Using Ca-based solid wastes from iron and steel industry to fix carbon-dioxide via carbonation reaction

Fang Lian

School of Material Science and Technology,

University of Science and Technology Beijing

Tel: 010-82377985

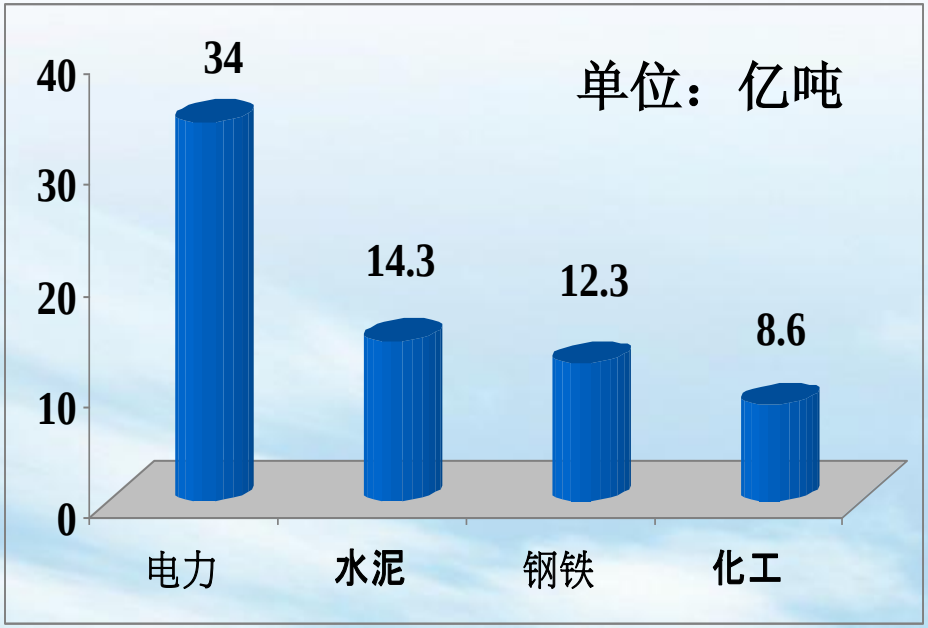
Email：lianfang@mater.ustb.edu.cn

Contents

I. Technical Need Analysis

The obligatory target to reduce 17% of CO_2 emission per unit of GDP during the 12th Five-year Plan period has been set.

Great pressure to reduce CO_2 emission lies on the shoulder of key industries in China.



Annual amount of CO_2 emission of the key industries in China

The main source of CO_2 emission involves electric power industry, cement industry, iron and steel industry and chemical industry.

Among them, the production of iron and steel in China is 7 hundred million t/y, and the CO_2 emission per ton is 1.8 tons.

Data Source: China Energy Statistical Yearbook 2011

I. Technical Need Analysis

Cement Industry

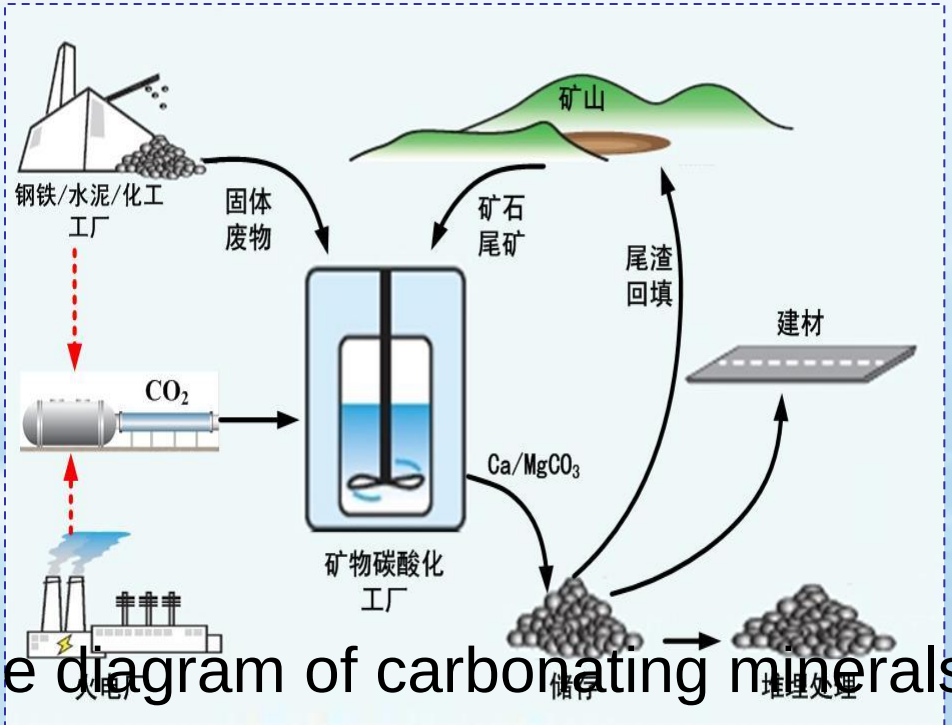
- **In 2009, the national production of cement was 1.63 billion tons, and according to the forecast, the global demand for cement will increase 50% by 2020.**
- **Along with the production of cement, there is a large amount of energy consumption and CO_2 emission. In 2005, the CO_2 emission of the cement industry in China was 867 million tons, accounted for 22.8% of the total emission in China in that very year.**
- **A great number of energy has been consumed along with the production of cement. Under the current technical conditions in China, the average heat consumption of the production of every ton of cement is 0.15 ton of standard coal, and the average power consumption is 110 kWh.**

✓ **A large-scale alternative green cement of slag and the inorganic building material made of this kind of cement**

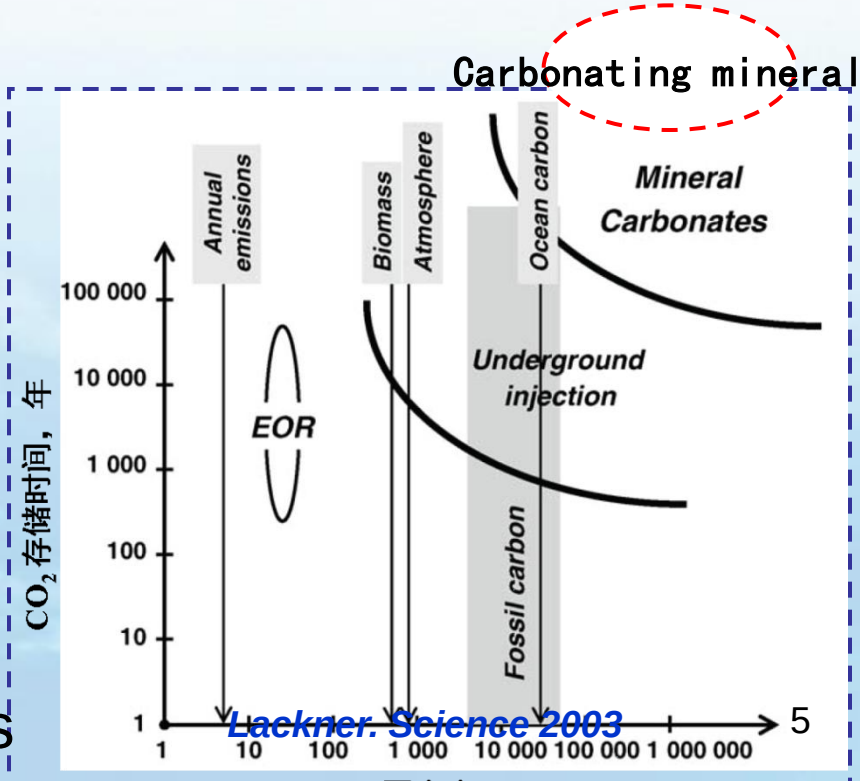
I. Technical Need Analysis

To fix CO_2 by carbonating minerals is a very important way to reduce CO_2 emission.

There are a variety of sources of the raw material used to be mineralized. The way of solidification has a large capacity with stable outputs which can be used as resources. Meanwhile, the safety and economy of CO_2 capture and storage are improved.



The diagram of carbonating minerals



I. Technical Need Analysis

- ✓ **The pilot tests to fix CO_2 by mineralizing the calcium-based solid waste (such as metallurgical slag and stove ash) have been in process in the research institutions in Finland, Korea, China and other countries.**
- ✓ **ALCOA has realized the large-scale application of solidifying carbon with red mud with alumina.**

Korea: pilot plant of solidifying carbon by incinerating ashes

US: red mud 2000-2500 thousand tons per year

Using industrial solid waste to fix CO2 is the focus of R&D

I. Technical Need Analysis

Utilization rate of the calcium-based solid waste from metallurgy has yet to be improved.

Steel slag is the main calcium-based industrial solid waste in the iron and steel industry, and its production is 80 million tons per year.

Waste of resources

Occupation of land

Environmental pollution

Green and efficient use

The road backfilled with steel slag is cracked.

The size of ionized CaO and MgO expands when meeting with water.

Its utilization rate is less than 35%.

Rich in CaO(35-50%), to fix CO_2 directly

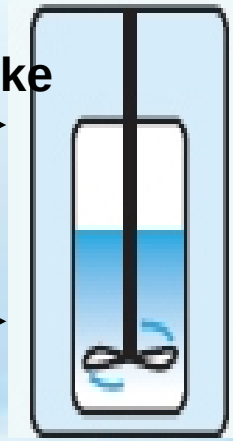
II. Status-quo of the Technologies

To fix CO_2 with mineralization is an effective path to use large-scale calcium-based solid waste.

Targets: to use calcium-based industrial solid waste and CO_2 collaboratively; to treat waste with waste, and to solidify in situ; to lower the cost of solidification of CO_2, and to improve the resource utilization rate of calcium-based solid waste.

CO_2 smoke

Calcium-based solid waste



Iron and steel factory

Carbonating transition

To solidify CO_2 in situ

concrete additive

dry-mixed mortar

calcium carbonate product

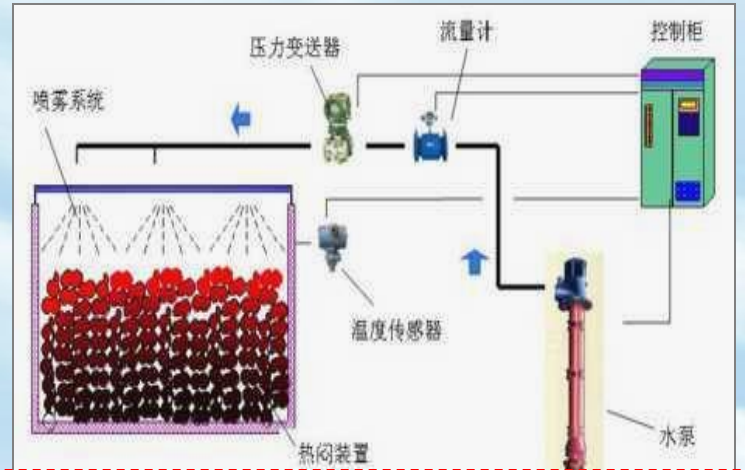
Large-scale use of the fixed product

II. Status-quo of the Technologies

Using water (vapor) to dissolve free calcium and magnesium in steel slag has been applied in the industry; using water/CO_2, sodium salt and other media to stabilize steel slag and to fix CO_2 at the same time has been put into pilot tests.

●Traditional way to dissolve steel slag has the following problems:

- ✓ **Long reaction time; low output of fixed CO_2.**
- ✓ **High energy consumption; limited utilization of the products of carbon sequestration.**



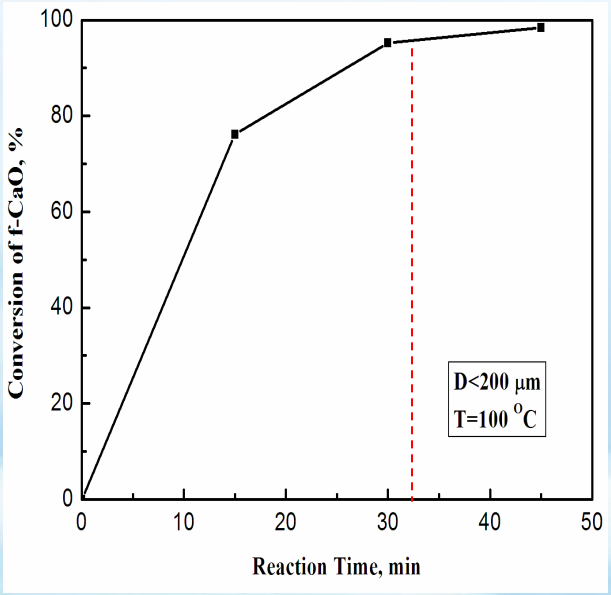
●Key technologies:

- ✓ **Technology to activate, strengthen and carbonate steel slag, which is highly effective and does not consume much energy.**
- ✓ **Technology to optimally design the coupling equipment of activating, strengthening and carbonating steel slag.**
- ✓ **Technology to use the product of carbon sequestration of steel slag massively.**

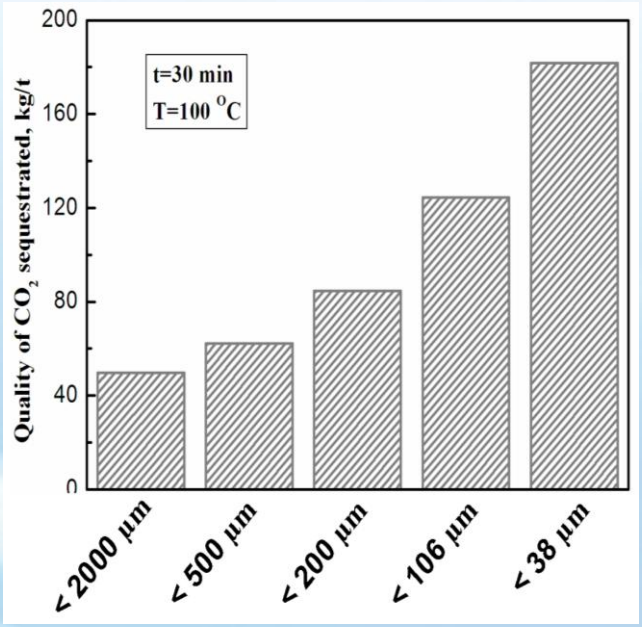
II. Status-quo of the Technologies

Reaction of activating, strengthening and carbonating steel slag

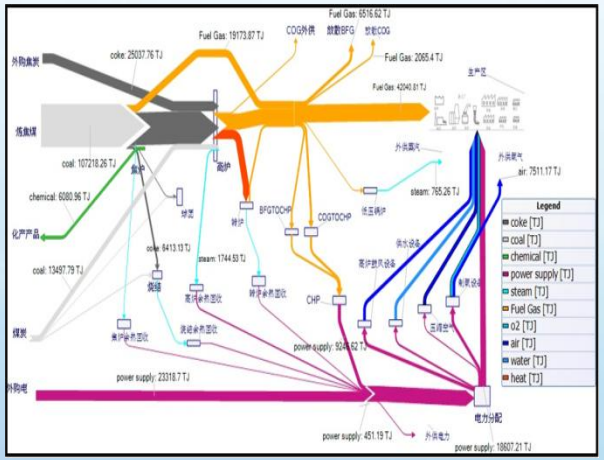
- **The technical conditions to fix CO_2 by activating, strengthening and carbonating steel slag have been optimized. Over 98% of steel slag can be transformed into free CaO. The model of CO_2 emission has been built. The computing system to calculate the amount of CO_2 emission in iron and steel industry has been exploited.**



Transformation rate of free CaO



Fixed amount of CO_2 in every ton of slag



The integrate analysis of carbon flow and energy flow during the process of metallurgy

III: Key Technologies

- **New technology to fix CO_2 by carbonating calcium-based solid waste:**

There is no need to capture and separate CO_2; CO_2 in smoke can be fixed directly. The calcium-based solid waste in metallurgical industry and CO_2 are efficiently transformed into building material or chemical fertilizer, which has obvious economic and environmental benefits.

- **Key technology to fix CO_2 by carbonating calcium-based solid waste:**

The coupling technology of activating and carbonating steel slag, and the technology to regulate and control the quality of the product of solidification.

- **Exclusive equipment for strengthening and carbonating:**

Exclusive equipment to fix CO_2 by activating field and mineralizing gas-solid moving bed coupling metallurgical slag.

- **Packaged technology:**

Packaged technology to fix CO_2 by mineralizing calcium-based industrial solid waste, which can be promoted in iron and steel industry

IV. Expected Economic and Social Benefits

Category	Benefit By mineralizing 10,000 tons of steel slag	Extended Benefit（Coverage: 40%）
Economic Benefit	490,000 yuan	1.12 billion yuan
Environmental Benefit	To fix CO_2 1,000 tons directly， To reduce CO_2 emission 8,400 tons	To fix CO_2 with steel slag directly 3.2 million tons, To reduce CO_2 emission 26 million tons， Available steel slag 32 million tons

V. Summary and Outlook

- **Carbonating mineral is an important way to largely reduce CO_2 emission, in particular, the application of fixing CO_2 by mineralizing calcium-based industrial solid waste has a good prospect.**
- **According to the characteristics of CO_2 emission in the metallurgical industry and the current situation of the use of calcium-based industrial solid waste, the methods of treating waste with waste and solidifying CO_2 in situ have a great practical significance for the development of recycling economy in China.**
- **Large-scale reduction of industrial solid wastes and CO_2 emission and recycling them collaboratively need a technical system in place, which will further promote the low-carbon technology development in the metallurgy and cement industries.**

Acknowledgements:

- **The State Science and Technology Support Program in the 12th Five-year Plan Period (No . 2011BAB03B05)**
- **The State Science and Technology Support Program in the 11th Five-year Plan Period (No .2006BAB12B03)**

Welcome to visit: www.liangroup.org


北京科技大学
University of Science and Technology Beijing
学风严谨
崇尚实践

Thank you!