

5C4. Technology to Recover Valuable Resources from Coal Ash

Technology overview

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Various R&D activities are being conducted to identify and develop effective coal ash utilization technologies. Potential technical applications that have been studied include the recovery of valuable resources from coal ash through physical and chemical treatments, and the utilization of coal ash as a

desulfurization agent, a rust inhibitor, and as an admixture and filler for polymeric materials (rubber and plastic). Through zeolitization, additional potential applications have been identified, including utilization as an adsorbent, a catalyst, an ion-exchanger, and a desiccant.

2. Valuable resource recovery

Coal ash contains valuable substances including cenosphere (hollow ash), magnetite silica, alumina, iron oxide, and titanium oxide, as well as trace amounts of other valuable metals.

1) Recovery of valuable resources through physical treatment

Magnetite recovery through magnetic separation

The recovery of magnetite (Fe_3O_4) from fly ash is performed prior to the chemical treatment process to recover valuable elements such as Si, Al, Ti, and Fe. Magnetite, recovered through a magnetic separation process, can be used, for example, as an alternative to a heavy separation medium.

2) Recovery of valuable resources through chemical treatment

(1) Direct hydrofluoric acid extraction method

An acid extraction method, which uses an acid mixture of hydrofluoric acid and hydrochloric acid, has been developed to recover valuable resources from fly ash. The SiO_2 recovered is characteristically of high purity (99.9% or higher) and fine particles ($1\mu m$ or less).

(2) Calcination method

In the calcination method, calcium is combusted with fly ash to convert the acid-stable mullite present in the fly ash into acid-soluble anorthite or gehlenite, resulting in a high recovery rate of Al.

3. Artificial zeolite

Zeolite is a generic term for hydrated crystalline alumina silicate that, as one of its characteristics, has a porous structure and therefore a large specific surface area. It also contains ion-exchangeable cations and crystallization water that can be adsorbed/desorbed. Because of such characteristics, zeolite can be used, for example, as an adsorbent, a catalyst, or a desiccant¹.

Treating a coal ash-alkaline aqueous solution mixture² hydrothermally produces various kinds of zeolite, depending upon the reaction conditions.

The Clean Japan Center³ conducted demonstration tests at a 10,000 ton/year-scale demonstration plant built for coal ash

zeolite production in 1990. In this coal ash zeolite production process, coal ash zeolite is obtained when coal ash is boiled with sodium hydroxide and stirred. Solid contents are then separated, washed and dehydrated. The zeolite produced is of an Na-P type. Meanwhile, coal ash zeolite production processes commercialized to date are of a batch method, similar to non-coal ash processes, while flow-through continuous synthesis processes have also been developed⁴. In addition, applications that are expected to use a large volume of zeolite are now being reviewed, with an eye on reducing production costs and developing technology to synthesize zeolite in ways suitable to each application.

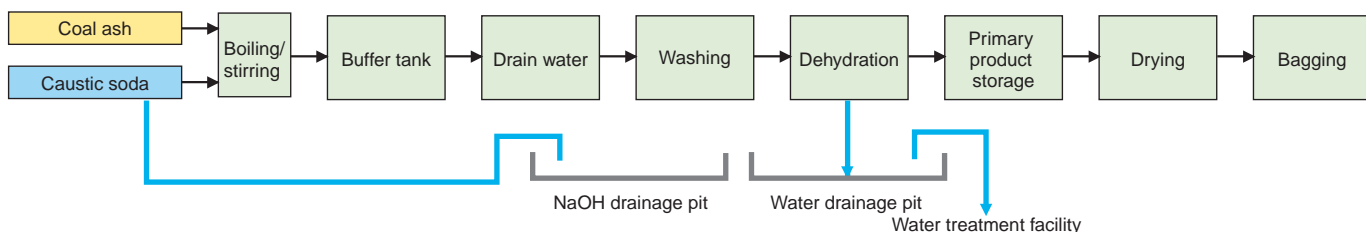


Fig. 1 Coal ash zeolite production process

4. Utilization in other sectors

1) Desulfurization agent

Dry desulfurization technology using coal ash has been commercialized, using a hardened mixture of coal ash, slack lime, and gypsum, which have excellent desulfurization capabilities.

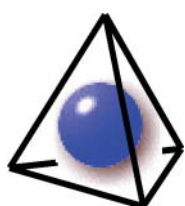
2) Admixture/filler for polymeric materials (including rubber and plastic)

Fly ash, since it is a collection of small, round glass-bead-like fine particles, is being studied for possible use as a rubber filler or as

an alternative to plastic admixtures including calcium carbonate, silica, alumina, wood flour, and pulp.

3) Other

Other than the above, technology development is currently focused on coal ash characteristics-based applications, such as in an agent to prevent rust caused by oxidation in steel-making, as well as for use in water purification or for casting sand.

SiO₄AlO₄

	Structure	Molecular formula	Pore size (Å)	Pore volume (cc/g)	CEC (meq/100g)
A		Na ₁₂ [(AlO ₂) ₁₂ (SiO ₂) ₁₂]•27H ₂ O	Na type: 4 Ca type: 5	Na type: 0.3	548
P		Na ₆ [(AlO ₂) ₆ (SiO ₂) ₁₀]•15H ₂ O	Na type: 2.6	Na type: 0.36	514 <small>(The figure is large but the exchange rate is small.)</small>
X		Na ₈₆ [(AlO ₂) ₈₆ (SiO ₂) ₁₀₆]•264H ₂ O	Na type: 7.4	Na type: 0.24	473

Cation-containing aluminosilicate found in different forms for different structures/compositions, with each having its own characteristics and applications.

References

- 1) Environmental Technology Association/The Japan Fly Ash Association: Coal Ash Handbook 2000 Edition, 2000.
- 2) Akio Itsumi: Japan Soil Science and Plant Nutrition, 58 (3), 1987.
- 3) The Clean Japan Center: Clean Japan, 86, 1991.
- 4) Masahiko Matsukata: CCUJ, 12th Annual Conference on Clean Coal Technology lecture collection, 2002.