

# 水泥窑氮氧化物 减排技术

Technological for nitrogen oxides emission  
reduction in cement kiln



## 主要技术优势 Main technical advantage

- 立足于现有设备改造;
- 应用先进的三维计算流体力学优化设计;
- 设备结构简单, 不增加维护保养负担;
- 空气分级燃烧不影响窑系统正常运转和水泥熟料质量;
- 自动化控制的SNCR系统;
- 最大程度的减少氨逃逸, 氨逃逸低于5ppm;
- 氮氧化物减排比例可达60~90%。
- Modified from existing equipment
- To apply state of art 3d fluid mechanics to optimize design
- Simple structure, no additional maintenance
- Not impacting normal operation of kiln and quality of clinker and cement
- Autoatically controlled sncr system
- To minimize the leaking of ammonia, less than 5ppm
- To reduce 60~90% nox emission

**天津水泥工业设计研究院有限公司**

Tianjin Cement Industry Design & Research Institute Co.,Ltd.

## 1 概况

### General situation

中国中材国际工程股份有限公司天津分公司从事水泥窑降低NOx技术与装备开发已有十多年的历史，在研发工程中，先后得到国家高新技术产业计划（863）项目、国家发改委“重大产业技术开发专项”的支持，研发的水泥窑降低氮氧化物的技术装备大量应用在水泥工程中，其技术处于国际先进水平，并得到工业应用，为企业带来了良好的经济效益和社会效益，为我国低氮氧化物排放技术的应用提供了范例。

Sinoma International Engineering (Tianjin) Co., Ltd is working on NOx reduction by cement kiln research and equipment development for more than ten years, during the development, has been support by National Hi-Tech industry Program (863) project, the National Development and Reform Commission “major industrial technology development special fund”, developed technology and equipment for NOx reduction in cement kiln has largely application in cement projects, the technology has reach international advanced level, and already use in industrial application, bring good economic and social benefits for customers, provides a model for application of low NOx emission technology in China.

## 2 水泥窑氮氧化物减排技术

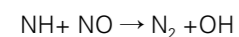
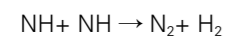
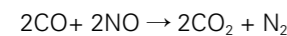
### Nitrogen oxides emission reduction in cement kiln technology

#### 1. 空气分级燃烧技术

利用助燃空气的分级加入，降低分解炉内燃料NOx的形成，并通过燃烧过程的控制，还原窑内产生的NOx，从而实现系统的NOx减排；

##### 技术原理

将燃烧所需的空气量分成两级送入，使第一级燃烧区内空气过剩系数小于1，燃烧生成的一氧化碳与氮氧化物进行还原反应，以及燃料氮分解成中间产物(如NH、CN、HCN和NHx等)相互作用或与氮氧化物还原分解，抑制燃料氮氧化物的生成：



##### 技术优势

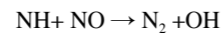
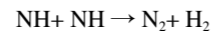
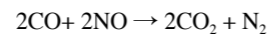
- 空气分级燃烧技术的实现立足于现有设备改造；
- 空气分级燃烧技术设备结构简单，不增加维护保养

#### Air staged combustion technology

Use the classification of combustion air, reduce the NOx content formation from the fuels in calciner, and by control the combustion process to deoxidize NOx produced in the kiln, in order to achieve NOx emission reduction for the system.

##### Technical Principle

Combustion required air amount will divided into two stages for feeding in, to make sure the excess air coefficient less than 1 in the first stage combustion zone, carbonic oxide produced by combustion will conduct reduction reaction with nitrogen oxides, and decomposition of fuel nitrogen into intermediate products( Such as NH,CN,HCN and NHx ) interaction with or reduction decomposition with nitrogen oxides, inhibit the formation of fuel nitrogen oxides.



##### Technical advantages

- Realization of air classification combustion technology is established in existing equipment modification;

负担；

- 空气分级燃烧不影响窑系统正常运转和水泥熟料质量；
- 氮氧化物减排比例可达30%。

##### 适用范围

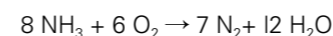
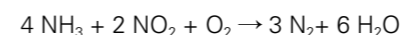
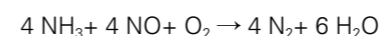
- 各种新型干法水泥窑

#### 2. 选择性非催化还原技术

将氨水（或其他氨/胺基物质）在一定的条件下与烟气混合反应，降低系统NOx排放。

##### 技术原理

选择性非催化还原技术（Selective Non-Catalytic Reduction，简称 SNCR）技术属于烟气脱硝技术，是将氨水或尿素等氨基物质在一定的条件下与烟气混合，在不使用催化剂的情况下将氮氧化物还原成为无毒的氮气和水，氨水还原氮氧化物总的化学反应为：



##### 技术优势

- 公司的SNCR技术是目前我国唯一在水泥行业得到应用的SNCR技术；
- 应用先进的三维计算流体力学优化设计；
- SNCR系统不局限于氨水，可以根据客户需求应用尿素、液氨等氨基物质；
- 最大程度的减少氨逃逸，氨逃逸低于5ppm；
- 自动化控制的SNCR系统；
- 系统结构简单，维护保养方便；
- 有针对性的设计减少喷枪数目以减少投资和运行成本；

- 氮氧化物减排比例可达60~90%。

##### 适用范围

- 各种新型干法水泥窑、电厂等

- Air classification combustion technology equipment with simple structure, does not increase maintenance burden;
- Air classification combustion does not affect the normal operation of kiln system and quality of cement clinker;
- The nitrogen oxides emission reduction proportion is up to 30%.

##### Scope of application

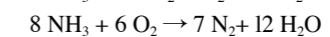
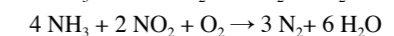
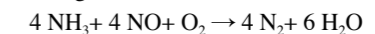
a variety of new dry process cement kiln

#### Selective non-catalytic reduction technology

Under certain conditions, the ammonia water (or other ammonia/amino substances) will mix reaction with flue gas, to reduce NOx emissions of the system.

##### Technical principle

Selective Non-Catalytic Reduction (referred as SNCR) technology belongs to flue gas denitration technology, under certain conditions mixed such as ammonia or urea these amino substances with flue gas, and under the conditions without use the catalyst to reduction nitrogen oxide become non-toxic nitrogen and water, the overall chemical reaction for ammonia to reduction nitrogen oxides is:



##### Technical advantages

- SNCR technology of Sinoma international (Tianjin) is the only application in cement industry in domestic market;
- The application of advanced three-dimensional computational fluid mechanics to optimize the design;
- SNCR system are not limited to ammonia, can based on customer's requirement to apply urea, liquid ammonia and other amino substances;
- Maximum to reduce the ammonia slip, ammonia slip is less than 5ppm;
- Automated control SNCR system;
- System structure is simple, easy maintenance;
- Targeted design to reduce spray gun numbers ,in order to reduce the investment and operating costs;
- Proportion of nitrogen oxide emission reduction is up to 60% to 90%.

##### Scope of application

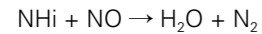
- A variety of new dry process cement kiln, power plant and etc.

### 3. 含氨(胺)基替代燃料

含氨(胺)基替代燃料可以作为水泥窑系统的替代燃料使用, 还可以实现降低氮氧化物排放的效果。

#### 技术原理

含氨基替代燃料与煤粉相比, 基本以挥发份为主, 挥发份占可燃物比例可达到90%以上, 且其中含有大量的氨(胺)基物质。其在燃烧过程中容易释放出大量的NH<sub>i</sub>等基团, 还原性的NH<sub>i</sub>等基团可以与NO发生如下反应:



利用干污泥降低氮氧化物的排放首先要保证污泥的完全燃烧。与煤粉相比, 污泥的燃烧特点是着火快但燃尽时间略长, 因此必须严格控制干污泥的进料粒度同时选择合理的加入点及加入方式保证污泥燃尽, 进而降低氮氧化物排放。

#### 技术优势

- 处理废弃物同时降低氮氧化物排放;
- 通过废弃物的处置费用和替代部分燃料, 可以形成可观利润。

#### 适用范围

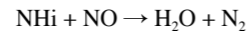
- 有废弃物处置需求的新型干法水泥窑

### amino( amido) alternative fuels

Amino (amido) alternative fuels can be used as alternative fuel for cement kiln system, also can decrease the effect of nitrogen oxide emissions.

#### Technical Principle

Compare Amino alternative fuels to pulverized coal, mainly are volatile content; volatile content can reach more than 90% of the combustible matters, and which contain large amounts of amino( amido) substances. It easy to release a large number of NH<sub>i</sub> and other groups in combustion process, reductive NH<sub>i</sub> and other groups can occur the following reactions:



Use the dry sludge to reduce emissions of nitrogen oxides, first should to ensure the sludge complete combustion. Compare with pulverized coal, the combustion characteristics of sludge is fast on fire but with slightly longer for burning time, therefore it must be strictly control the particle size of dry sludge feeding in and meanwhile to choose the reasonable feeding point and feeding method to ensure the sludge complete burning, in order to reduce nitrogen oxide emission.

#### Technical advantages

- Disposal waste and meanwhile to reduce nitrogen oxide emission;
- By use of waste disposal cost and alternative fuel saving to earn considerable profits.

#### Scope of application

- New dry process cement kiln with waste disposal requirements

表 水泥窑氮氧化物减排技术比较

Chart: cement kiln nitrogen oxide emission reduction technology comparison

主要脱硝措施 main denitration measures	排放水平*mg/Nm <sup>3</sup> emission level	减排比例 Emission reduction proportion
本底排放水平 background emission level	880	0
低NO <sub>x</sub> 燃烧器(单项使用) Low NO <sub>x</sub> burner (single use)	~830	~5%
空气分级燃烧技术(单项使用) air staged combustion technology( single use)	~600	~30%
含氨基替代燃料喂入分解炉(单项使用) amino alternative fuel feeding into calciner( single use)	~700	~20%
选择性非催化还原技术(单项使用) Selective Non-Catalytic Reduction technology (single use)	<350, 可达200以下 can reach to less than 200	>60%
空气分级燃烧技术+选择性非催化还原 Air staged combustion technology + Selective Non-Catalytic Reduction	<350, 可达200以下 can reach to less than 200	>60%

\*标况气体, 折算为NO<sub>2</sub>, 以10% 氧含量为基准

Standard conditions of gas, convert to NO<sub>2</sub>, as benchmark of 10% oxygen content

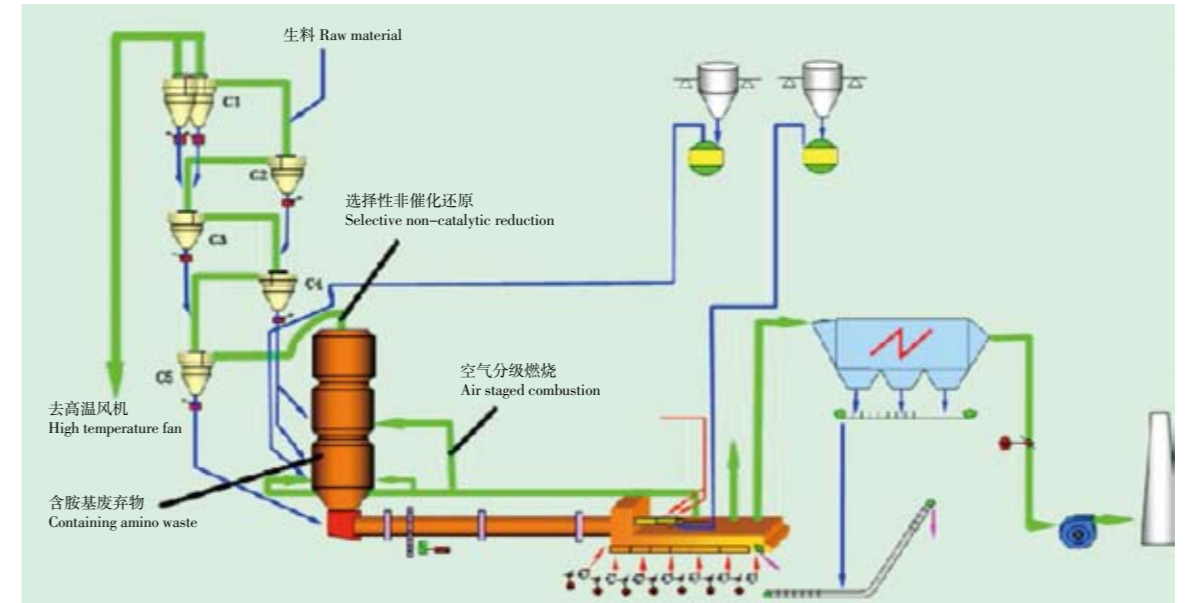


图 水泥窑氮氧化物减排技术

Chart: nitrogen oxide emission reduction technology of cement kiln

## 3 工程案例

### Project examples

#### 空气分级燃烧技术应用案例:

1) 河北燕赵水泥有限公司5000t/d生产线

河北燕赵水泥有限公司5000t/d生产线采用双系列五级旋风余热分解炉和5\*60m两档短窑。燕赵水泥采用具有较高挥发分含量(~27.6%)的烟煤作为燃料, 挥发分的释放比较稳定。在采用空气分级燃烧技术以后, 氮氧化物排放水平随主燃烧区空气过剩系数的下降而下降, 最高氮氧化物排放降低幅度可达~40%。实现了在不增加生产成本的基础上, 有效降低氮氧化物排放。

2) 中材湘潭水泥有限公司5000t/d生产线

中材湘潭水泥有限公司拥有5000t/d生产线采用低挥发份(~2.7%)、高灰分(~34.4%)低热值(4900~5000kcal/kg)的劣质无烟煤作为燃料。在采用空气分级燃烧技术后, 氮氧化物排放水平显著下降, 最高氮氧化物排放降低幅度可达~35%。

#### 选择性非催化还原技术应用案例:

1) 中材湘潭水泥有限公司

中材湘潭水泥有限公司拥有目前国际上技

#### Air staged combustion technology and application

Hebei Yanzhao cement Co., Ltd 5000t/d cement production line

Hebei Yanzhao cement Co., Ltd 5000t/d cement production line use double strings- five staged cyclone waste heat calciner and 5\*60m two pier short kiln. The fuel used in the plant are high volatile content(~27.6%)soft coal, with relatively stable release of volatiles. After use the air staged combustion technology, the emission level of nitrogen oxide decreased with the decline of excess air coefficient in the main combustion zone. The maximum decreasing of nitrogen oxide emissions is up to ~ 40%. It reduces the nitrogen oxide emission based on not increasing the production cost.

Sinoma Xiangtan 5000t/d production line

Sinoma Xiangtan Cement Co., Ltd 5000t/d production line use low volatile content (~2.7%), high ash content (~34.4%), low heat value (4900~5000kcal/kg), this kind of poor quality anthracite as fuel. After using air staged combustion technology, the plant is remarkable decreasing the nitrogen oxide emission level, maximum decreasing range of nitrogen oxide reach to ~ 35%.

#### Application of Selective Non-Catalytic Reduction technology

Sinoma Xiangtan Cement Co., Ltd

Sinoma Xiangtan Cement Co., Ltd owns one 5000t/d clinker new

术先进的 5000t/d 熟料新型干法水泥生产线。公司配合中材湘潭水泥进行SNCR技术改造后，氮氧化物排放最多可降低~80%，对促进湘潭新型工业化进程，带动社会经济发展所产生的积极影响，对推进节能减排，实现科学发展，建设资源节约型、环境友好型社会，起到良好示范作用。

2) 广州珠江水泥厂

广州珠江水泥厂拥有史密斯设计的 5000t/d 熟料生产线一条。在亚运会期间，广州市要求氮氧化物排放水平在原有基础上降低60%，实际排放水平~200mg/m<sup>3</sup>。我公司配合该厂进行SNCR技术改造，使氮氧化物排放水平达到环保局要求，在亚运期间可以进行正常生产，得到的业主的好评。

含氨（胺）基替代燃料脱硝技术应用案例：

广州越堡水泥有限公司6000t/d生产线采用本公司的600t/d污泥处置系统，将含水率~20%的干污泥喂入分解炉。检测结果显示：干污泥入分解炉，可以有效的降低氮氧化物的排放水平；随喂泥量的增加，氮氧化物排放量下降；在最大干污泥喂料量的条件下，氮氧化物排放水平最多可降低~56%，达到~300mg/m<sup>3</sup>的水平；在长期稳定运行的条件下，氮氧化物排放水平可降低基本排放水平的~20%。

dry process cement production line with international advanced technology. After Sinoma international engineering (Tianjin) cooperate the plant for SNCR technical modification works, maximum to decrease the nitrogen oxide emission to ~80%. It promotes the new industrialization process of Sinoma Xiangtan and brings positive impact to social and economic development, and plays a good role on promote energy conservation, realize scientific development, build resource-conserving and environment -friendly society.

Guangzhou Zhujiang Cement Plant owns a 5000t/d clinker production line designed by FL-smith. During the Asian Games, Guangzhou city requires the nitrogen oxide emission level to reduce 60% based on the existing level, with the actual emission level about~200mg/m<sup>3</sup>. Our company did the SNCR technical modification of this plant; the level of nitrogen oxide emission had met the requirement of environmental protection bureau, it ensures the normal production during the Asian Games, get good reputation from the owner.

**Mino (amido) alternative fuels denitration technology application**  
Heidelberg Guangzhou Cement Co., Ltd 6000t/d production line uses 600t/d sludge disposal system from Sinoma international engineering (Tianjin), feeding dry sludge with ~20% moisture content into the calciner. The test results show that: dry sludge feeding in calciner, can effectively reduce the emission level of nitrogen oxide; following by the increasing amount of sludge feeding, decrease the nitrogen oxide emission; in the condition with maximum dry sludge feeding, the maximum decreasing level of nitrogen oxide emission of ~56%, reach the level of ~300mg/m<sup>3</sup>; in the long-term stable operation conditions, emission level of nitrogen oxide can be decrease ~20% of the basic emission levels.

5 工程案例

Photo & Sketch



SNCR脱硝系统  
SNCR denitration system

4 专利及获奖情况

Patent & awarding

水泥窑低氮氧化物技术领域拥有多项专利：

Many patent s in Cement kiln low nitrogen oxide emission technology

低氮氧化物分解炉( ZL01205946.3); Low nitrogen oxide calciner ( ZL01205946.3);

一种水泥窑用降低氮氧化物排放的煤粉燃烧器 ( ZL200420029390.7 );

One kind of pulverized coal burner for cement kiln decrease nitrogen oxide emission (ZL200420029390.7);

一种降低水泥窑氮氧化物排放的方法(ZL03129932.6 );

One cement kiln nitrogen oxide emission reduction method (ZL03129932.6);

水泥窑喷氨脱除氮氧化物的装置 ( ZL200320128993.8 );

Cement kiln injection of ammonia & removal nitrogen oxide device

一种降低水泥窑氮氧化物排放的装置(ZL03257712.5).

On kind of cement kiln nitrogen oxide emission reduction device (ZL03257712.5).



公司开发的降低NO<sub>x</sub>技术获得建材行业技术革新二等奖  
Nox reduction technology developed by Sinoma Internatioal Engineering (Tianjin) won the second class prize of technical innovation in building material industry



水泥企业及环保检测单位实察SNCR使用效果  
Cement enterprise and environmental testing unit inspect the SNCR using effects



河北燕赵水泥公司分级燃烧脱硝系统  
Hebei Yanzhao Cement Co.,Ltd air staged combustion denitration system



中材湘潭水泥公司分级燃烧脱硝系统  
Sinoma Xiangtan Cement Co.,Ltd air stage combustion denitration system



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