2022 Rotary Kiln Technology Development Report

1、 Development of China's economy and lime related industries

1. Overview of China's Economic Development in 2022

In 2022, facing multiple unexpected factors, China efficiently coordinated epidemic prevention and control as well as economic and social development, maintaining overall economic and social stability; In the three years since the pandemic, the annual compound growth rate of gross domestic product (GDP) has been 4.5%, ranking among the top among major global economies. In 2022, the Chinese economy is facing triple pressures of demand contraction, supply shock, and weakening expectations, with the industrial economy growth rate falling below the pre pandemic level.

2. Development status of lime related industries

(1) The main demand industries for steel, alumina, and calcium carbide all have increased production

1) Steel: In the past decade, the wave of cross regional and cross ownership mergers and acquisitions in the steel industry has swept across the country, especially with the continuous acceleration of strategic restructuring based on specialization, aimed at reducing homogeneous competition, and characterized by asset transfer, building a new industrial pattern with the main framework of "Nanbaowu and Bei'angang". CITIC Taifu Special Steel Group has restructured Qingdao Steel, Hualing

Xigang, Zhejiang Steel Pipe, and Tianjin Steel Pipe, With an annual production capacity of over 14 million tons of steel, it has become the largest and most comprehensive specialized special steel production enterprise in the world, and truly a leading global special steel enterprise.

Table 1: Enterprises with Active Mergers and Reorganizations in Recent Years

中国宝武			鞍钢集团			沙钢集团			建龙集团		
时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）
2016.12	宝钢和武钢合并	5850	2021.08	鞍本重组	6300	2017.09	重组东北特钢	4423	2015.09	重组海鑫钢铁	
2019.09	马钢	3150	2022.06	凌源钢铁	600	2023.01	南京钢铁	1158	2017.09	北满特钢	
2020.08	太钢	1294							2017.11	阿城钢铁	
2020.09	重钢	806							2018.08	马来西亚东钢	
2020.11	新疆新兴、伊犁	400							2018.12	包钢万腾	
2022.04	新余钢铁	1000							2018.12	西林钢铁	
进行中	昆明钢铁	1000							2019.05	申银特钢	
进行中	山东钢铁	3100							2020.06	海威钢铁	
未来	包钢	1650									
未来	西宁钢铁	210									
合计		18460	合计		6900	合计		5581	合计		4200

According to data from the China Iron and Steel Industry Association, the proportion of crude steel production in China's top 10 steel enterprises has increased from 35.9% in 2016 to 41.5% in 2021, but overall it is still at a relatively low level, lower than that of the United States, Japan, South Korea, and others.

In the first three quarters of 2022, the steel industry fell into another predicament and prices were deeply lowered. From January to September, the national crude steel consumption decreased by 4%, but there were differences among different varieties. The demand for threads decreased by 15.8%, the demand for hot rolling decreased by 4.3%, the demand for cold rolling decreased by 2.4%, the demand for medium and thick plates increased by 1.6%, the demand for long materials decreased, and the demand for plates increased and decreased, reflecting the active adjustment of the economic structure.

The statistics of crude steel production from 2017 to 2022 are shown in Table 2. It is expected that the cost of steel raw materials in 2023 will show a downward trend compared to the previous year. The average price of the iron ore index may remain around 85 US dollars, a decrease of 26%, while the average price of the coal coke index will remain around 1600 yuan/ton, a decrease of 30%. The overall steel price first decreased and then increased, with an annual average price dropping by 15%.

According to 2021 statistical data, China's pig iron production is 86.8568 million tons. Calculated based on the consumption of 85kg of lime per ton of iron, the annual consumption of stone ash is 73.82828 million tons. The crude steel production in 2021 is 10310.5 million tons, and based on the consumption of 38kg of lime (including refining) per ton of steel, the annual

consumption of steelmaking lime is 39.18 million tons; The market capacity of metallurgical lime in 2021 is 113 million tons. It is expected that the demand for steel in 2023 will remain unchanged compared to 2022, with a crude steel production of approximately 1.02 billion tons and a total demand for lime of approximately 111.9 million tons.

Table 2 Statistical Table of Crude Steel Production from 2017 to 2022 (Unit: 10000 tons)

年 \ 月	1	2	3	4	5	6	7	8	9	10	11	12	总计
2017	6758	6119	7199	7278	7226	7323	7402	7459	7183	7236	6615	6705	84503
2018	7188	6493	7398	7670	8113	8020	8124	8033	8085	8255	7834	7612	92825
2019	14958.1		8032.6	8503.2	8909.1	8753.3	8522.3	8725.1	8277.3	8152.1	8028	8426.5	99287.6
2020	15470.2		7897.5	8503.3	9226.7	9157.9	9335.9	9484.5	9255.5	9220.2	8766	9125	105442.7
2021	17498.92		9402.1	9784.6	9945.4	9387.5	8679	8323.9	7375	7158	6931.3	8619.3	103105.02
2022	15796		8829.5	9280	9661.3	9073	8143	8000	8695	7976			85453.77

2) Aluminum oxide: In the first half of 2022, the overall supply of domestic aluminum oxide is abundant, and a large amount of new production capacity is concentrated and released. As of the end of May, the domestic alumina production capacity was 94.17 million tons, an increase of 5.2% compared to the end of December last year, and the operating capacity was 82.4 million tons, an increase of 12.3% compared to the end of December last year. The alumina operating rate was 87.5%.

Affected by a significant increase in production capacity, the price of aluminum oxide in the first half of the year fell significantly after the Winter Olympics production restrictions and the easing of the impact of the summer epidemic.

Table 3 List of New Domestic Alumina Production Capacity from 2017 to 2023 and Long Term

公司	地区	省份	城市	原有产能（万吨/年）	新建产能（万吨/年）	开始投产时间	2022年	2023年及以后	当前进度
靖西天桂2	华南	广西	百色	0	85	2022年	85	0	2022年1月初投产试运行，2022年5月出料
靖西天桂3	华南	广西	百色	0	85	2022年	85	0	计划2022年7月投产
博塞万州	西南	重庆	重庆	0	360	2022年	480	0	2022年6月全部投产完毕
田东锦鑫2	西南	广西	田东	0	120	2022年	120	0	2021年7月底开始建设，计划2022年12月投产
河北文丰新材料	华北	河北	曹妃甸	0	360	2022年	240	120	一段120万吨2022年1季度投产，二段6月满产
山西田园化工	华北	山西	孝义	0	40	2022年	40	0	扩产于2022年第1季度投产，总产能80万吨
山西奥凯达	华北	山西	孝义	40	40	2022年	40	0	计划2022年6月投产，总产能90万吨
鲁北化工2	华东	山东	滨州	50	100	2022年	100	0	计划2022年8月投产
鲁豫博创2	华东	山东	滨州	0	80	2022年	100	0	计划2022年下半年投产
东方希望北海	西南	广西	北海	0	480	2023年或之后	0	400	环评通过，项目暂停
国电投北海	华南	广西	北海	0	400	2023年或之后	0	400	环评通过，项目暂停
中铝防城港2	华南	广西	防城港	0	200	2023年或之后	0	200	待定
锦国投	东北	辽宁	大连	0	650	2023年或之后	0	650	待定
其亚铝业	西南	贵州	黔东南	0	60	2023年或之后	0	60	2019年12月政府与其亚签订项目协议，投产待定
2022年新增							1290		
2023年及远期新增								1830	

It is expected that the newly invested alumina production capacity will reach 12.9 million tons in 2022. As the production capacity continues to increase rapidly in the second half of the year, there may be downward pressure on the subsequent price of alumina.

The actual production of alumina in 2021 was 77.171 million tons, and the total production from January to October 2022 was 68.1782 million tons, an increase of 5.1% compared to the same period last year. It is expected that the annual production will reach 81.1 million tons. The consumption of lime per ton of alumina is about 200kg, and the demand for lime in 2022 is about 16.22 million tons.

Table 4 Statistical Table of Aluminum Oxide Production from 2020 to 2022

年 \ 月	1	2	3	4	5	6	7	8	9	10	11	12	总计
2020	1045.1		588.1	606.7	593.5	629.3	610	644.9	656	638.9	630	613.4	7255.9
2021	1264.26		653.7	649	659.6	680.4	650.3	646.6	654.8	629.1	605	624.3	7717.06
2022	1177.5		685.3	682	698.8	731.66	708.16	718.4	705.2	710.8			6817.82

3) Calcium carbide: The downstream of the domestic calcium carbide industry is mainly concentrated in PVC production, with an apparent consumption of approximately 27 million tons/year of calcium carbide in the past five years. The demand for PVC is steadily increasing, and it is conservatively expected that PVC's demand for calcium carbide will maintain a

compound growth of 3% in the next five years. Driven by biodegradable plastic PBAT, BDO is expected to maintain rapid growth. Currently, there are up to 220 BDO projects in operation, under construction, and planned in China, and preliminary work has been carried out. By the end of 2029, the expected production capacity will exceed 17.5 million tons. It is predicted that by 2025, the BDO of the calcium carbide route will consume 4.2 million tons of calcium carbide per year. Assuming that other demands for calcium carbide remain unchanged, the domestic demand for calcium carbide in the coming years is estimated to be approximately 27 million tons in 2022 and 31.5 million tons in 2023, with a domestic consumption of approximately 33.85 million tons by 2025.

The demand for lime in the three major industries mentioned above in 2022 is approximately 155.2 million tons, which is basically the same as the previous year. Due to macroeconomic impact, these industries are in a state of low profit or loss, coupled with high prices of coal and other fuels. The lime industry as a whole is in a state of low profit, and enterprises without supporting limestone mines are in a difficult situation. Many enterprises have limited production or even stopped production.

(2) Sustainable growth of environmental protection and agricultural lime

During the 14th Five Year Plan period, China will comprehensively carry out the treatment of air, water, soil, and new pollutants, promote ecological protection and restoration, and achieve pollution reduction and capacity increase. Green development and the construction of a beautiful China will push the environmental protection industry to a new level. In

developed countries, the proportion of lime used for environmental protection and agriculture is over 20%, while in China, the proportion of lime used for environmental protection and agriculture is less than 10%. Lime, as a highly active alkaline agent with high cost-effectiveness and no secondary pollution, has been widely used in fields such as waste gas, wastewater, solid waste treatment, soil improvement, and has become an important economic growth point for China's lime industry. During the 14th Five Year Plan period, environmental protection and agricultural ash will form an incremental market with an annual demand of over 30 million tons. The estimation of lime consumption in some environmental protection fields is shown in Table 5.

Table 5 Estimation of Lime Consumption in Some Environmental Protection Fields

序号	环保领域	年石灰用量(万吨)	备　　注
1	垃圾焚烧	240	按生活垃圾 4 亿吨，吨垃圾消耗石灰 6kg 计算。
2	城市污水治理	1492.60	城市日污水量 18846 万吨，万吨耗石灰 10×0.22 吨。
3	工业污水治理	447.79	按城市污水治理用量的 30%计算。
4	用煤作燃料的烟气治理	527.35	年煤炭消耗量 39.65 亿吨，按平均含硫 1%计算，按 10%采用半干法脱硫，脱 1 吨 SO_2 需 85%生石灰计 1.33 吨。
5	土壤改良	429.89	土壤改良亩消耗石灰 100Kg，年改良土地占耕地面积的 2%。
	合计	3137.6	

2、 Construction status of rotary kiln

As of now, there are approximately 580 lime and dolomite rotary kilns that have been built and put into operation in China that have been included in the statistical approach. According to preliminary statistics from key enterprises of the Lime Association, approximately 25 lime rotary kilns are expected to start construction in 2022, with a production capacity of approximately 8 million tons after production. The newly added production capacity accounts for a relatively high proportion of all kiln types.

3、 Characteristics and Development of Rotary Kiln Technology

1. Technical characteristics of rotary kiln

(1) Lime has the highest quality: calcination is the most uniform, activity is the highest, raw calcination is the lowest, and S content is the lowest;

(2) Maximum single machine production capacity: up to 2000t/d per machine;

(3) The most flexible adjustment: open calcination, with independent and controllable preheating, calcination, and cooling stages;

(4) The range of particle size of limestone entering the furnace is wide: 10-20mm small particle size and 40-80mm large particle size limestone, which can still ensure high-quality calcination when entering the furnace;

(5) Multi fuel mixed combustion: Rotary kiln fuel has strong adaptability, and available fuels include gaseous, liquid, and solid states, which can be burned alone or in combination, and can be freely switched;

(6) Can achieve ultra-low emissions: Among the existing kiln types, rotary kiln is the most mature environmentally friendly ultra-low emission process at present, with stable and mature desulfurization and denitrification processes and low operating costs.

2. Innovation in Rotary Kiln Technology

(1) Rapid progress in large-scale rotary kilns

In the newly built rotary kiln production line in 2022, there will be 3 kilns with a diameter of 5.8 meters and a daily output of 1600 tons; Two kilns with a diameter of 5.2 meters and a daily output of 1300 tons (put into operation in November). The above kiln types are all original designs in China and have a large technological span. After these new rotary kilns are put into operation, they will have a significant impact on lime production equipment in China and even the world.

(2) The energy consumption of the rotary kiln is gradually decreasing

In recent years, the heat consumption of newly built rotary kilns has gradually decreased, with benchmark heat consumption indicators below 1050kcal/kg. Measures to reduce consumption:

1) Standardize operational management, improve personnel quality and management level;

2) Reduce the air leakage rate of the rotary kiln system;

3) Improve the thermal efficiency of the preheater and cooler, and reduce the temperature of exhaust gas and ash discharge;

4) Optimize refractory materials to reduce heat dissipation loss of the cylinder;

5) Fully utilize thermal energy, such as drying coal powder with kiln exhaust gas, producing steam or hot water for secondary utilization, and radiating heat from the calcination section for heating, bathing, etc;

6) Improve burner burnout rate and thermal efficiency;

7) Using frequency converters to reduce electrical energy consumption;

8) Adopting an intelligent combustion control system, optimizing operating procedures, reducing fuel consumption and production costs.

4、 Existing problems and solutions

1. Uneven levels of production line construction

The rotary kiln lime production line is the most complex among the existing lime kiln types, with high requirements for construction units. However, there are many units engaged in rotary kiln construction in China, with varying levels, resulting in poor construction quality and operational effectiveness of some production lines. To ensure the quality of production line

construction, it is recommended to choose a professional construction unit. A professional construction unit should have a professional team with professional design capabilities to ensure reasonable factory planning and processes, strong manufacturing capabilities to ensure production quality and progress, a skilled installation team to ensure installation quality and progress, and a professional debugging team to ensure trial production safety and meet production standards in a short time. Secondly, owners should not blindly pursue low prices, but should pay attention to the cost-effectiveness of production line investment to avoid losses caused by frequent shutdowns and renovations. Thirdly, the Lime Association should strengthen consulting services and guide enterprises to correctly select construction units based on their own situations and needs.

2. Insufficient awareness of the importance of raw fuel conditions among lime production enterprises

The smooth operation of the furnace is directly related to the raw materials and fuels. Not all limestone can enter the rotary kiln for calcination, and there are a series of indicator requirements such as composition, particle size, hardness, and mud content; Fuel has various requirements such as calorific value, volatile matter, coke residue characteristics, moisture, fineness, ash content, etc. The stable and high yield of the rotary kiln production line must have stable and qualified raw fuel conditions.

3. Lack of high-end talents in the industry

Due to historical reasons, lime enterprises are generally small in scale and have low overall employee quality, which restricts their development. Advocating industry enterprises to strengthen employee training. The quality of employees and teams is a key factor in ensuring smooth production and excellent indicators. Cultivating and retaining talents is the most cost-effective investment for enterprises.

5、 Market Analysis and Prospect Prediction of Rotary Kiln

1. Market Analysis of Rotary Kiln

As the world's largest industrialized country, China currently has a wide variety of lime kiln types, and rotary kilns have won the trust of many users due to their unique advantages. With the innovative development of rotary kiln technology, its share in the high-end activated lime market will continue to expand.

(1) Rotary kiln lime is preferred for stainless steel, special steel, and steelmaking in the steel industry; As the energy consumption of rotary kilns decreases year by year, the range of rotary kiln ash used in sintering has expanded year by year, such as Jiuquan Iron and Steel, Jingye Iron and Steel, and Xinxing Cast Pipe.

(2) High activity lime improves the recovery rate of alumina and reduces production costs. At present, the alumina industry mainly relies on rotary kilns as direct supporting furnaces, and it has become an industry consensus to select high-end rotary kiln lime for alumina production.

(3) The number of supporting rotary kilns for technological transformation in the calcium carbide industry has been increasing year by year, which not only reduces process power consumption, but also utilizes the advantages of multi fuel mixed combustion in rotary kilns to directly use blue carbon dust removal ash as fuel for combustion, solving the problem of environmental pollution.

(4) The low sulfur content of rotary kiln exhaust gas, mature denitrification processes, and lower denitrification costs are conducive to the promotion and application of rotary kiln technology.

2. Prospect prediction

The transformation of lime production organization and operation mode will become an opportunity for the development of rotary kilns.

(1) With industrial collaboration and capital restructuring, lime enterprises will move towards collectivization and large-scale transformation

Limestone mining, lime, heavy calcium, calcium hydroxide, light calcium, nano calcium carbonate, and derivatives are interrelated and complementary industries. Integrated enterprises will fully recycle and utilize solid waste, waste heat, exhaust gas, etc. in production, with more cost advantages and more guaranteed product quality. With the gradual integration of the industry, large-scale integrated comprehensive enterprises will become a trend.

In recent years, the lime industry has gradually entered the perspective of capital. The association has taken the initiative to establish a lime industry fund to promote industry transformation and upgrading. Local governments are actively promoting enterprise mergers and acquisitions to change the "scattered, disorderly, and polluted" situation of lime and upstream and downstream enterprises. It is expected that in the next 5 years, there will be tens of millions of tons of lime enterprise groups in the industry, and high-end lime kiln types such as rotary kilns will dominate the backbone enterprises.

The downstream demand side of lime, such as steel, calcium carbide, alumina, etc., will have super large customers in the future with industry restructuring. It is not ruled out that there will be mutual shareholding between upstream and downstream large customers.

(2) The arrival of 5G will change the operation mode of lime production enterprises

The basic construction of China's 5G infrastructure will be completed. During the 14th Five Year Plan period, the widespread application of big data technology in the industrial sector will change the company's operational ecology. The lime industry should be proactive and integrate into this big data industrial revolution. It is expected that big data will change the operation mode of lime production enterprises in the following two aspects: firstly, big data will support the industry to establish a unified service platform, including remote diagnosis and technical service support, spare parts and maintenance service platform, unified finished product sales and raw fuel supply platform. Secondly, the intelligent control system is combined with the company's big data platform to gradually achieve intelligent factories and reduce personnel

demand. The establishment of a unified service platform and big data platform is conducive to leveraging the technological advantages of rotary kilns.

The development of the times and technological progress have provided broad development space for the development of rotary kilns, and the market prospects are promising.

6、 Development Trend of Rotary Kiln Technology

On November 2, 2022, the Ministry of Industry and Information Technology, the National Development and Reform Commission, the Ministry of Ecology and Environment, and the Ministry of Housing and Urban Rural Development jointly issued the "Implementation Plan for Carbon Peak in the Building Materials Industry". The plan proposes that during the 14th Five Year Plan period, significant progress has been made in the structural adjustment of the building materials industry, energy-saving and low-carbon technologies in the industry continue to be promoted, and the unit energy consumption and carbon emission intensity of key products such as cement, glass, and ceramics continue to decrease, The comprehensive energy consumption level per unit product of cement clinker has been reduced by more than 3%. During the 15th Five Year Plan period, significant breakthroughs were made in the industrialization of green and low-carbon key technologies in the building materials industry, and the level of raw material and fuel substitution was significantly improved. A green and low-carbon circular development industry system was basically established to ensure that the building materials industry achieves a "carbon peak" by 2030.

To achieve the above goals, rotary kiln technology must be innovatively developed:

1. Promote large-scale rotary kilns and reduce energy consumption

The large-scale lime kiln is an effective means to reduce fuel and electricity consumption. According to incomplete statistics in China, rotary kilns above 800t/d save about 10% energy compared to rotary kilns below 600t/d. Therefore, it is recommended to promote rotary kiln production lines with a capacity of over 800t/d based on market conditions.

2. Application of alternative fuels such as biomass energy

Many large lime multinational companies internationally are actively developing alternative fuels, such as waste fuels, hydrogen energy, biomass fuels, etc. Currently, the proportion of alternative fuels used exceeds 20% to significantly reduce carbon emissions from energy combustion processes.

The fuel adaptability of the lime rotary kiln production line is strong. If there are abundant waste fuels and biomass fuels near the production line, suitable alternative fuel utilization methods can be selected based on resource characteristics, partially or completely replacing conventional fuels to reduce the use of conventional fuels and reduce carbon emissions.

3. Application of oxygen rich combustion technology

After adopting oxygen rich combustion, the fuel is burned more fully, the amount of smoke is reduced, and the heat

generated per unit of fuel is greatly increased, which is beneficial for saving fuel resources. But it is necessary to solve the problem of controlling the increase of nitrogen oxides in the exhaust gas and the air volume required for lime cooling. The solution is to combine oxygen enrichment, reduce air consumption, reasonably introduce kiln exhaust gas, increase CO2 concentration in the exhaust gas, and utilize CO2 resources. However, the investment in its process route equipment is huge, and it needs to be implemented with a reasonable industrial chain economy, such as raising the carbon trading price to a reasonable level or applying it in high-altitude hypoxic areas.

4. Developing energy-saving processes, energy-saving hosts, and adopting energy-saving equipment to improve the energy-saving level of production lines

The continuous optimization of the production line process route, the improvement of energy conservation and efficiency of main engines such as preheaters, rotary kilns, and coolers, and the use of high-efficiency products for fans and motors can further reduce the energy consumption level of the production line.

5. Adopting intelligent control to stabilize the overall energy consumption level

The same equipment, different operators and management levels, and energy consumption indicators vary greatly in

China. Improving the intelligence level of production lines, especially by adopting intelligent combustion control systems, can reduce human factors and stabilize the energy consumption level of production lines.

6. Develop and promote efficient utilization technology for low-temperature waste heat

Due to differences in calcination methods, the heat consumption of rotary kilns is relatively high compared to advanced kiln types. If the waste gas from the kiln tail and the waste heat from the kiln skin can be reasonably utilized, the disadvantage of high energy consumption of rotary kilns will be overcome, and the overall energy consumption of the industrial chain will be reduced. Ultra low emissions and denitrification are examples of the advantages of rotary kilns.

7. Promote the industrial application of carbon dioxide capture, utilization, and storage technology

Regardless of fuel and electricity, each ton of lime calcination can generate 0.78 tons of CO_2. The lime industry is a major CO_2 emitter, and the process is designed reasonably to produce high concentrations of CO_2 in the kiln exhaust gas. According to different regions, reasonable CO_2 resource utilization methods should be selected, such as industrial and food CO_2, production of baking soda, salicylic acid, etc., to reduce greenhouse gas emissions.

2022 年度回转窑技术发展报告

一、我国经济及石灰相关行业发展情况

1、2022 年我国经济发展概况

2022 年，面对多重超预期因素冲击，中国高效统筹疫情防控和经济社会发展，保持了经济社会大局稳定；疫情三年国内生产总值（GDP）年均复合增长 4.5%，在全球主要经济体中居前列。2022 年中国经济面临着需求收缩、供给冲击、预期转弱的三重压力，工业经济增速回落至低于疫情前的水平。

2、石灰相关行业的发展情况

（1）钢铁、氧化铝、电石三大石灰主要需求行业产量均有增加

1）钢铁：十年来，钢铁行业跨区域、跨所有制兼并重组浪潮席卷全国，尤其是在专业化的基础上规模化、以减少同质化竞争为目的、以资产划转为特点的战略性重组不断提速，构建起以“南宝武、北鞍钢”为主框架的产业新格局，中信泰富特钢集团重整青岛钢铁、华菱锡钢、浙江钢管、天津钢管后，钢铁年产能超 1400 万吨，成为全球范围内规模最大、品类最全的专业化特钢生产企业，成为名副其实的全球特钢龙头企业。

表 1 近年来兼并重组较为活跃的企业

中国宝武			鞍钢集团			沙钢集团			建龙集团		
时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）	时间	钢厂	产能（万吨）
2016.12	宝钢和武钢合并	5850	2021.08	鞍本重组	6300	2017.09	重组东北特钢	4423	2015.09	重组海鑫钢铁	
2019.09	马钢	3150	2022.06	凌源钢铁	600	2023.01	南京钢铁	1158	2017.09	北满特钢	
2020.08	太钢	1294							2017.11	阿城钢铁	
2020.09	重钢	806							2018.08	马来西亚东钢	
2020.11	新疆新兴、伊犁	400							2018.12	包钢万腾	
2022.04	新余钢铁	1000							2018.12	西林钢铁	
进行中	昆明钢铁	1000							2019.05	申银特钢	
进行中	山东钢铁	3100							2020.06	海威钢铁	
未来	包钢	1650									
未来	西宁钢铁	210									
合计		18460	合计		6900	合计		5581	合计		4200

中国钢铁工业协会数据显示，我国前 10 家钢铁企业粗钢产量占全国比重由 2016 年的 35.9%提升到 2021 年的 41.5%，但整体仍处于较低水平，低于美国、日本、韩国等。

2022 年前三季度钢铁业再陷困境，价格深度下调。1～9 月全国粗钢消费下降 4%，但各品种间存在差异，螺纹需求下降 15.8%，热轧需求下降 4.3%，冷轧需求下降 2.4%，中厚板需求增长 1.6%，长材需求下降，板材需求有增有减，反映出经济结构正在积极调整。

2017～2022 年粗钢产量统计见表 2。预计 2023 年钢铁原料成本同比上年呈下降趋势，铁矿石指数均价或维持在 85 美元左右，下跌 26%，煤焦指数均价维持在 1600 元/吨左右，下跌 30%。总体钢材价格先抑后扬，年均价下跌 15%。

根据 2021 年统计数据：我国生铁产量为 86856.8 万吨，按吨铁消耗 85kg 石灰计算，烧结石灰年用量为 7382.828 万吨。2021 年粗钢产量为 10.3105 亿吨，按吨钢消耗石灰（含精炼）38kg 计算，炼钢石灰年用量为 3918 万吨；2021 年冶金石灰市场容量为 1.13 亿吨。预计 2023 年钢铁需求同比 2022 年持平，粗钢产量约 10.2 亿吨，石灰总需求预计约 1.119 亿吨。

表 2 2017～2022 年粗钢产量统计表（单位：万吨）

月 / 年	1	2	3	4	5	6	7	8	9	10	11	12	总计
2017	6758	6119	7199	7278	7226	7323	7402	7459	7183	7236	6615	6705	84503
2018	7188	6493	7398	7670	8113	8020	8124	8033	8085	8255	7834	7612	92825
2019	14958.1		8032.6	8503.2	8909.1	8753.3	8522.3	8725.1	8277.3	8152.1	8028	8426.5	99287.6
2020	15470.2		7897.5	8503.3	9226.7	9157.9	9335.9	9484.5	9255.5	9220.2	8766	9125	105442.7
2021	17498.92		9402.1	9784.6	9945.4	9387.5	8679	8323.9	7375	7158	6931.3	8619.3	103105.02
2022	15796		8829.5	9280	9661.3	9073	8143	8000	8695	7976			85453.77

2）氧化铝：2022 上半年国内氧化铝供应总体充裕，且新投产能集中大量释放。截至 5 月底，国内氧化铝建成产能 9417 万吨，较上年 12 月底增加 5.2%，运行产能 8240 万吨，较上年 12 月底增加 12.3%，氧化铝开工率为 87.5%。受产能大幅增加的影响，上半年氧化铝价格在冬奥限产和夏季疫情影响缓解后大幅回落。

表 3 2017～2023 年及远期国内氧化铝新建产能列表

公司	地区	省份	城市	原有产能（万吨/年）	新建产能（万吨/年）	开始投产时间	2022年	2023年及以后	当前进度
靖西天桂2	华南	广西	百色	0	85	2022年	85	0	2022年1月初投产试运行，2022年5月出料
靖西天桂3	华南	广西	百色	0	85	2022年	85	0	计划2022年7月投产
博塞万州	西南	重庆	重庆	0	360	2022年	480	0	2022年6月全部投产完毕
田东锦鑫2	西南	广西	田东	0	120	2022年	120	0	2021年7月底开始建设，计划2022年12月投产
河北文丰新材料	华北	河北	曹妃甸	0	360	2022年	240	120	一段120万吨2022年1季度投产，二段6月满产
山西田园化工	华北	山西	孝义	0	40	2022年	40	0	扩产于2022年第1季度投产，总产能80万吨
山西奥凯达	华北	山西	孝义	40	40	2022年	40	0	计划2022年6月投产，总产能90万吨
鲁北化工2	华东	山东	滨州	50	100	2022年	100	0	计划2022年8月投产
鲁豫博创2	华东	山东	滨州	0	80	2022年	100	0	计划2022年下半年投产
东方希望北海	西南	广西	北海	0	480	2023年或之后	0	400	环评通过，项目暂停
国电投北海	华南	广西	北海	0	400	2023年或之后	0	400	环评通过，项目暂停
中铝防城港2	华南	广西	防城港	0	200	2023年或之后	0	200	待定
锦国投	东北	辽宁	大连	0	650	2023年或之后	0	650	待定
其亚铝业	西南	贵州	黔东南	0	60	2023年或之后	0	60	2019年12月政府与其亚签订项目协议，投产待定
2022年新增							1290		
2023年及远期新增								1830	

预计 2022 年新投氧化铝产能将达到 1290 万吨，在下半年产能继续保持快速增加的形势下，氧化铝后续价格或存在下行压力。

2021 年氧化铝实际产量为 7717.1 万吨， 2022 年 1～10 月份产量总计为 6817.82 万吨，较上年同期增长 5.1%，预计全年产量将达到 8110 万吨。吨氧化铝消耗石灰用量约 200kg，2022 年需求石灰量约 1622 万吨。

表 4 2020～2022 年氧化铝产量统计表

年＼月	1	2	3	4	5	6	7	8	9	10	11	12	总计
2020	1045.1		588.1	606.7	593.5	629.3	610	644.9	656	638.9	630	613.4	7255.9
2021	1264.26		653.7	649	659.6	680.4	650.3	646.6	654.8	629.1	605	624.3	7717.06
2022	1177.5		685.3	682	698.8	731.66	708.16	718.4	705.2	710.8			6817.82

3）电石：国内电石产业下游主要集中在 PVC 生产，近五年电石表观消费量约 2700 万吨/年。PVC 需求量稳定增长，保守预计未来五年 PVC 对电石需求拉动维持 3%的复合增长。而 BDO 受到可降解塑料 PBAT 的拉动，有望保

持高速增长，国内目前运行、在建和规划且已开展前期工作的 BDO 项目多达 220 个，到 2029 年底预计产能超过 1750 万吨。预测到 2025 年电石路线 BDO 将消耗电石 420 万吨/年。假设电石其它需求不变，未来几年国内电石需求量测算结果：2022 年约 2700 万吨、2023 年约 3150 万吨，到 2025 年国内电石消耗量约为 3385 万吨。

上述三大行业 2022 年石灰需求量约为 1.5512 亿吨，与上年基本持平。受宏观经济影响，这些行业均处于微利或亏损状态，外加煤炭等燃料价格高企，石灰行业整体处于微利状态，无配套石灰石矿山企业处境艰难，不少企业限产，甚至停产。

（2）环保及农业用石灰持续增长

“十四五”期间，我国将全面开展大气、水、土壤和新型污染物的治理，推进生态保护修复，实现减污增容。绿色发展和美丽中国建设将把环保产业推上新的风口。发达国家环保和农业用石灰占比达 20%以上，而中国环保及农业用石灰的占比不足 10%。石灰作为性价比高、无二次污染的高活性碱剂，在废气、废水、固废处理、土壤改良等领域

得到广泛应用，已成为中国石灰工业的一个重要经济增长点。十四五期间，环保及农业用灰将会形成年需求3000万吨以上的增量市场。部分环保领域石灰消耗量估算见表5。

表5 部分环保领域石灰消耗量估算

序号	环保领域	年石灰用量(万吨)	备　　注
1	垃圾焚烧	240	按生活垃圾4亿吨，吨垃圾消耗石灰6kg计算。
2	城市污水治理	1492.60	城市日污水量18846万吨，万吨耗石灰10×0.22吨。
3	工业污水治理	447.79	按城市污水治理用量的30%计算。
4	用煤作燃料的烟气治理	527.35	年煤炭消耗量39.65亿吨，按平均含硫1%计算，按10%采用半干法脱硫，脱1吨SO_2需85%生石灰计1.33吨。
5	土壤改良	429.89	土壤改良亩消耗石灰100Kg，年改良土地占耕地面积的2%。
	合计	3137.6	

二、回转窑建设情况

截止目前，纳入统计途径的在国内已建成投产的石灰及白云石回转窑约 580 座。据石灰协会骨干企业初步统计，2022 年预计开工建设的石灰回转窑约 25 座，投产后形成约 800 万吨的生产能力，新增产能在所有窑型中占比较高。

三、回转窑技术特点与发展

1、回转窑技术特点

（1）石灰品质最高：煅烧最均匀、活性度最高、生烧最低、S 含量最低；

（2）单机产能最大：单机可达 2000t/d；

（3）调节最灵活：开放式煅烧，预热、煅烧、冷却三段独立可控；

（4）入炉石灰石粒级范围广：10～20mm 小粒级及 40～80mm 大粒级石灰石，入炉仍能保证煅烧的高品质；

（5）多燃料混烧：回转窑燃料适应性强，可用燃料有气态、液态和固态，可单烧或混烧，并可自由切换；

（6）可实现超低排放：在现有窑型中，回转窑是现阶段环保超低排放工艺最成熟的窑型，脱硫脱硝工艺稳定成熟，运行成本较低。

2、回转窑技术的创新

（1）回转窑大型化取得跨越式进展

2022 年新建回转窑生产线中，窑径 5.8 米、日产 1600 吨窑 3 条；窑径 5.2 米、日产 1300 吨窑 2 条（11 月份投产）。以上窑型均为国内原创设计，且技术跨度大，这些新建回转窑投产后将对国内乃至世界石灰生产装备产生重大影响。

（2）回转窑能耗逐步下降

近年来新建回转窑热耗逐步降低，标杆热耗指标在 1050kcal/kg 以下，降耗措施：

1）规范操作管理，提高人员素质和管理水平；

2）降低回转窑系统漏风率；

3）提高预热器和冷却器热效率，降低废气和出灰温度；

4）优化耐火材料，降低筒体散热损失；

5）充分利用热能，如窑尾废气烘干煤粉、生产蒸汽或热水进行二次利用，煅烧段辐射热用于取暖、洗浴等;

6）提高燃烧器燃尽率和热效率；

7）采用变频器，降低电能消耗；

8）采用智能燃烧控制系统，优化操作程序，降低燃料消耗和生产成本。

四、存在问题与解决措施

1、生产线建设水平参差不齐

回转窑石灰生产线在现有石灰窑型中最为复杂，对建设单位要求较高，但国内从事回转窑建设单位众多，水平参差不齐，造成某些生产线建设质量及运行效果不佳。为保证生产线建设质量，建议如下：一是选择专业的承建单位。专业的承建单位应有专业的团队，具有专业设计能力保证厂区规划及工艺合理，强大的制造能力保证制作质量和进度，熟练的安装队伍保证安装质量和进度，专业的调试团队保证试生产安全及短时间达产达标。二是业主不要片面追求低价，应注重生产线投入的性价比，避免频繁停产、改造造成的损失。三是石灰协会应加强咨询服务，引导企业根据自身情况和需求正确选择建设单位。

2、石灰生产企业对原燃料条件的重要性认知不足

炉窑运行是否顺畅，与原燃料有直接关系，不是所有石灰石均能进入回转窑进行煅烧，有成分、粒度、硬度、含泥量等一系列指标要求；燃料有热值、挥发分、焦渣特征、水分、细度、灰分等各种要求。回转窑生产线的稳产高产必须具备稳定合格的原燃料条件。

3、行业缺乏高端人才

由于历史原因，石灰企业普遍规模小、员工整体素质偏低，制约着企业的发展。倡导业内企业加强员工培训，员工和团队素质高低是保障生产顺行和指标优良的关键因素，培养和留住人才对企业是最划算的投资。

五、回转窑市场分析与前景预测

1、回转窑市场分析

作为世界最大的工业化国家，我国现有石灰窑型种类多，回转窑以其独有的优势，赢得了众多用户的信赖。随着回转窑技术的创新发展，其在高端活性石灰市场中的份额将继续扩大。

（1）钢铁行业不锈钢、特钢、炼钢优选回转窑石灰；随着回转窑能耗逐年降低，烧结使用回转窑灰的范围逐年扩大，如酒钢、敬业钢铁、新兴铸管等。

（2）高活性石灰使氧化铝回收率提高，生产成本降低。目前氧化铝行业直接配套炉窑以回转窑为主，氧化铝生产优选高端回转窑石灰成为行业共识。

（3）电石行业技改配套回转窑逐年增多，既降低工艺电耗，又能利用回转窑多燃料混烧优势，将兰炭除尘灰直接作为燃料入窑燃烧，解决了环境污染问题。

（4）回转窑尾气低硫，成熟的脱硝工艺、较低的脱硝成本有利于回转窑技术的推广和应用。

2、前景预测

石灰生产组织和运营模式的变革将成为回转窑发展的契机。

（1）随着产业协同及资本重组，石灰企业将走向集团化和大型化

石灰石开采、石灰、重钙、氢氧化钙、轻钙、纳米碳酸钙及衍生品，产业间相互关联且具有互补性，一体化企业将生产中的固废、余热、尾气等充分循环利用，成本更具优势、产品质量更有保障，随着产业的整合逐渐进行，大规模一体化综合企业将成为趋势。

近年来，石灰行业已逐渐进入资本的视野。协会主动作为，为推动行业转型升级，已牵头成立石灰产业基金。各地政府为改变石灰及上下游企业“散、乱、污”现状，积极推进企业兼并重组。预计未来 5 年行业将出现千万吨级的石灰企业集团，回转窑等高端石灰窑型将在骨干企业中占主导地位。

石灰下游的需求端，如钢铁、电石、氧化铝等，随着行业重组，未来将出现超级大客户，不排除出现上下游大客户间互相持股现象。

（2）5G 的到来将改变石灰生产企业运营模式

我国 5G 基础设施将基本建设完成，“十四五”期间，工业领域由于大数据技术的普遍应用将改变公司的运行生态。石灰行业应积极主动，融入本次大数据工业革命。预计大数据将会在以下两方面改变石灰生产企业的运营模式：一是大数据将支持行业建立统一服务平台，包括远程诊断及技术服务配套、备件与维保服务平台、统一成品销售及原燃料供应平台。二是智能控制系统结合公司大数据平台，逐步实现智能工厂，减少人员需求。统一服务平台和大数据平台的建立，有利于发挥回转窑的工艺优势。

时代发展和科技进步，为回转窑发展提供了广阔的发展空间，市场前景看好。

六、回转窑技术发展趋势

2022 年 11 月 2 日，工业和信息化部、国家发展和改革委员会、生态环境部、住房和城乡建设部等四部门联合印发了《建材行业碳达峰实施方案》，方案提出，“十四五”期间，建材产业结构调整取得明显进展，行业节能低碳技术

持续推广，水泥、玻璃、陶瓷等重点产品单位能耗、碳排放强度不断下降，水泥熟料单位产品综合能耗水平降低 3%以上。“十五五”期间，建材行业绿色低碳关键技术产业化实现重大突破，原燃料替代水平大幅提高，基本建立绿色低碳循环发展的产业体系，确保 2030 年前建材行业实现“碳达峰”。

为实现上述目标，回转窑技术必须创新发展：

1、推进回转窑大型化，降低能源消耗

石灰炉窑大型化是降低燃料、电力消耗的有效手段。据国内不完全统计，800t/d 以上回转窑较 600t/d 以下回转窑节能约 10%。因此建议根据市场情况，推广 800t/d 以上的回转窑生产线。

2、应用生物质能等替代燃料

国际上许多大型石灰跨国公司正在积极开发替代燃料，如废弃物燃料、氢能、生物质燃料等，目前替代燃料使用比例超过 20%，以大幅减少能源燃烧过程的碳排放。

石灰回转窑生产线燃料适应性强，如生产线附近废弃物燃料、生物质燃料丰富，可根据资源特点，选择合适的替代燃料利用方式，部分或全部代替常规燃料，减少常规燃料使用量，降低碳排放。

3、应用富氧燃烧技术

采用富氧燃烧后，燃料燃烧更为充分，烟气量减少，单位燃料所产生的热量大大增加，有利于节约燃料资源。但需解决如何控制废气中氮氧化物升高和石灰冷却用风量问题。解决思路是：富氧、减少空气用量、合理引入窑尾废气、提高废气中 CO2 浓度、CO2 资源化利用相结合。但其工艺路线设备投资巨大，有待于产业链经济合理才能实施，如碳交易价格升高到合理价位，或在高原缺氧区域应用。

4、开发节能工艺、节能主机和采用节能设备，提高生产线节能水平

生产线工艺路线的持续优化，主机如预热器、回转窑、冷却器节能及效率的提高，风机、电机采用高效能产品，可进一步降低生产线的能耗水平。

5、采用智能化控制，稳定整体能耗水平

国内同样的装备，不同的操作人员和管理水平，能耗指标千差万别。提高生产线的智能化水平，特别是采用智能燃烧控制系统，可减少人为因素影响，稳定生产线能耗水平。

6、研发和推广低温余热高效利用技术

由于煅烧方式差异，回转窑与先进窑型相比热耗偏高，如能对窑尾废气和窑皮余热合理利用，将克服回转窑能耗高的劣势，并降低产业链整体能源消耗，超低排放和脱硝就是回转窑劣势变优势的一个例子。

7、推进二氧化碳捕集、利用与封存技术的产业化应用

不考虑燃料和电力，每吨石灰煅烧可产生 0.78 吨 CO2。石灰行业为 CO2 排放大户，合理设计工艺，窑尾废气中能够产生高浓度 CO2，根据区域不同，应选择合理的 CO2 资源利用方式，如工业及食品用 CO2、生产小苏打、水杨酸等，以减少温室气体排放。

中国石灰协会技术专家组　闫炳宽、韩海照