IOP Conf. Series: Materials Science and Engineering **274** (2017) 012086 doi:10.1088/1757-899X/274/1/012086

Research on the Application of Risk-based Inspection for the Boiler System in Power Plant

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Abstract. Power plant boiler is one of the three main equipment of coal-fired power plants, is very tall to the requirement of the safe and stable operation, in a significant role in the whole system of thermal power generation, a risk-based inspection is a kind of pursuit of security and economy of unified system management idea and method, can effectively evaluate equipment risk and reduce the operational cost.

1. Introduction

According to the ITU statistics, by the end of 2016, China's power generation capacity of 1.65 billion kilowatts, including coal and electricity installed capacity of 940 million kilowatts, accounted for 57.3% of generating capacity, million-kilowatt level units 96 units have been put into operation in China, more than 300000 kilowatts thermal power unit ratio from 27.8% growth in 1995 to 79.1% in 2016, power generation and installed quantity are now among the world's highest. Power plant boiler belong to high temperature and high pressure equipment, if the pressure in the process of production more than ultimate strength equipment, can produce physical explosion[1].Power plant boiler is the electric power enterprise production safety accident, the biggest threat to the power plant boiler may have very serious consequences in the event of accident, not only relates to the life and health of the worker and the enterprise benefit, also related to the development of national economy and social stability.

Risk-based inspection (RBI) in the western developed countries is nearly 30 years the rise of a kind of pursuit of security and economy of unified system management idea and method, it is the risk of equipment as the basis of optimization and management of equipment inspection method for a system. In the process of maintenance, according to this high-risk equipment to determine the maintenance cycle and inspection items, not only can greatly save maintenance cost, also can effectively reduce the risk of a complete set of equipment, to ensure safety in production. According to the experience of the application of large foreign petroleum companies, after adopting the RBI, can cut down the cost of equipment maintenance and maintenance commonly 15% ~ 40%. The RBI for power plant boiler, apply to the inspection and it is also very abroad have many power plants use this maintenance mode, our country also has the power plant boiler the RBI technology research as an important scientific research projects.

2. The Basic Concept of RBI.

Risk-based inspection is in recent years the rapid development of international concept, is widely applied in the western developed countries at present, the American petroleum institute issued a public

publication. It defines the risk to the product of the consequences of failure probability and failure. Know the composition of the risk of a device, then by adopting the corresponding test methods such as on-line monitoring to reduce equipment failure probability, also can alleviate by setting the facilities such as fire control system and isolation system to reduce the failure consequences. About inspection to reduce the failure possibility, will test according to function normally divided into highly effective, effective, such as poor basic effective, effect and invalid five levels of effectiveness, and for each failure mechanism specifies the corresponding content of each test the effectiveness of the test methods, and quantitative.

3. The RBI Application Status at Home and Abroad

3.1. The RBI Application Status Abroad

Foreign RBI technology application initially in the nuclear power industry, power plant boiler RBI business now is mainly technical institutions carried out cooperation with the electric power enterprise [2]. In the United States, the boiler pressure vessel inspection for a long time mainly adopt the method of periodic inspection, the general standard is ASME specification boiler and pressure vessel, the scope of the ASME specification covers of boiler and pressure vessel design, manufacture, inspection, etc. But how to regulate the boiler and pressure vessel by each state and territory and a handful of autonomous city legislative decisions, the general requirements for high pressure boiler internal check 1 time each year (the furnace status) and a external inspection (running).Power due to the liberalization of development in recent years, the United States for generating set accomplish maintenance cost is low and running time is long, thus put forward on the basis of objective risk parameters of overhaul, namely the RBI or matter, start the risk quantitative and other related research work.

In recent years, Japanese power plant preventive maintenance of the rules a bit, and large user implementation of liberalization, and close to the United States. Some electric power research institute, the residual life evaluation technology of power station boiler are studied, residual life assessment technology is an important content of the RBI system, Japan has made some achievement of the research in this area, have been put into practical application.

Risk assessment technology is the SEVESO directive rules have major dangerous device enterprise must be submitted to the government's security report contained in the content. As a result, the RBI business has been widely used in European countries, petrochemical, thermal power, nuclear power and other companies are doing business with the RBI. At present, the UK, Finland and Norway's government has approved enterprises to adopt the RBI to determine the equipment maintenance cycle; The Swedish government is under examination and approval; French and German government adopted a relatively conservative measure.

3.2. The RBI Application Situation in China

Risk analysis and risk assessment technology in our country generally referred to as the safety evaluation, is the core technology in the process of risk management. Power plant equipment of the RBI technology research in China is still at the beginning of the pilot stage, although there are defects of power plant boiler in recent 10 years continuous assessment and life prediction and risk management articles been reported, but not form a system, is scattered, not mature, is not standard, does not have universal significance [3].

On May 12, 2006, general administration of quality supervision, inspection and quarantine issued the monitor "about began to show a risk-based inspection (notice technology pilot application, technology is an advanced equipment inspection method, in order to safeguard the safety of the equipment on the basis of using the method of risk analysis reduce equipment inspection and maintenance cost, achieve the goal of safety and economy. General administration of quality and technical supervision, inspection and quarantine decision in special test equipment industry technology pilot the legalization of technology application in the field of special equipment.

Published by the state administration of quality supervision, inspection and quarantine of the "twelfth five-year" the development plan of science and technology has been clear about the special equipment to carry out to satisfy the needs of the development and use of special equipment of risk based inspection and safety assessment and life assessment technology research, improve the level of special equipment safety assessment technology. Key research tasks has been clear about the power plant boiler risk-based inspection (RBI), the safety evaluation and life assessment technology research.

4. The Implementation of the RBI Technology and Application

4.1. The Implementation of the RBI Technology

(1) data collection; (2) perform selection, determine the damage mechanism of equipment failure; (3) the analysis and calculation in detail: according to different damage mechanism, calculate the failure possibility of each device; Calculate each device related failure consequences; (4) combining with the failure probability and failure consequence, calculate the risk of each device related, and sorted according to the results of the risk; (5) based on the different damage mechanism, determine the effective inspection method, and calculating the corresponding degree of risk reduction; (6) according to the test cost and risk mitigation, preparation of cost-effective optimization of inspection plan [4].

4.2. The RBI Technology Application

Through the understanding on the actual situation of boiler operation, reference of similar boiler failure analysis data and listen to DNV experts, after comprehensive analysis to determine. Boiler equipment and pipelines in the main failure mechanism of the existence of potential failure mechanism is as follows: (1) or internal thinning;(2) external injury;(3) alkali stress corrosion cracking;(4) fatigue, including thermal fatigue and vibration fatigue;(5) creep;(6) wear, including fly ash abrasion slag, blowing wear and abrasion.

4.3. Risk Assessment Based on RBI

Risk evaluation is calculated through the equipment level of risk. The equipment level of risk by matrix. Failure probability is extremely low, low, middle, high, high grade 5 with Numbers 1, 2, 3, 4, 5, said. Failure consequences according to the severity from low to high respectively with the letters A, B, C, D, E, said. Eventually determine equipment's risk grade, and take corresponding measures according to the corresponding risk level [5].

4.4. Based on the RBI Technology Inspection Plan

RBI according to equipment level of risk, made clear in the test and inspection cycle, the RBI method according to damage mechanism to select appropriate test method and test effect, the RBI through formulating the plan of inspection for different failure mechanism and failure consequences of high project implementation of the project is more comprehensive than low failure consequences of inspection, the contents of inspection.

Determine the inspection the overall goal is to make sure by fully making equipment can be identified in the early failure. Inspection cycle can be a certain percentage of remaining life equipment, this percentage to consider the reliability of the data and the process of uncertainty [6]. The RBI through the overall understanding of boiler plant, prolonged the running period, reduced the frequency of the furnace inspection, improve the utilization rate of equipment, directly bring the increase of economic benefits [7].

5. Conclusion

The steady and rapid economic development of our country depends on the stability of the power supply, ensure the safe and stable operation of motor cycle team leader fire is of great significance to the development of the national economy. State clearly in the "twelfth five-year" science and technology development planning special equipment to conduct inspection of power plant boiler based

on risk, because of the RBI technology in our country starts late, lack of experience, the application in power plant boiler system is still on the stage of research, the future also make efforts from the following aspects: the RBI technology commonly used in power plant boiler high temperature mechanical properties of metal database should be constantly enrich and perfect the creep properties of metals, such as high fracture toughness and fatigue resistance performance parameters of should also be added to database; For power plant equipment in our country at present the RBI research scope is limited to the boiler, evaluation object can be extended to other power plant equipment, such as steam turbines and transformers, etc.; Power plant boiler efficiency high reliability testing and monitoring of key technology research and equipment development and application of; Safety evaluation of power plant boiler main pressure components and residual life assessment technology research; Complex service environment power plant boiler heat exchange tube main failure reason analysis; The relevant standards for power station boiler RBI inspection as soon as possible, make the power plant boiler RBI business laws, rules, which is beneficial to radically change the preventive maintenance model of power plant boiler in our country, the national power plant boiler of the RBI technology, promotes our country power plant boiler based on the risk of maintenance mode as soon as possible [8].

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