Study on operation status of SCR denitration system in Chinese coal-fired power plants

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Abstract. Since the beginning of the 12th Five-Year Plan, coal-fired power plants have carried out large-scale denitration and ultra-low emission transformation in China, among which SCR denitration technology is the most widely used. However, some hidden problems in the process of project implementation have gradually emerged after operation due to various factors, such as the centralized reconstruction task, lack of technical experience, inadequate quality control of main equipment, uneven quality of denitration catalysts, and insufficient operation and maintenance experience of power generation enterprises. In this context, the future direction of SCR denitration operation and maintenance management is proposed after a systematic summarization and analysis of the operation status of SCR denitration system in recent years to provide reference for subsequent work.

1. Introduction

NOx emitted by the combustion of fossil fuels is a pollutant which is known to cause serious environmental problems [1]. Since the beginning of the 12th Five-Year Plan, coal-fired power plants have carried out large-scale denitration and ultra-low emission transformation in China, among which SCR denitration technology is the most widely used [2]. SCR removes NOx in flue gas by reacting nitrogen oxides with ammonia and oxygen to form nitrogen and water at approximately 370°C over titania supported vanadia catalysts [3]. Through introducing, absorbing and digesting foreign SCR denitration technologies, engineering companies have built a large number of SCR denitration devices [4]. In this context, the future direction of SCR denitration operation and maintenance management is proposed after a systematic summarization and analysis of the operation status of SCR denitration system in recent years to provide reference for subsequent work.

2. Application status of catalyst

A power generation group in China has made it mandatory to conduct third-party testing before SCR catalyst installation. According to the test results, the catalyst quality was divided into five color grades: green, yellow, orange, purple and red [5]. Where green represents the excellence level, yellow indicates a small problem, orange indicates a big problem, purple indicates a serious problem, and red indicates immediate scrap. As shown in Figure 1, the group conducted 400 tests in 2014-2018. The results show that the overall quality of catalyst has been effectively controlled and improved in recent years. The level of green and yellow proportion increased year by year, while the level of red, purple
and orange reduced year by year, which have effectively avoided the economic loss caused by catalyst quality accident.

![Catalyst rating statistics of a power generation group from 2014 to 2018 (%).](image1)

**Figure 1.** Catalyst rating statistics of a power generation group from 2014 to 2018 (%).

![Representative operating problems of catalyst.](image2)

**Figure 2.** Representative operating problems of catalyst.

However, the long-term operation effect of catalyst is determined by the quality of catalyst product, operation condition and maintenance mode of denitration [6]. But current procurement mode of catalysts is a ready-to-use purchase, which leads to lack of means to supervise the long-term performance of catalyst manufacturers. The detection and evaluation is mainly for newly-installed catalysts, but lack of long cycle life evaluation and management. In addition, power generation enterprises need to go through a course to accumulate experience in denitration operation and maintenance management experience.

As shown in Figure 2, there have been many abnormal accidents of catalyst blockage, wear, poisoning and life attenuation in recent years. For example, large-scale abrasion and collapse of the catalyst occurred within one year after the SCR denitration unit of a power plant was put into operation, and subsequent expansion of the denitration reactor and catalyst replacement caused a direct economic loss of nearly 50 million yuan. Less than 2 months after the SCR denitration of a 300MW unit was put into operation, about 1/2 of the catalyst area was blocked and the resistance increased significantly. The catalyst was replaced several times, but the problem was not completely solved, resulting in an economic loss of more than 10 million yuan.

### 3. Performance status of SCR denitration system

Figure 3 shows the statistical results of major performance indicators of 214 denitration performance tests of a power generation group from 2014 to 2018. The results show that there are unqualified main
performance indicators in 54 renovation projects, and the unqualified ratio reaches 25%. Among them, the proportion of unqualified denitrification efficiency is 5%, the proportion of unqualified ammonia escape is 17%, the proportion of unqualified resistance is 7%, and the proportion of unqualified SO₂/SO₃ conversion rate is 6%. Considering that the denitrification performance test is generally carried out within 2-6 months after the renovation project is put into operation, the unqualified main performance indexes during this period indicate that there are serious defects in the project quality.

Figure 3. Main performance index statistics of a power generation group from 2013 to 2017.

In addition, it should be noted that the statistical results show that the proportion of the entrance NOx concentration exceeding the design value also reaches 17%. Attenuation characteristics enables the SCR denitrification catalyst to work more efficiently than the design output in the early operation [7]. But as the operation is prolonged, catalyst activity gradually reduces [8]. The inlet NOx concentration is higher than design value, which will directly lead to catalyst overload operation and excessive ammonia escape [9].

Figure 4. Flow field index statistics of a power generation group from 2013 to 2017.

The denitrification performance is not only directly related to the catalyst, but also has a great relationship with the distribution of flow field in the reactor. The current problems of catalyst blockage, wear and performance attenuation are often caused by the flow field [10]. Figure 4 shows the flow index statistics of the completed denitrification performance test. The NOx distribution deviation of denitrification device outlets is put into four categories: < 20%, 20 ~ 30%, 30 ~ 30% and > 40% which was defined as qualified, with hidden danger, with bigger hidden danger and with biggest hidden
danger respectively. It is concluded that projects with biggest hidden danger account for 6%, bigger hidden danger projects for 13%, and hidden danger project for 41%, while qualified projects account for only 40%. The deviation of NOx distribution at the outlet of denitration system can directly reflect the flow field in the denitration reactor [11]. The above statistical results show that there is a potential flow field hazard in denitration reconstruction projects.

Figure 5 shows the statistical results of the operating resistance of 94 air preheaters. The resistance <1200Pa, 1200 ~ 2000Pa and >2000Pa were defined as normal, slight and severe respectively. The above statistics show that severe blockage accounts for 29%, minor blockage for 22%, and normal blockage only for 49%. Considering that the NOx emission index is stricter and the flow field problem is more prominent after the full implementation of ultra-low emission in coal-fired power plants, the risk of air preheater clogging will be further increased [12].

![Figure 5. Pressure drop statistics of air pre-heater of a power generation group.](image)

4. Causes of problems
1) Due to the tight schedule of the transformation, the lack of design and operational experience, the incomplete control of key technology and quality control of main equipment or material, the transformation quality is not ideal and hidden problems have emerged gradually in the practical operation. In addition, although some problems left from previous denitration transformation are temporarily covered by the second round of ultra-low emission transformation, subsequent denitration operation accidents may still occur frequently and cause great losses if problems cannot be effectively contained and rectified in the early stage and passive response could not be turned into active management.

2) The demand of operational management of SCR denitration technology is high. At present, some enterprises still have deficiencies in denitration technology management. Besides, there are many complicated and hidden problems such as poor coal quality, unstable working condition of boiler combustion, inaccurate ammonia escape measurement, denitration catalyst or problems related to the flow field. All these bring serious challenges to the operation and maintenance of denitration devices in coal-fired power plants.

3) The procurement and management of catalysts in power generation enterprises are in chaos, and low-price bidding is common. Moreover, the addition and replacement of catalysts are all carried out passively, which has a negative impact on the quality control and service life management of catalysts. With the implementation of ultra-low emission transformation in recent years and the upgrading of denitration performance index, the reliability requirements for products and systems are further improved. Moreover, ultra-low emission changes the original catalyst addition and replacement mode, making the subsequent management mode more complex and diversified.
5. Conclusions
In view of the current coal-fired power plant SCR denitration device and catalyst operation status, power generation enterprises should carry out thorough inspection and analysis in response to current problems, and formulate supporting measures, such as timely spraying ammonia optimization adjustment or flow optimization, timely catalyst addition/replacement/regeneration according to the catalyst life assessment of professional institutions, normal operation of denitration devices, intensive maintenance in downtime, so as to realize stable, efficient and reliable operation of SCR denitration devices.

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