

**give me overview of technology on manufacturing process of alumina from coal ash or coal combustion residuals at thermal power plant.**

The production of alumina from coal ash or coal combustion residuals at thermal power plants uses innovative chemical and thermochemical processes to recover alumina, an important industrial raw material, from waste streams rich in aluminum oxides.[[1]](#fn1)[[2]](#fn2)[[3]](#fn3)

**Sources and Types of Coal Ash**

Coal-fired thermal power plants generate significant quantities of ash, mainly as fly ash and bottom (clinker) ash. **Fly ash** generally contains appreciable amounts of alumina (Al₂O₃) and silica (SiO₂), making it a candidate for alumina extraction.[[4]](#fn4)[[5]](#fn5)[[1]](#fn1)

**Key Extraction Technologies**

Several methods are used for alumina extraction from coal ash:

* **Alkaline Leaching**: Pressure or atmospheric leaching using sodium hydroxide (NaOH) is employed to dissolve the alumina. Pre-treatments, such as desilication or high-temperature roasting with additives (e.g., calcium compounds), are used to break down resistant minerals like mullite and boost efficiency, yielding recovery rates over 80% under optimized conditions.[[2]](#fn2)[[1]](#fn1)
* **Acid Leaching**: Treatment of ash with inorganic acids such as sulfuric, hydrochloric, or nitric acid can extract alumina, often in combination with prior calcination or sintering. The acid process can achieve high recovery but needs further purification steps to separate alumina from impurities and dissolved silica.[[6]](#fn6)[[2]](#fn2)
* **Ammonium Sulfate Roasting**: Roasting fly ash with ammonium sulfate and subsequent leaching can convert alumina-bearing phases into soluble complexes, with reported recovery rates exceeding 90% under ideal conditions.[[3]](#fn3)
* **Soda-Lime Sintering**: This thermochemical route involves sintering ash with lime and soda at high temperatures, transforming mullite into more extractable phases and subsequently leaching with alkaline solutions.[[7]](#fn7)
* **Hybrid and Pilot Methods**: Some research explores combinations of heat treatment, magnetic separation to remove iron, and sequential chemical processing, aimed at maximizing alumina purity and yield.[[8]](#fn8)[[2]](#fn2)

**Process Flow Overview**

1. **Preparation and Enrichment**: Ash is collected, dried, and may be enriched by removing carbon, magnetic impurities (iron), or desilication.[[9]](#fn9)[[8]](#fn8)
2. **Chemical Conversion**: Targeted chemical/thermal treatment converts alumina to soluble forms.
3. **Leaching**: Alumina is solubilized using strong alkali or acid (sometimes with autoclave conditions).
4. **Separation and Purification**: Dissolved alumina is separated from impurities (e.g., silica, iron, calcium) through selective precipitation, filtration, or additional chemical treatments.
5. **Calcination**: Aluminum hydroxide is precipitated and then calcined at 700–800 °C to produce high-purity alumina powder.[[9]](#fn9)
6. **Residue and By-product Management**: Non-alumina components are often managed as secondary construction materials or, if nonreactive, as waste.[[4]](#fn4)

**Sustainability and Challenges**

Current research focuses on improving extraction efficiency, economic viability, energy consumption, and the purity of the final alumina product. Acid and alkali processes require careful waste handling and recovery steps to manage environmental impacts. Transitioning from pilot to industrial scale also needs technical advances in chemical recycling and residue management.[[2]](#fn2)[[6]](#fn6)

In summary, alumina extraction from coal combustion residuals is an active field using pressure alkaline leaching, acid leaching, salt roasting, and sintering routes, each adapted to address the challenging chemistry of coal ash and maximize sustainable resource utilization.[[1]](#fn1)[[3]](#fn3)[[2]](#fn2)

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