Processing of finely dispersed aluminum waste with different content by-product metals

Alexandra Petrova

Engineer of department of mining ecology
Institute of Comprehensive Exploitation of Mineral Resources
Russian Academy of Sciences,
Moscow, Russian Federation
aleks.pet.93@mail.ru

Irina Shadrunova

Head of department of mountain ecology, Doctor of Engineering science, professor
Institute of Comprehensive Exploitation of Mineral Resources
Russian Academy of Sciences,
Moscow, Russian Federation
shadrunova_@mail.ru

Tatyana Skakova

Associate professor of department of "Materials science",
candidate of physical and mathematical sciences, associate professor
Moscow Polytechnik University,
Moscow, Russian Federation
tanya.skakova@mail.ru

Tatiana Chekushina

Leading researcher of department of mining ecology,
candidate of Technical Sciences, associate professor
Institute of Comprehensive Exploitation of Mineral Resources
Russian Academy of Sciences,
Moscow, Russian Federation
council-ras@bk.ru

Abstract
Chemical dispersing waste recycling method was developed for aluminum alloy. Method of chemical dispersing is the dissolution of small particles of aluminium alloy (chips, small pieces) in alkaline solutions with the formation of precipitate-powder of aluminum hydroxide. The resulting sediment filters and washes by the method of successive decantation. This sediment possesses a complex of unique properties that are difficult to obtain using traditional technologies. Precipitate morphology structure inherits predominantly original alloy and its chemical composition, affects the phase composition of sediment. Control phase composition may exercise through the introduction of necessary additives in the original stage alloy weld. Formed when processing chips of aluminum hydroxide are a source of raw materials for advanced ceramic materials on the base of aluminum oxide for the manufacture of a new class of ceramic materials with unique properties. At the same time the problem of recycling aluminum alloys, including waste disposal, Al-Li alloys involved a number of features that impede this process with traditional technologies.
Key words: WASTE RECYCLING, CHEMICAL DISPERSION, ALUMINIUM HYDROXIDE, RESIDUE, POWDER, CERAMIC MATERIALS

Nowadays, in terms of environmental paradigm of industrial development, various issues are resolved. The most important of them is the research of technogenic raw materials (mining waste and mineral processing) allowing us to settle the issue of using it as a source of metal materials for the construction industry, agro-chemical complex, and etc. or to determine the best possible prospects to removal of waste. The priority directions of development exploratory and applied scientific research in the sphere of using mining waste and processing of minerals in industrial scale were represented by academician V.A. Chanturia with collegues [1]. Preparation of technogenic raw materials to conditionally required standards in related industries with the creation of new standards for products of technogenic raw materials for use in the related industries, and expanding the range of enterprise products based on recycling technologies are one of the presented methods. Typically, these researches are interdisciplinary, due to the reasonable combination of research methods, and based on these technologies, borrowed from a variety of industrial areas, and adapted to solving economic and environmental problems. It should be based on intensification of the existing methods of extraction and creating new components from rebellious ores and wastes based on the latest achievements of fundamental sciences, combine dressing and chemical-metallurgical processes with modern pyro- and hydrometallurgical technologies. New scientific knowledge allows creating high-quality innovative materials, processes and technologies for comprehensive and deep processing of technogenic raw materials, implementation of which will provide high-quality finished products produced at Russian enterprises.

Interest in the use of aluminum in the industry and aluminum alloys is growing all over the world in recent years. It increases the number of small aluminum waste produced by machining aluminum workpieces. The chips are not suitable for immediate remelting.

Typical scheme of aluminum chip's recovery necessarily involves operations such as collecting chips, purification and separation of non-metallic inclusions and impurities, washing, briquetting for efficient remelting and mechanical testing of finished briquettes and only then remelting.

Particular difficulties arise when the alloying elements occur lithium in the aluminum alloy. This chip

requires special disposal methods and compliance with additional security measures.

The presence of lithium impurities is unacceptable in many aluminum alloys and therefore melting should be carried out in separate units, which are only suitable for melting lithium-containing chip. These devices are usually very expensive and require melting under a controlled atmosphere to avoid the risk of detonation. Only trained professionals may be permitted to work on some units. All these factors impose significant limitations on the recovery of lithium-containing chips and make this process extremely expansive and ineffective.

The authors [2] developed and abundantly used to produce powders with unique characteristics of chemical dispersing method. Chemical dispersion method is included: aluminum fines are merging in alkali liquor with slag formation - aluminum hydroxide.

Chemical deposit obtained after filtration and repetitive washing by successive decanting processed by thermal fusion oxide phases, is simple and effective method of obtaining micro- and nanodisperse alumina powders. It is possible to achieve fundamentally different results in the finished structure by dispersing varying few basic parameters of powders: particle shapes, their morphology, sizes, spatial distribution of phases. The structure of the powder affects the characteristics of the ceramic material. Residue morphology predominantly inherits the original structure of the alloy and its effect on the chemical composition of the residue phase. [3] This fact is the basis for an effective method of controlling a powder structure and phase composition. The method is much simpler and more predictable, as compared to the currently existing control options powder structure obtained by other methods.

Powder, which particles differ fundamentally in their morphology from particles by dispersing forming alloys containing no lithium, is obtained from aluminum alloys containing lithium. The reason for this is specific reticulation of lithium phases on the metal sample volume, as well as the lithium is most active, dispersion process takes place in these areas. Areas containing lithium are distributed by crystal junction line and the volume of crystallites. Destruction of such alloy leads to the formation of nanodispersed flakes of irregular shape [2]. Therefore, plate-like powder is formed by dispersion of alloys by system Al-Li, where the lithium phase is distributed not only at crystal junction line but also through the body of the aluminium crystals.

The thickness of the thin plate lies in the nanometer range, and the linear dimensions are a few microns. These flakes are arranged in intricate designs. Construction is quite durable, that is why its form has a strong framework of prospective material at low-pressure conditions. Figure 1 shows the structure of an oxide powder obtained by chemical dispersing an aluminum alloy containing lithium.

Particles are formed having a rounded shape due to chipping group's crystals by dispersing Al-Si alloy system. These small pieces coalesce and form volumetric aggregates. An example of such a structure is shown in Figure 2.

Volumetric rhombic form particles are obtained by dispersing alloys Al-Cu system. Photo of the powder structure is shown in Figure 3. In alloys containing Sn and Zn, it was obtained a powder composition comprising complex irregular form globules. An example of such a powder aggregate structure is shown in Figure 4.

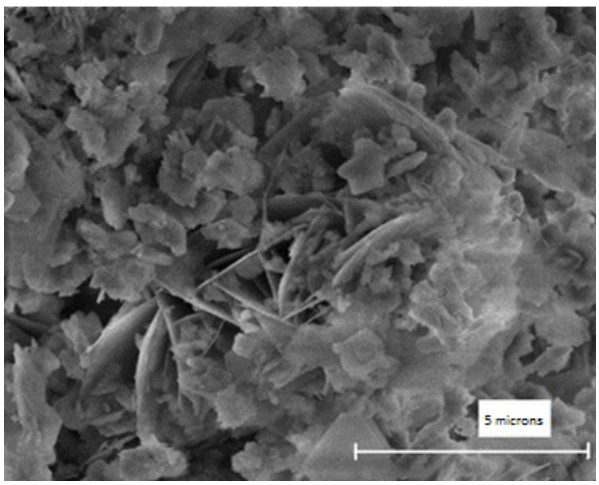

Figure 1. Structure of the powder aluminum alloy containing lithium

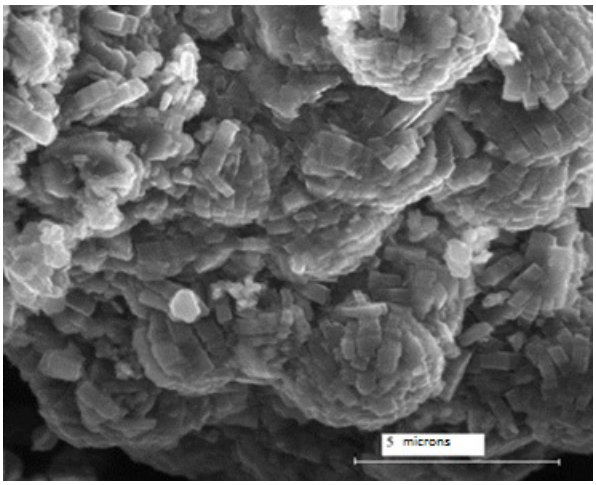

Figure 2. Structure of the powder of aluminum alloy containing silicon

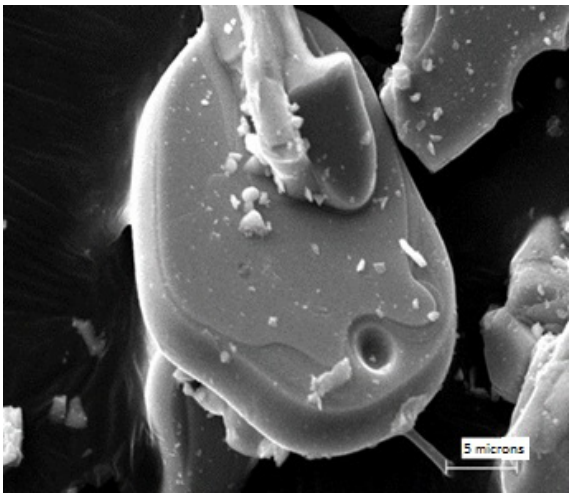

Figure 3. The structure of the powder of aluminum alloy containing Zn and Sn

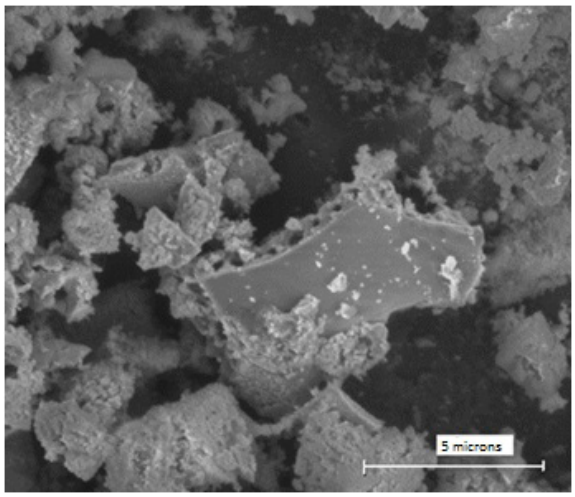

Figure 4. Globules in the powder obtained from Aluminum alloy containing copper

Using the Al-Mg system, alloys can be prepared as the structure of the powder particles of regular shape tending to spherical. These particles are subject to minor deformation when compressed and are not broken when subjected to pressure. This leads to the formation of ductile ceramic material during sintering them. An example of the structure of the powder is shown in Figure 5.

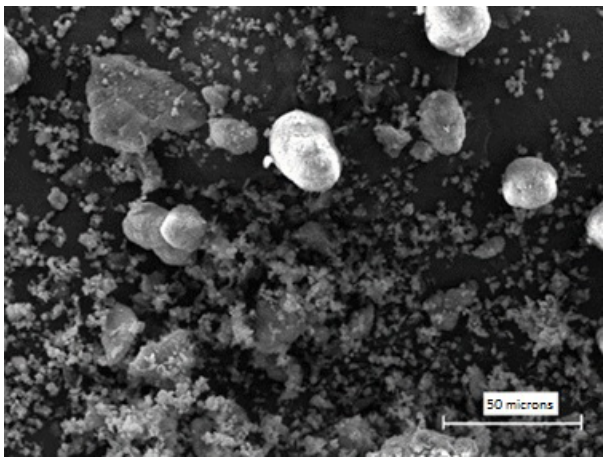

Figure 5. Spherical powder particles obtained from aluminum alloy containing Mg

The characteristic features of the structure of the powders obtained by dispersing, a regular distribution of the specific particle surface phases. This has a fundamental influence on the properties in the manufacture of the finished ceramic compacts. In some cases, a result of the dispersion on the surface of powder particles could achieve phase synthesis such as nepheline or aluminum-magnesium spinel. In certain cases, the concentration phases containing calcium and sodium at the surface of the flake particles during sintering are possible to obtain highly durable porous aggregate. The flakes of due orientation are lined up in the body, and this was due to the strength of the frame by sintering calcium phase to the surface of flakes. It is important to note that the production of nepheline phase and spinel ceramic samples is quite challenging, requiring complex manufacturing processes.

Dispersing parameters such as the medium and dispersing rate of the reaction and temperature affect the powder structure. Fundamentally different structures are obtained by using various alkalis. Experiments were conducted with KOH, LiOH and NaOH. Each of the dispersed medium affects the final structure and the phase composition of the powder as well as on the intensity of the ongoing process. Most medium reactivity leads primarily to a refinement of the powder in the pellet structure that affects the physical and mechanical properties of the products.

Aluminum hydroxide resulting from swarf processing is a source of raw material for the development of advanced ceramic materials based on alumina for the production of a new class of ceramic materials having unique properties. The development of new ceramic materials, in turn, is the most important task of modern industry, because only the ceramic materials have a number of specific, unique properties, which are of fundamental importance for the whole engineering. At the same time, a solution of aluminum alloys recycling, including recycling Al-Li alloy slows down due to the peculiarities alloys.

Chemical process dispersing an aluminum alloy containing 1.5% lithium and 4.5% copper has been studied in detail. Prepared sample with extremely high (over 70%) interconnected porosity can be obtained

from this powder of the proposed technology. The resulting material, despite the high porosity and low density (1800 kg / m3) exhibits high mechanical properties parameters (tensile strength, static bending about 180 MPa). Such material may be successfully used as insulation, the filter elements and the basis for post-combustion catalysts. Residue morphology predominantly inherits the original structure of the alloy and its effect on the chemical composition of the residue phase. The phase composition is possible to carry out to the introduction of dopants into the source alloy melting stage.

Conclusion

A comprehensive solution to the problem of technogenic waste product - fine aluminum alloy with different content of free metals (copper, zinc, tin, lithium and magnesium) based on materials science and chemical technology provides new materials with desired properties. Formed when processing chips of aluminum hydroxide are a source of raw materials for advanced ceramic materials on the base of aluminum oxide for the manufacture of a new class of ceramic materials with unique properties. At the same time the problem of recycling aluminum alloys, including waste disposal, Al-Li alloys involved a number of features that impede this process with traditional technologies.

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References

1. Chanturia V.A., Kozlov A.P., I.V. Shadrunova I.V. Oshogina E.G. (2014) Priority directions of development of search and applied scientific research in the field of industrial-scale mining and processing of mineral resources. *Mining*. No 1 (113). P. 54
2. Trifonov Y.G., Skakova T.Yu., Omarov A.Yu., Koroleva P.S., Shlapin A.D. (2013) Doped powder of aluminum oxide produced by chemical dispersion alloy-1469. *Nanoengineering*. No 8, p.p. 8-11.
3. Shliapin A.D., Rybalchenko V.V., Ivanov D.A., Khairy A.H., Omarov A.Yu. (2011) Physico-mechanical properties new ceramic material. *Mechanical engineering and engineering education*. No. 4, p.p. 31-35.