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G20 भारत 2023 INDIA

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ASPIRE PROGRAMME

Accelerating Smart Power & Renewable Energy in India

SUGGESTED POLICY INTERVENTIONS FOR UTILISATION OF SPENT POT LINING (WASTE PRODUCT OF ALUMINIUM SECTOR) IN CEMENT INDUSTRY

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Industrial Decarbonization and Energy Efficiency Knowledge Sharing Platform

June 2023

Background

The Aluminium and Cement sectors play a crucial role in India's industrial landscape, contributing significantly to its economy. However, these industries are highly energy-intensive and have a significant carbon footprint of **~20 tons of CO_2e** per ton of aluminium and **~0.6 tons of CO_2e** per ton of cement produced. India is a major player in these sectors, ranking second globally in both aluminium and cement production with market share of ~5.3%[1] and ~9%[2] in terms of production output. Given India's significant presence, it is crucial for the country to prioritise decarbonisation efforts in these industries to achieve its net-zero emissions target by 2070.

To address these challenges, the ASPIRE Programme[3] in collaboration with the Bureau of Energy Efficiency (BEE) organised sector-specific workshops for the Aluminium and Cement sectors in November 2022 and March 2023, respectively. The workshops highlighted the importance of adopting Circular Economy and Resource Efficiency practices in both the sectors to promote sustainability.

In the above workshops, the need for adopting Circular Economy and Resource Efficiency practices to promote sustainability in both the sectors was highlighted. In view of this, the ASPIRE Programme in collaboration with the BEE organsied a Policy Roundtable on June 9th, 2023 at the Bureau of Energy Efficiency, Conference Room, New Delhi. The theme of the policy roundtable was - 'Enabling Circular Economy and Resource Efficiency in Aluminium and Cement Sectors: Utilising Spent Pot Lining (SPL) and other waste products of Aluminium Sector'.

About Spent Pot Lining (SPL)

SPL is a solid waste byproduct generated during the production of primary aluminium. Primary aluminium production involves the Hall-Héroult process, an electrolytic process where alumina feedstock is subjected to a molten bath mixture of cryolite, alumina and aluminium fluoride. Through the application of a significant electric current, the process separates aluminium and oxygen, resulting in molten aluminium metal. This process occurs within carbon-lined steel pots to produce molten aluminium metal. Carbon-lined steel pots are utilized during this process to contain the molten metal, consisting of an insulating refractory lining and an interior carbon lining. As the pot lining ages, it gradually deteriorates, leading to the formation of cracks that compromise its ability to retain the liquid metal within the cell. At the end of operational lifespan, typically after 4-7 years, the lining of the pot is deemed as Spent Pot Lining (SPL).

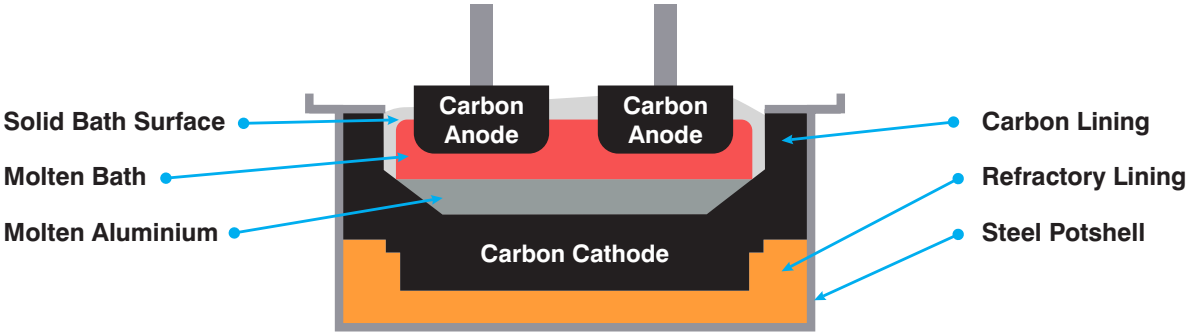

Figure 1 Cross-section of aluminium pot

SPL waste consists of two distinct components: (i) the carbon cathode (referred to as "first cut" and (ii) the refractory portion (referred to as "second cut"). In terms of weight, SPL typically comprises ~60% carbon and ~40% refractory material. The specific generation of SPL is estimated to be ~15-25 kilograms per metric ton of Aluminium produced. In the Aluminium smelting industry, the lifespan of a pot is ~2500-3000 days, with each pot generating ~55-60 metric tons of SPL at the end of its operational life.

[1] https://www.indianmirror.com/indian-industries/2022/aluminium-2022.html
[2] https://www.ibef.org/industry/cement-india
[3] About ASPIRE Programme
Accelerating Smart Power and Renewable Energy in India (ASPIRE) is a bilateral programme implemented by Foreign Commonwealth and Development Office, Government of UK in association with Ministry of Power and Ministry of New and Renewable Energy, Government of India. KPMG is the lead delivery partner for the ASPIRE Programme. Idam Infrastructure Advisory Private Limited (India) and Carbon Trust (UK) are the key consortium members.

SPL has been classified as hazardous waste due to several factors including, presence of toxic fluoride and cyanide compounds that are leachable in water; exhibits corrosive properties resulting from high pH due to alkali metals and oxides and reacts with water producing inflammable, toxic and explosive gases.

To ensure safe and effective utilisation of SPL, the **Central Pollution Control Board (CPCB)** has developed comprehensive guidelines in form of **Standard Operating Procedures (SOPs)**. Key provisions of the CPCB guidelines are as follows:

- SPL transportation to be carried out using covered containers for the SPL ranging in size from 200-500 mm
- Authorization from State Pollution Control Board (SPCB) is necessary for both sender and receiver involved in the transportation of SPL
- SPL storage requires a cool, dry, well-ventilated covered shed with impervious Reinforced Cement Concrete (RCC) flooring to prevent rainwater intrusion. The design and authorization of this shed should be approved by SPCB/Pollution Committee. The covered storage shed should have a designated space for unloading of SPL
- The crushing and screening system should operate in a closed environment under negative suction, connected to a cyclone, pulse jet bag filter, and ID fan.
- The screened SPL (less than 30 mm) should be subjected to heat treatment in the rotary kiln at a minimum temperature of 430°C.
- Proper ventilation should be maintained in the work zone and process areas. It is mandatory for personnel to use appropriate Personal Protective Equipment (PPE) to mitigate potential risks
- The unit shall provide suitable fire safety arrangements and flame-proof electrical fittings to minimise fire-related risks
- SPL should only be sourced from industries with valid authorization for its generation and storage, as mandated by Rules and Regulations
- The unit is liable for addressing environmental damage caused by improper handling of hazardous waste, including spillage of hazardous waste
- The unit must comply with the requirements of the Public Liability Insurance Act, 1991, as amended, during the utilization and handling of hazardous waste, where applicable.

Current Disposal Practices for SPL

- **Encapsulation and Landfilling:** SPL is encapsulated within a suitable matrix and disposed of in designated landfills with necessary approvals from SPCB.
- **Utilization in Cement Kilns:** SPL is utilized as an alternative fuel and raw material in cement kilns, following specific guidelines and approvals from SPCB.
- **Recycling and Recovery:** SPL is treated and processed to recover valuable materials such as carbon, fluoride, and aluminium, through approved recycling facilities authorized by SPCB.
- **Secure Storage and Monitoring:** SPL is stored in secure facilities equipped with necessary safety measures and regular monitoring to ensure compliance with environmental regulations.

Effective management and utilization of SPL is critical to ensure environmental sustainability and adhering to regulatory requirements since it is classified as a hazardous waste material, posing several environmental and health related risks. Mitigation of these risks would require a detoxification process for SPL to produce Carbon Mineral Fuel which can then be safely utilized in high-temperature applications (exceeding 1000°C) in industries such as Cement, Iron, Steel and Ferro-Alloy.

Current Scenario:

Dalmia Cement Bharat Limited's Rajganjpur plant in Odisha and Vedanta Limited, Jharsuguda have recently completed a successful trial run of co-processing SPL-Mixed Fines (MF) in their Kiln. This trial run has demonstrated the potential for incorporating SPL-MF as a fuel and raw material, with up to 1.0% absorption in clinker production.

The successful trial run and its positive impact on the clinker production highlights the potential benefits of utilizing processed SPL in cement sector, there is limited interest from the cement industries due to various challenges, including the following:

- **High Capex and Opex cost:** Ensuring environmentally safe storage and handling of SPL involves significant capital and operational expenses.
- **Grinding process failure:** Uneven size and wide variation in composition of SPL can lead to difficulties in the grinding process in the Raw mill
- **Inter-state movement restriction:** SPCBs often impose restrictions on the interstate movement of SPL, adding logistical complexities

Detoxification limitation: Detoxification of SPL, while necessary for regulatory compliance, results in loss of other beneficial components present in SPL.

Suggested Policy Interventions:

In the policy roundtable, various stakeholders including representatives from aluminium & cement industries, research institutions, industry associations and government officials from BEE, engaged in detailed discussions regarding the challenges and opportunities associated with accelerating the utilization of SPL in cement industries. Following extensive deliberations, **two** key national-level policy interventions have emerged as outcomes to the roundtable discussion, aimed at facilitating and enhancing the utilization of SPL within the Cement Industries. The **two** key suggested policy interventions are mentioned in the table below.

Sr No	Suggested Policy Intervention	Issuing Department/ Ministry
1	Establish clear regulations and guidelines for SPL management and utilization in cement industries.	Central Pollution Control Board (CPCB) / Ministry of Environment Forest & Climate Change (MoEFCC)
2	Mandate minimum percentage utilisation of SPL in cement kilns.	Central Pollution Control Board (CPCB) / Ministry of Environment Forest & Climate Change (MoEFCC)

1. **Establish clear regulations and guidelines for SPL management and utilization in Cement Industries:**

   The existing SOP established by CPCB mandates the detoxification of SPL before utilizing it in high-temperature applications (exceeding 1000°C) such as Cement Kilns, Iron, Steel & Ferro Alloy industries. These SOPs are not industry specific and are applicable across the board.

   During the detoxification process, heating treatment leads to the destruction of cyanide and conversion of leachable fluoride non-leachable CaF2 resulting in loss of both components in carbon mineral fuel.

   For cement industries, Fluoride is **beneficial for reducing clinkering temperature** through fluxing action effectively lowering it from 1450°C to 1350°C. Additionally **ammonia and cyanide present in SPL contribute towards reduction of nitrous oxide (NOX) emissions** from the cement kiln by up to one-third with cyanide being destroyed.

In view of the above, it is imperative to develop and establish new regulations and guidelines specifically tailored to cement sector for the management and utilisation of SPL. The regulations and guidelines need to address the challenges faced by cement industries in effective utilisation of SPL by enabling creation of an ecosystem to foster increased utilisation.

Co-processing of SPL without the need for detoxification can offer greater benefits to both cement plants and aluminium plants.

2. Mandate minimum percentage utilisation of SPL in cement kilns

Presently, there is a lack of interest among the cement industries to utilize the SPL in their plants owing to various reasons. However, the SPL offers significant benefits to cement industries including potential savings in fuel, raw material input, carbon emission reduction, and NOx reduction.

Considering the potential savings in primary fuel, raw materials, and reduction in carbon emissions, it is also in the interest of the nation to conserve resources and achieve net-zero target by 2070. Moreover, there is the legacy stock of SPL accumulated in aluminium plants, emphasising the need to create demand for its utilisation.

Therefore, it is crucial to establish plant-specific mandates for percentage utilisation of the SPL in cement kiln, initially for a period of 2-3 years and then review the target based on the adoption by cement industries.

Benefits of Policy Interventions:

With more than 500 Mn MT/Annum installed capacity in the cement industries and ~1,20,000 MT of SPL generated from 7 Smelter Units, it is estimated that the aluminium industry is likely to grow at a CAGR of ~7% over the next five years resulting in generation of ~5 million tonnes of SPL by 2026-27[4].

Implementation of the suggested policy interventions would accelerate the efforts for enhanced utilisation of SPL in cement industries resulting in savings in primary fuel and carbon emissions. The actual savings would depend on the percentage utilization of SPL and variation of raw material and SPL quality. Additionally, aluminium plants will be able to dispose off historical hazardous wastes stockpiled within their premises.

Additionally, these interventions enables the government to promote sustainable and efficient utilization of SPL from the aluminium industry in cement production, contributing to both waste reduction and environmental sustainability goals.

Recommendations:

The establishment of regulations and guidelines for utilisation of SPL in the Cement Sector by CPCB along with determining a mandatory percentage is a crucial aspect for the successful implementation of the proposed policy implementation. To ensure successful execution of these measures, it is recommended to formulate a task force led of Bureau of Energy Efficiency (BEE) and Global Cement and Concrete Association (GCCA) as the coordinating agency. The taskforce may comprise of representatives from various agencies/bodies as depicted in the diagram below.

Beauru of Energy Efficiecny (BEE)	Ministry of Environment Climate Change and Forest (MoEFCC)	Central Pollution Control Board (CPCB)	Selected State Pollution Control Board (SPCBs)	Global Cement and Concerte Association (GCCA)
Jawaharlal Neharu Aluminum Research Development & Design Centres (JNARDDC)	National Council for Cement and Building Materials (NCCBM)	Aluminium Industries	Cement Industries	Subject Mattter Experts in Aluminium and Cement Industries - Apoointed by GoI

[4] https://www.alcircle.com/specialreport/325/outlook-for-the-indian-aluminium-industry

The task force will play a critical role in formulating comprehensive regulations and guidelines, monitoring their implementation, and addressing any challenges that may arise during the utilisation of SPL in the cement sector. Their collective expertise and collaborative efforts will help ensure the smooth and effective implementation of proposed policies.

The taskforce will prepare guidelines and recommendations which will be submitted to the BEE. The BEE in turn will engage with the MoEFCC/CPCB to seek acceptance of the recommendations. Following their acceptance, the guidelines will be officially notified.

These interventions will facilitate the co-processing of SPL in cement industries, leading to significant savings in fuel and raw material. Additionally, this will address the challenge associated with SPL disposal for the aluminium industries. Co-processing in cement has already been established as the proven and most reliable method for SPL disposal. Cement plants in Europe, Australia, Latin America are regularly using SPL as part of their alternative fuel usage strategy.

Adoption of such sustainable approaches such as utilisation of SPL enable enhancing resource efficiency and minimisation of waste generation, thus enhancing overall efficiency in the sector. This would contribute to the country's action on climate change. India can also leverage the learnings and leading practices in utilisation of SPL from other regions.

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