Can Hydrogen hasten the utilisation of alternative fuel resources in the cement industry?

In 2021, Hanson — a subsidiary of Heidelberg Cement in the United Kingdom — substituted 100% of thermal energy with energy from alternative fuels in one of its cement kilns by using a mixture of hydrogen (39%), glycerine (49%), and meat and bone meal (MBM; 12%) instead of coal. This is the world's first usage of 100% climate-neutral fuel and one of the first demonstrations of hydrogen-based technology in the cement kiln. Such adaptations, comprising a climate-neutral fuel blend, in the Indian cement industry remain elusive, even in 5% of the plants. This is because of the large size of the Indian cement industry, which is the second-largest producer of cement in the world. According to the Cement Manufacturers Association, India produces over 360.2 million tonnes of cement every year and has a production capacity of 541 million tonnes per annum (MTPA). Moreover, the Indian cement industry — one of the most energy-and emission-intensive industries in the country — uses over 50 million tonnes of coal every year for thermal energy requirements, contributing to about 8% of the national emissions. Although not enough hydrogen, MBM, and glycerine are produced in India, hydrogen adoption in the cement industry needs to be carefully examined, especially in the context of the increasing need for decarbonisation and coal shortage.

Decarbonisation challenges and breakdown of emissions

The cement industry is considered one of the hard-to-decarbonise industries. Approximately 31% of the emissions from this industry originate from the use of fuels (mainly via coal). Further, 56% of the total CO2 emissions stem from the cement-making process itself (i.e. from chemical reactions). Or, to be more specific, from the decomposition of limestone — a crucial raw material for clinker production, which in turn is an essential component of almost all types of cement, such as Ordinary Portland Cement and Portland Pozzolana Cement. The remaining 13% of emissions are indirect and result from the electrical energy requirements within the plant. Today, most decarbonisation efforts in this industry target 31% thermal emissions—a readily attainable goal.

Co-processing: A decarbonisation option

To substitute coal, co-processing — the use of waste with sufficient energy content, such as biomass, industry waste, and municipal waste — is currently being explored in the cement-making process. Generally, most of the waste is incinerated or disposed of in landfills, leading to environmental and health hazards. With the co-processing of waste materials or the use of alternative fuels in cement plants, a symbiotic relationship is established. Plants are benefitted by the energy content, while waste is disposed of in a controlled manner. The high temperatures and long residence time in the cement kilns ensure the complete combustion of waste or the elimination of organic compounds, leading to reduced levels of toxic substances and volatile organic compounds. The inorganic components, including mercury, residue, and ash, are trapped within the intricate structure of the clinker or cement, leaving no residual ash.

Co-processing: The current situation

In India, about 1.9 million tonnes of hazardous waste is co-processed in over 96 cement plants under the aegis of the Central Pollution Control Board (CPCB). In addition to developing frameworks to oversee pollution norms, the CPCB has put forth guidelines on business models that link the local municipality and cement plants. Apart from this, individual industry giants, such as ACC and Dalmia Cement, are conducting extensive research in this area. Further, thermal substitution rates (TSRs; of coal) as high as 35–40 per cent are being reported in cement plants.

Nevertheless, the widespread acceptance of alternative fuels in cement kilns is limited to large companies within the industry. Lack of infrastructure and high investments are some of the challenges in the adaptation process. For instance, to achieve 15% TSR, an additional investment of about Rs 25–35 crores per million tonnes of cement is required.

How hydrogen can hasten co-processing in the cement industry

Today, several states rank as the top sources of hazardous waste materials in the country, and Tamil Nadu, Odisha, and Rajasthan have an enormous potential of co-processing this waste. In these states, hydrogen can be used along with waste materials to enhance their processing. While in states like Uttar Pradesh and Punjab, hydrogen can be used in conjunction with agricultural residues for co-processing, keeping seasonality in consideration. In theory, around 24 kg of hydrogen alone would be sufficient to produce 1 tonne of clinker. However, injecting hydrogen into the kiln is practically difficult. The high flame temperature and rapid flame propagation velocity of hydrogen can result in the formation of nitrogen oxides and create non-uniform, localised burning zones. Hence, instead of using hydrogen alone, it can be used in unison with alternative fuels to enhance their processing rates.

Apart from the major consumers of hydrogen, such as refineries and fertilisers, the cement industry can also examine the scope for hydrogen blending and contribute to the growth of the hydrogen ecosystem in the country. This requires more pilots and demonstrations, assisted by suitable policies from the government. Achieving even 15% TSR using hydrogen can increase total hydrogen demand in the country to about 1.1 MTPA, making the cement industry a significant consumer of hydrogen. Further, the adoption of hydrogen in co-processing could also lead to a substantial reduction in CO_2 emissions in the cement industry—a significant step towards combating climate change. By minimising the utilisation of fossil fuels, such a step would contribute to forging a sustainable future.

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