武汉建筑材料工业设计研究院有限公司
Wuhan Building Material Industry Design & Research Institute Co.,Ltd.

Application Research and Discussion on Green Low-carbon Technology in Fiber Cement Board Factory

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I Preface

Green Low-Carbon Fiber Cement Board Plant

- Industrial waste (fly ash, desulfurization gypsum, slag, etc.) to partially replace cement, utilizing production waste materials
- Lower temperature curing or room temperature
- Utilizes residual steam from autoclaves
- Recycles treated production wastewater back into production
- Utilizes solar photovoltaic panels on factory roofs

Traditional Fiber Cement Board Plant

- Raw materials: cement, sand, and paper
- Uses high-temperature and high-pressure steam curing, resulting in high energy consumption
- Residual steam from autoclaves is discharged to the environment
- Production wastewater is discharged externally

II Green and Low Carbon Technologies

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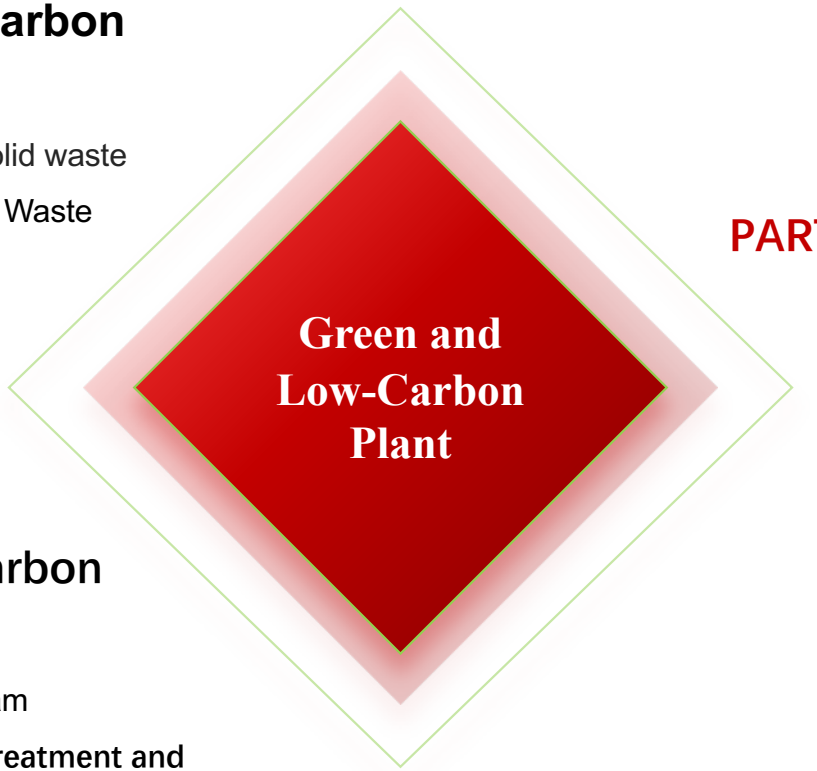
PART A: Source carbon reduction

01 Utilization of industrial solid waste

02 Recycling of Production Waste



PART B: Process carbon drop

03 Recycling of residual steam

04 Production wastewater treatment and recyling technology

05 Intelligent microgrid system

PART C: End-point carbon sequestration

06 Carbon-fixing material

Comprehensive utilization of low-value waste materials

Thermal Power Plant

Fly ash, Desulfurization gypsum, Flue gas

Steel Plant

Steel slag

FCB Plant

Waste boards, Sanding powder

01 Utilization of industrial solid waste

Preparation formula and product properties of fiber cement board (180℃, 10 bar, 8h)

Series	Preparation formula						Product properties	
	Cement	Quartz sand	FGD gypsum	Flya sh	Booster	Paper pulp	Density (g/cm³)	Dry flexural strength (MPa)
1	20	23	30	20	2	7	1.37	10.2
2	20	23	30	20	3	7	1.32	9.8
3	20	23	30	20	4	7	1.31	10.5
4	15	23	40	10	2	7	1.24	9.5
5	15	23	40	10	3	7	1.24	9.8
6	15	23	40	10	4	7	1.34	12.5
7	12	23	45	25	2	7	1.32	10.5
8	12	23	45	25	3	7	1.31	11.3
9	12	23	45	25	4	7	1.33	12.8

Flue gas desulfurization gypsum (FGD) and fly ash, two major industrial by-products are commonly used to replace a portion of cement in the production of fiber cement boards

$2CaO \cdot SiO2 + nH2O \rightarrow xCaO \cdot SiO2 \cdot yH2O + (2-x)Ca(OH)2$

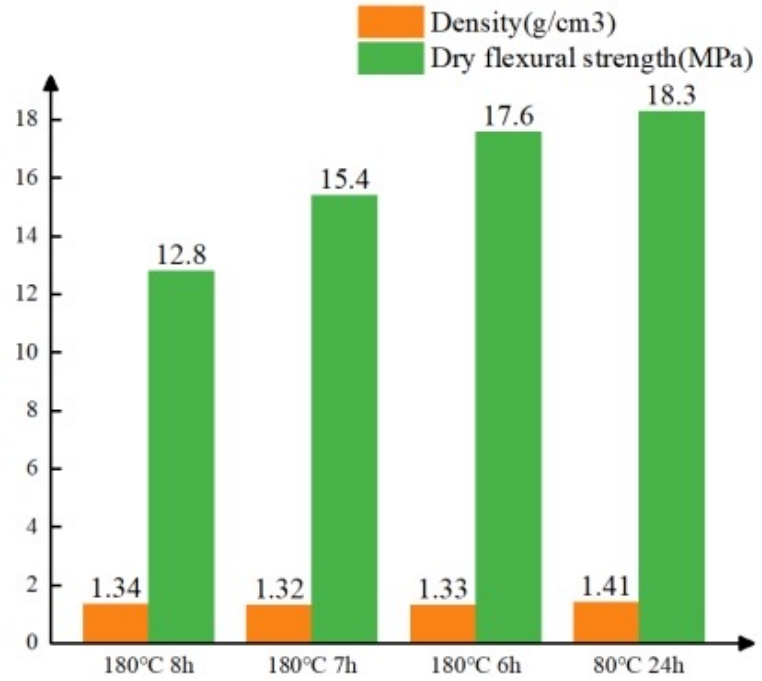
$2(3CaO \cdot Al2O3) + 27H2O \rightarrow 4CaO \cdot Al2O3 \cdot 19H2O + 2CaO \cdot Al2O3 \cdot 8H2O$

Desulfurized gypsum can react with cement to form ettringite

$3C_3A + 3(CaSO_4 \cdot 2H_2O) + 26H_2O = 3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$

$C_3A + 3(CaSO_4 \cdot 2H_2O) + 2Ca(OH)_2 + 24H_2O = 3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$

01 Utilization of industrial solid waste



Comparison of curing condition of fiber cement board

The flexural strength of the fiber cement board cured under atmospheric pressure at 80°C for 24 hours was even higher than that under the autoclave curing condition. This is due to the formation of more ettringite under atmospheric pressure curing at 80°C, providing higher early strength.

01 Utilization of industrial solid waste

All performance tests are conducted in accordance with the Chinese standard *GB/T7019-2014*. The results indicate that the curing condition of 80°C for 24 hours under atmospheric pressure

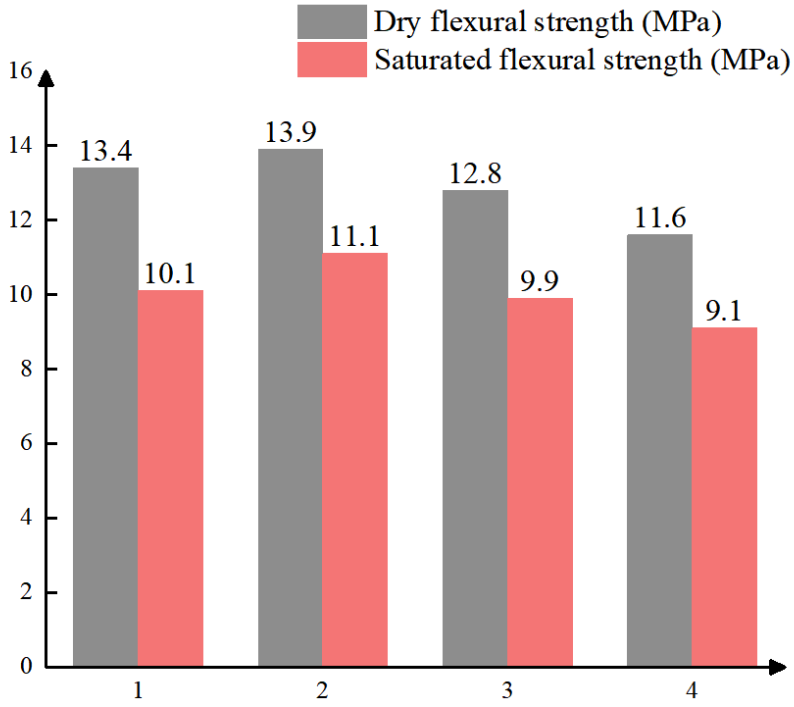
Comparison of curing regime of fiber cement board

Properties		Standard requirements	180℃、6h	80℃、24h
Apparent density (g/cm^3)		Not less than the value specified in the manufacturer's documentation	1.5	1.5
Saturated flexural strength (MPa)		R3≥12 R4≥16	16.0	17.6
Impact-resistance strength (kJ/m^2)		C3≥1.8	2.3	2.9
Water absorption rate(%)		Class A≤30 Class B≤45	26	25
Wet expansion rate(%)		0.25	0.1	0.1
Frost-resistance test	Frost-resistance	Class A 100 times、Class B 25 times freeze-thaw cycle without rupture and stratification	100 freeze-thaw cycles without rupture and stratification	100 freeze-thaw cycles without rupture and stratification
	Flexural strength ratio	≥70%	78%	90%

02 Recycling of Production Waste

Preparation formula of fiber cement board

Series	Quartz sand	Cement	Waste board	Paper pulp	wollastonite	Total
1	54	38	0	7	1	100
2	36	36	20	7	1	100
3	18	34	40	7	1	100
4	0	32	60	7	1	100



Influence of different content of waste board on physical properties of fiber cement board

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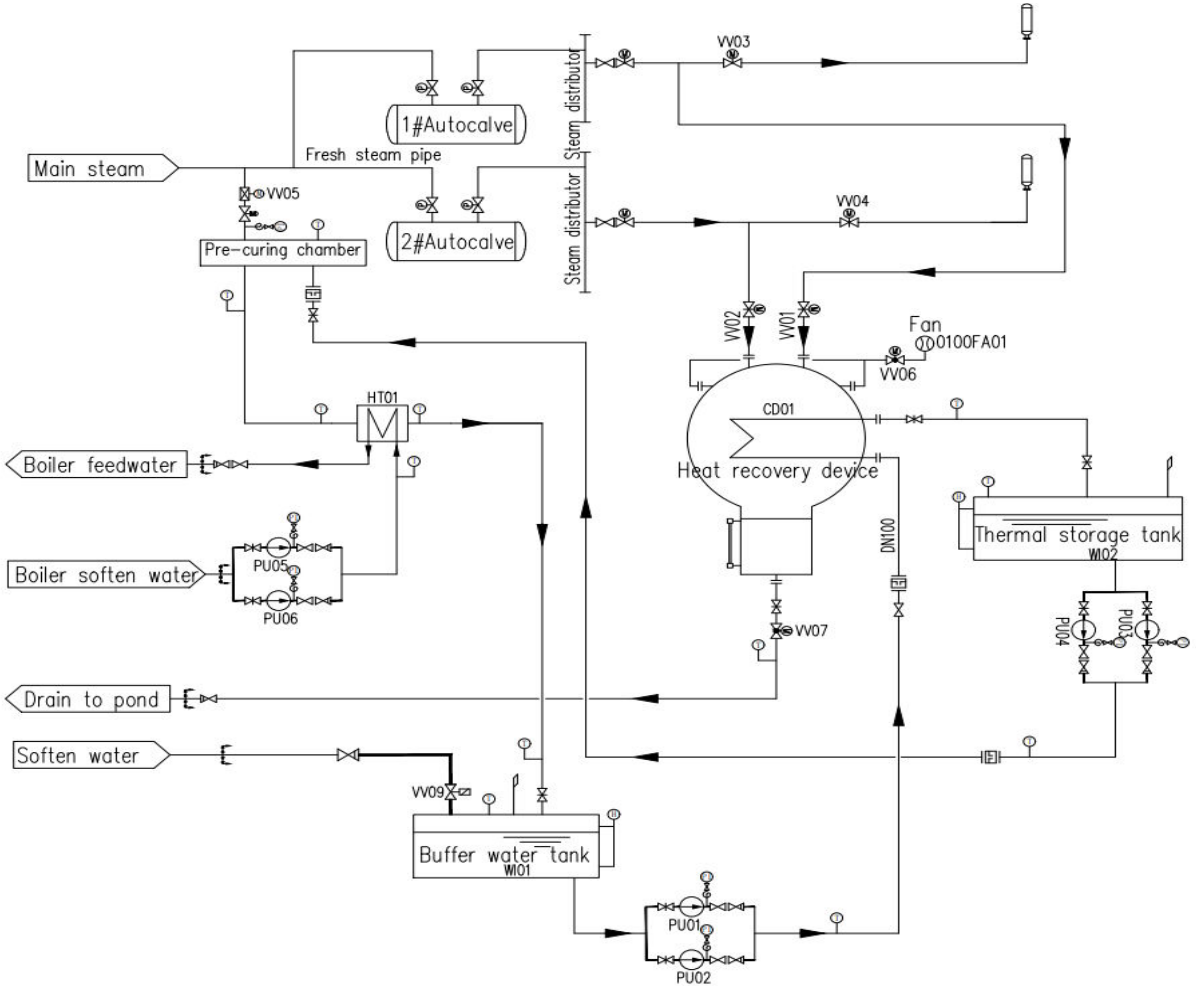
03 Recycling of residual steam from autoclave

After steam transfering between two autoclaves, the waste heat recovery from 0.5MPa exhaust steam accounts for around 15-18%

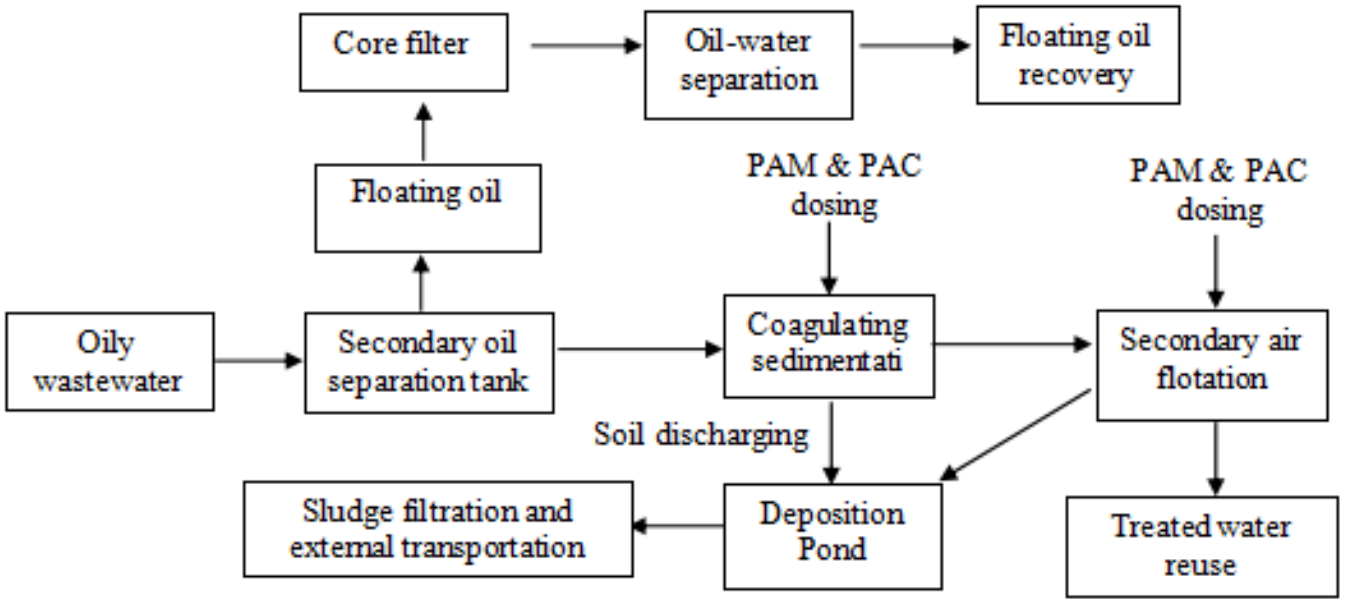
- **Residual steam can be recycled, saving energy**
- **The condensed water can be directly used**
- **Reduce odor emissions**
- **Does not affect exhaust speed**
- **Automation with low maintenance costs**



03 Recycling of residual steam from autoclave

This highly integrated and automated system occupies an area of 5m*16m = 80㎡.

04 Production wastewater treatment and recyling technology



The accumulation of harmful components in circulating water leads to a shortened service life of woolen fabrics and a decrease in product qualification rate.

04 Production wastewater treatment and recyling technology

Comparison before and after treatment: oil content reduced from 20.6mg/L to 3.16mg/L

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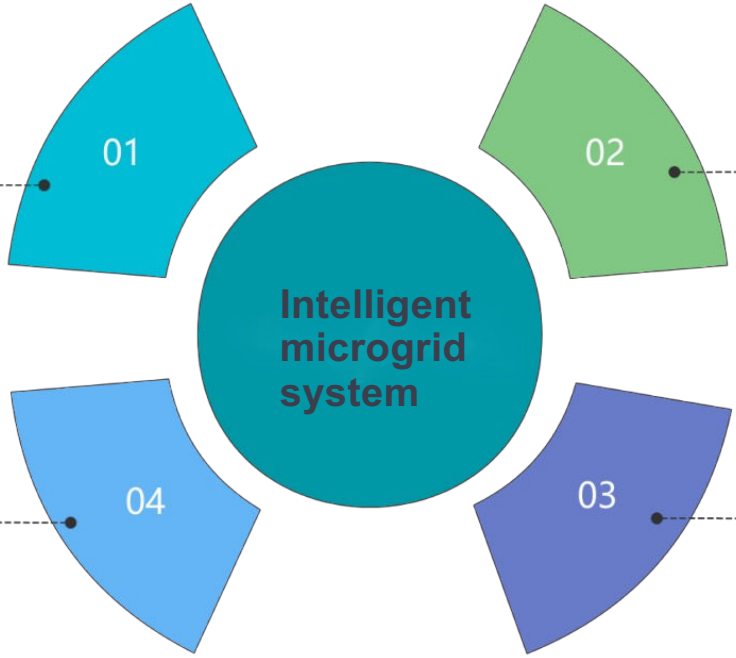
05 Intelligent microgrid system



Distributed Photovoltaic Power Generation System

One production line area is 10000 square meters, with a rooftop installed with a 1MW photovoltaic power generation system, capable of generating approximately 1 million kWh annually

Energy Storage System

The 0.5mW/2mWh energy storage system converts the peak-valley electricity price difference into economic benefits, saving 85,000 dollars electricity annually in China

Intelligent Load Management

Intelligent scheduling and optimized operation of electrical equipment at various stages of the production line, saving 1-3% of electricity costs

Electric Forklift Charging Pile System

Two electric forklifts can replace traditional internal combustion forklifts, reducing diesel consumption by approximately 35 tons per year

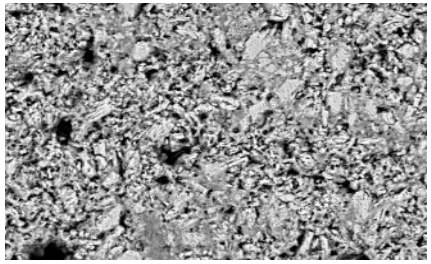
06 New Material Carbon Fixation Technology

$$3CaO\cdot SiO_2+(3-x)CO_2+yH_2O \rightarrow xCaO\cdot SiO_2\cdot yH_2O+(3-x)CaCO_3$$
$$2CaO\cdot SiO_2+(2-x)\ CO_2\ +yH_2O \rightarrow xCaO\cdot SiO_2\cdot yH_2O+(2-x)CaCO_3$$

Carbon-fixing material (CSM)

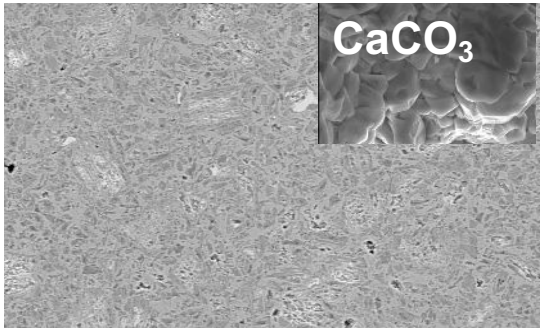
Industrial kiln flue gas CO_2

Mineralization at room temperature for 12 hours



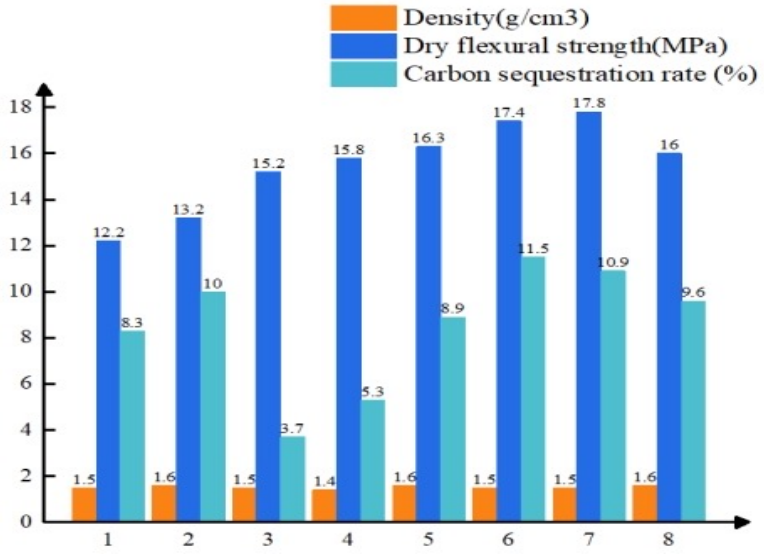
Intermediate state

Final state



Carbon sequestration fiber cement board formula

Series	WISCO steel slag	Flyash	FGD gypsum	Cement	Carbide slag	CSM	Paper pulp	Total
1	66	23	4	/	/	/	7	100
2	65	8	4	16	/	/	7	100
3	65	8	4	8	8	/	7	100
4	65	8	4	4	12	/	7	100
5	93	/	/	/	/	/	7	100
6	47	/	/	/	/	46	7	100
7	65	/	/	/	/	28	7	100
8	84	/	/	/	/	9	7	100

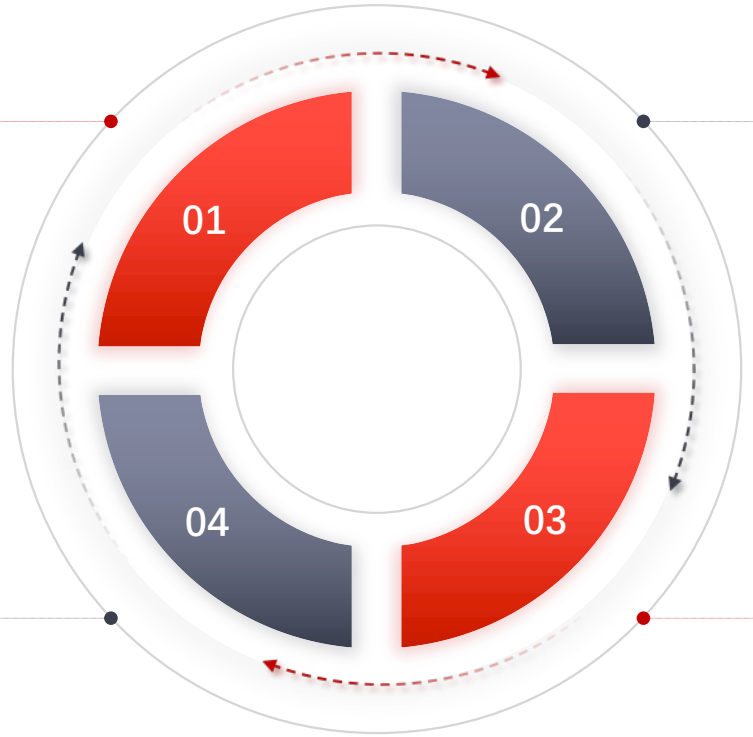


Comparison of carbon sequestration rate of fiber cement board

Ⅲ Conclusions

Comprehensive solid waste utilization technology

- Desulfurization gypsum and fly ash can be used as raw materials to replace quartz sand, reaching 45% and 25% respectively
- Waste boards replaced quartz sand 20%



Waste steam heat recovery technology

- The exhaust steam from 6 autoclaves is recovered and utilized through the waste heat recovery system, the annual natural gas savings can reach 163,800 Nm^3, reducing carbon dioxide emissions by 309.5 tons per year.

Intelligent microgrid system

- Energy savings of about 1.06-1.20 million kWh can be achieved annually, reducing CO_2 emissions by around 1,100 tons.

Production wastewater treatment and recyling technology

- 57,600 tons of water resources can be saved annually

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Thanks