPOSITION ANALYSIS AND MOLDING PROCESS

Due to the reason of reducing the total weight of the car, the gearbox housing 7G Tronic (722.9) is made of magnesium. Magnesium has the lowest specific weight (1750 kg / m³) of all materials used in automotive production. Hence the most applications in aeronautics, space, textiles, cars, fine mechanics, etc.

According to the literature specifications magnesium structure is hexagonal compact .

Due to material of automatic gearbox housing obtained from an alloy in which magnesium has the highest percentage with about 96%, aluminum about 3% and silicon and manganese together with 1%, it follows that the enclosure has been obtained by the pressure molding method.

The main technical characteristics of the automatic gearbox housing:

The alloys of aluminum-magnesium belong to the group of superlight alloys; they have good mechanical strength, have better the cutting properties, good polishing properties to obtaining a very clean surface after anodization, and have a very good corrosion resistance. Increased production of such alloys casting is difficult due to their poor casting properties, including: low flow, high oxidation tendency to cast development and high tendency to form shrinkage, air bubbles and cracks.

Figure Equilibrium diagram of an Aluminum-Magnesium alloy

Increasing the mechanical properties of the magnesium increases the capacity of polishing and the corrosion resistance in sea water or weak alkaline solutions, on the other hand welding properties and plasticity decrease.

At ambient temperature the magnesium does not have only three sliding systems, and therefore the ductility is relatively low. Also the mechanical strength is not at significant values. [9].

Non-ferrous alloys may also contain besides the base metal and the alloying elements, a certain amount of undesirable components called impurities (which may be metallic, non-metallic, gas). These impurities decrease the values of the physical, chemical, mechanical and technological properties of ferrous alloys.

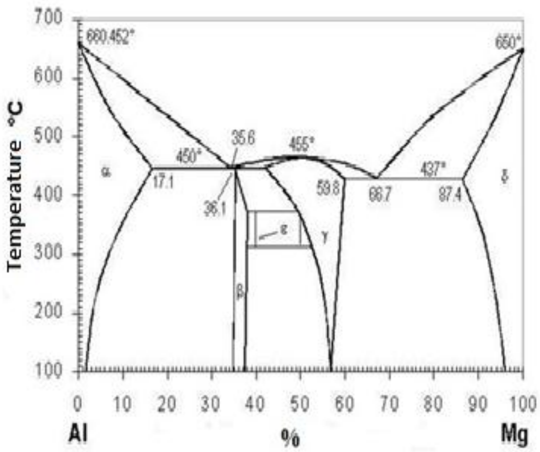

Fig. 2. Equilibrium diagram of an Aluminum-Magnesium alloy

After processing technologies ferrous alloys can be divided into:

- foundry alloys
- wrought alloys

In the automotive industry there are mostly used to lightweight alloys (aluminum, magnesium).

Aluminium-magnesium alloys are distinguished by a specific weight lesser than other aluminum alloys, very good corrosion resistance in various environments, considerable strength and ability to be polished.

Magnesium has the lowest density of all metals used in the construction of cars, but their strength and plasticity are reduced. Therefore used exclusively as alloys (ultra light - ρ <2 g / ml) for foundry or deformable (laminated), which, however, are generally somewhat lower than those of Aluminum, both in terms of mechanical strength and behavior of corrosion.

The major alloying elements are magnesium Aluminum (3-9%), Zinc (0.5-3%) Mangan (up to 1.5%), the first one improving molding properties and the last, particular resistance to corrosion. Higher contents of Aluminum (7-10%) result in a eutectic, thereby improving molding.

Cast Magnesium alloys are widely used in aircraft industry (propeller, landing gear) for other lightweight construction, pumps, optical and electronic devices, etc.

When magnesium is allied with aluminum, as aluminum increases its mechanical strength increases, and when allied with manganese, corrosion resistance in moist air increases.

Magnesium alloys that contain about 90% Mg and the rest small amounts of other metals such as aluminum, zinc, copper, manganese, etc., are known as electron alloys. They are resistant to acids and to alkaline hydroxides but not to water (which they decompose). With high hardness and strength and a low density, they are used in the manufacture of aircraft, automotive, industrial machinery and manufacturing of various instruments.

III. Structural analysis by x-ray diffraction

To start with, we achieved diffraction spectra of x-rays in order to be able to notice any difference between the three areas. In Fig (3) are presented X-ray diffraction spectra for three samples.

X-ray diffraction is a nondestructive technique that allows obtaining precise information about the chemical composition and crystalline structure of natural and synthetic materials.

The basic principle of this method is to study the link between the scattering of X-ray and the layout space of the atoms.

X-ray diffraction is a structural analysis method currently used in studying the crystalline structure of mono- or polycrystals, in phase identification and quantitative phase analysis, in phase transformations, and in order to determine the parameters of the network, the internal tensions, or the dimensions of semi-processed [3; 9; 10].

To describe 7G-Tronic's housing material analysis it is being used the X Pert Pro MPD ' (Panalytical), that is a X-ray diffractometer with X-ray tube, with copper anode having the wavelength λ = 0,154 nm. For all the samples the 2θ angle = 10°-70°, the pitch is 0.131 seconds, and a random time of 60 min. Spectra have been interpreted and analyzed with Pert Plus Highscore X ' due to the active database.

Structural analysis of 7G-Tronic automatic gearbox casing is represented in fig (4) and fig (5) by highlighting the characteristic spectra of key chemical elements, especially through the length spectrum, Magnesium (Mg), Aluminum (Al), Silicon (Si), Manganese (Mn).

Fig 3. X-ray stress measurements at (RX) Pro MPD Panalytical

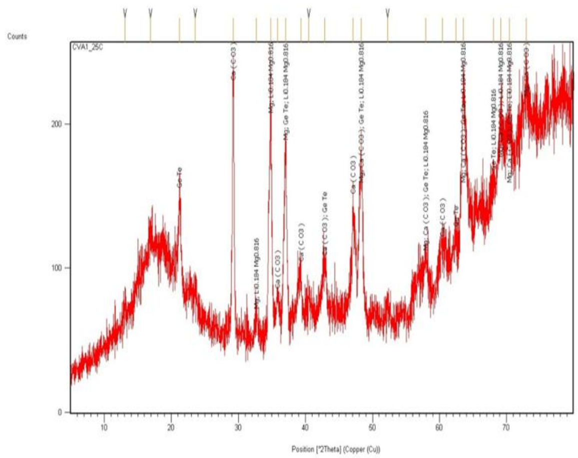

Fig 4. Analysis of diffraction spectra characteristic of the material

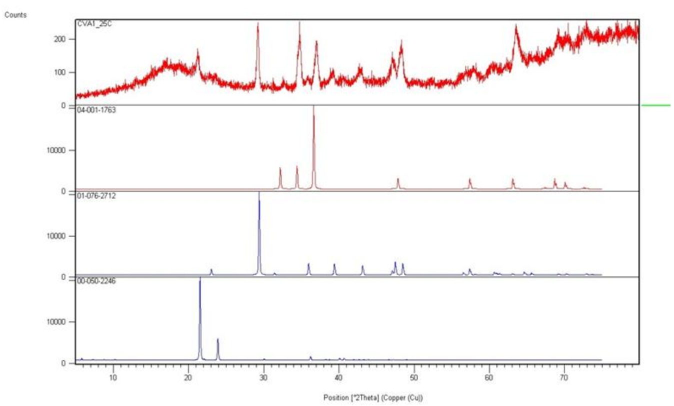

Fig 5 . Analysis of x-ray diffraction of major chemical elements (EDAX)

From the spectra of x-ray diffraction is observed no difference among the three areas, which shows that the homogeneity of the material is the same over the whole surface of the gearbox.

IV. Structural Analysis by scanning electron microscopy

Scanning electronic microscopes are used to study the surface ultra-morphology with the help of secondary electrons or reluctant. This type of microscope enables the examination of materials with a thickness ranging between 1 mm and cm have stayed with irregular surfaces, providing three-dimensional images of objects. Image formation is carried out with the help of secondary electrons or refracted arising from the bombing of the primary electron beam.

Electron beam produced by electron gun is reduced to the Max through two or three electromagnetic lenses thus aiming to achieve an extremely narrow beam with a diameter less than 100 Å, which is designed on the sample. With the help of two deflexiune coils, placed inside the last activated by electromagnetic lenses a current streak of primary electron beam, such focus is determined to make a zig-zag move over the sample, thus a sweep of the area.

An electron microscope with scanning (SEM) has a direction of inlet light similar to that of an optical microscope. The resolution of an optical system is defined as the minimum distance between two objects that produce images separable and is expressed by the relation:

$$d = \frac{0.61\lambda}{n\,sin\theta} \qquad (1)$$

where:

λ-the wavelength of light, emission wavelength, in the case of fluorescence

θ- angular semi-aperture of the optical system's lens

n –the index of refraction of the media surrounding the radiating points.

So, as the wavelength of the radiation is less, the resolution is better. In the case of optical microscopy, where it is considered a light wavelength of 200 nm, to obtain a resolution of approximately 2000 Å. in the case of electrons accelerated by a potential difference V, the wavelength of the associated radiations is given by the relations:

$$\lambda = h/[meV\left(1 + \frac{eV}{2mc^2}\right)]^{\frac{1}{2}} \qquad (2)$$

Where: h-Planck

m-mass of the electron

e- the electron charge

c-light speed

V- acceleration voltage

At the usual acceleration voltages in electron microscopy there are obtained smaller wavelengths of approximately 104-105 times than the wavelength of light. Therefore, resolution of electronic microscopes is clearly superior to the optical ones, on the order of a few Angstrom the most fine-tuned tools [2; 5; 7; 11].

Characterization of the automatic gearbox housing structure was achieved by means of an electronic microscope streak-Inspect (FEI Company) with EDAX (dissipated energy spectrometer x-rays). Inspect Fig (6) is a scanning electron microscope with easy to use, able to generate and collect all information available from any type of material.

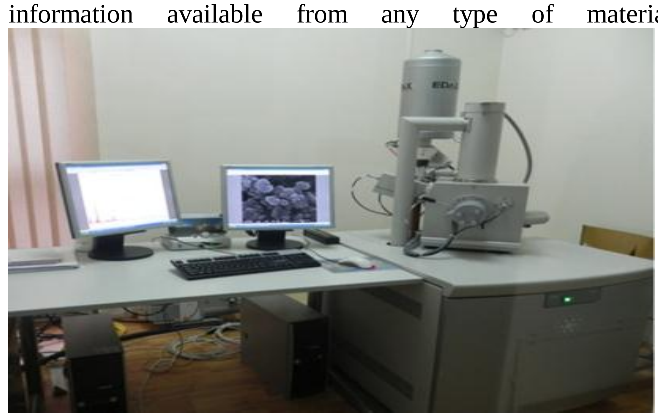

Fig 6 . Electron microscope (SEM) streak-Inspect (FEI Company) + EDAX

Scanning electron microscope is used for qualitative analysis (Imaging) and quantitative (EDAX).

This shows that manufacturing processes (casting) were conducted with a very high precision and perseverance.

Also this analysis regards the structural aspect of the housing material excluding some chemical elements that appear in the diffraction but have a very low amount of quantity and percentage therefore are excluded from the beginning of the final and exact analysis.

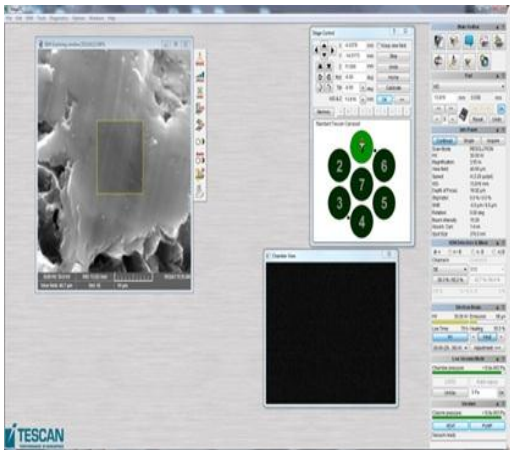

Fig 6. (a)

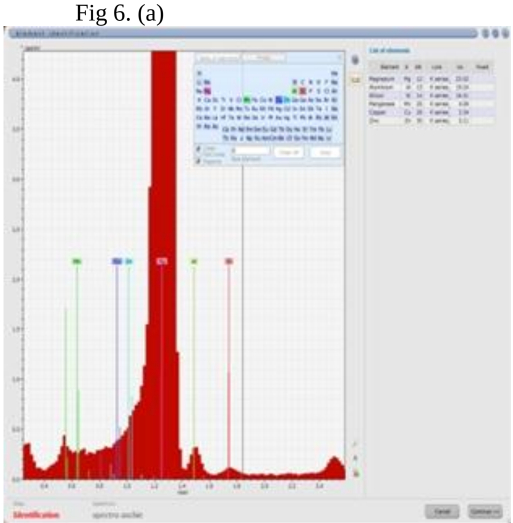

Fig 7. (b)

Screenshot taken following the inspection of samples with scanning electron microscopy qualitative Fig 7 (a) and quantitative (EDAX) Fig 7 (b)

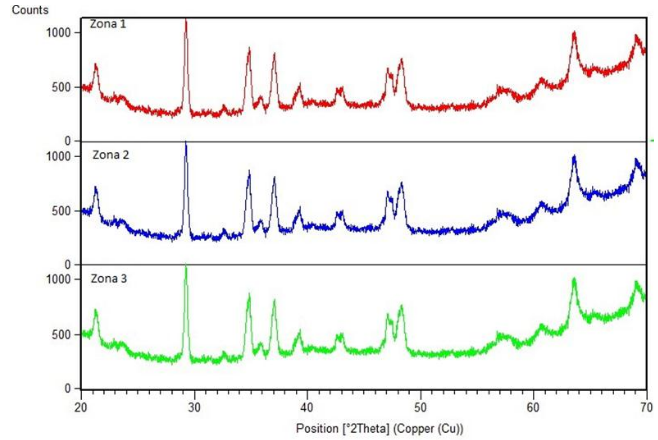

Fig. 8. The spectrum of x-ray diffraction samples: a) area1, b) area 2, c) area 3

Due to the fact that during operation of the vehicle, one of the parts subjected to tension and major thermal fluctuations is the gearbox, due in particular to oil that has direct contact with the material as well as other external and internal factors is good to achieve thermal stability perspectives.[1; 3; 4; 6; 14]

For this study were taken from zone 1 more test pieces (pieces of-wool Board) which have undergone a heat treatment annealing temperature of 100 ° C and up to a temperature of 500 ° c. The samples were heated with 10 ° C\/min, after which they were kept for three hours at the desired temperature. Sample cooling was naturally up to room temperature.

Of the spectrum of x-ray diffraction Fig(9) and Fig (10)observes specific diffraction Maxima mg O2 per compounds identified in the database with the number 01-076-1363, Al2O3 identified in the database with the number 00-001-1305, Mg identified in the database with the number 00-001-1148. He obtained a mixture of Aluminium and magnesium (AlMg) identified in the database with the number 00-011-0571.

The chemical structure of the gearbox casing:

Normal temperature 25 °

c: a Mg-96,67%,-2.40%, And-0.66%, Mn-0.23%

• Temperature 200 °

c: a Mg-83,92% 12,16% O-, Al-3,93%

• Temperature 400 °

c: a Mg-45,74% O-, Al-28,66% 25.6%

• Temperature 500 °

c: a Mg-43,44% 55,27% O-,-0.75%, And-0.54%

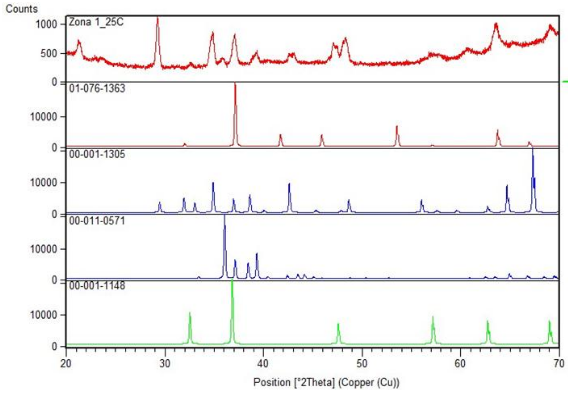

Fig 9 The spectra of x-ray diffraction for zone 1 achieved at room temperature

As shown in Figure 10 It can be seen that in the application of annealing heat treatment at different temperatures is observed the formation of other compounds that affect both the thermal stability as well as the composition of the material. Diffraction Maxima are the same for all the beach temperatures (25-500 ° C).

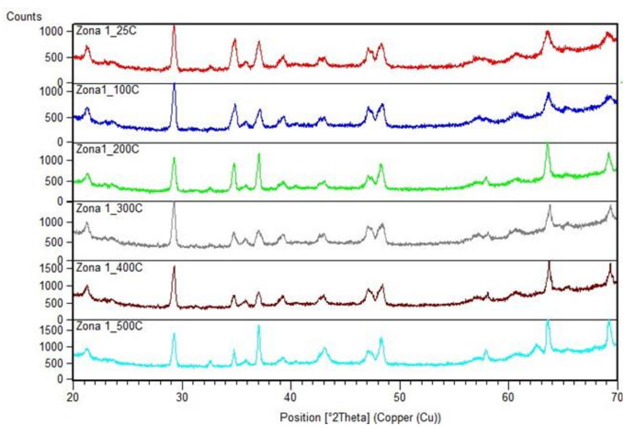

Fig 10 The spectra of x-ray diffraction for zone 1 at different annealing temperatures

In order to have a more precise confirmation of the chemical composition of the samples may have used the electronic scanning microscopy SEM and qualitative form.

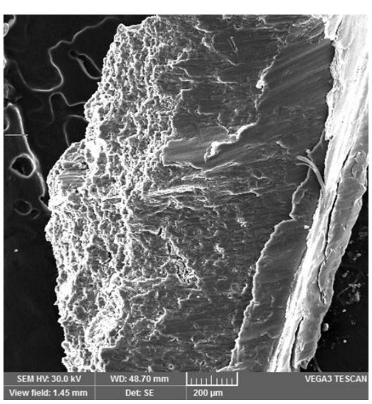

Fig 11 . SEM image of breaking the area 1 sample of housing (75X)

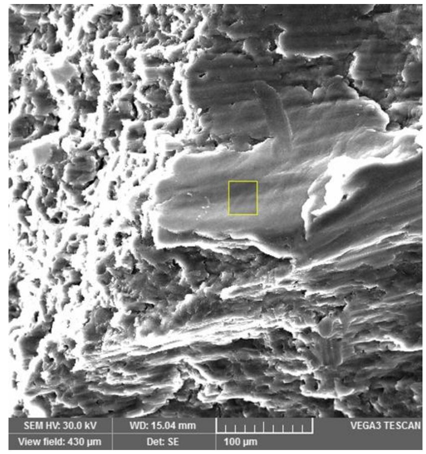

Fig 12 . SEM image of breaking the area1 sample of housing (333X)

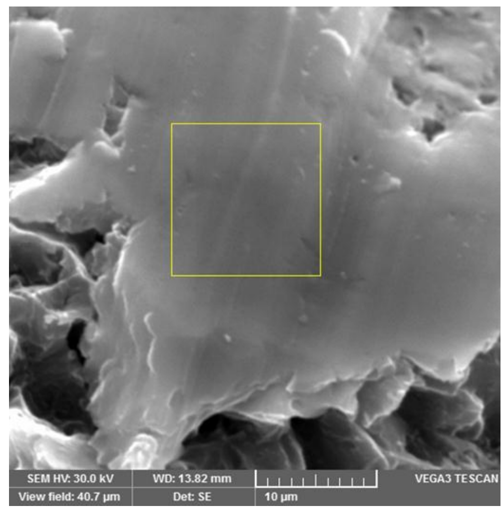

Fig 13 SEM analysis of the spectrum of materials (3300X)

SEM images of an homogenous surface without any other defects in the surface of the material, such as pores, leading to loss of mechanical and chemical properties. The same area is observed in the case of heat-treated at 200 ° c. EDAX images seen just peak caraceristice-magnesium and Aluminium.

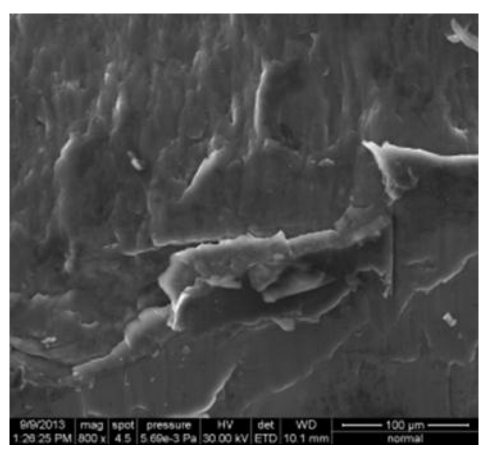

Fig 14 (a)

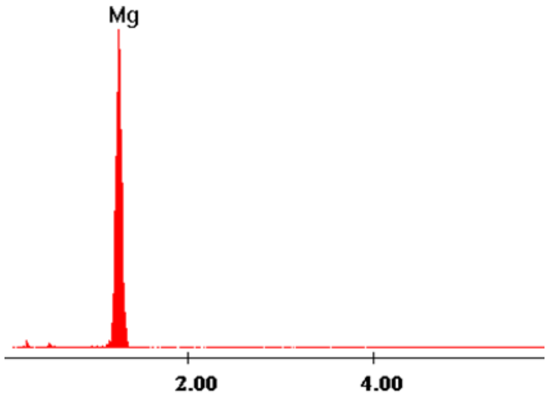

Fig 14 (b)
SEM images,Fig 14 (a) and EDAX Fig 14 (b) at room temperature

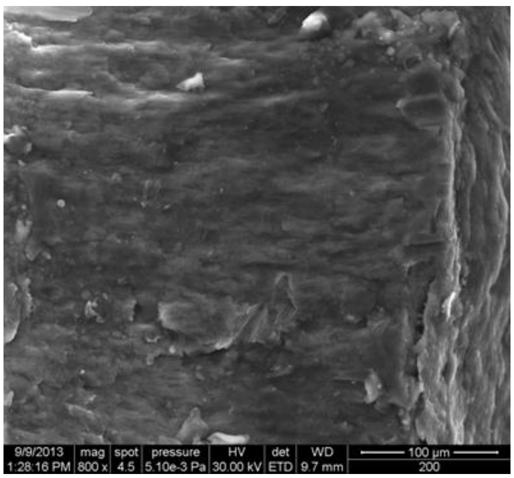

Fig 15 a

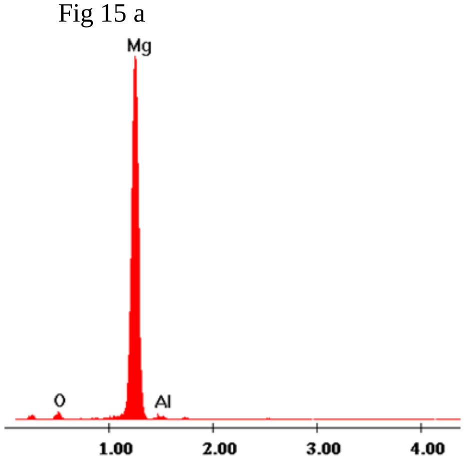

Fig 15 (b)
SEM images,Fig 15 (a) and EDAX Fig 15 (b) at a temperature of 200 ° C

Where the sample was calcined at 550 ° C, it is observed that the material's surface begin to form porous areas leading to the decomposition of materiaului and its destruction. EDAX analysis is very interesting that in addition to magnesium and aluminum materials may appear Manganese and Silicon. They were detected in x-ray difracţia with less than 1%. This can be put in the account of the fact that silicon and manganese in material composition, are amorphous and therefore could not be identified very well by x-ray diffraction.

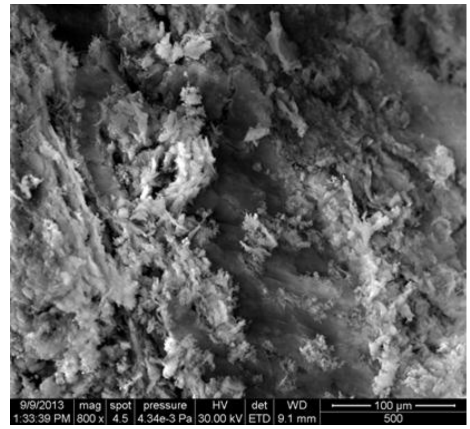

Fig 16 (a)

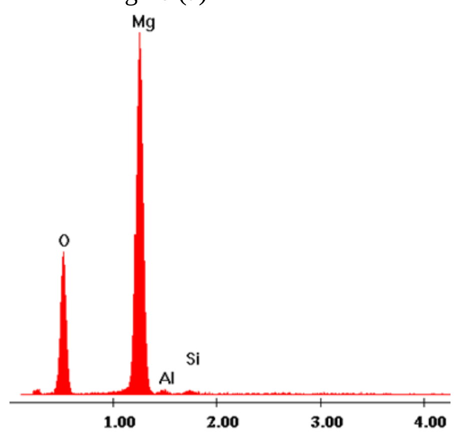

Fig 15 (b)
SEM images,Fig 16 (a) and EDAX, Fig16 (b) at a temperature of 500 ° C

In image analysis can be seen as a homogenous surface without any defects.

As a result of making qualitative and quantitative analysis of the material of the housing it is noted that this is an Al-Mg alloy that owns Mg in greater proportion of 90%, is observed at the same time a homogeneous structure in the entire housing and the maintenance of this structure and very high temperatures. From the chemical point of view, the casing can optimize by increasing aluminum composition the housing structure, which would result in improving the properties of casting, high corrosion resistance, the introduction of paramagnetic and improving properties of good thermal conductivity properties. If you increase the amount of Silicon improves corrosion resistance. A higher percentage of manganese it might get paramagnetic properties and abrasion resistance slightly higher.

IV. CONCLUSION

Conclusions can be drawn regarding the homogeneity of housing, proving that its structure retains the same chemical composition in all areas. At the same time highlights the characteristics of the material to extreme heating. As an optimization matter , it is recommended to improve the heat exchange in the high temperature zone by increasing the surface cooling ribs. For a high quality casting conditions and to improve the corrosion resistance it is recommended to possible change the chemical composition of the housing of the automatic gearbox.

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