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TECHNICAL PAPER

THE IMPROVING OF B2 ALUMINIUM COMPOSITE PANEL CORE MATERIAL WITH ELOXAL SLUDGE BY USING RECYCLING PROCESS

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ABSTRACT

In this study, it is aimed to improving core material by using eloxal sludge for production B2 composite panel. The calcination study of eloxal sludge which arises from anodic oxidation process has a highest Al_2O_3 percentage by weight was performed with different temperature and time. It was focused how will be used the eloxal sludge such as relative humidity, dried or calcine because of tend to agglomerate structure. Optimal calcine eloxal sludge form was obtained at heat treatment regime with 700 ^{0}C and 270 minutes. The milling process with a different time was performed for obtaining fine grain size distribution. Also it was aimed to investigate possible agglomerate form in the polyurethane. The X-Ray Diffraction (XRD) and particle size analysis were performed to understand detailed structural analysis. Grain size distribution was obtained 306 µm, 247 µm and 203 µm for different milling time. The eloxal sludge was respectively doped with different percentage with 15 % and 6 % in the polyurethane for obtaining core material. . B2 composite panels were produced as 1250-1500 mm as a standard. The mechanical properties were measurement for different doped of eloxal sludge. The highest mechanical properties was obtained by using 15 % eloxal sludge has a 247 µm when it was observed that surface defects such as air bubbles. Also the thickness of the composite panel was measurement for all samples with 3.8 mm-4.2 mm.

Keywords: Aluminium composite panel, Core Material, Eloxal Sludge, Recycling Process

INTRODUCTION

Aluminium and its alloy have an increasing usage in last decade because of its various mechanical and physical properties which can provide use a wide range of applications [1]. Aluminium alloys have been used in various purposes in different industries because of the thermal conductivity, non-flammable and also excellent mechanical properties [2].

The anodic oxidation (eloxal) is called surface finishing process is performed in acidic baths under high voltage by controlling the current density [3]. The pre-surface finishing process is also defined cleaning and etching+matting to prepare the aluminium surface for anodic oxidation process [4]. These process produce alkaline effluents contain aluminium caused by etching process [5].

Aluminium and its alloys have a good corrosion resistance. The native oxide layer on the aluminium surface is very thin and also provides restricted corrosion resistance. Thus the controlled anodic oxidation must be performed for all aluminium and its alloys for improving the surface quality [6].

The natural oxide film on the extrude aluminium profile surface is removed for forming of controlled anodic oxidation surface [7]. The eloxal sludge arises from anodic this electrochemical process that physically modifies the aluminium surface. The anodic oxidation process is carried out using water based chemicals. The reactions that occur as a result of the contact of these chemicals with the aluminium surface cause the bathrooms to become dirty and aluminium anodized waste sludge is formed. This waste sludge contains aluminium -based particles and compounds that break off from the aluminium surface during the anodizing process [8]. Anodized waste sludge contains the main chemicals sodium aluminate and aluminium sulfate. Anodizing wastes are generally a mixture of aluminium oxide, aluminium hydroxide and some substances such as sodium, silicon, magnesium and calcium [9].

The disposal of this anodized waste sludge is most important problem in the aluminium industry. There are many types of industrial waste. The improvement of the recycling waste has a critical role in the sustainability and production efficiency [10]. The identification of method which is carried out the waste recycling process is developed is most important [11].

The aluminium industry cause to a high number of waste arise from different production plants. The anodized sludge is one of them waste in the aluminium industry [12].

Many research have been focused on the extract aluminium in this sludge has high aluminium with different method. These applications and also recycling the anodized sludge is more attractive due to high aluminium content and also has a constant chemical composition [13]. Mahecha-Rivas et al. have studied the recycling process of the aluminium in the sludge by using Bayer method [14].

Different applications have been tried for anodized waste sludge. These applications can be explained that extraction of valuable materials from anodized waste sludge or the use of all waste with some processes. Sodium aluminate and aluminium

sulfate are the main chemicals obtained from anodizing waste sludge. Also some studies were performed doping of the anodized waste sludge into various matrix materials such as concrete, glass and ceramic [15].
The 475 kg anodized sludge are produced for each 1 tonnage aluminium anodized. It has been reported that the EU countries produce about 100.000 metric tons per year [16]. The disposal of this aluminium industry waste has a critical role because of can cause to environmental problem [17].
Also the various applicable studies have been carried out on the composition of anodized waste sludge with other raw materials. The three main factor that determine the properties of the developed material. These factors can be explaining that the physical condition of the anodized waste sludge (as received, dried or calcined, the composition of other materials to be used in the formulation, the technique to be used to combine the products [18].The one of the most important of these factors is physical condition of anodized waste sludge. It is predicted that drying of the anodized sludge at 100 ^{0}C exhibits a strong agglomeration structure which prevents it from forming a good mixture with other materials. The resulting materials exhibit reduced mechanical properties [19].
Anodic aluminium oxidation has become a rapidly growing industry in many countries around the world for metal surfacing. While industrial activities with high added value have a significant impact on the growth of the economy, the impact of these industrial developments on the environment is also significant. The effective use of energy, clean energy sources have become centralized topics in terms of maintaining the continuity and competitive power of the companies [20].

2. EXPERIMENTAL STUDIES

2.1. Chemical Composition Analysis

Aluminium anodized waste sludge has a very high relative humidity and has a gel-like structure. It contains humidity up to 85%. This creates the necessary of pre-drying of the anodized waste sludge in order to provide homogeneous structure in the matrix material. **Table 1** shows chemical composition of anodized waste sludge arises from anodic oxidation production plant.

Table 1 Chemical composition of eloxal waste sludge

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
%	0,49 - 0,81	51,88 - 52,17	0,32-0,54	0,58 - 0,67	0,26-0,28	6,97 - 9,28

2.2. Calcination Process

It is important that the anodized waste sludge has a calcined structure in order not to exhibit agglomerate structure in the core material due to its relatively moist structure and gel-like consistency. The calcination parameters that include different time and temperature were examined for obtaining of the optimal calcination behavior. **Table 2** shows the calcination process parameters were performed.

Table 2 Calcination process parameters

Time (min)	Temperature (C)	Ignition Loss (%)
120	550	85.42
240	550	85.71
360	550	85.77
60	110	4.75
120	110	11.39
180	110	14.87
240	110	19.26

The optimal calcination behavior was obtained by using 550 °C and 120 minutes in the experimental studies. The anodized waste sludge lost 85 % of its weight. This loss of the mass can explain that physical and chemical water away from the structure in this temperature and time. The two different heat treatment regimens were performed for obtaining calcine behavior and degassing process. **Table 3** and **Table 4** show the different applied heat treatment regime process after obtaining calcine form structure.

Table 3 Heat treatment regime process parameters with number 1

Regime Step	Exit time (minutes)	Exit temperature (°C)
1	10	550
2	120	550

Table 4 Heat treatment regime process parameters with number 2

Regime Step	Exit time (minutes)	Exit temperature (C)
1	10	100
2	10	100
3	30	475
4	15	475
5	45	550
6	120	550
7	15	700
8	25	700

The temperature of 475 °C has a critical role that ensures the resoluble gases away from structure. Also the calcined regime was determined based on critical temperature and time for obtaining of the calcined structure. The temperature of the 550 °C was exceeding very slowly because of forming of calcined structure. Its predicted that there is no the gases in the calcined structure to 700 °C.

2.3. Grind Process

Homogeneous distribution of the anodized waste sludge in the composite material is important in terms of obtaining the final product mechanical properties and adhesion characterization homogeneous in unit area. The particle size distribution homogenization experiments of the anodized waste sludge were carried out by using mill in the laboratory. The grind process was carried out with different hour for comparative analysis in terms of particle size distribution. The particle size distribution analysis were performed these sample.

2.4. Composite Production

It has been determined that anodized waste sludge was added to B2 raw material at the rate of 15%. The final composite panel production was carried out on the B2 composite production line with the current production process conditions. The mixing process of the added anodized waste sludge and B2 raw materials in bumblebee mixer with the vacuum process in the B2 production line was performed. The mixing process has been determined 180 °C and 8 minute. Composite panels were produced as 1250-1500 mm as a standard.

3. RESULTS AND DISCUSSION

3.1. XRD Analysis

Chemical structure analyses were carried out with powder diffraction technique in X-ray diffraction (XRD). X-ray diffraction pattern in the range of 5-90˚ was obtained with the XRD device. It was observed that magnesium oxide, silicon oxide, calcium and aluminium oxide peaks in the investigated samples. **Fig. 1** shows XRD analysis of calcined structure of anodized waste sludge.

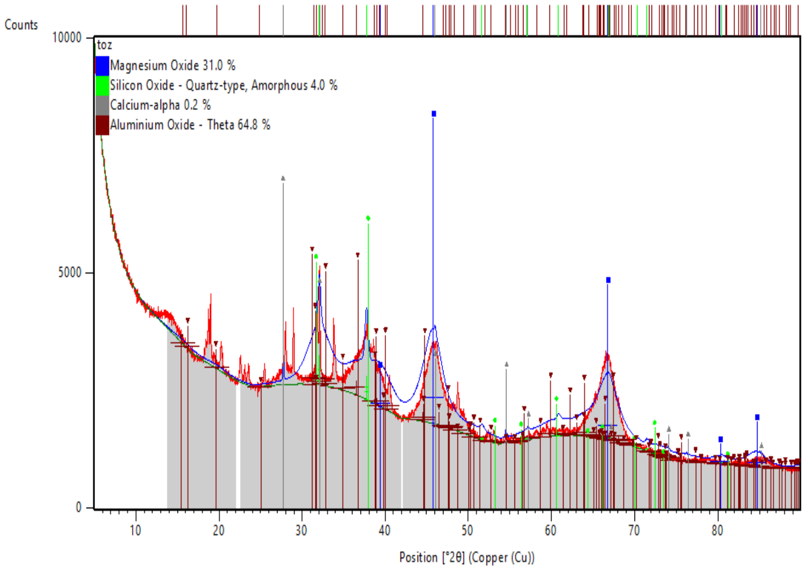

Fig. 1 XRD Analysis of anodized waste sludge

3.2. Particle Size Distribution Analysis

The particle size distribution analyses were performed for calcined anodized waste sludge with different milling time for comparative analysis. **Table 5** and **Table 6** show the particle size distribution analysis results of different heat treatment regime with different grind time.

Table 5 The particle size distribution analysis of heat treatment regime with number 1

Sample	Record Number	Sample Name	Dx (10) µm	Dx (50) µm	Dx (90) µm
1 hour grinded	**5**	Calcine eloxal mud	2.28	47.4	309
	6		2.28	51.0	319
	7		2.30	48.0	292
	8	Average of calcine eloxal mud	2.29	48.7	306
Mean			2.29	48.8	306
1xStd Dev			0.00559	1.56	11.2
1xRSD (%)			0.244	3.21	3.67
3.5 hour grinded	**11**	Calcine eloxal mud	1.93	27.2	239
	13		2.00	28.2	244
	18		1.94	27.5	258
	19	Average of calcine eloxal mud	1.95	27.7	247
Mean			1.96	27.6	247
1xStd Dev			0.0332	0.396	8.29
1xRSD (%)			1.70	1.43	3.36

Table 6 The particle size distribution analysis of heat treatment regime with number 2

Sample	Record Number	Sample Name	Dx (10) µm	Dx (50) µm	Dx (90) µm
1 hour grinded + 3.5 hour grinded	**6**	Calcine eloxal mud	1.66	21.9	209
	7		1.64	22.0	203
	8		1.72	21.4	196
	12	Average of calcine eloxal mud	1.67	21.8	203
Mean			1.67	21.8	203
1xStd Dev			0.0333	0.269	5.26
1xRSD (%)			1.99	1.24	2.59

Fig. 2, **Fig. 3** and **Fig. 4** show the particle size distribution with different heat treatment and milling time.

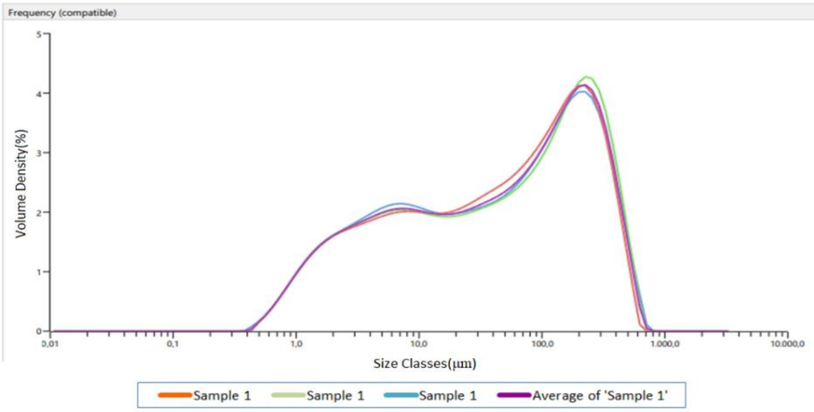

Fig. 2 The particle size distribution for heat treatment regime with number 1 (60 minutes grinded)

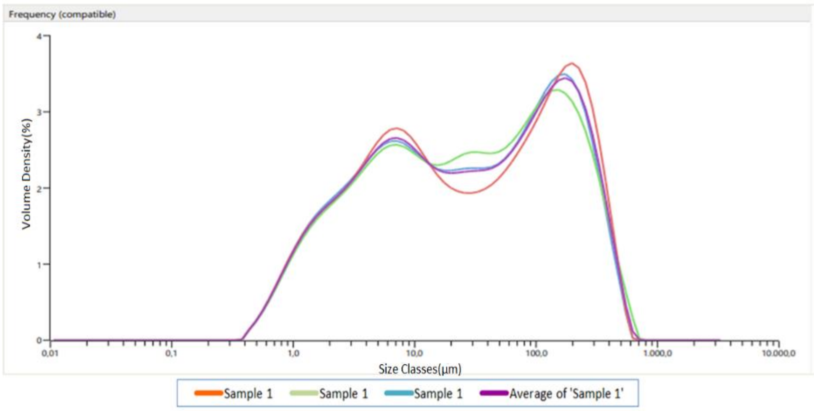

Fig. 3 The particle size distribution for heat treatment regime with number 1 (210 minutes grinded)

The mean value of particle size distribution was respectively obtained 306 µm and 247 µm for grind time with 1 hour and 3.5 hour. This value corresponds to decrease of 19.28 % in terms of particle size distribution.

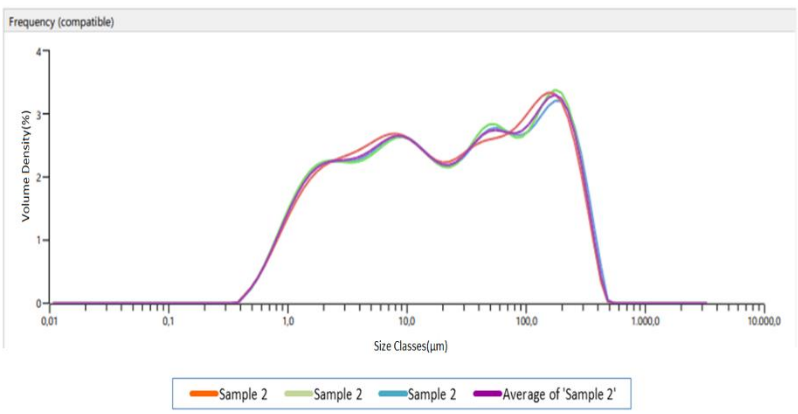

Fig. 4 The particle size distribution for heat treatment regime with number 2 (270 minutes grinded)

3.2. Surface Quality and Thickness Test

Firstly, the eloxal sludge has a 306 µm particle size was used at the rate of 15 %. It was observed that the surface defects such as air bubble in the composite panel. **Fig. 5** show the composite panel has a air bubble and the filling material.

Fig. 5 Filling material, 306 µm (left) and composite panel (right)

It was clearly seen that the nonhomogeneous structure of the filling material which is doped eloxal sludge in the **Fig. 5**. These porous structures caused the air bubble on the composite panel surface. Also the other experimental study was performed with eloxal mud has a 203 µm particle size at doping rate of 6 %. The adhesion characterization of the raw material was obtained homogeneously. Also it was no observed that air bubble defect on the composite panel surface. **Fig. 6** shows filling material form and composite panel.

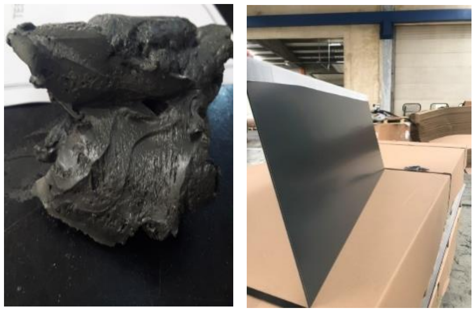

Fig. 6 Filling material, 203 µm (left) and composite panel (right)

Composite panel thickness measurements were obtained within standard (3.8 mm-4.2 mm) for all sample with different rate of added eloxal sludge. It was no observed that raw material dissolution problem in the composite panels. Also the adhesion characterization of the raw material was obtained homogeneously. **Table 7** shows the thickness measurements of the composite materials with different points. When the comparative analysis of **Fig. 5** and **Fig. 6** has been performed, the difference of particle was obtained. The particle size of 306 µm cause to air bubbles. We have found that the coarser particle size cause to surface defect.

Table 7 The thickness measurements of composite panel

Sample	Point 1 (mm)	Point 2 (mm)	Point 3 (mm)	Point 4 (mm)	Point 5 (mm)
Doping rate of 15%.	3.82	3.96	3.88	4.01	3.94
Doping rate of 6%.	4.07	4.18	4.23	4.20	4.24

3.3. Mechanical Test

Tensile test machine called ZwickRoell with 20 tons was used for tension test. Tensile strength, yield strength and the amount of % elongation were determined. **Table 8** shows mechanical properties of the composite panel which is doped eloxal mud with 15 % and 6 %.

Table 8 The mechanical properties of the composite panel

Sample	Peeling Strength (N/25 mm)					
	Top-left	Top-back	Upper-middle	Upper-back	Top-right	Top-back
Doping rate of 15%.	276	183	201	254	196	192
Doping rate of 6%.	251	154	180	213	170	174

The mechanical measurements were carried out different surface points. The comparative analysis was performed for the adhesion behavior of composite panel with a new core material. The highest mechanical properties were obtained for doping rate of 15 % with particle size 247µm with heat treatment number 1.

4. CONCLUSION

This study is aimed at investigation of the B2 composite panel by using eloxal sludge with different doping ratio. The eloxal sludge calcine behaviour was investigated by using different temperature and time. The two different heat treatment regimens were performed at different time and temperature. It's observed that the calcine form was obtained at 700 °C with 270 minutes. The milling process was performed to obtain fine particle size distribution. The particle size distribution was obtained respectively 306 µm, 247 µm and 203 µm for different milling time. Firstly, the eloxal sludge has a 306 µm with 15 % by weight was doped at polyurethane in production line. It was observed that air bubble surface defects on the aluminium composite panel. Also there were no any surface defects for doping eloxal mud has 203 µm with 6 % by weight. The mechanical test was performed for all samples at different surface points. The highest mechanical properties were obtained for doping rate 15 %.

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