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TRIBOLOGICAL CHARACTERISTIC STUDY OF ALUMINIUM 5220 ALLOY WITH GRAPHITE

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Abstract

Automotive sector is taking a massive turnaround in the production of vehicles using electric power only as a part of an initiative to reduce carbon emission. Since the number of automobiles are growing drastically the carbon emissions are also increasing resulting in Global Warming. There are several other Dangers in automotive industry namely Build quality which is an issue overshadowed and not properly addressed by the manufacturers. While high end cars use superior quality materials for their products other budget automobile manufactures compromise in build quality by using low quality materials as a part of the cost cutting process. This results in endangerment of lives and total destruction of the vehicles due to this trend. Our focus is to create and test the properties of a new alloy consisting of aluminium and Graphite.

Keywords: Aluminium ,Graphite ,Tensile ,XRD ,FESEM

1. Introduction

Automotive sector is taking a massive turnaround in the production of vehicles using electric power only as a part of an initiative to reduce carbon emission. Since the number of automobiles are growing drastically the carbon emissions are also increasi9ng resulting in Global Warming. There are several other Dangers in automotive industry namely Build quality which is an issue overshadowed and not properly addressed by the manufacturers. While high end cars use superior quality materials for their products other budget automobile manufactures compromise in build quality by using low quality materials as a part of the cost cutting process. This results in endangerment of lives and total destruction of the vehicles due to this trend. Our focus is to create and test the properties of a new alloy consisting of aluminium and Graphite.

Most of the high end cars use materials like carbon fibre, AL-MG alloys etc which are strong as well as light weight at the same time which plays a major role in fuel efficiency, aerodynamics, centre of gravity, weight distribution, stability etc which contributes in the better performance of the automobile. These come at a price which most people can't afford.

In the case of budget cars or family cars for the middle class manufacture use low end materials like aluminium sheet, hard plastics, soft plastics as a process of cost cutting which are brittle and easily breakable under any collision. Some manufacturers use iron and steel in their product which leads to high levels of weight gain which reduces and efficiency and engine life which also leads to high expense. Our goal is to create an alloy which is budget friendly but also has the performance of high end materials. Hence, the literature with respect to those aspects is significantly less in number. Journals that are relevant to materials used in automobiles from three different printers are taken for discussion.

II Literature survey:

This article is devoted to systematization information on the introduction and application of modern materials in the automotive industry. Given both domestic and foreign sources of information, it follows that car manufacturers are constantly pushing to create the lightest cars possible to increase speed and power. [1] Carbon fiber and aluminum has a tendency to be a lighter material when contrasted with different metals like steel and has a more extensive scope of utilization in the automotive field.[2] . Applying high strength materials – beside high strength steels like DP1000, TRIP780 recently aluminium alloys, e.g., AA7021 or AA7075 – have a positive response for many of the requirements: increasing strength results in the application of thinner sheets together with significant mass reduction, leading to lower consumption with increased environment protection[3] The effect of different thermal treatment temperatures (from 472 to 783 K) on the characteristics of serrated yielding of three commercial aluminum alloys, AA5052, AA5754 and AA5182, was investigated. In the high temperature treatment range, the stress drop ($\Delta\sigma$) decreases with increasing thermal treatment temperature.[4] Aluminium metal matrix composites have been shown to make significant contributions to the area of new materials and have become widely accepted in high-tech structural and functional applications such as those in the aircraft, automobile, marine, mineral, defence, transportation, thermal management, automotive, and sports and recreation fields.[5] For this reason, our attention is mainly directed toward the electronic structure change with alloying elements in Al and Mg. A new alloying parameter, *s*-orbital energy level, *Mk*, is calculated and used for the quantitative prediction of the mechanical properties of Al alloys and Mg alloys.[6] The first marine applications of aluminium date back to the early 1890s. Naval architects had perceived the advantages of this metal for shipbuilding . Among the first vessels were the Mignon, a yacht 12 m long and purchased by Alfred Nobel in 1902 , and several military vessels, including two 18-m-long torpedoboats, Le Foudre and Le Lansquenet, ordered in 1895 by the French Admiralty from the British shipyard Yarrow[7] As long as galvanic contact with more noble metals is avoided, most structural alloys, such as those in the AA1000 (commercially pure), 3000 (AlMn), 5000 (AlMg), and 6000 (AlMgSi) series, are resistant to corrosion in seawater, especially the so-called seawater-resistant alloys in the 5000-series[8] This chapter gives an overview of the joining technologies applicable in the design and manufacturing of lightweight automobile bodies. It covers liquid-phase welding, solid-phase welding, mechanical joining, and adhesive bonding for steels, aluminum alloys, and magnesium alloys. The process parameters and their effects on joint performance for each process are described[9] This chapter deals with the process of work hardening in aluminium and a number of its alloys. The approach taken is to develop a simple one parameter model based on dislocation density and modify this to try and describe the essential behaviour of a range of solid solution and precipitation hardening alloys. Attention is also given to large strain behaviour and its description[10]

2. Materials and Methods

Aluminium:

Natural an aluminum alloy (or aluminum alloy) is an alloy in which aluminium (Al) is the predominant metal. The typical elements which are mixed with Al are copper, magnesium, manganese, silicon, tin, nickel and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required

Aluminium–magnesium alloy, primarily alloyed with magnesium and chromium.

The 5000 series of aluminum alloys are known for their excellent corrosion resistance and are used in a wide range of applications, including marine, automotive, and architectural industries. These alloys are also known as magnesium alloys because they are alloyed with magnesium to improve their strength and corrosion resistance.

The most common alloy in the 5000 series is 5052, which contains approximately 2.5% magnesium and 0.25% chromium. This alloy has excellent corrosion resistance, good formability, and is often used for sheet metal fabrication, marine and automotive parts, and cooking utensils.

Other alloys in the 5000 series include 5083, 5086, and 5754, each of which has a slightly different composition and set of properties. For example, 5083 is known for its excellent strength and corrosion resistance in harsh marine environments, while 5754 has excellent formability and is often used in architectural applications.

The 5000 series alloys have higher strength than the 3000 series alloys, but lower strength than the 2000 or 6000 series alloys. However, their excellent corrosion resistance makes them an excellent choice for applications where corrosion is a concern, particularly in marine and automotive industries.

Methodology

DIFFUSION BONDING PROCESS:

Diffusion, from an atomic perspective, is just the stepwise migration of atoms from lattice site to lattice site. In fact, the atoms in solid materials are in constant motion, rapidly changing positions.

For an atom to make such a move, the following two conditions must be met:

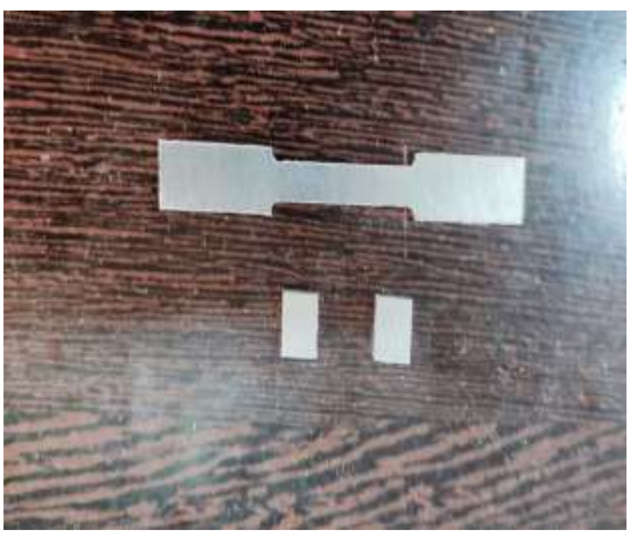
i) There must be an empty adjacent site,

ii) The atom must have sufficient energy to break bonds with its neighbor atoms and then cause some lattice distortion during the displacement. This energy is vibrational in nature. At a specific temperature some small fraction of the total number of atoms is capable of diffusive motion, by virtue of the magnitudes of their vibrational energies. This fraction increases with temperature.

Diffusion is the process of mixing which involves the movement of atoms from area of higher to those of lower concentration or Diffusion is the shifting of atoms and molecules to new sites within a material resulting in the uniformity of composition as a result of thermal agitation. Movements in diffusion may be relatively short-range, as in allotropy, recrystallization and in precipitation. Diffusion is fundamental to phase changes and is important in heat treatments. Diffusion is basically, statistical in nature, and the term applies to macroscopic flow (not individual movements) resulting from innumerable random movements of individual atoms. The path of an individual atom is random, zig-zag, and unpredictable. Nonetheless, when large number of atoms make such movements, they can produce a systematic flow.

Diffusive processes are irreversible and therefore, they increase entropy. At room temperature, diffusion occurs very slowly in most solids and is of little or no importance. Diffusion occurs more and more rapidly as the temperature rises and is the basis for most metallurgical processes. It is important in the annealing, recrystallization and grain growth of cold worked metal, in doping of semiconductors and in the formation of metallic bonds (soldering, welding, powder metallurgy). Diffusion, or lack of it, will determine the degree of homogeneity attained in solid crystals forming from a melt. The absence of homogeneity in a solidified casting is called “dendritic segregation” or “coring.”

Sample:



Tests:

Tensile Strength:

Tensile testing is a destructive test process that provides information about the tensile strength, yield strength, and ductility of the metallic material. It measures the force required to break a composite or plastic specimen and the extent to which the specimen stretches or elongates to that breaking point.

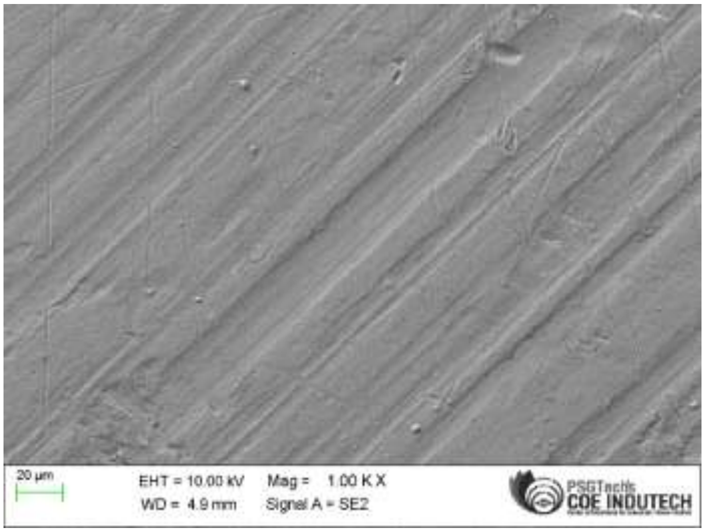
XRD Test:

X-ray diffraction analysis (XRD) is a technique used in materials science to determine the crystallographic structure of a material. XRD works by irradiating a material with incident X-rays and then measuring the intensities and scattering angles of the X-rays that leave the material [1].

FESEM Test:

Field emission scanning electron microscopy (FESEM) provides topographical and elemental information at magnifications of 10x to 300,000x, with virtually unlimited depth of field. Compared with convention scanning electron microscopy (SEM), field emission SEM (FESEM) produces clearer, less electrostatically distorted images with spatial resolution down to 1 1/2 nanometers – three to six times better.

TENSILE AND XRD TEST:



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TEST REPORT

REF NO: COE/2023/APR/11381

Receiving Date: 18-04-2023
Tested Date(s) : 25-04-2023
Report Date : 26-04-2023

Name of the Applicant : R.TARUN.
SNS College of Engineering, Cbe.

Sample Description : NA

Type of sample : Metal

Type of test : Tensile Strength / X-ray Diffraction.

Results Summary / Conclusion:

Test	Test Method	Remarks
X-ray Diffraction	Not Applicable	Refer Result
Tensile Strength	ASTM E8	Refer Result

Muthukumar. V
Authorized Signatory

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TEST REPORT

REF NO: COE/2023/APR/11381 Report Date: 26-04-2023

RESULTS

1.TENSILE STRENGTH- (Test method: ASTM E8)

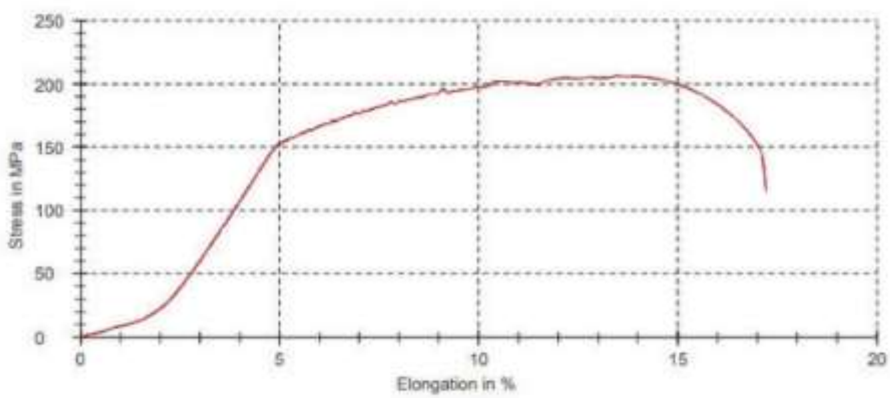
1. SAMPLE: 01

Test speed : 0.5 1/min

Test results:

No.	Specimen ID	TS MPa	$A_{50.8}$ %
1	01	206.9	13.1

Series graph:



Statistics:

Series n = 1	TS MPa	$A_{50.8}$ %
x̄	206.9	13.1
s	-	-
v	-	-

TEST REPORT

REF NO: COE/2023/APR/11381 Report Date: 26-04-2023

RESULTS

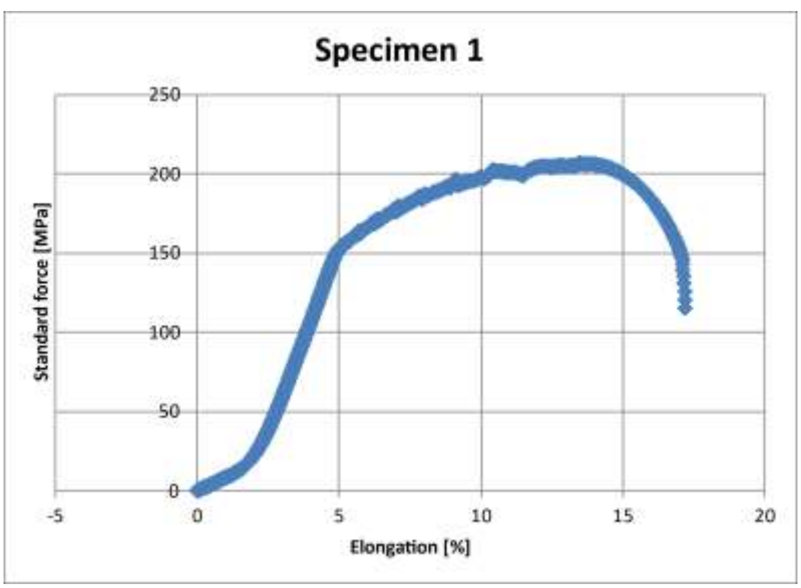
2.XRD-(Normal Scan) (Test method: Not Applicable)

1. SAMPLE: METAL

Pattern List

Score	Compound Name	Chem. Formula	Mineral Name	Cryst. Syst.
43	Aluminium	Al 1		Cubic

<<< END OF THE TEST REPORT >>>



Anchor Scan Parameters

Dataset Name	Spinner stage with- 11381-METAL
File name	D:\XRD Data\SNS\11381\Spinner stage with-11381-METAL.xrdml
Comment	Configuration=Reflection-Transmission Spinner, Owner=User-1, Creation date=6/11/2014 10:44:27 AM
Goniometer	=PW3050/60 (Theta/Theta); Minimum step size 2Theta:0.001; Minimum step size Omega:0.001
Sample stage	=Reflection-Transmission Spinner PW3064/60; Minimum step size Phi:0.1
Diffractometer system	=XPERT-3
Measurement program	=C:\PANalytical\Data Collector\Programs\Demo\Spinner stage with-11381-METAL.xrdmp, Identifier={C71C7F4E-E298-4555-8212-0BAD3587E6A6}
RT Spinner	
Measurement Start Date/Time	4/25/2023 4:19:27 PM
Operator	User
Raw Data Origin	XRD measurement (*.XRDML)
Scan Axis	Gonio
Start Position [°2θ]	5.0066
End Position [°2θ]	90.3126
Step Size [°2θ]	0.0130
Scan Step Time [s]	48.1950
Scan Type	Continuous
PSD Mode	Scanning
PSD Length [°2θ]	3.35
Offset [°2θ]	0.0000
Divergence Slit Type	Fixed
Divergence Slit Size [°]	0.4354

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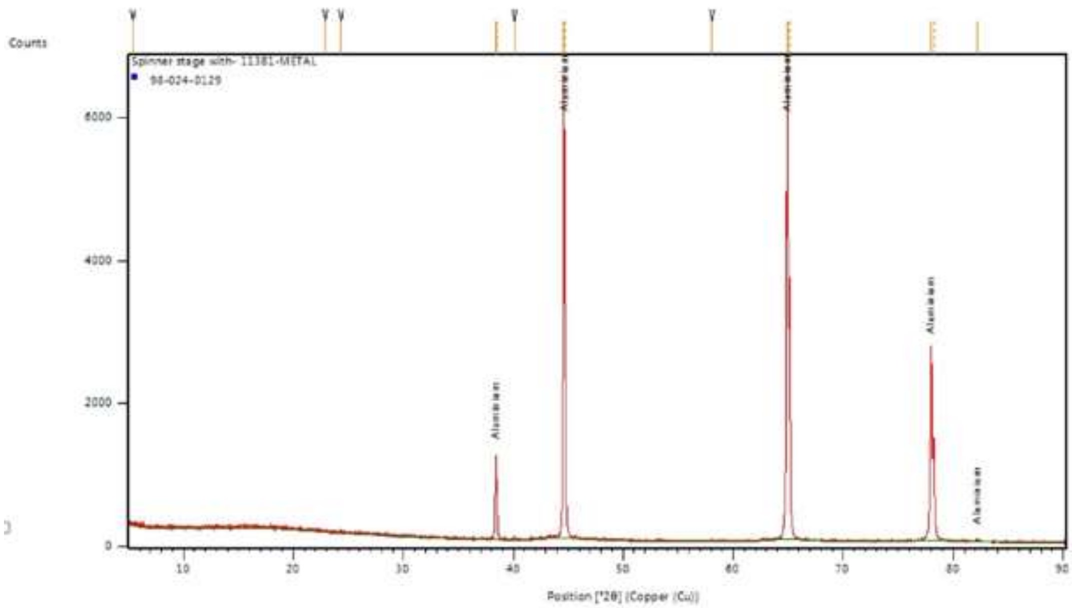
Specimen Length [mm]	10.00
Measurement Temp [°C]	25.00
Anode Material	Cu
K-Alpha1 [Å]	1.54060
K-Alpha2 [Å]	1.54443
K-Beta [Å]	1.39225
K-A2 / K-A1 Ratio	0.50000
Generator Settings	30 mA, 45 kV
Diffractometer Type	0000000011155153
Diffractometer Number	0
Goniometer Radius [mm]	240.00
Dist. Focus-Diverg. Slit [mm]	100.00
Incident Beam Monochromator	No
Spinning	Yes



Pattern List

Score	Compound Name	Chem. Formula	Mineral Name	Cryst. Syst.
43	Aluminium	Al1		Cubic

Peak List

Pos. [°2θ]	Height [cts]	FWHM Left [°2θ]	d-spacing [Å]	Rel. Int. [%]
5.3865	27.62	0.8187	16.40686	0.41
22.9238	33.83	0.0895	3.87958	0.50
24.3339	42.27	0.0640	3.65787	0.62
38.3943	1184.80	0.0780	2.34262	17.44
38.4984	686.60	0.0624	2.34233	10.11
40.1140	39.53	0.1872	2.24607	0.58
44.6160	6474.73	0.0936	2.02932	95.33
44.7438	3356.72	0.0624	2.02885	49.42
58.0486	29.82	0.3744	1.58766	0.44
64.9217	6792.12	0.1248	1.43519	100.00
65.1125	3506.24	0.1092	1.43500	51.62
77.9931	2672.28	0.1248	1.22411	39.34
78.2453	1392.11	0.1092	1.22383	20.50
82.1746	34.27	0.1872	1.17208	0.50

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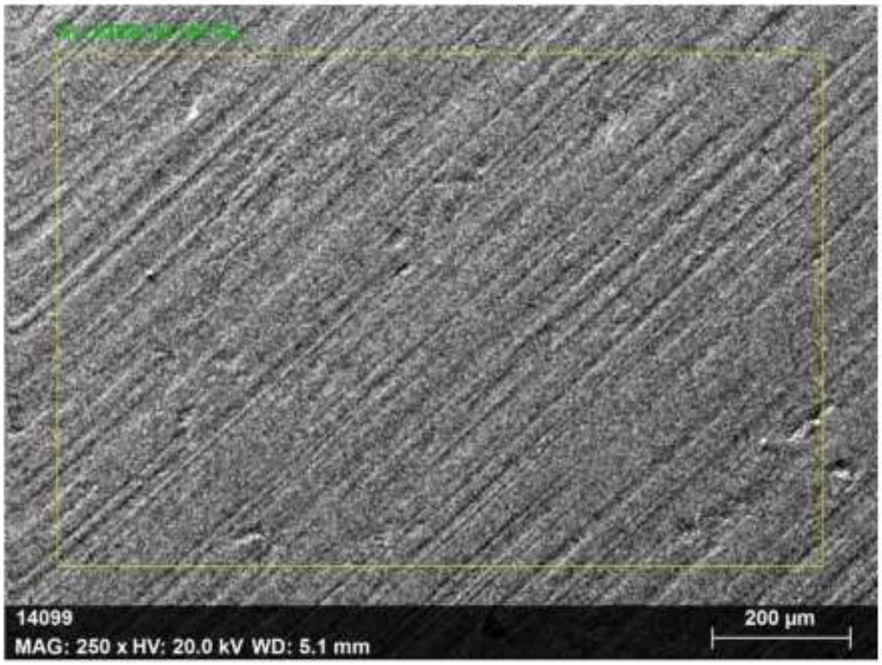
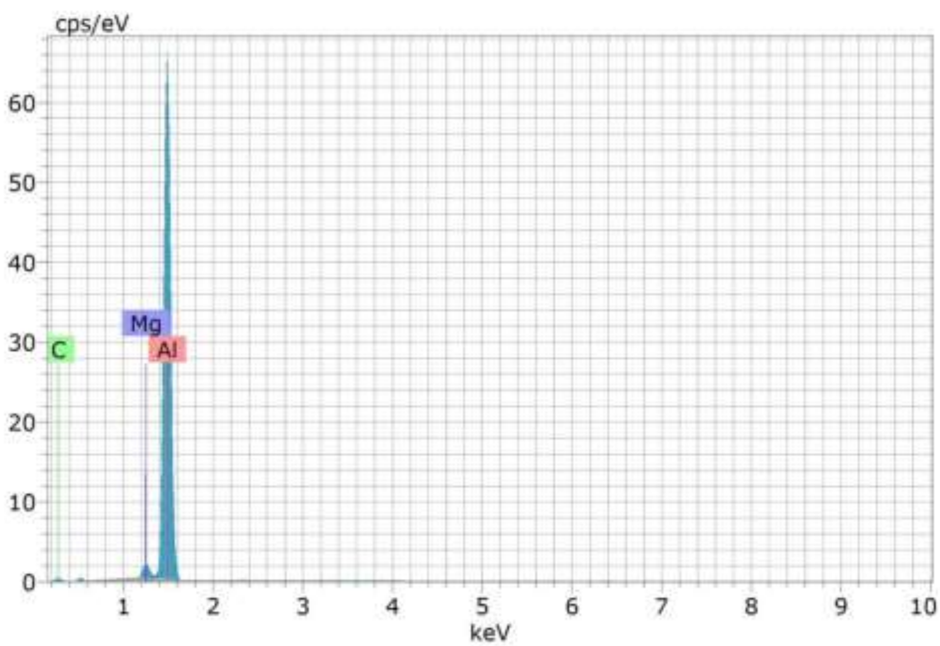
Application Note
Company / Department





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Spectrum: ALUMINIUM METAL

Element	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (3 Sigma) [wt.%]
Aluminium	K-series	60.80	79.66	64.73	8.79
Carbon	K-series	13.99	18.33	33.47	9.20
Magnesium	K-series	1.53	2.00	1.80	0.35
	Total:	76.32	100.00	100.00	

RESULTS AND CONCLUSION:

Thus, after few researches we have come to a decision:

The test was conducted to determine if graphite can be used with Aluminium 5220 alloy to have better strength ,heat resistance and reduced weight. But after the tests the data gathered shows that graphite is not a suitable material for this process.

Hence we infer and suggest different materials to experiment with.

Reference:

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