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(54) DENSE-PHASE SWIRL PULVERIZED COAL BURNER

(57) A dense phase swirl pulverized coal burner comprises a primary air channel, a direct flow secondary air channel and a outermost swirl secondary air channel; and multiple levels of pulverized coal concentration rings are arranged axially at intervals along the oil gun casing in a straight tube section of the primary air channel, so that pulverized coal air flow is distributed thickly outside and thinly inside the primary air nozzle. In the invention, dense phase pulverized coal outside the primary air nozzle passes through guide vanes, forms disturbed flow, is ejected into a furnace and mixes with high temperature backflow flue gas rapidly and sufficiently at an outlet. Meanwhile, dilute pulverized coal air flow at the center is ejected into the furnace by direct flow, ensuring subsequent mixing and combustion of pulverized coal flow. The primary air nozzle and the secondary air nozzle are provided with cone flaring structures with certain angle to effectively control appropriate mixing of secondary air and pulverized coal. The invention has advantages of strong ignition and combustion stability, good coal adaptability, low nitric oxide emission, simple primary air channel structure and small resistance, which effectively slows wear rate of parts.

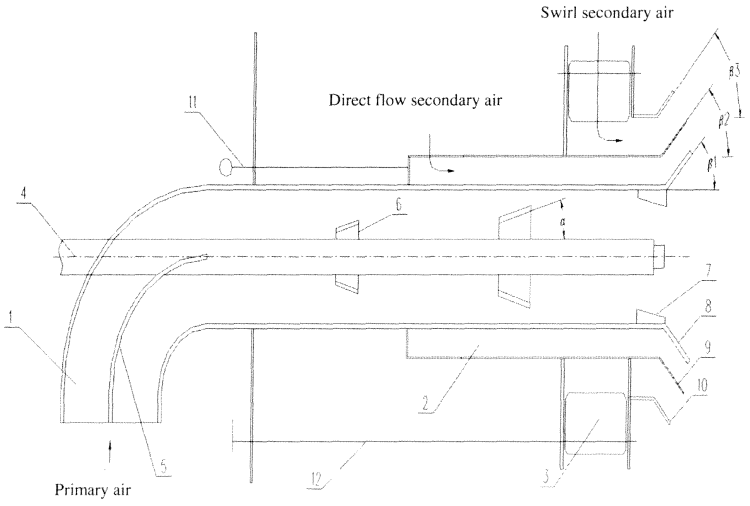

Fig. 1

EP 2 597 367 A1

Description

Field of the Invention

[0001] The invention relates to the technical field of coal fired boilers in power plants, in particular to a dense phase swirl pulverized coal burner used for a coal-fired boiler.

Description of the Related Art

[0002] As nitric oxide emissions from boilers of coal-fired power plants are strictly controlled in China in recent years, a supporting low NOx burner technology of full furnace staged combustion low NOX technology is widely used, particularly various different low NOx swirl burner technologies in wall-fired boilers.

[0003] In order to effectively reduce nitric oxides produced from combustion in a furnace of a wall-fired boiler, for the full furnace staged combustion technology, part of oxygen that is delivered from a main combustion zone to realize burning-cut in early technologies (i.e. pulverized coal is sent to a burner zone of the furnace, hereinafter referred to as the main combustion zone) is supplied to the furnace through a special air port at the upper part of the furnace in a delayed manner, thus forming oxygen-deficient combustion atmosphere when chemical equivalent ratio of air in the main combustion zone is less than 1 and forming a reducing atmosphere area between the main combustion zone and the upper air port (burning-out zone), which allows sufficient reduction of early nitric oxides. Meanwhile, most of the swirl burners are subject to rich-lean combustion and multichannel grading air supply mode so as to control mixing time of air and pulverized coal, form the reducing atmosphere in the burner zone and achieve the purpose of reducing nitric oxides in the burner zone.

[0004] However, three issues exist for application of the burner technology: Firstly, in order to divide pulverized coal air flow in the primary air channel into dense flow and thin flow circumferentially, uniformly and effectively, the burner always has relatively complex structure, which may increase system resistance, increase fan load and house supply, wear the channel, shorten life cycle of equipment and increase operation and maintenance cost of power plants; secondly, due to poor adaptability of coal, particularly poor steam coal in China, actual coal ignition and combustion stability can not reach original design requirements, and flame at outlet of the burner is always unstable during peak regulation of the boiler; and thirdly, due to poor subsequent mixing performance of primary air pulverized coal air flow and secondary air pulverized coal air flow at the nozzle of the burner, coal in the burner cannot be burnt out, possibly increasing loss.

Summary of the Invention

[0005] The purpose of the invention is to provide a dense phase swirl pulverized coal burner used for a coal-tired boiler of a power plant. The dense phase swirl pulverized coal burner can enhance mixing of dense phase pulverized coal air flow and outlet high temperature backflow with the help of dense phase pulverized coal disturbed flow at a nozzle to realize rapid ignition and stable combustion of pulverized coal, and control appropriate mixing of secondary air and primary air so as to enhance subsequent mixing and burning-out of the pulverized coal air flow. Besides, a pulverized coal concentration ring inside a primary air channel has simple structure and small resistance, effectively slowing wear rate and extending use and maintenance period of equipment.

[0006] In order to achieve the purpose, the technical solution of the invention is to provide a dense phase swirl pulverized coal burner which comprises:

a primary air channel provided with the following parts communicating successively: an elbow section as a pulverized coal inlet, a straight tube section arranged horizontally and a primary air nozzle; and an oil gun casing arranged on a central axis of the straight tube section and an torch oil gun of a burner arranged inside the oil gun casing;

a direct flow secondary air channel arranged around outer wall of a nozzle of the primary air channel, and a swirl secondary air channel arranged around outer wall of a nozzle of the direct flow secondary air channel with the direct flow secondary air channel and the swirl secondary air channel distributing air in a same big wind box; a regulating device arranged in the direct flow secondary air channel for regulating air flow; and a regulating device arranged in the swirl secondary air channel for regulating swirl air strength.

[0007] The elbow section of the primary air channel is provided with a pulverized coal flow equalizing plate arranged around the central axis of the elbow section and divided into two-layer air channels in the elbow section; one end of the pulverized coal flow equalizing plate is arranged at an inlet of the elbow section and the other end thereof extends to an outlet of the elbow section, i.e. the position where the elbow section communicates with the straight tube section, so that the pulverized coal air flow passes through the elbow section to be distributed uniformly and circumferentially, and enters the straight tube section.

[0008] Multiple levels of pulverized coal concentration rings are arranged axially at intervals along the oil gun casing in the straight tube section of the primary air channel; and each level of pulverized coal concentration ring is a cone flaring structure arranged around outer edge of the oil gun casing, and a cone flaring opening thereof

faces the primary air nozzle so as to allow the pulverized coal air flow to be distributed thickly outside and thinly inside the primary air nozzle after being subject to multiple levels of cone flaring.

[0009] Preferably, the oil gun casing of the straight tube section is provided with 2 to 3 levels of pulverized coal concentration rings, and size of the pulverized coal concentration rings is enlarged by levels. Cone flaring angle of each level of pulverized coal concentration rings is within the range of 10° to 25°.

[0010] The nozzle of the primary air channel is provided with multiple guide vanes arranged uniformly and circumferentially around inner wall thereof; the guide vanes have positions matched with path field of dense phase pulverized coal air flow outside the nozzle, and disturb peripheral dense phase pulverized coal only, thus allowing the dense phase pulverized coal air flow to eject at a certain swirl angle; and dilute phase pulverized coal air flow at center of the nozzle will be ejected into an external furnace directly.

[0011] Preferably, the nozzle of the primary air channel is provided with 10 to 20 guide vanes around inner wall thereof. An included angle between each of the guide vanes and axial direction of the primary air channel is 10° to 30°, and radial height of the guide vanes along the primary air channel is 0.05 to 0.1 time diameter of the primary air channel.

[0012] Outer walls of the nozzles of the primary air channel, the direct flow secondary air channel and the swirl secondary air channel are respectively provided with the flow expanding cone structures, and cone flaring openings thereof are respectively arranged toward the external furnace to delay mixing time of secondary air and primary air.

[0013] Preferably, the cone flaring angles of the multiple flow expanding cone structures are not more than 45°.

[0014] Compared with the prior art, the dense phase swirl pulverized coal burner of the invention has advantages that the primary air passes through the pulverized coal flow equalizing plate and forms relatively uniform two layers around the air channel; due to effect of the multiple levels of pulverized coal concentration rings in the horizontal straight tube section, the primary air can distribute thickly outside and thinly inside the primary air nozzle under the action of cone flaring.

[0015] As the flow expanding cone structures are arranged on the primary air nozzle and the secondary air nozzle respectively, mixing time of the secondary air and the primary air is delayed under the action of cone flaring. Based on reasonable control of the cone flaring angles, an oxygen-deficient atmosphere is formed in the primary air during initial ignition, which allows sufficient reduction of early nitric oxides. Appropriate mixing of the primary air and the secondary air can keep water cooled walls of the nozzles to be in an oxidizing atmosphere for a long time, effectively preventing clogging and high temperature corrosion of the water cooled wall of the burner zone.

[0016] Besides, due to cone flaring effect of the primary air nozzle, a high temperature flue gas backflow area is formed around the nozzle; and multiple guide vanes are arranged on the inner wall of the nozzle of the primary air channel to disturb the dense phase pulverized coal before being ejected into the furnace and eject the dense phase pulverized coal into the high temperature flue gas backflow area at a certain swirl angle for strong mixed combustion, thereby achieving the purpose of rapid ignition and enhancing stable combustion.

[0017] In addition, dilute phase pulverized coal at the center of the primary air nozzle is ejected into the furnace by direct flow, which keeps rigidity of the primary air and allows thorough mixing and burning-out of the subsequent primary air and secondary air.

[0018] Therefore, the invention can be strongly adaptable to various types of coal. For different coal types, the cone flaring angles and grading arrangement of the pulverized coal concentration rings can be designed to control dense and dilute separation degree of pulverized coal; radial height of the guide vanes and size of the included angles between the guide vanes and the axial direction can be designed to control disturbed flow of dense phase pulverized coal; and the flow expanding cone structure of the primary air nozzle can be used to control size of the high temperature backflow area. According to change of coal quality during operation, swirl intensity of the secondary air can be regulated by the regulating device to adapt to ignition and stable combustion requirements of different types of coal.

[0019] The invention is characterized by simple primary air channel structure, good wear resistance, strong overall ignition and stable combustion, good coal adaptability, high efficiency and low nitric oxide emission.

Brief Description of the Drawings

[0020]

Figure 1 is a sectional view of an overall structure of the dense phase swirl pulverized coal burner in the invention; and

Figure 2 is a schematic diagram of structural layout of guide vanes of a nozzle of the dense phase swirl pulverized coal burner in the invention.

Description of the Preferred Embodiment

[0021] The invention will be described in combination with accompanied drawings.

[0022] As shown in Figure 1, the dense phase swirl pulverized coal burner of the invention (hereinafter referred to as the burner) comprises a primary air channel 1, a direct flow secondary air channel 2 arranged around outer wall of a nozzle of the primary air channel 1, and a swirl secondary air channel 3 arranged around outer wall of a nozzle of the direct flow secondary air channel 2. The direct flow secondary air channel 2 and the swirl secondary air channel 3 distribute air in a same big wind

box.

[0023] The primary air channel I is provided with the following parts communicating successively: an elbow section as a pulverized coal inlet, a straight tube section arranged horizontally and a primary air nozzle. An oil gun casing 4 is arranged on a central axis of the straight tube section of the primary air channel 1, and a torch oil gun of the burner is arranged inside the oil gun casing 4.

[0024] The elbow section of the primary air channel 1 is provided with a pulverized coal flow equalizing plate 5 arranged around the central axis of the elbow section and divided into interior and exterior two-layer air channels near and far from a turning center in the elbow section; one end of the pulverized coal flow equalizing plate 5 is arranged on an inlet of the elbow section, and the other end thereof extends to an outlet of the elbow section, i.e. the position where the elbow section communicates with the straight tube section. Therefore, when primary air pulverized coal air flow passes through the elbow section of the primary air channel 1, the pulverized coal flow equalizing plate 5 and the horizontal straight tube section to form upper and lower two-layer uniform air flow, thus ensuring that pulverized coal is relatively circumferential and uniform at the outlet of the elbow section.

[0025] Further, 2 to 3 levels of pulverized coal concentration rings 6 are arranged axially at intervals along the oil gun casing 4 in the horizontal straight tube section of the primary air channel 1; and each level of pulverized coal concentration rings 6 is a cone flaring structure arranged around outer edge of the oil gun casing 4, a cone flaring opening thereof faces the nozzle, and cone flaring angles α of the pulverized coal concentration rings is within the range of 10° to 25°; and size of the pulverized coal concentration rings 6 is enlarged by levels. After the pulverized coal air flow uniformly distributed in the straight tube section under the action of the pulverized coal flow equalizing plate 5 successively passes through the cone flaring structures of each of pulverized coal concentration rings 6, most pulverized coal air flow will be kept in the straight tube section of the primary air channel I due to inertia, flow from the periphery of the central axis, and finally he distributed thickly outside and thinly inside the nozzle of the primary air channel 1.

[0026] As shown in Figure 1 and Figure 2, the nozzle of the primary air channel 1 is provided with multiple guide vanes 7 arranged uniformly and circumferentially around inner wall thereof (10 to 20 vanes); an included angle between each of the guide vanes 7 and axial direction of the primary air channel 1 is 10° to 30°, and radial height of the guide vanes along the primary air channel I is 0.05 to 0.1 time diameter of the primary air channel 1. That is, the multiple guide vanes 7 are arranged on an area at the periphery of the channel where the dense phase pulverized coal flows; dense phase flow is disturbed to eject at a certain swirl angle before being ejected into the furnace, and the dilute phase pulverized coal air flow at the center is still ejected into the furnace along the axis of the channel by direct flow.

[0027] Flow expanding cone structures facing one end of the furnace and corresponding to serial number 8, 9 and 10 in Figure 1 are arranged on outer walls of the nozzles of the primary air channel 1, the direct flow secondary air channel 2 and the swirl secondary air channel 3 respectively, thus delaying mixing time of the secondary air and the primary air under the action of cone flaring. Based on reasonable control of the cone flaring angles, an oxygen-deficient atmosphere can be formed in the primary air during initial ignition, which allows sufficient reduction of early nitric oxides. The preferred cone flaring angles $\beta 1$, $\beta 2$ and $\beta 3$ corresponding to the flow expanding cone structures 8, 9 and 10 are not more than 45° respectively.

[0028] In addition, negative pressure is produced due to arrangement of the flow expanding cone structure 8 in the burner, and the nozzle of the primary air channel 1 entrains high temperature flue gas to form an annular high temperature flue gas backflow area. Thus, the dense phase pulverized coal air flow at the periphery of the primary air nozzle is disturbed by the guide vanes 7 and ejected into the high temperature flue gas backflow area to strongly mix with air there, which can cause rise temperature of the pulverized coal sharply due to great heat and ignite the pulverized coal for a moment.

[0029] In addition, according to arrangement of the flow expanding cone structures 8 and 9, the direct flow secondary air channel 2 and the swirl secondary air channel 3 are provided with regulating devices 11 and 12 respectively for controlling air flow and swirl air strength to control mixing time of the secondary air and the primary air. Appropriate mixing of the primary air and the secondary air can allow water cooled walls of the nozzles to be in an oxidizing atmosphere for a long time, effectively preventing clogging and high temperature corrosion of the water cooled wall of the burner zone.

[0030] Besides, the dilute phase pulverized coal air flow at the center of the primary air nozzle is directly ejected into the furnace along the axis of the channel without disturbed flow, which can keep rigidity of the primary air and ensure that the primary air is ejected into a certainly deep position in the furnace. Subsequently, due to disturbed flow of the swirl secondary air, the pulverized coal air flow is strongly mixed to ensure subsequent mixing and combustion of the pulverized coal air flow, reduce nitric oxides in the burner during initial oxygen-deficient combustion and achieve the purpose of efficient burning-out of the pulverized coal.

[0031] Therefore, the invention can be strongly adaptable to various types of coal. For different types of coal, the cone flaring angle and grading arrangement of the pulverized coal concentration rings 6 can be designed to control dense and dilute separation degree of the pulverized coal; radial height of the guide vanes 7, and size of the included angle between the guide vanes 7 and the axial direction can be designed to control disturbed flow of the dense phase pulverized coal; and the flow expand-

ing cone structure 8 of the primary air nozzle can be used to control the size of the high temperature backflow area. According to changes of coal quality during operation, swirl intensity of the secondary air can be regulated by the regulating devices 11, 12 to adapt to ignition and stable combustion requirements of different types of coal.

[0032] The invention is characterized by simple structure, good wear resistance, strong ignition and stable combustion, good coal adaptability, high efficiency and low nitric oxide emission.

[0033] While the invention has been described in detail and with reference to the preferred embodiment, it is to be understood that the invention is not restricted thereto. It is apparent to those skilled in the art that various changes and modifications can be made therein in accordance with the disclosure. Therefore, scope of the invention is to be restricted only by the appended claims.

Claims

1. A dense phase swirl pulverized coal burner, **characterized by** comprising
   a primary air channel (1) provided with the following parts communicating successively: an elbow section as a pulverized coal inlet, a straight tube section arranged horizontally and a primary air nozzle; and an oil gun casing (4) arranged on a central axis of the straight tube section and a torch oil gun of the burner arranged inside the oil gun casing (4);
   a direct flow secondary air channel (2) arranged around outer wall of the nozzle of the primary air channel (1), and a swirl secondary air channel (3) arranged around outer wall of a nozzle of the direct flow secondary air channel (2) with the direct flow secondary air channel (2) and the swirl secondary air channel (3) distributing air in a same big wind box;
   wherein, multiple levels of pulverized coal concentration rings (6) are arranged axially at intervals along the oil gun casing (4) in the straight tube section of the primary air channel (1); and each level of the pulverized coal concentration rings (6) is a cone flaring structure arranged around outer edge of the oil gun casing (4), and a cone flaring opening thereof faces the primary air nozzle so that pulverized coal air flow is distributed thickly outside and thinly inside the primary air nozzle after being subject to multiple levels of cone flaring.

2. The dense phase swirl pulverized coal burner according to claim 1, **characterized in that**
   the elbow section of the primary air channel (1) is provided with a pulverized coal flow equalizing plate (5) arranged around the central axis of the elbow section and divided into two-layer air channels in the elbow section;
   one end of the pulverized coal flow equalizing plate (5) is arranged on an inlet of the elbow section, and the other end thereof extends to an outlet of the elbow section, i.e. the position where the elbow section communicates with the straight tube section so that the pulverized coal air flow passes through the elbow section, is distributed uniformly and circumferentially, and enters the straight tube section.

3. The dense phase swirl pulverized coal burner according to claim 1, **characterized in that**
   the nozzle of the primary air channel (1) is provided with multiple guide vanes (7) arranged uniformly and circumferentially around inner wall thereof; positions of the guide vanes (7) are matched with path field of the dense phase pulverized coal air flow so that the dense phase pulverized coal air flow forms disturbed flow and is ejected at a certain swirl angle; and dilute phase pulverized coal air flow at the center of the nozzle is ejected into an external furnace directly.

4. The dense phase swirl pulverized coal burner according to claim 1, **characterized in that**
   outer walls of the nozzles of the primary air channel (1), the direct flow secondary air channel (2) and the swirl secondary air channel (3) are provided with flow expanding cone structures (8, 9, 10) respectively; and
   cone flaring openings of the flow expanding cone structures (8, 9, 10) are respectively arranged toward the external furnace so as to delay mixing time of secondary air and primary air.

5. The dense phase swirl pulverized coal burner according to claim 1, **characterized in that**
   the oil gun casing (4) of the straight tube section is provided with two to three levels of pulverized coal concentration rings (6), and size of the pulverized coal concentration rings (6) is enlarged by levels.

6. The dense phase swirl pulverized coal burner according to claim 5, **characterized in that**
   a cone flaring angle (α) of each level of the pulverized coal concentration rings (6) is within the range of 10° to 25°.

7. The dense phase swirl pulverized coal burner according to claim 3, **characterized in that**
   the nozzle of the primary air channel (1) is provided with 10 to 20 guide vanes (7) around inner wall thereof.

8. The dense phase swirl pulverized coal burner according to claim 7, **characterized in that**
   an angle between each of the guide vanes (7) and axial direction of the primary air channel (I) is 10° to 30°, and radial height of the guide vanes (7) along the primary air channel (1) is 0.05 to 0.1 time the diameter of the primary air channel (1).

9. The dense phase swirl pulverized coal burner according to claim 4, **characterized in that** cone flaring angles ($\beta 1$, $\beta 2$, $\beta 3$) of the multiple flow expanding cone structures are not more than 45° respectively.

10. The dense phase swirl pulverized coal burner according to claim 1, **characterized in that** the direct flow secondary air channel (2) is provided with a regulating device (11) for regulating air flow; and the swirl secondary air channel (3) is provided with a regulating device (12) for regulating swirl air strength.

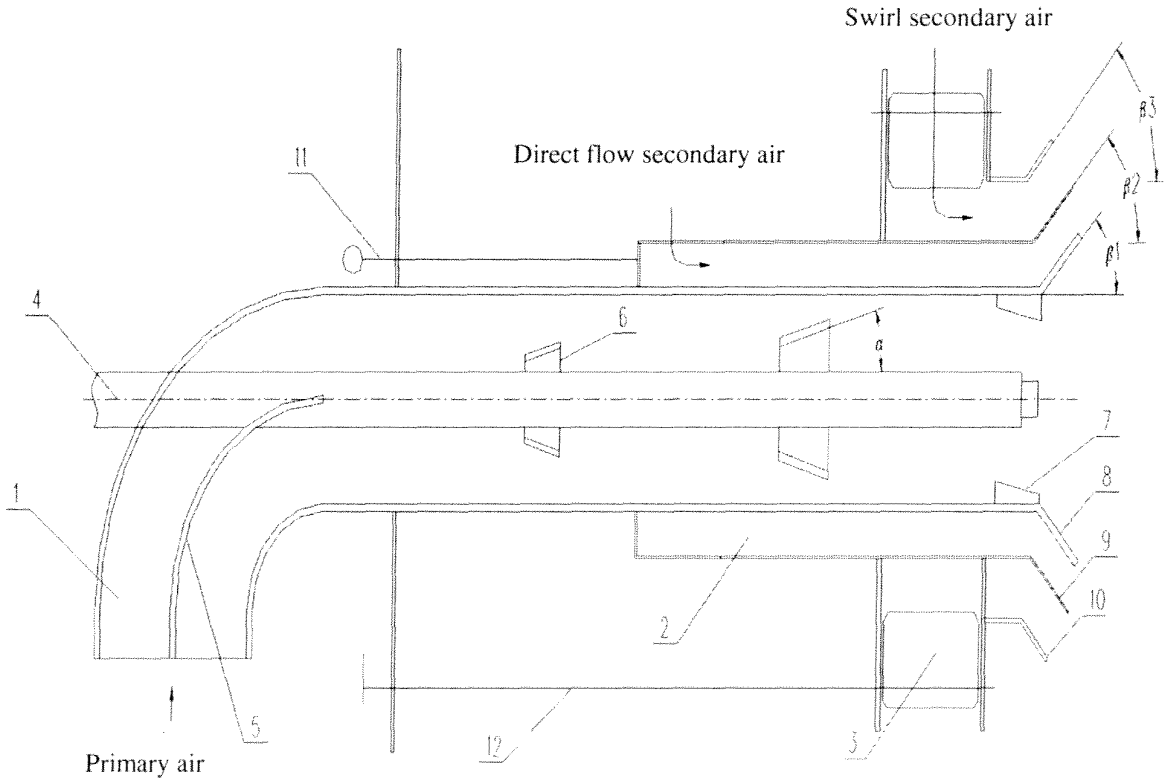
Swirl secondary air
Direct flow secondary air
11
β3
β2
β1
4
6
a
7
8
9
10
1
2
5
12
3
Primary air

Fig. 1

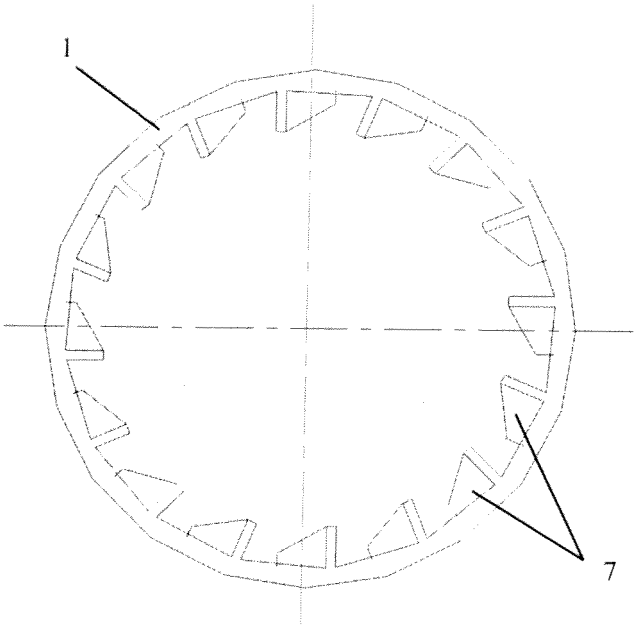

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/071214

A. CLASSIFICATION OF SUBJECT MATTER

F23D 1/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F23D 1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: vortex, cyclone, whirl, swirl, concentrat+, dense, strong, thin, weak, dilute, first, primary, second, secondary

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN101832550A(UNIV SHANGHAI JIAOTONG)15 Sep. 2010(15.09.2010) description, paragraphs 22-42, figures 1-2	1-10
Y	CN201448834U(DAI, Weijun) 05 May 2010(05.05.2010) description, paragraph 9, figure 1	1-10
Y	CN101578482A(HARBIN INST TECHNOLOGY)11 Nov. 2009(11.11.2009) the abstract, fig.1	1-10
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A	US2002174810A1(BABCOCK BORSIG POWER INC)28 Nov. 2002(28.11.2002) the whole document	1-10

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 May 2012(07.05.2012)	24 May 2012(24.05.2012)
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451	Authorized officer GUO, Yunzhi Telephone No. (86-10)62085033

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/071214

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP0260382A1(HITACHI LTD et al.)23 Mar. 1988(23.03.1988) the whole document	1-10

Form PCT/ISA /210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/071214

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