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STUDY ON OPTIMIZATION SIMULATION OF SCR DENITRATION SYSTEM FOR MARINE DIESEL ENGINE

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ABSTRACT

With the rapid development of shipbuilding industry exhaust world is also very harmful one kind of environmental issues, and the ship marine diesel engine exhaust gas is mainly produced, so in recent years it has developed a diesel engine SCR system. SCR system can control emissions of nitrogen oxides in the exhaust of vessel, furthermore air pollution can be reduced. The main goal of article was using fluent software to correct SCR system selection and flue gas flow under different size best deflector arrangement is simulated. Next goal is further optimize the structure of the SCR system.

Keywords: marine diesel engine, SCR system, flue gas, flow deflector

INTRODUCTION

In order to control the pollution of marine diesel engine exhaust gas, in October 2008, the Marine Environment Protection Committee (IMO MEPC) of the International Maritime Organization (IMO) made a more stringent amendment to VI, a subsidiary of the MARPOL73/78 Convention. For marine diesel engines built on or after January 1, 2016, NOx emission limits must be implemented in accordance with the third level Standard when navigating within the global emission limitation zones. At present, the proportion of NOx pollution is increasing. In particular, in some large ocean-going ports, heavily traded straits and shipping routes, the source of pollution in the region comes mainly from emissions from these diesel engines [1,2]. Therefore, the NOx emission control of marine diesel engine has become an unavoidable practical problem in air pollution control [3,4]. It is particularly important to develop a reasonable and feasible exhaust gas purification technology for marine diesel engine. In the experimental study of diesel engine NOx emission reduction, Koga, Raptotasios and so on have put forward the relevant solutions [5,6], such as Koga has given out the countermeasures that accord with the Nox emission regulation of marine diesel engine. Ma have carried out the experiment of reducing the NOx emission of diesel engine by the method of inlet water injection [7]. The results show that when the fuel consumption rate of the diesel engine is maintained at a specific value, the intake port water injection can greatly reduce the emission of NOx.

Magnusson also pointed out in the study that the marine SCR system has reached a certain technical maturity, is an efficient NOx emission reduction technology, can meet the third layer and possibly more stringent nitrogen oxide regulations in the future [8]. Calvillo studied the characteristics of SCR at low temperature. The carbon materials with V catalyst were loaded on honeycomb support. The denitrification rate reached 59.8% -72.1% when the temperature was 150 °C[9]. Lv H treated the CeO_2 with NH_3, it was tested with BET, XRD, TPR and XPS . The results showed that the NH_3 treated CeO_2 catalyst had excellent SCR activity and stability because of the decrease of crystallinity and the improvement of reductivity [10]. Daniel C Haworthsimulate the evaporation, pyrolysis and hydrolysis of urea solution in Urea-SCR system of diesel engine by using CFD software model [11]. The swirl and turbulence in SCR reactor are helpful to enhance the evaporation, decomposition and mixing of urea solution with diesel engine exhaust.With the development of SCR technology, this technology has been widely used in the field of nitrogen oxide emission control. In 1989, MAN B & W Company first installed the SCR rear processor on the ship's two-stroke diesel engine [12], and controlled the NOx emissions from the exhaust gas to about 2g/kW*h. At present, MAN B & W company diesel engine denitrification technology is mainly SCR technology, and the installation and layout of the SCR system, and the matching status of the engine and other aspects of a deeper study. The first installation of the SCR system on a ship by Vacelan Diesel Company of Finland in 1992 reduced NOx by 85%, CO and HC by 70%. After 2005, H + H Environment and Industry Co., Ltd. in the shipboard SCR system technology and market gradually matured, became the main supplier of Wachelan Company [13]. Mitsubishi Corporation of Japan successfully developed a honeycomb denitrification catalyst with Ti-V-W as the active material, and more than 70% of the power plants began to use this catalyst [14]. In order to improve the activity of the catalyst, control the arrangement of the atomic components of the catalyst and promote the mixture of NOx, reductant and catalyst to be more uniform, the catalyst for denitrification of SCR at low temperature was developed [15] . In 2011, on the basis of the working principle of reducing the NOX emission of vehicle diesel engine by SCR system, Siemens Company of Germany continued to develop a SCR system suitable for the rear exhaust control of marine diesel engine, making the denitrification rate more than 90%.

Among the various post-treatment methods of NOx emissions, SCR (Selective Catalytic Reduction) technology is the fastest developing, most widely used and most mature process for denitrification of marine diesel engines [16].

THE BASIC MODEL

SCR SYSTEM PRINCIPLE

Controlling nitrogen oxide emissions from ships exhaust gas, the diesel engine may be externally from exhaust or an internal combustion diesel engine control [17]. Diesel engine while the internal transformation process is very difficult, so that the external technique commonly used for processing a diesel engine exhaust gas (referred to as SCR technology) [18]. SCR technology is the use of a catalyst and ammonia as a reducing agent, the reaction after a certain nitrogen oxides in diesel exhaust gas is converted into water vapor and nitrogen gas, so that nitrogen oxides in the exhaust gas can be recycled, Greatly reduce the nitrogen oxide emissions of diesel engines, thereby capable of reducing diesel exhaust pollution of the environment [19].

SCR SYSTEM COMPOSITION

Marine diesel engine SCR system is mainly composed of a catalytic reactor, a urea storage and injection system, a mixer, blowing system, the detection and control system components. among them The catalytic reactor is the core of SCR technology, It is the main place catalytic reduction of NOx and a reducing agent [20]. Discharging the flue gas from the flue diesel engine, a reducing agent in a pipe system with injection ejected, entering the SCR catalyst chemical reaction. Throughout the process, control (e.g. reaction temperature, inlet and outlet NOx concentration, main power, etc.) according to various types of signal detection of the detection system to regulate the injection system, the injection amount of reducing agent and adjusting the injection angle of the entire system running in good condition.

DESIGN OF SCR SYSTEM

To facilitate the simulation of the present Venter appropriately simplified overall structure of the SCR, as shown in Fig. 1 below:

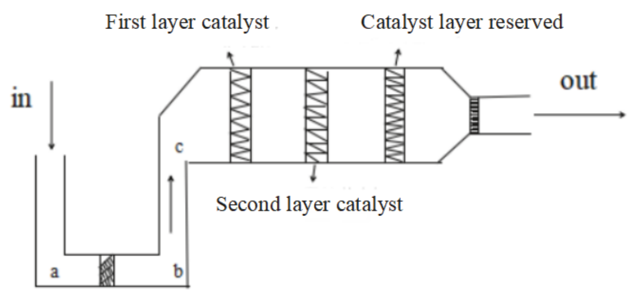


Fig. 1. Simplified diagram SCR catalytic reaction system

FLUE STRUCTURE SIMULATION ANALYSIS

SLANT FLUE DESIGN

After injection of NH_3 into the flue, the flue gas mixing with the SCR injection system, the structure of the turning of the flue at b at Fig [21]. 1 is designed to be oblique, using the inner chamfer (150mm × 45 °) design, the corresponding structural shape, dimensioned below Fig. 2, The unit mm.

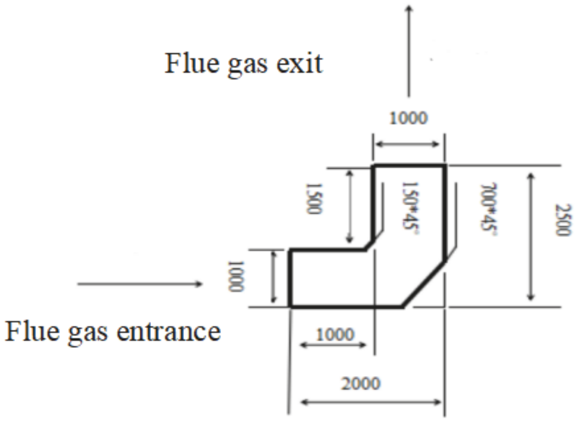


Fig. 2. Inclined type flue structure diagram (no guide plate)

Simulation results of the swash flue and analyzed as shown below.

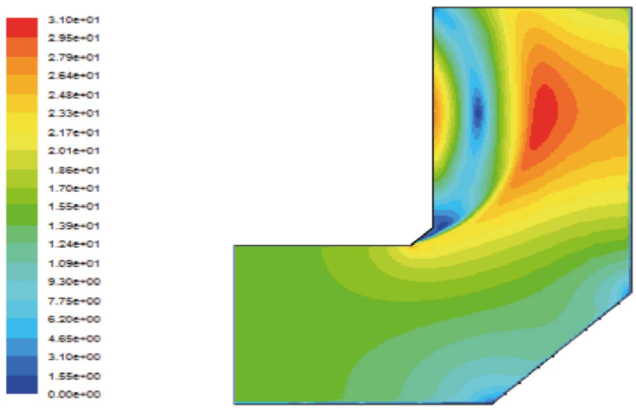


Fig. 3. The velocity distirbution of the flue gas in the non-deflector plate

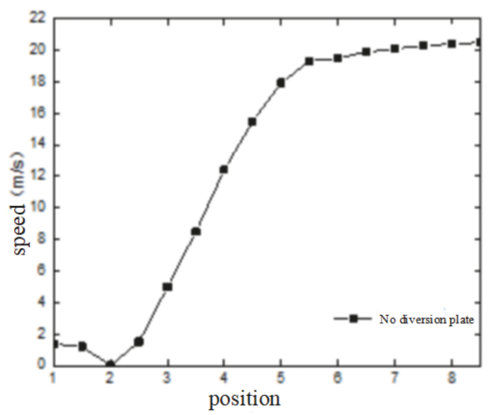


Fig. 4. A graph of the exit velocity of a flue without a deflector

As can be seen from Fig. 3, the flue gas flow in the flow channel, the outer side of the swash plate and the rear left corner of the flue are a large number of low-speed region, the area of the 1/3 vertical regions. Internal corner vortex due to gas generation, high-speed vertical apparent area, 2/3 vertical region, while a lot entrances significantly higher flow speed, and the formation of large vortices [22]. As can be seen from Fig. 4,You can look at the flow rate fluctuation range of import and export greatly, not only high-speed zone speed is too large, and the minimum value of zero speed appears. The pressure at the entrances to the value to calculate the pressure drop can be obtained as 64.44Pa.

ARC FLUE DESIGN

The flue design arc, the radius of curvature of 1150mm outer, inner curvature radius of 150mm, other sizes as shown in Fig. 5.

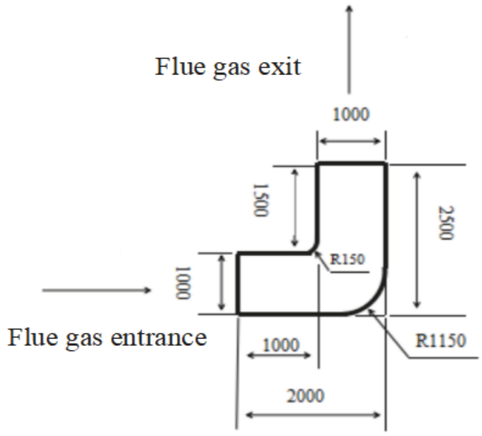


Fig. 5. Circular flue structure diagram (no guide plate)

Arc flue the simulation results and analysis:

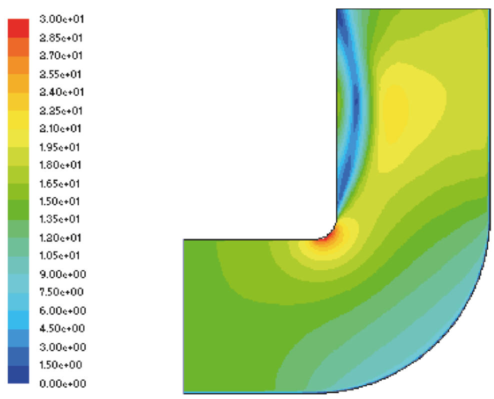


Fig. 6. The velocity distirbution of the flue gas in the non-deflector plate

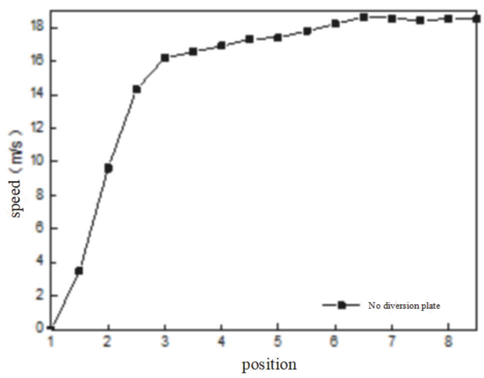


Fig. 7. A graph of the exit velocity of a flue without a deflector

As can be seen from the Fig. 6,the flue gas flows in an arcuate flow path, the outer corner appears a low speed region, area accounted Shui Angle 1/3, In the left corner of the smoke .Also a large number of low-speed channel region, and the speed was significantly much lower than the outer corner region accounts for less than 1/3 of the vertical part of the flue area. Internal corner vortex due to gas generation, high-speed region apparent, small footprint. From Fig. 7 in export to enlarge the flow rate fluctuation range, a large number of high-speed region, and the lowest velocity value of 0 m/s. The outlet pressure value,Computing system pressure to give difference of 30Pa.

Original gas flow path flowing suddenly encountered corner, swirls, so that the flow rate increases,Large amount of gas toward the vertical wall, impact damage to the wall easily, reducing its service life. Comparative simulation results of both analyzes of the flue, in order to reduce the flow rate and pressure range, reduce the impact force of the gas to reduce the wall damage, to reduce the loss of the flue, the flow channel design is more reasonable arc corner.

SIMULATION ANALYSIS OF ADDING FLUE DEFLECTOR UNDER DIFFERENT FLUE GAS FLOW IN ARC FLUE

According to the size of the flue, the circular arc deflector is arranged in turn. In order to reduce the energy loss of the system, six design schemes and sizes of the guide plate are filled in the flue, as shown in Table .1 below.

Tab. 1. Setting of reducing agent inlet parameters

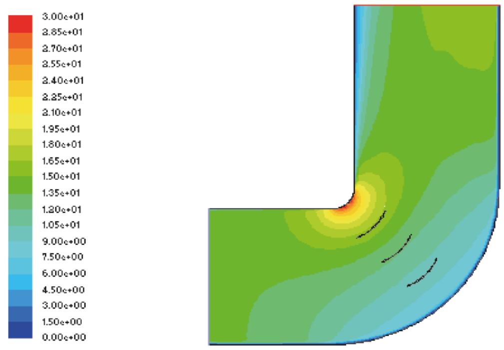
Six kinds Refinement parameters baffle								
No.	a	b	c	d	e		f	
(Piece)	3	4		5				
Arrangement	a row Arrange	a row Arrange	Disaggregated arrangement (2 + 2)	a row Arrange	Disaggregated arrangement (2 + 3)		Disaggregated arrangement (3 + 2)	
Radius (R,mm)	210	210	210	210	210		210	
Arc length (L,mm)	281	281	281	281	281		281	
The distance (D,mm)	250	200	250	167	330	250	250	330

In the flue gas flow rate 43490kg/h, 61570kg/ h,102733kg/h, Under the simulation, respectively, to obtain the optimal solution.

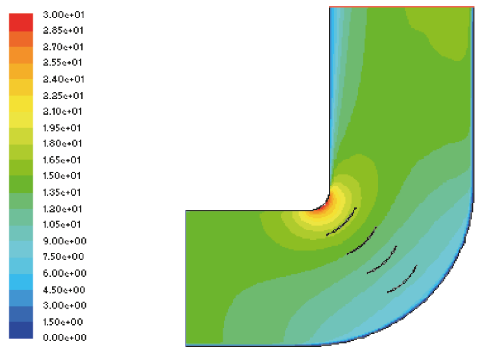
IN THE FLUE GAS FLOW 43490KG / H

After the addition of baffles, each of the arcuate baffle flue Six simulation arrangement shown in Fig. 8.

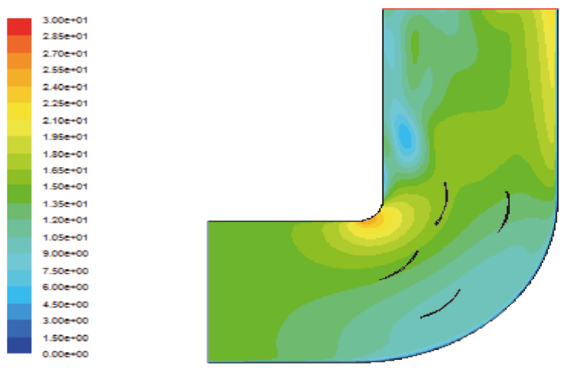
(a) Three baffles are arranged



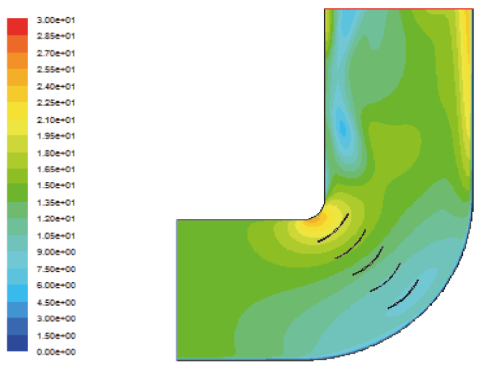
(b) Arranged in a four baffles



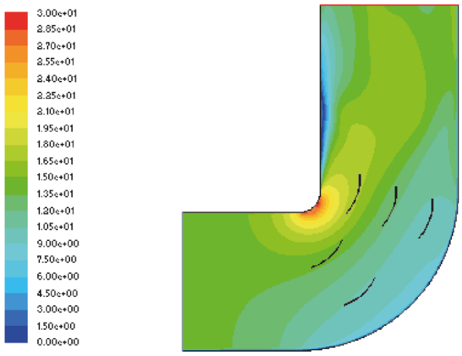
(c) Four baffles arranged disaggregated



(d) Five baffles are arranged on



(e) Five points out baffle arrangement (after the first two three)



(f) Five points out baffle arrangement (two after the first three)

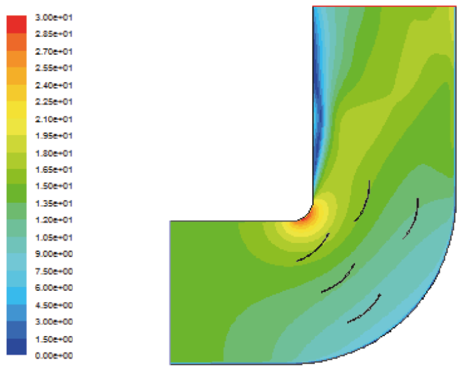


Fig. 8. The velocity field profile of the different deflector plates

The velocity curve at the exit is drawn according to the simulation process, as shown in Fig. 9.

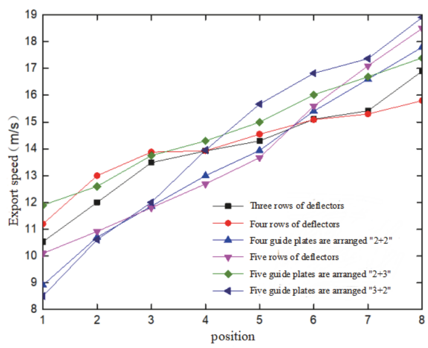


Fig. 9. The velocity diagram of the exit velocity of different guide plate is given

The pressure loss can be obtained by simulation programs such as Fig.10.

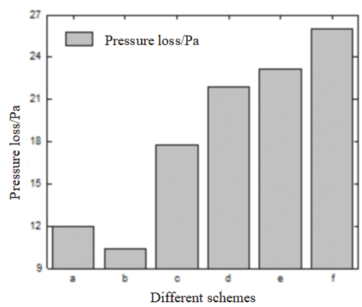


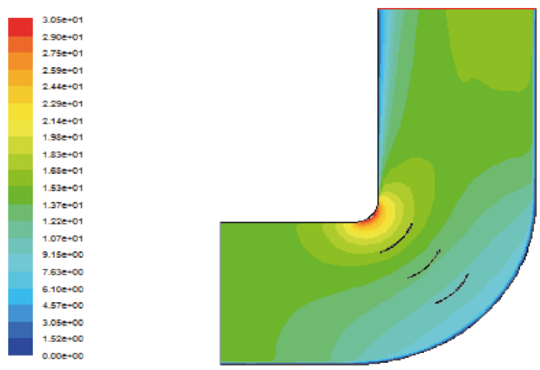
Fig. 10. Different design scheme of smoke pressure loss

In summary, Simulation results of the six kinds of flue deflector according to the design, Binding design velocity field distribution within the flue six kinds of arcuate deflector, outlet cross-sectional flow graph, the pressure loss can be seen in FIG. Analysis: Accordingly, the simulation results can be seen in conjunction with the program: when flue gas flow rate 43490kg/h, When four baffle a baffle disposed best results.

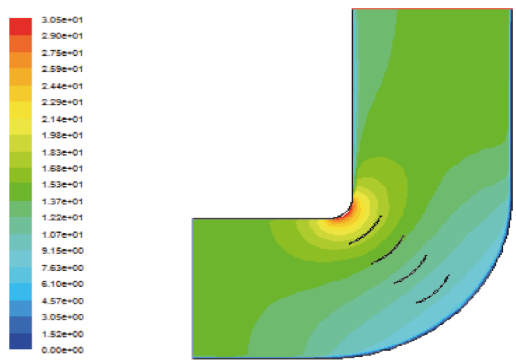
IN THE FLUE GAS FLOW 61570KG / H

After the addition of baffles, each of the six kinds of flue arcuate deflector arrangement simulation, shown in Fig .11.

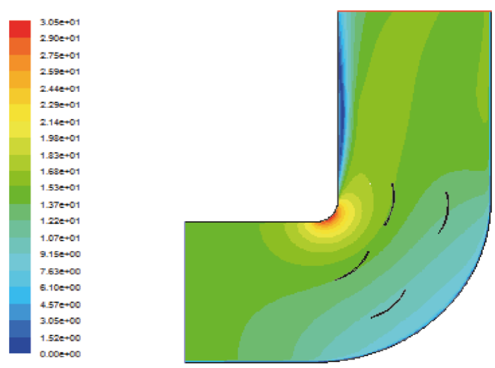
(a) Three baffles are arranged



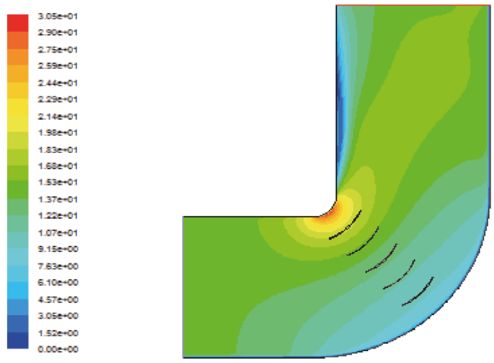
(b) Arranged in a four bafflesort



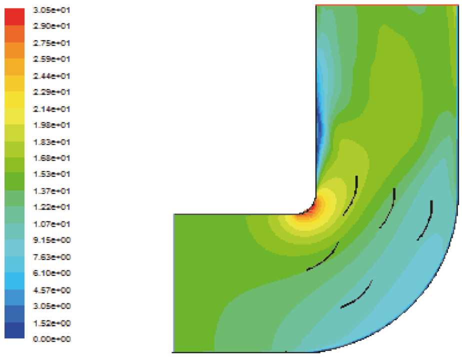
(c) Four baffles arranged disaggregated



(d) Five baffles are arranged one



(e) Five points out baffle arrangement (after the first two three)



(f) Five points out baffle arrangement (two after the first three)

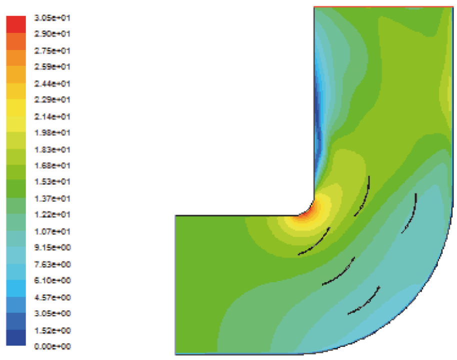


Fig. 11. The velocity field profile of the different deflector plates

The velocity curve at the exit is drawn according to the simulation process, as shown in Fig.12.

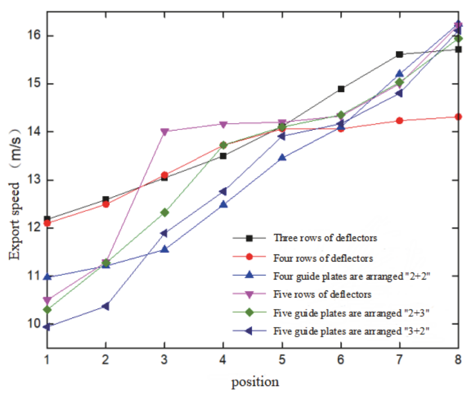


Fig. 12. The velocity diagram of the exit velocity of different guide plate is given

According to the simulation results, the pressure loss Fig.13 of different schemes is drawn as follows:

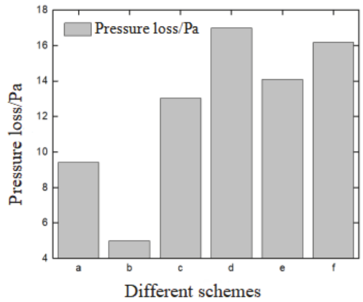


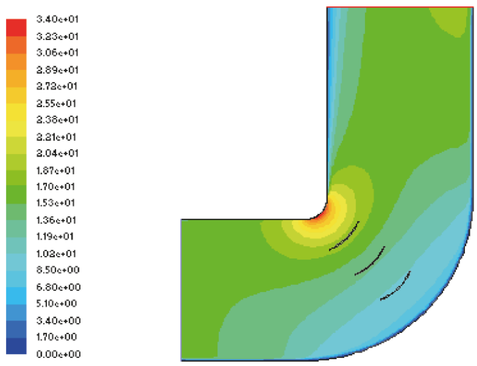
Fig. 13. Different design scheme of smoke pressure loss

In summary, Simulation results of the six kinds of flue deflector according to the design, Binding design velocity field distribution within the flue six kinds of arcuate deflector, outlet cross-sectional flow graph, the pressure loss can be seen in FIG. Analysis: Accordingly, the simulation results can be seen in conjunction with the program: when flue gas flow rate 61570kg/h, When four baffle a baffle disposed best results.

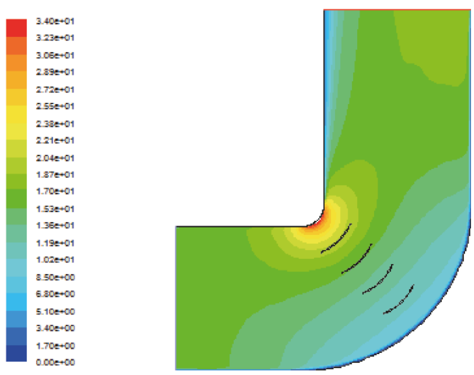
IN THE FLUE GAS FLOW 102733KG / H

After the addition of baffles, each of the six kinds of flue arcuate deflector arrangement simulation, shown in Fig.14.

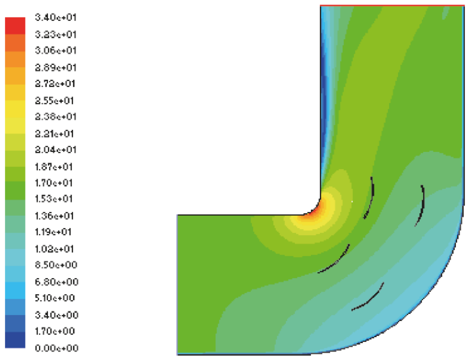
(a) Three baffles are arranged



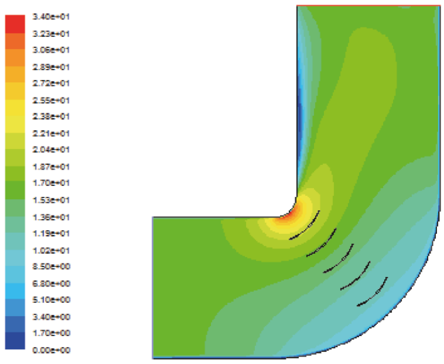
(b) Arranged in a four baffles



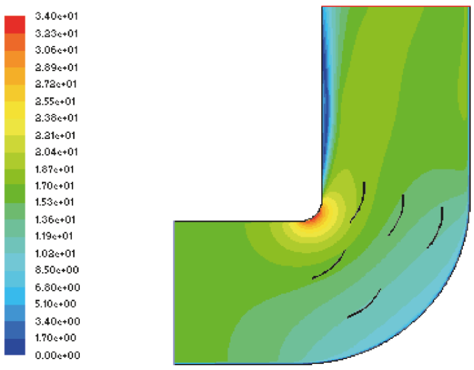
(c) Four baffles arranged disaggregated



(d) Five baffles are arranged one



(e) Five points out baffle arrangement (after the first two three)



(f) Five points out baffle arrangement (two after the first three)

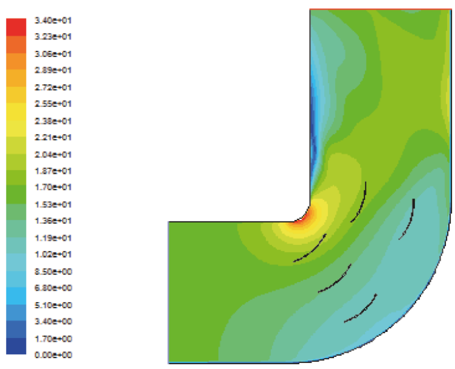


Fig. 14. The velocity field profile of the different deflector plates

The velocity curve at the exit is drawn according to the simulation process, as shown in Fig.15.

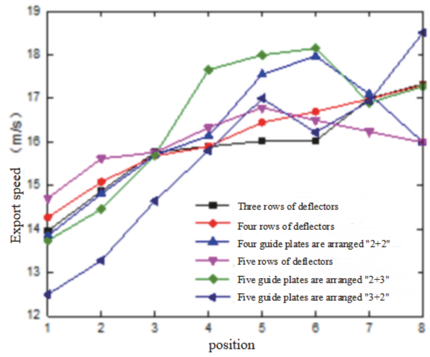


Fig. 15. The velocity diagram of the exit velocity of different guide plate is given

According to the simulation results, the pressure loss Fig.16 of different schemes is drawn as follows:

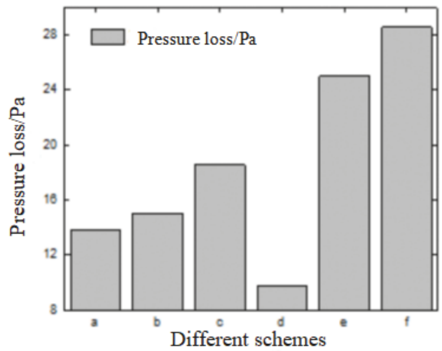


Fig. 16. Different design scheme of smoke pressure loss

In summary, Simulation results of the six kinds of flue deflector according to the design, Binding design velocity field distribution within the flue six kinds of arcuate deflector, outlet cross-sectional flow graph, the pressure loss can be seen in FIG. Analysis: Accordingly, the simulation results can be seen in conjunction with the program: when flue gas flow rate 102733kg /h Time, Five flow deflectors are arranged in columns best.

CONCLUSIONS

1. SCR system to simplify the structure, Analysis of the results of comparison of the two simulated flue sloping and curved, in order to reduce the wall damage, problems such as flue losses, the flow channel design is more reasonable arc corner.
2. Flue corner Office Developing the design arrangement of the baffles, the baffles simulate drainage effect in terms of velocity, pressure loss, etc., with a view to determine a flue Different flue gas flow Best baffle arrangement.
3. When flue gas flow rate 43490 kg/h Time, Program guide arc length becomes four baffles and arranged in an arc to reduce the pressure loss of the flue best; when flue gas flow rate 61570 kg/h Time, The arc length of

the arc flue four variant embodiment is preferably a baffle arrangement; when flue gas flow rate 102733 g/h Time, The arc length of the arc becomes five flue baffle disposed a best solution.

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