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Challenge of Taiheiyo cement for Carbon Neutral 2050

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Introduction

Against the backdrop of the Paris Agreement, an international framework adopted at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), efforts to reduce greenhouse gas emissions have become increasingly active worldwide. In order to hold the global warming below 2°C compared to the pre-industrial level, it is necessary to reduce global greenhouse gas emissions to practically zero in the second half of this century. With the aim of achieving carbon neutrality by 2050, active discussion is now underway on scenarios to limit the temperature rise further, to 1.5°C.

The cement industry accounts for 5-8% of the world's carbon dioxide (CO_2) emissions, making it the second largest industrial contributor. This paper outlines an initiative adopted by Taiheiyo Cement Corporation aiming at carbon neutrality by 2050.

The cement manufacturing process and resource recycling

Cement production can be divided into three main processes: raw material processing, calcination, and finishing (Fig. 1). Limestone, clay, silica, and iron oxide are the main raw materials used. Waste industrial materials are also used to the extent that they cause no issues with quality and safety. The mixed raw materials are calcined at about 1450°C in a rotary kiln. The energy source for calcination is generally coal, but waste from fossil energy sources (such as waste oil) as well as biomass (such as wood waste) are also used in some cases. The calcined raw materials form black lumps measuring several centimeters in diameter called clinker. In the finishing process, gypsum is added to the clinker, and the material is cooled before being ground into cement powder in a finishing mill. The Japanese cement industry plays an important role as a key resource-recycling business, producing about 59 million tons of cement per year while reusing about 28 million tons of waste and by-products.

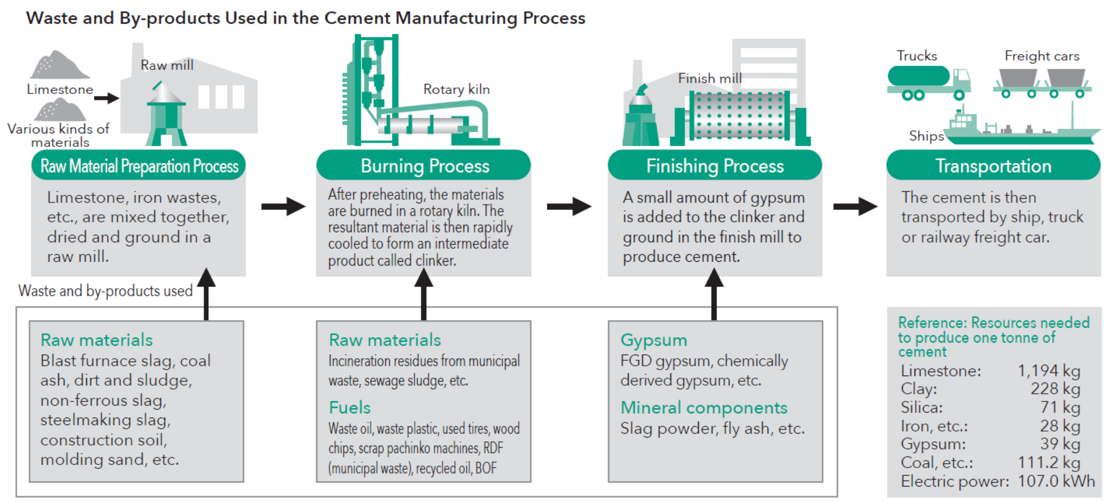

Fig. 1 Waste and by-products used in the cement manufacturing process

Carbon neutrality in the cement sector

1. CO_2 emissions from cement production

The energy efficiency at cement plant in Japan has the highest level in the world, because the energy-saving equipment was introduced to the cement plants earlier than other countries. However, in addition to energy-derived CO_2 emissions arising from the calcination process, CO_2 is emitted by the main raw material, limestone, during the calcination reaction ($CaCO_3 \Rightarrow CaO + CO_2\uparrow$). If the electricity used by the cement grinding equipment in the finishing process is also taken into account, then about 55% of CO_2 emissions during cement production derive from calcination of the raw materials, about 35% from the input thermal energy, and about 10% from electricity use (Fig. 2).

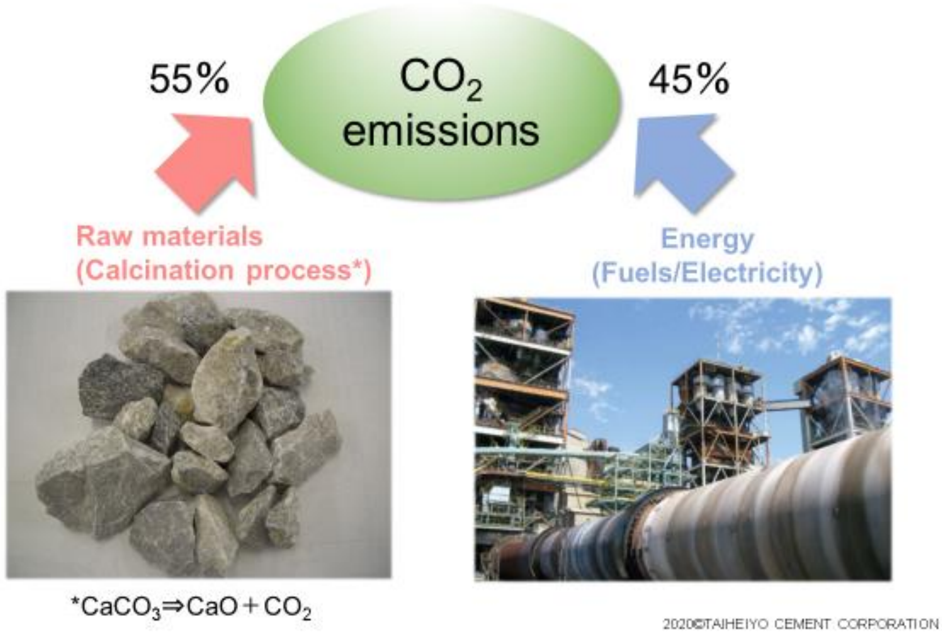

Fig. 2 CO_2 emissions from cement production

2. Measures to reduce CO_2 emissions

Conventional measures to reduce CO_2 emissions from the thermal energy input include (1) introduction of energy-saving equipment such as high-efficiency clinker coolers, (2) greater use of energy derived from waste materials (e.g., waste plastic, waste oil, wood waste, etc.) in place of fossil fuels such as coal and heavy oil, and (3) conversion from coal to fossil fuels with lower carbon intensity, such as natural gas.

Similarly, conventional measures to reduce CO_2 emissions from processing of the raw materials include: (1) the blending of other materials such as blast furnace slag powder, fly ash, and limestone powder to reduce the proportion of clinker in the cement, (2) the use of clinker cement with low CO_2 emissions from production, and (3) the use of calcium raw materials derived from calcined waste and by-products.

3. Innovative technology for CO_2 reduction

Considering the societal demand for the utilization of waste and by-products from other sector as well as the expectation of decrease in SCMs (fly ash, GGS etc.) due to decarbonization of the power generation and steel sector, it will be difficult to significantly reduce CO_2 emissions from cement production using the conventional measures outlined above. There is a need to develop and introduce innovative technologies that are not simply an extension of conventional thinking.

Innovation aimed at decarbonization has increased across industry in recent years. In 2018, we installed the first CO_2 recovery equipment in a cement plant in Japan and began developing the technology to recover CO_2 from exhaust gas in earnest. At present, using a newly scaled-up facility (Fig. 3), we are working with a cement plant and nearby cement users on the development of a circular carbon cement manufacturing technology supported by Japan's New Energy and Industrial Technology Development Organization (NEDO) (Fig. 4); this combines CO_2 capture technology with techniques for immobilizing the captured CO_2 as carbonate ($CaCO_3$) in the concrete end products made with the cement.

Fig. 3 Pilot-scale plant for CO_2 capture by chemical absorption

A chemical absorption method using amine as the absorbent is adopted for CO_2 recovery. The recovered CO_2 is immobilized as carbonate throughout the whole cement life cycle, including fresh concrete, finished product, and concrete waste. Carbonate-immobilized concrete does not only serve to fix CO_2; it is also a product that offers new functions in the cement supply chain.

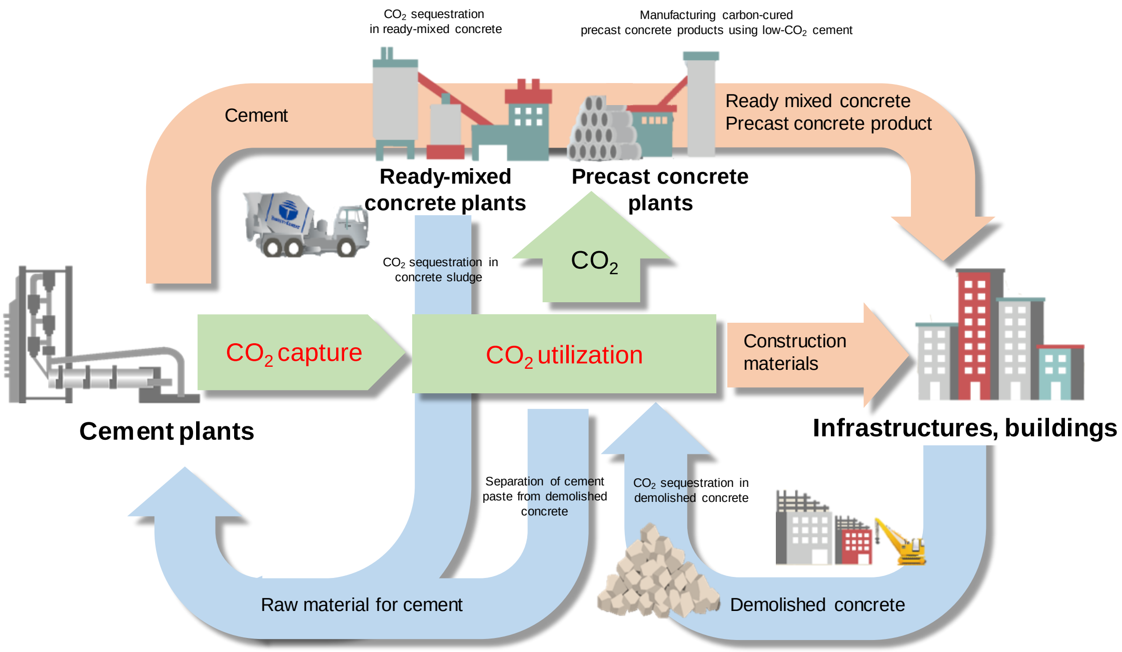

Fig. 4 Carbon recycling technology for the cement industry (supported by New Energy and Industrial Technology Development Organization)

Conclusion

In order to achieve the long-term goal of carbon neutrality by 2050, innovative technologies are required that are not extensions of conventional thinking. Taiheiyo Cement Corporation is working to introduce carbon recycling technology into the cement supply chain. The CO_2 released during the manufacture of cement is recovered as an intermediate product, and this recovered CO_2 is then incorporated into concrete end products made with the cement. In order to embody such decarbonization technologies in the supply chain, it is important to obtain the understanding and cooperation of a wide range of stakeholders, including not only the cement industry itself, but also concrete manufacturers, designers, building contractors, and clients. Public policy will play an important role in the ability of the industry to decarbonize cement sector. A comprehensive policy framework will need to be developed.

The cement industry makes use of large amounts of waste and byproducts from other industries as well as municipal waste, re-utilizing them in the manufacturing process as both raw materials and as an energy source. This makes us a major player in the shaping of Japan as a resource-recycling society. We must take on the challenge of creating a future society in which resource recycling and carbon recycling are compatible.