LARGE DIAMETER FRP FLUES IN LARGE DIAMETER CHIMNEYS

Inventor: Qun Xia, Weston, FL (US)

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ABSTRACT

Large diameter fiber-reinforced plastic (FRP) flues are installed inside large diameter concrete chimneys or steel structures, comprising a plurality of large diameter FRP cylindrical sections, jointed end to end and stacked up longitudinally. Large diameter cylinders are comprised of circumferential segments, side jointed together by means of chemical bonding and mechanical fastening to complete the enclosures. Longitudinal sides of each segment are designed in specific joints of inward flanges for connections. The novel mean for large diameter FRP flue design using compositional modular segments, accommodates rapid construction, shop fabrications, corrosion resistance for low maintenance, inertness of over a wide range of adverse, weather conditions for onsite vertical filament winding, overcomes the limitations or even infeasibility of monolithic large diameter FRP cylinders for shipping and transportation and eliminates needs of large opening on the outside chimney structures. In addition to the nature of filament wound FRP composites in low density and physical properties, this invention surpasses steel, alloy metal and conventional FRP flues in numerous aspects in quantity shop fabrications, lower costs, lighter weight, and easier installations, in flue gas desulfurization industries.
LARGE DIAMETER FRP FLUES IN LARGE DIAMETER CHIMNEYS

CROSS REFERENCES TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Disclosure
[0003] This invention relates to the large diameter chimney technologies and, more particularly, to large diameter fiber-reinforced plastic (FRP) flues installed in large diameter chimneys.

[0004] 2. Background Art
[0005] The implementations of environmental conservation policies in US and western countries, particularly flue gas desulphurization, initiated the sulfur dioxide removal in the late 1970s and early 1980s by using desulphurization equipment and the techniques. China (PRC) has since 2005 required and encouraged national environmental policies for chimneys in operations and newly constructed ones nationwide to be fit or retrofit for desulfurization so as to reduce the emission of sulfur dioxide.

[0006] Most conventional desulphurization techniques are in the method of wet scrubbing, meaning that flue gas comes out of boiler, through the scrubber and the shower of alkaline solutions, then enters breaching and the chimney to be discharged into atmosphere. However, about 5% of the sulfur dioxide still remains in the flue gas being discharged. Since the temperature of the flue gas stays around 120° F., sulfur dioxide mixing with oxygen and water turns into diluted sulfuric acid. Sulfuric acid causes acidic corrosions to the concrete and steel flues and chimneys. Over a period of time, the corrosion will damage the concrete and steel chimneys partially or in a large scale, even collapse the chimney.

[0007] The work conditions of the flue gas in chimneys before desulphurization go as high 266° F. to 302° F. in temperature. While scrubbers are in operations, the temperature of the wet flue gas goes down to about 120° F. When the generation units start up, flue gas will be super heated to as high as about 350° F. in a short period of time.

[0008] At the time of massive promotions of the desulphurization, the protections of the chimney structures are facing extraordinary serious challenges: no matter what conventional anti-corrosion materials or techniques are used, foreign or domestic, almost 90% or more chimneys will leak within a year. Consequently, acids penetrate into the substrates of steel, seriously damaging the structure of the chimney and put safety at risks. The potential losses in China alone can be dozens of billions RMB (billions of dollars).

[0009] The anti-corrosion linings inside chimneys have been categorized as: coating, mortar, borosilicate and foaming block lining, tile, alloy or titanium, and fiber-reinforced plastic (FRP) laminate lining.

[0010] Coatings crack easily, delaminate with limited thickness, and mortars performs poorly on permeation and often disband and cracks. Borosilicate and foam blocks need extended time for constructions. Tens of thousands grouting seams will be generally damaged from several flawed seams, which is co-related and interactive. Tile types of lining are the same as well due to the numerous seams. Titanium alloys are expensive and welding seams are subject to damages. Inevitable leaking also occurs. FRP flues on the other hand are more and more applied due to its temperature resistance, corrosion resistance, and reliable performance.

[0011] The main reason of the above mentioned anti-corrosion material failures in the chimney is because the materials are in contact with an acid proof brick liner or concrete. Once damaged, acidic solutions penetrate into the brick liner and concrete, which can cause structural damage.

[0012] In order to avoid the chimney structural damages, flues inside the chimney shells or supporting structures are required. Flues are categorized into steel flues, brick/concrete flues, and fiber-reinforced plastic (FRP) flues. While steel and brick flues are easily damaged, FRP flues perform well.

[0013] However, at the time of using FRP or composites flues, large diameter FRP flues with diameters bigger than 10 feet or 12 feet, have to be manufactured with a vertical filament winding apparatus established near the project site, in order to avoid high costs in trucking the FRP flues from the shop to the chimney site, or difficulty of transportation.

[0014] Even if the large diameter flues are cylindrically and vertically wound and manufactured onsite, with the diameter from 10 feet to 12 feet, even 15 feet to 30 feet wide, onsite vertical windings could face difficulties, such as weather, temperature, wind etc. A large hole needs to be cut in the chimney or duct to carry the FRP cylinders for installations. In the meantime, hoisting FRP cylinders around the chimney demands high level hoisting equipment and operations.

[0015] The above mentioned problems still restrict the extensive applications of large diameter FRP flues. The major limitations are existing complications in manufacturing large diameter FRP flues, difficulties in transportations, complexity in constructions, elevated costs, and low acceptance by industrial customers.

BRIEF SUMMARY OF THE INVENTION

[0016] The purpose of the invention is to provide large fiber-reinforced plastic (FRP) flues in large diameter chimneys, allowing fabrications of the flues in shops and accommodating substantial quantity of productions. It offers the convenience in transporting the flues components, overcoming the difficulties in setting up apparatus and facilities onsite for vertical filament winding, and resolving difficulties in the installations.

[0017] In order to realize the above purposes, the invention adopts the following technical solutions:

[0018] The invention is about a new design large diameter FRP flues installed in large diameter chimneys, made of either concrete or steel structures. The FRP flue is composed of a plurality of FRP cylinders which stack up from the chimney floor area to the top of the chimney. Each FRP cylinder is assembled by the same circumferential segmented FRP sections. On both longitudinal sides of the modular segment sections, are inward flanges which are integrally connected with the circumferential segment of FRP cylinder.

[0019] These modular sections are in numbers varying from 2, 3, 4, 6 or even 8. In certain circumstances when the diameter of a vessel is big enough, the numbers of the segments for one cylinder might be a few dozens.

[0020] For the inward flanges, bolting holes are drilled through the adjacent side flange of the next section, along the entire longitudinal flange. When the sections are being assembled together inside the large diameter chimney, two
adjacent sections will be first chemically glued together, while bolting through all the holes normally with stainless steel bolts, nuts, washers. All the designed numbers of segment sections can be joined together to complete the enclosure of the FRP cylinder. An option in case that further corrosion protections are needed for the chemical glue between flange face seams and bolts seams, includes specific areas to be further coated, sealed and covered with fiber reinforced mats.

[0021] Chemically gluing the flanges faces together with bolting devices are sufficiently strong to hold two segment sections together, and keep the integrity of the entire cylinder. While the boilers and scrubbers are in operation, the design of the FRP cylinder can also be sufficiently strong enough to reduce the possibility of corrosion. Longitudinally jointed inward flanges along all the FRP cylinder sections also function like extra beams, contribute additional structural strength and support the entire flue system.

[0022] Other designs of the section side joint devices as described which are basically in the similar method. All the composite mating and touching surfaces between segment sections are chemically glues together. All the glued tight surfaces are reinforced with stainless steel bolts, nuts, washers and holding pressure dissipated stainless steel plate sandwiched between the composite and washers. The stainless steel plates connected at all the inner cylinders can serve as the static grounding safety devices by collecting and conducting electrical charges from lightening and flue gas frictions with the FRP flue.

[0023] A new design of large diameter FRP flue can be installed in large diameter chimneys. The FRP flue can be composed of a plurality of FRP cylinders stacking up from the chimney floor area to the top of the chimney. Each FRP cylinder can be assembled by the same circumferential segment FRP sections. On both longitudinal sides of the modular segment sections, are joint devices to link all the designed numbers of segment sections together to complete the enclosure of the FRP cylinder. One of the typical joint devices is the lap joint design. The lap joints bolting holes are drilled through the two lapped section areas, along the entire longitudinal lapped areas. When the sections are being assembled together inside the large diameter chimney, two lapped sections can be first chemically glued together, while bolting through all the holes normally with stainless steel bolts, nuts, washers. On each side of the flange, a stainless steel plate can be positioned between the hardened FRP composite and the washer for the purpose of relatively evenly holding tight and pressing on the FRP lapped areas.

[0024] A new design large diameter FRP flue can be installed in large diameter chimneys. The FRP flue can be composed of a plurality of FRP cylinders stacking up from the chimney floor area to the top of the chimney. Each FRP cylinder can be assembled by the same circumferential segment FRP sections. On both longitudinal sides of the modular segment sections, are joint devices to link all the designed numbers of segment sections together to complete the enclosure of the FRP cylinder. One joint device can be the outward flange design. The outward flanges bolting holes can be drilled through the two section outward flanges, along the entire longitudinal outward flanges. When the sections are assembled together inside the large diameter chimney, two section outward flanges can be first chemically glued together, while bolting through all the holes normally with stainless steel bolts, nuts, washers. On each side of the flange can be a stainless steel plant positioned between the hardened FRP composites and the washer for the purpose of relatively evenly holding tight and pressing on the FRP outward flanges.

[0025] A new design large diameter FRP flue can be installed in large diameter chimneys. The FRP flue can be composed of a plurality of FRP cylinders stacking up from the chimney floor area to the top of the chimney. Each FRP cylinder is assembled by the same circumferential segment FRP sections. On both longitudinal sides of the modular segment sections, are joint devices to link all the designed numbers of segment sections together to complete the enclosure of the FRP cylinder. One joint device is the butt joint of end to end joint design. When the segments are assembled together inside the large diameter chimney, two ends can be first chemically glued together, in addition to the internal and external connecting plates.

[0026] A new design of large diameter FRP flues can be installed in large diameter chimneys. The FRP flue can be composed of a plurality of FRP cylinders stacking up from the chimney floor area to the top of the chimney. Each FRP cylinder can be assembled by the same circumferential segment FRP sections. One longitudinal side of the modular segment sections can be straight edge, while the other side can be an integral outside joint cover matching the straight edge of another segment. All the designed numbers of segment sections can be joined together to complete the enclosure of the FRP cylinder. When the sections are being assembled together inside the large diameter chimney, two lapped sections can be chemically glued together.

[0027] At all the seam areas of the cylinder segments, fiber-glass mesh cloth and resins can be used to cover and for bonding completely.

[0028] This invention is directed to assembling large diameter FRP cylinders into large diameter flues with modular segment sections, jointing by means of inward flanges, outward flanges, outside cover joints, butt joints, internal and external connecting plates together with chemical gluing, fiber reinforced mat bonding, and additional mechanical stainless steel bolting for complete enclosure of large diameter cylinders. Cylinders are then vertically assembled and jointed, for construction of the entire large diameter FPR chimney.

[0029] A more detailed explanation of the invention is provided in the following detailed descriptions and appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 shows a basic longitudinal cross section of a large diameter concrete chimney with a centrally installed large diameter fiber-reinforced plastic (FRP) chimney flue, which comprise 4 circumferential segments.

[0031] FIG. 2 shows a horizontal cross section of a large diameter FRP flue with 4 segments and a bolt fastened inward flange joint design.

[0032] FIG. 3 shows a horizontal cross section of a large diameter FRP flue with 3 segments and a bolt fastened inward flange joint design.

[0033] FIG. 4 shows a horizontal cross section of a large diameter FRP flue with 6 segments and a bolt fastened inward flange joint design.

[0034] FIG. 5 shows a horizontal cross section of a large diameter FRP flue with 4 segments and a bolt fastened outward flange joint design.
FIG. 6 shows a horizontal cross section of a large diameter FRP flue with 4 segments and a butt head or butt joint design.

FIG. 7 shows a horizontal cross section of a large diameter FRP flue with 4 segments and a straight edge joint with outside cover from another segment design.

DETAILED DESCRIPTION OF THE INVENTION

The following is a detailed description and explanation of the preferred embodiments of the invention and best modes for practicing the invention.

With reference to FIG. 1, a large diameter fiber-reinforced plastic (FRP) chimney flue 1 is installed in a large diameter concrete chimney 2 or a steel structure. The flue is stacked up and longitudinally connected with a plurality of cylindrical sections 3, 4, 5, 6. FIG. 1 illustrates cylinder sections made of four modular segments. Load support structures 4 are designed to also fix the FRP flue 1 for the stability.

With reference to FIGS. 2-4, the cylindrical sections are comprised of a plurality of jointed segments 5 (3 segments, 4 segments, 6 segments etc.). Both sides of the segments 5 are monolithically fabricated with inward flanges 6.

The inward flanges are drilled with flange holes 7. The cylinders 3 are jointed (joined) together by bolts 8 through the flange holes 7 and adjacent inward flanges 6. The stainless steel plates between the bolts 8 and the surfaces of inward flanges are used to disperse the pressure and for internal grounding. The seams inside and outside of said inward flanges 6 can be covered by fiber reinforced mat and composites to complete bonding type of seal.

With reference to FIG. 5, the FRP cylinders 3 are jointed together by circumferentially segmented modular sections 9 in certain number (4 sections in this case, and could be 3, 5 or 6 etc.). Both sides of said segments 9 are monolithically fabricated with outward flanges 10.

The outward flanges 10 are drilled with flange holes 7. The cylinders 3 are jointed together by bolts 8 through flange holes 7. The contiguous surfaces of the outward flanges 10 can be chemically bonded together. The stainless steel plates between the bolts 8 and the surfaces of inward flanges are used to disperse pressure. The internal seams the outward flanges can be covered by fiber reinforced mat and composites to complete bonding type of seal.

With reference to FIG. 6, the FRP cylinders 3 are end-to-end jointed and chemically glued together by circumferentially segmented modular sections 13 in certain number (4 sections in this case, and could be 3, 5 or 6 etc.). The internal and external seams can be covered and sealed with composites and further covered and reinforced with internal 12 and external stainless steel plates 11.

With reference to FIG. 7, the FRP cylinders 3 are straight edge jointed and chemically glued together by circumferentially segmented modular sections 16 in certain number (4 sections in this case, and could be 3, 5 or 6 etc.). One side of the cylinder segment section 16 is a straight edge 15, while the other side provides an outside cover 14. The outside cover 14 on each of the cylinder segments 16 is chemically bonded with the straight edge of another cylinder segment to complete the enclosure of the cylinder.

The internal seam of the cylinder segment 16 can be covered by fiber reinforced mat and composites for complete bonding type of seal.

As shown in the drawings, a new design of large diameter FRP flues can be installed in large diameter chimneys. The FRP flue can be comprised of a plurality of FRP cylinders stacking up from the chimney floor area to the top of the chimney. Each FRP cylinder can be assembled by the same circumferential segmented FRP sections. On both longitudinal sides of the modular segment sections, are joint devices to link all the designed numbers of segment sections together to complete the enclosure of the FRP cylinder. One of the typical joint devices is the lap joint design. The lap joints bolting holes are drilled through the two lapped section areas, along the entire longitudinal lapped areas. When the sections are being assembled together inside the large diameter chimney, two lapped sections can be first chemically glued together, while bolting through all the holes normally with stainless steel bolts, nuts, washers, etc. The surplus of the flange, a stainless steel plant can be positioned between the hardened FRP composite and the washer for the purpose of relatively evenly holding tight and pressing on the FRP lapped areas.

The design provides conveniences for attaching accessories, such as lifting gudgeons, segment stiffening ribbings, weight support structures, anti-vibration devices, flexible couplings, external circumferential tightening metal straps for each composed cylinder. Since inward flanges form additional structural beams, the inward flanges enhance the stability of the entire composite FRP flues. The inward flanges induce no flue gas flow resistance. The invention possesses novelty, creativity and practicability.

Among the many advantages of the design of large diameter flue can be:

1. The invention allows quantity productions and fabrications of the large diameter FRP sections in shop facilities, and later has the flue assembled on site in the chimneys.

2. The compositional design by using modular segment sections brings large diameter flue unprecedented convenience in shipping and installations.

3. The invention resolves the difficulties in transporting large diameter FRP columns, as well as the problems of near site plant establishments and large diameter FRP fabrications.

4. The invention overcomes the obstacles in installations by reducing the weight and size of each section piece.

5. The invention makes large diameter FRP flue applications and installations feasible in retrofit concrete chimneys, especially the ones later equipped with flue gas desulfurization (FGD) and converted from discharging high temperature dry flue gas to discharging low temperature desulfurized but acidic wet gas. Retrofit chimneys cannot normally be structurally modified such as by cutting big openings to install conventional large diameter flues.

6. The invention reduces costs of installing an FRP flue, enhances and broadens the applications of the FRP flue as the best mean in corrosion control and chimney protections, thereby helping to benefit and protect our environment.

Although embodiments of the invention have been shown and described, it is to be understood that various modifications, substitutions, and rearrangements of parts, components, and/or process (method) steps, as well as other uses, shapes, construction, and design of the large diameter FRP flues can be made by those skilled in the art without departing from the novel spirit and scope of this invention.
What is claimed is:

1. Large diameter fiber-reinforced plastic (FRP) flues installed in large diameter chimneys made of concrete and steel structures, comprising:
   - large diameter FRP flues stacked up longitudinally and comprising a plurality of large diameter FRP cylinders;
   - said cylinders comprising a plurality of modular circumferential segments with longitudinal sides, jointed side to side to complete circular enclosures; and
   - said longitudinal sides of said segments are fabricated with monolithic outward flanges.

2. Large diameter FRP flues in accordance with claim 1, wherein:
   - the inward flange comprises contiguous surfaces on respective segments and are chemically bonded;
   - said segment comprise inward flanges with flange holes for receiving stainless steel bolts going through the flange holes to fasten and join together, completing the cylindrical enclosures;
   - stainless steel plates underneath washers are pressed against said inward flanges;
   - additionally connected continuously from the top of said flues to the bottom, so that grounding wirings are equipped in said flues; and
   - exposed seams, bolts and nut areas being covered and bonded with fiber and mat reinforced composites for a complete seal.

3. Large diameter fiber-reinforced plastic (FRP) flues installed in large diameter chimneys made of concrete and steel structures, comprising:
   - large diameter FRP flues that are stacked up longitudinally and comprised of a plurality of large diameter FRP cylinders;
   - said cylinders comprising a plurality of modular circumferential segments with longitudinal sides, jointed side to side to complete circular enclosures;

4. Large diameter FRP flues in accordance with claim 3, wherein:
   - the outward flange comprises contiguous surfaces on respective segments and are chemically bonded;
   - said segment comprises outward flanges with flange holes for receiving stainless steel bolts going through to fasten and joint together, completing the cylindrical enclosures; and
   - exposed seams, bolts and nut areas being covered and bonded with fiber and mat reinforced composites for a complete seal.

5. Large diameter fiber-reinforced plastic (FRP) flues installed in large diameter chimneys, comprising:
   - large diameter FRP flues with end-to-end contiguous joint surfaces on respective segments that are chemically bonded; and
   - said segments end-to-end joints that are connected and bonded with internal and external bonding plates, completing cylindrical enclosures.

6. Large diameter fiber-reinforced plastic (FRP) flues installed in large diameter chimneys, comprising:
   - large diameter FRP flues with corresponding contiguous edge surfaces on respective segments that are chemically bonded;
   - said segments comprising straight edge on one side and an outer cover on the other side; and
   - said straight edge with the outer cover side are chemically aligned to another segment until completing a cylindrical enclosures.

7. Large diameter FRP flues in accordance with claim 6 wherein the large diameter FRP flues comprises exposed seams covered and bonded with fiber and mat reinforced composites for a complete seal.

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