ST03 - Sustainability of the Indian Aluminium Industry through Circular Economy

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Abstract

Worldwide there is a growing recognition of the circular economy-based development approach, reflected in the United Nations Sustainable Development Goal Agenda 2030 about Ensuring Responsible Consumption and Production. Versatile applications of aluminium form the backbone of economic development, and India looks into the opportunities for establishing a "Circular Economy in Aluminium Metal Sector" for a sustainable future.

India has 3.8 billion tonnes of bauxite deposits which make it the fifth largest in the world but these resources are limited. The competent use of these resources is a must to ensure the acceptance of the basic principle of sustainable development. A resource-efficient circular economy is a must which may require a regulatory framework that integrates various aspects across life cycle stages with adequate focus on efficient extraction of resources, fostering design for resource efficiency and circularity, enhancing the implementation of waste management laws, and ensuring product recycling across sectors so that the aluminium metal remains in use even after end-of-life products.

Aluminium metal is a key material in the transition from a linear economy to a circular economy as it is highly recyclable and can be an excellent substitute for metal produced from virgin mineral resources without compromising on basic properties. With an initiative to work on the circular economy, there are efforts to map the scrap markets, waste generators, waste aggregators, waste processors, and sellers. Attempts are being made to develop Integrated Metal Recycling Zones that co-locate different recyclers with end-use producers having common facilities and shared infrastructure.

A circular economy model for the Indian aluminium sector will be restorative or regenerative by intention, and design and will replace the 'end-of-life' concept with restoration. It will shift the Indian aluminium sector towards the use of renewable energy, eliminate the use of toxic waste, which impairs reuse, and aims for the elimination of waste through the superior design of materials, products, and value addition.

The presentation will deliberate the ensuing policy and framework associated with circularity to attain sustainability in the aluminium industry in India

Keywords: Aluminium, Sustainability, Circular economy, Recycling.

1. Introduction

The Indian aluminium industry is committed to achieving the nation's ambitions for a climate-neutral and circular economy. The relationship between circular economy and sustainability in the Indian aluminium industry is well established and supported by research and industry initiatives. By embracing circular economy framework, the Indian aluminium industry can achieve resource efficiency, promote recycling and reuse, extend product life, foster

collaboration, and minimize waste generation, thereby contributing to a more sustainable and resilient Indian aluminium sector.

India is a bauxite-rich nation, but the resources are finite and resource efficiency in aluminium sector can play a key role in the transition from a linear economy to a circular economy as the aluminium metal is highly recyclable and can be a good substitute for primary metal without compromising on basic properties. The treatment and utilization of wastes generated from mining to finished aluminium metal production and issues in effective recycling of the aluminium metal thereafter is the path to a circular economy in the aluminium sector. A strong aluminium recycling industry is required where domestically available scrap must be collected and processed scientifically and in an environmentally safe manner.

Thus, to bring the recycling business into an organized system, the integration of scrap collectors/aggregators/rag pickers into the formal system is planned. A strong scrap metal recycling industry shall go a long way in establishing a circular economy in the aluminium metal sector which shall not only create large employment opportunities but will also help in mitigating climate change by complying with the commitment made in COP21 and meeting sustainable development goals (SDG) goals [1].

The Indian aluminium industry has high significance in the Indian economy as, a result of its widespread use across several industries of both economic and strategic significance. It forms a significant part of economic growth as it provides basic raw feed to a wide range of key industries including defence, engineering, electrical and electronics, infrastructure, automobile, and railways. These sectors also form the core of the Government's schemes and programmes such as Make in India, Power for All, Smart Cities Scheme, National Solar Mission, and Housing for All among others.

For efficient utilization of wastes generated in the aluminium sector and for the transition from the present practice of a linear economy to a circular economy, a Multi-Disciplinary and Multi-Ministerial approach involving all the stakeholders has been adopted, due to multiple and complex issues involved.

2. Framework for Circular Economy

The share of secondary production in total finished metal output has generally increased over time in aluminium sector. This pattern, combined with concerns about domestic supply risks, the negative environmental consequences of primary aluminium metal extraction and processing, and the management of steadily growing waste streams have led to increased interest in how to move towards an economy in which waste materials from aluminium sector are captured and fed back into the economy.

Because of large environmental and social benefits, fiscal/policy support is being extended by Government to the aluminium secondary sector to attract investment and to promote resource efficiency practices in the country as well as to show the country's commitment towards sustainable development goals (SDG). Similarly, the government is framing waste management policies – zero landfill, extended producer responsibility (EPR) schemes, and the public provision of separated aluminium scrap recycling collection systems which can induce and encourage transfers to the aluminium secondary sector, albeit without any direct financial outlay for governments.

The primary aluminium industry produces large wastes like overburden and low-grade ores during mining, tailings in beneficiation, solid wastes like red mud, and spent pot lining which have a large environmental impact. Thus, by encouraging a circular economy, all these wastes

can be utilized efficiently resulting in the conservation of natural resources and addressing environmental concerns. The policy framework is under consideration to strengthen the mechanism of material resource efficiency and facilitate movement from a linear economy to a circular economy in aluminium sector [2, 3].

Government has brought out a "National Non-Ferrous Metal Scrap Recycling Framework, 2020", especially for the aluminium sector intending to promote aluminium metal recycling and recommended certain action points for promoting a formal and well-organized recycling ecosystem and work towards economic wealth creation, job creation and increased contribution to gross domestic product (GDP) through metal recycling

3. Strategy for Resource Efficiency [4, 5]

Indian aluminium sector aims to maximize resource efficiency by minimizing the consumption of raw materials and energy through circular economy principles. This involves optimizing extraction methods, improving production processes, and reducing resource inputs. By doing so, the aluminium industry will minimize its environmental impact, conserve natural resources, and contribute to long-term sustainability.

The strategy describes that adopting resource efficiency strategies, such as material recycling and process optimization, can reduce energy consumption and greenhouse gas emissions in the aluminium industry.

4. Approaches for Waste Elimination and Utilisation

The report on the circular economy in the metal sector by the government of India emphasizes the reduction of waste generation and promotion of recycling in aluminium sector. aluminium is highly recyclable, and recycling plays a crucial role in the circular economy of the industry. Recycling aluminium requires significantly less energy compared to primary production, resulting in reduced greenhouse gas emissions and lower energy consumption. By promoting the collection, sorting, and recycling of aluminium scrap and end-of-life products, the secondary industry can minimize waste and close the material loop.

The major solid wastes produced during the aluminium value chain include dross, red mud, and spent pot lining (SPL). India produces roughly 0.15 million tonnes of dross, 9 million tonnes of red mud, and 0.13 million tonnes of SPL each year. Though considerable R&D work has been done across many countries including India for the effective utilisation of such wastes, commercialisation of these wastes is yet to gain a foothold in India. To meet environmental sustainability, it is imperative to convert these wastes into valuable products as such conversions will also ensure sustainability and circular economy in aluminium sector.

Utilizing red mud, spent pot lining, and dross in various applications contribute to the circular economy in the aluminium industry by reducing waste, recovering valuable materials, conserving resources, and promoting sustainability. These by-products, when repurposed effectively, can contribute to a more resource-efficient and environmentally friendly aluminium production and consumption cycle.

4.1 Mandating the use of Red Mud and Spent Pot Lining (SPL) in the Cement Industry

Red mud, a by-product of alumina refining, is being explored for various applications, reducing waste and promoting circularity. It contains valuable components such as rare earth elements, iron, alumina, and titanium dioxide that can be recovered and used in different industries. The

government is exploring the mandatory incorporation of red mud in cement production, demonstrating its potential as a substitute for traditional raw materials.
Government to explore the possibility of formalizing guidelines concerning dry stacking so that the same can be utilized in other industries.

Spent pot lining (SPL), a by-product of aluminium smelting, can be repurposed to contribute to the circular economy. SPL consists of carbon-based materials, refractories, and metal residues that can be recovered and used in various applications. Framework initiatives have explored the use of SPL as a fuel source for energy recovery or as a raw material for other industries, such as cement production. Recycling SPL as a fuel in cement kilns has shown the potential to reduce greenhouse gas emissions and conserve non-renewable resources. SPL can also be processed to recover valuable metals such as aluminium, fluorides, and other valuable constituents. By extracting and reusing these materials, the aluminium industry reduces waste and promotes circularity.

As the use of red mud and SPL in the cement industry is an established practice and adopted globally, mandating the use of these in the cement industry in line with the Fly Ash Notification will benefit the industries in conserving natural resources and minimising greenhouse gas (GHG) emissions. Bureau of Indian Standards (BIS) may consider revising its standard allowing red mud as an alternative raw material. Further, for making if economically feasible, standardization of freight guidelines for all waste products is under consideration so that uniform rates are followed for the transportation of similar materials.

India's cement production is around 300 million tonnes per year and likely to be doubled by 2030, thus the use of red mud in cement to the tune of 4-5 % is an alternative available immediately under Indian conditions which can help in the utilisation of total red mud generated in the country. Regarding transportation costs, a relook into the freight to rationalize it in line with the freight applicable for other similar large-volume wastes like fly ash is being considered. Simultaneously, the possibility is also being explored to cover transportation costs as extended producer responsibility in line with fly ash and issuing directions to the cement industry for utilizing the same in their manufacturing by bearing the differential cost.

4.2 Centralised Dross Treatment Facility

Aluminium dross, a byproduct of aluminium smelting and refining, can be utilized to promote circularity in the industry. Dross consists of aluminium metal, aluminium oxide, and other oxides, etc. Innovative processes have been developed to recover aluminium metal from dross, allowing it to be reintroduced into the production cycle. By recovering and recycling aluminium from dross, the industry conserves resources, reduces energy consumption, and minimizes waste. By using dross residue to produce refractory materials and construction products and other applications, the industry contributes to the circular economy by reducing waste and preserving resources.

Although, the quantity involved is very less and setting up of dross treatment plant by each producer may not be economically viable, possibilities can be explored for setting up a centralised dross treatment facility. For setting up such facilities, associations/ institutions/manufacturers, producers, etc., may first study the working of the facilities on such zero waste technologies.

4.3 Zero Waste Concept for the Industry

The aluminium industry produces more waste (solid) than primary metal during its making. About 8-10 tonnes of by-products/wastes such as bauxite residue (red mud), fly ash (generated during power production required for electrolysis of aluminium), SPL, dross, etc., are generated for every

tonne of aluminium. All these materials have great potential for value-added applications/circular economy. The waste can be converted into value-added products with less effort and resources. The aluminium industry can very well compensate for all energy and GHG through the circular economy route.

5. Strengthening Recycling Network

The framework indicates that with the appropriate policy in place, 50 % of the Indian demand for aluminium could be supplied through recycled aluminium by 2030. This transition would lead to a reduction of up to million of tonnes of GHG emissions per year from aluminium sector. The primary driver for this reduction would be the replacement of carbon-intensive primary aluminium with recycled aluminium. Increasing scrap collection and recycling rates would also reduce import dependency and vulnerability to supply disruptions.

5.1 Creation of Recycle Zones and Circular Economic Parks

The industry needs to come up in a systematic and organised manner by carving out recycling zones within/outside city limits. Identifying/Prioritising regions/cities having the maximum potential for scrap generation and setting up model eco-parks (recycling zones) in prioritised regions/cities is the government priority. Promoting investments for circular economy/industrial ecology wherein, by-products of an industry feed in as raw material for other industries is under consideration.

5.2 Preference in Public Procurement

Some preference may be accorded in public procurement for products manufactured by secondary route subject to meeting quality standards.

5.3 Development of Standard Operating Procedures

Central Pollution Control Board (CPCB) has already developed Standard operating practices (SOP) for SPL and dross and those are being implemented on priority. Similar SOPs can be prepared for red mud also.

6. Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is under formulation which can potentially reduce the cost of end-of-life management of the products and wastes, also reducing the financial load on taxpayers and municipalities. Also, it will incentivise the integration of sustainability measures into the design of products, including design for value recovery. EPR systems will be accompanied by reporting and monitoring mechanisms, possibly by State Pollution Control Board (SPCB). An evolved EPR will be supported by creating and accreditation more Producer Responsibility Organisations (PROs). The PROs, as contractors to the EPR system, need to design appropriate collection schemes adapted to the various local situations and carried out in cooperation with the local municipality. These collection schemes could be innovative and based on a register to be compiled of waste streams. Collection costs to be covered by the PROs must include the entire cost of end-of-life management of the product.

7. Carbon Credit Trading Scheme

The government has taken a step towards reducing greenhouse gas emissions and promoting a circular economy by launching the carbon credit trading scheme 2023. This scheme assigns a value known as carbon credit to every tonne of carbon dioxide equivalent reduced or avoided

proving a structured framework for the country's carbon market. Under the scheme, the Indian aluminium industry will play a major role in contributing to India's emission reduction goals. The government will assign Indian aluminium industries carbon emission targets to meet for promoting a circular economy through carbon credits.

8. Green Credit Programme

The Green Credit Programme is an incentive provided for a specified activity for delivering a positive impact on the environment. The Green Credit Programme is a mechanism that complements the domestic carbon market. While the domestic carbon market focuses solely on GHG the Green Credit System aims to meet other environmental obligations as well, incentivizing circular economy actions by companies, individuals, and local bodies. The green credits will be tradable and those earning it will be able to put these credits up for sale on a proposed domestic market platform.

9. Integration of AI and Industry 4.0

The integration of artificial intelligence (AI) and Industry 4.0 technologies in the Indian aluminium industry is enhancing efficiency, optimizing resource usage, and facilitating the implementation of circular economy practices. By leveraging data-driven decision-making, predictive maintenance, smart sorting, supply chain optimization, product lifecycle management, and collaborative networks, the industry is achieving higher levels of circularity and sustainability.

Overall, the circular economy is instrumental in driving sustainability in the aluminium industry. By embracing circular economy principles and practices, the industry can optimize resource use, reduce and utilise waste, promote recycling, and collaborate across the value chain. This not only enhances the industry's environmental performance but also supports its long-term economic viability and social responsibility, making it more sustainable in the broader sense.

10. Conclusions

A circular economy's impact is based on the broad principles of tackling waste and pollution, making sure products and materials are kept in use maintaining natural systems in aluminium sector. It extends beyond recyclability, focusing on keeping products as resources at the end of their lifecycle and giving a similar output as its linear counterpart with minimal ecological and environmental impact.

Government is examining policies and strategies that allow maximum resource use, tackle pollution concerns, and open up various business opportunities. Consequently, aluminium industry projections indicate that by following a circular economy model, India could move directly to a more effective system and avoid getting locked into linear models and infrastructure, as is the case of mature markets.

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