Technical process of operation of bubbling and circulating fluidized bed technology incinerator to domestic solid waste treatment for energy

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Abstract

In order to meet the development trend of incinerator technology with high efficiency and suitability to Vietnam's conditions in the future, the research focuses on developing technical instructions for the operation process of fluidized bed incinerator technology (BFB, CFB) in domestic solid waste treatment. The content of the article presents the procedures for starting the incinerator, the operation of the incinerator and the process of stopping the incinerator. The research results are aimed at providing materials for use in training engineers specializing in urban environmental engineering. It is also a reference for engineers who directly perform operational management at waste power plants or scientists and managers interested in research in the field of domestic solid waste management.

Key words: *domestic solid waste, fluidized bed technology incinerator, Bubbling Fluidized Bed (BFB), Circulating Fluidized Bed (CFB), technical process of operation*

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Heading

Burning solid waste to generate electricity has become a new trend in Vietnam. Finding technology to turn solid waste into a valuable resource has also become an important component of Vietnam's environmental industry, in accordance with Decision 491/QD-TTg dated May 7/ 2018 "on adjusting the national strategy on integrated solid waste management to 2025, vision to 2050" [1] and the Law on Environmental Protection 2020 (promulgated and amended by the Government according to consolidated document No. 21/VBHN-VPQH dated December 29, 2022) [2]. Currently, the technology of burning waste to generate electricity is of interest to Vietnamese cities. Among them, there are three waste incinerator technologies that are used and implemented in most localities: Stocker Incinerator, Rotary Kiln Incinerators and (Fluidized Bed Incinerators. Evaluation of these technologies shows that: fluidized bed combustion technology is the most advanced combustion technology used for many types of fuel [3]. Fluidized bed burners burn fuel in and on the fluidized bed with the boiling material usually being natural sand. The high heat capacity of the fluidized bed keeps combustion in the incinerator even when the input fuel has a low calorific value. Low temperatures and high combustion efficiency create lower emissions into the environment than other combustion technologies. Simple incinerators with no internal moving parts ensure reliable operation with low maintenance costs. The incinerator was designed with consideration so that mechanical components were manufactured by reputable manufacturers in Vietnam as much as possible [4].To be able to apply fluidized bed technology to operate effectively when disposing and burning domestic solid waste to recover energy in Vietnam's urban areas, below the research team will present in detail the characteristics of technology and technical process of operation for CFB and BFB fluidized bed technology incinerators.

1. Introduction about CFB and BFB fluid bed technology incinerator

There are two types of fluidized bed incinerator technology commonly designed in waste-to-energy plants (waste power plants): bubbling fluidized bed incinerator technology (BFB) or circulating fluidized bed incinerator technology. (CFB). The operating principles of these two technologies are basically the same and are described as follows: After preliminary processing, fuel is brought into the combustion chamber, level 1 air is supplied from below the combustion chamber to create a fluid layer. Level 2 air is supplied to the combustion chamber at a certain height. Fuel particles move up and down in the combustion chamber and burn. The cycle is repeated until the fuel particles are completely burned. To desulfurize, limestone is added to the fire chamber. The amount of heat emitted during the fuel combustion process is supplied to the steam generating tubes arranged around the fire chamber. High-temperature smoke (800-900°C) coming out of the combustion chamber will transfer heat to the superheaters and heaters. water heater, air dryer, etc. Smoke discharged from the incinerator at low temperature (below 200°C) is passed through a dust removal system to filter ash and slag flying with the smoke before going through the chimney into the environment. The only difference between the two technologies is:

BFB is a fluidized bed boiler with low boiling point. In BFB, the coefficient "intake of air into the incinerator" is less. The fluidized bed temperature is controlled by providing a suitable amount of primary boiling gas and circulating the gas in the incinerator. Normally, the boiling speed in a bubbling fluidized bed incineratoris only 1.5-2.5 m/s and the fluidized bed height when operating is about 0.8m. The base material and fuel mainly burn in the bottom part of the combustion chamber, a clear boundary can be seen between the fluidized layer and the upper combustion chamber[5].

CFB circulating fluidized bed incinerator has a high boiling rate, with smoke velocity in the combustion chamber up to 4 - 6 m/s, solid particles in the smoke (including substrate and fuel) will be retained by the Cyclone separator. (hot or cold type) and circulated back to the combustion chamber [5]. The lowest calorific value of waste for the incinerator to operate is 4 MJ/kg. The factory has a reserve area for fuel (waste) with high calorific value for use at times when the fuel loaded does not reach the minimum calorific value. The difference when choosing a BFB or CFB incinerator depends on many issues. But basically, CFB works more effectively with waste with higher calorific value.

CFB and BFB fluidized bed incinerators have some common characteristics as follows:

Flexible fuel:

+ Capable of handling all types of classified and crushed domestic solid waste, TDF, RDF, a variety of biomass fuels, peat, wood chips and sludge and coal at a controlled level wide, different humidity.

+ Fluidized bed allows effective removal of raw materials on the incinerator surface.

+ Easy to use additives;

High availability:

+ Careful design ensures good operational features and high availability.

+ Low maintenance because of simple and reliable structure.

Improved technological structure:

+ There are no moving parts in the heating chamber;

+ Homogeneous burning conditions; Very high fuel burning efficiency (High heat transfer ability)

+ Very low residual oxygen for best combustion efficiency and low exhaust gas flow;

+ Automation can reach 100%, minimizing impact on workers at the factory.

Low emissions:

+ Effective waste incineration technology ensures the amount of hard-to-burn carbon in fly ash along with low CO emissions. Reduces greenhouse gases 17-23 times compared to landfills.

+ Optimize air and combustion temperature with reasonable residual residue, ensuring low NOx emissions. If it is necessary to reduce emissions, it can be solved by installing an SNCR system (non-catalytic filtration system) to measure the amount of Urea or ammonium entering the flue gas stream in the incinerator and vortex cage.

+ SO2 capture is done by lime as an additive to the incinerator and the remaining SO2 is retained by the flue gas cleaning system [7].

+ The remaining ash and slag ratio is 8%; Therefore, the required area of landfill after burning exhaust outletis relatively suitable;

+ Wastewater from the factory is treated to meet environmental protection standards.

Reduce dependence on coal by generating non-fossil fuel electricity

Defects:

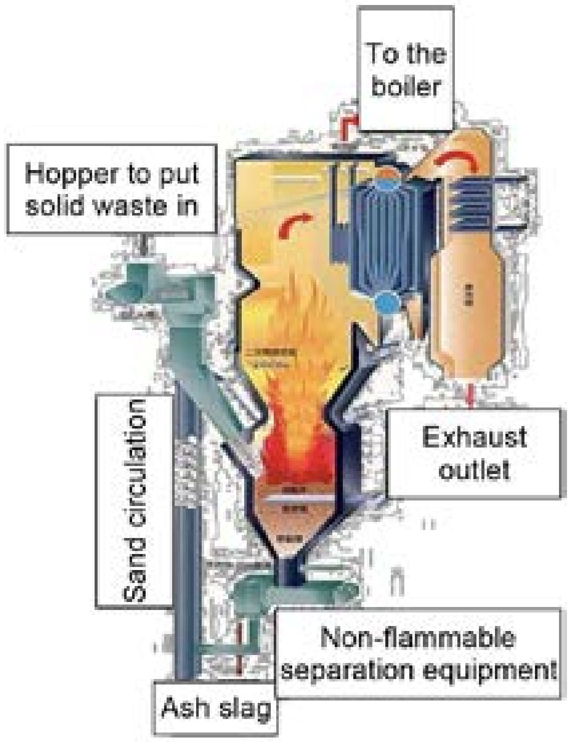

Figure 1. Diagram of fluidized bed incinerator
Source: Engineering Co., Ltd. et al., 2013 [6]

+ High initial investment price and operating costs;

+ Must pre-treat waste (crushing and drying);

+ Need to add fluidized bed material (sand);

+ Partial load operation requires a second combustion stage;

+ High precision regarding ash slag;

+ Moderate corrosion in the heat exchanger.

2. Research methods

Method of collecting information, surveying and investigating the current status: collecting and understanding the current status of management and operation of current household solid waste incineration technologies in Vietnam

Theoretical research method: learn about the theoretical foundations related to the technical process of incinerator operation

Inheritance method: inheriting relevant content from existing research.

Methods of synthesis, analysis, comparison: synthesize and analyze technologies for treating household solid waste using incineration technology, compare and evaluate with actual requirements and trends in choosing incinerator technology fluidized bed combustion.

Expert method: listen and absorb opinions of experienced experts in the field of training and research in fields related to environmental engineering.

3. Technical process of operating CFB, BFB

3.1. Incinerator start-up procedure

Requirements when starting a waste incinerator:

Check the specifications of the waste feeding equipment into the incinerator.

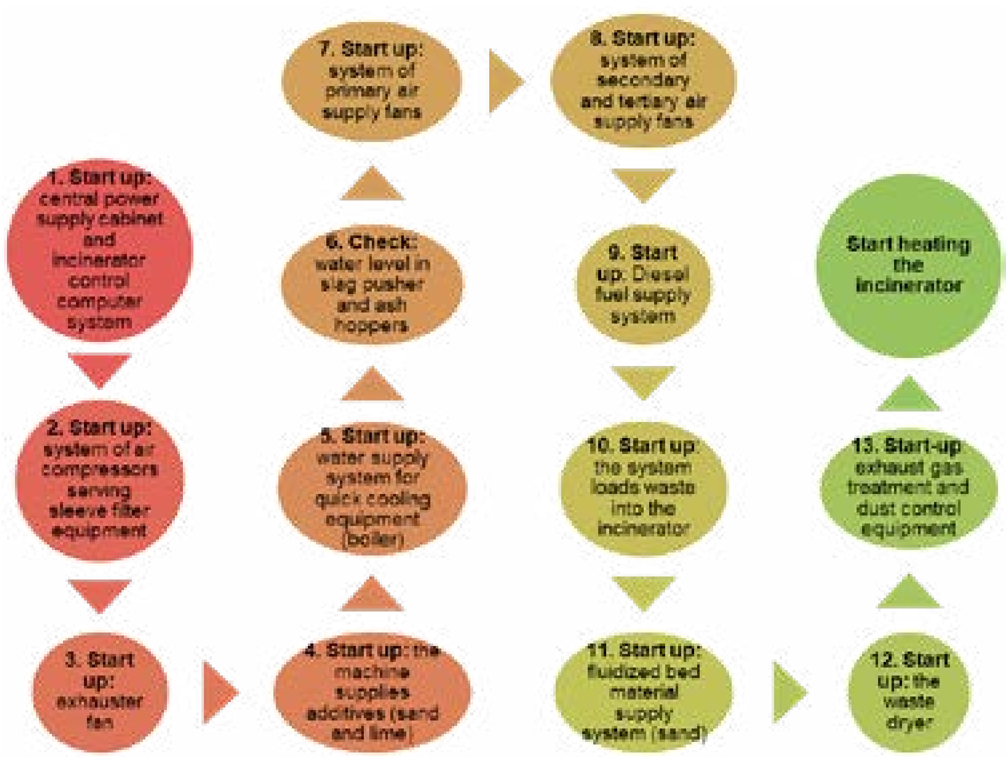

Figure 2. Diagram of the incinerator start-up process [8]

Operating status of the pressure control unit.

Based on waste characteristics and combustion conditions, adjust the combustion chamber temperature, air pressure inside and outside the incinerator, solid waste loading dosage, combustion gas flow and other ratios accordingly.

Monitor the fire in the incinerator and make adjustments to the waste burning conditions when you see the fire has black smoke, the fire is not spreading horizontally, the back is extinguished, etc.

When waste burning conditions are unstable, the waste burning temperature in the incinerator cannot be maintained at a temperature of 850°C or more, so auxiliary fuel is added to the incinerator.

Avoid placing the slag collection hopper in a high position near the incinerator so that the hot slag can gradually reduce its temperature when it reaches the collection hopper without melting the hopper.

Adjust the amount of clean air supplied to the incinerator while optimizing the system's waste heat usage conditions.

Check steam, water, oil, wind and other systems related to equipment operating conditions.

Waste water and waste heat from the boiler must be discharged continuously every day.

Regularly blow and clean coke stuck outside the incinerator.

Check the steam and waste heat parameters of the boiler to meet technical equipment requirements when designing.

Check steam quality according to domestic water quality standards.

Check the igniter and other parts of the incinerator to ensure that after ignition, the incinerator operates normally and stably. Specifically: Check and remove coke and slag on the door and walls of the incinerator; Clean dust from the air collection funnels of chimneys, air pipes, insulation pipes, heat exhaust pipes...; Check thermal relay; Check clean water supply equipment to ensure there are no leaks; Close the locks on the water supply pipes; Check remote control devices; Check heating components and compressed air supply system; Check the auxiliary combustion unit according to flexible and precise combustion programs; Watch for signs of water supply lines during combustion (normal water flow is 100mm); In case of using oil as auxiliary fuel: Check the stability of oil pressure, the normal fluctuation range is not more than 98kPa, then the safety of the ignition device is good; Check the air heating system

The process of starting the incinerator must strictly comply with water regulations stated in the National Technical Regulation on domestic solid waste incinerators QCVN 61:MT/BTNMT and follow the basic steps presented. Details on picture 2:

3.2. Incinerator operating procedures

Waste is loaded into the incinerator for burning according to standards and ensures that the volume of waste fed into the incinerator does not exceed the design capacity; Monitor the temperature of the combustion chamber gradually increasing to the required value: when the combustion chamber temperature is ≥600- 6500C, turn off the combustion equipment.

Bottom ash catchers and slag pushers: there must always be enough water inside, the water level must cover the ash and slag discharge mouth from the incinerator to avoid drawing air from outdoors into the incinerator. Therefore, you must pay attention to regularly adding water to these devices. When the amount of slag in the bottom ash collecting bins is full, a rotating forklift must be used to carry these collecting bins to the designated place of the factory.

At rapid cooling equipment or heat recovery boilers: At the beginning of the shift, operators use compressed air to clean the cooling tube system and check the equipment's safety monitoring devices. cool down quickly (level indicator, glass, observation device); Boilers are equipment that require great attention to operational safety. Therefore, there must be specialized workers in charge of monitoring the situation of the boiler and promptly taking action when detecting the risk of an unsafe situation.

Operators must regularly check the amount of primary, secondary and tertiary gas entering the incinerator to ensure the fluidized bed keeps the fluidized bed material particles suspended.

Other tasks: Check the operation of the burner system for the combustion chamber; Check the operation of the bypass system and explosion prevention valve to ensure the system is operating.

Work contents that need to be checked during operation include:

(1) Steam drum: Check to see if there is a steam or water leak at the connection flanges of the steam drum.

Before stopping the incinerator: Check the steam pressure gauges, safety valves, and water level gauges to see if they work accurately and reliably.

(2) Superheater

Monitor the steam temperature leaving the superheater and compare it with design values.

Monitor steam line and smoke line pressure loss.

Monitor inlet and outlet smoke temperature.

Pressure loss and smoke temperature tell us the level of fouling by ash and allow us to plan the cleaning of the superheater.

Listen for unusual sounds and check for steam leaks at the superheater installation. This will help identify the problem of the superheater's tube bursting.

(3) Water heater

Check the outside of the pipes to see if there are any signs listed below: Warping; Do not follow rows; Erosion; Dirty

If pitting is detected on the inner surface of the steam drum, examine the water sample of the heater and check to see if the inner surface of the heater tubes is pitted.

If it is discovered that the inner surface of the pipes is covered with scale, the pipe sections should be removed for inspection purposes. Before putting the superheater into operation, the cause must be found and corrected.

Check the support system.

Check the positioning steel bars and mounting brackets for wear.

Check whether the welds used to connect pipes are worn or cracked.

(4) Combustion chamber

Check at high temperature locations to see if there is a smoke leak or layer material leak.

Check for cracks or blisters on the outside wall of the combustion chamber.

Check whether the combustion chamber wall temperature shows any signs of abnormality.

Check whether the thermocouples used to measure combustion chamber temperature and fuel layer temperature are working well.

(5) Air box

Check if there are air leaks or layer material leaks around the air box.

Check for signs of overheating of the air box, a fire inside the air box, or the reverse passage of hot smoke into the air box.

Regularly check the air pressure difference between the air box and the combustion chamber. For a specific load value, the phenomenon of air box pressure changes indicates that the boiling air flow is hindered because of improper operation of the inlet flow regulator, clogged air mushroom or layer density. high material.

(6) Smoke, ductwork, and shield-type flow regulators

Check around all pipes and smoke lines for signs of leaks.

Check the position of fans and shield-type flow regulators.

Check locations with high temperatures.

(7) Ash hoppers

Make sure there are no air leaks in the ash hopper flanges of the entire system. Air intrusion can lead to solidification of the ash and impede the flow of ash out of the ash hoppers.

Check to see if the ash hoppers have unusual colors, the hopper temperature is higher than normal and if there are protrusions on the hopper surface.

Make sure all ash hoppers are emptying properly.

Periodic cleaning: Make sure all ash hoppers are empty; Replace all manhole insert rings; Make sure the condition of the barriers does not have a flow-directing effect.

(8) Wear-resistant material layer / insulation layer

Check around all smoke ducts and air ducts for leaks.

Check the wear-resistant material layer at the ash return ports to see if it is damaged or not. If damaged, repair it.

Check the wear-resistant material layer at the fuel supply ports/layer material for damage and repair.

(9) Canopy

Visually check for air leaks

Before stopping every year: Check the outside of the roof area to see if there is any smoke leak. If so, mark the location of the smoke leak for handling when stopping the incinerator.

(10) RAV

Check all bearings for signs of overheating or friction.

Check whether the bearing seal and shaft seal are intact. This seal prevents air, dust and foreign substances from entering the bearing housing.

(11) Fans

Check to see if the bearings are lubricated, check the oil level.

Check the temperature of the bearings. If the bearings are abnormally hot, find the cause and handle it.

Make sure all seals are intact and working properly.

Check vibration; Listen for unusual sounds from the motor and fan.

Visually inspect bearing seals.

Before stopping the fan: Record the temperature and vibration parameters of the fan; Review the fan parameters

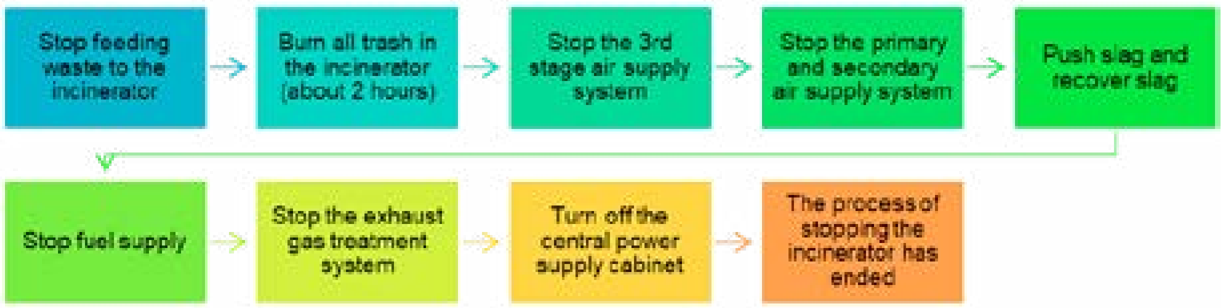

Figure 3. Procedure for stopping solid waste incinerators [8]

record kept in the control room: Fan vibration a few months ago; Bearing temperature at a few months ago; Oil used; Check the operation of the flow regulator and the display of fan parameters.

(12) Fuel supply system

Check for unusual sounds coming from the rotary feeders and bearings.

Check to see if the drive chain is loose.

Lubricate the bearings: periodically lubricate because the equipment works in a dusty environment and close to the combustion chamber.

(13) Degassing tank

Visually check for leaks in the valves before checking for sound at normal working pressure.

Check the working of the level meter and level signal transmitter.

(14) Incinerator water pump

Check the bearing lubrication status and check whether the oil level meets the requirements.

Check bearing temperature. If the bearing temperature is high, find the cause and correct the situation.

Make sure all inserts are intact and working properly.

Check vibration

Listen for any unusual sounds coming from the pump or motor.

Check for signs of water leakage at the seals and connections.

Check the differential pressure at the filter and clean the filter if necessary.

(15) Safety valves

Check for leaks in the valves before checking audibly and visually, at normal working pressure.

Check drain lines and condensate sections for signs of blockage.

When the safety valves go into operation, pay attention to the operating pressure and setting pressure of the valve. After the normal working pressure is restored, check whether the valve is leaking or not. Prices Wrong setting value needs to be adjusted.

Assess the level of valve leakage through the inspection book if the valve leakage level is increasing. Plan to stop the incinerator early for repair. Stopping the incinerator early can reduce the level of damage to the valve.

(16) Incinerator valves

Mark valves with high leaks and prepare a report.

Refer to the deaerator operating manual for more information.

(17) Water level display elements

Check the gauges or evaporator water level display elements. With level gauges, the check can be done by slowly opening the discharge line, then quickly closing the discharge line. to avoid damaging MICA. Observe whether the water level returns to its normal position.

Check to see if there is a water or steam leak at the connection points to the steam drum.

A leak in the water column or connection of the discharge line will lead to an incorrect display value of the device in the meter.

Replace the lights used for the damaged level display element.

Check the water tube to see if it is discolored or dirty. If the water tube is dirty, flush it to clean it, or remove it and replace it. Install a new water tube if it is discolored., stained or broken. If for any reason, the water tube and packing become loose, replace them.

Clean the watch. Perform a dirty flush for the level display element to remove suspended substances from the pipeline. Remove only two or three cuffs. Before that, it is necessary to close the valves used for measuring purposes.

(18) Electrostatic precipitator

Check and ensure the protective interlocks are working properly.

Check and ensure the cleaning air supply fan operates properly and ensure the cleanliness of the filter installed at the fan suction end.

Make sure the ceramic heater works well, the presence of moisture particles can cause the ceramic to crack.

Closely monitor working parameters related to electricity, if any unusual signs are detected, handle them immediately.

Ensure continuous circulation of ash out of each ash hopper of each electric field.

Monitor the temperature of the smoke entering and leaving the electrostatic precipitator.

Make sure there are no air leaks in the connecting flanges of the ash hopper of the entire electrostatic precipitator system. Outside air entering the interior can create ash clumps, thereby hindering the circulation of ash. out of the ash hopper.

(19) Chemical supply system

Check the lubrication status of the drive system

(continue reading page 82)

Furthermore, like other provinces with hydroelectric works, the management of drainage in Hue city is more difficult because the operation of the reservoir would also lead to floods. The hydrometeorological monitoring equipment in the upstream area, equipment for warning, building and updating flood maps, and measures to ensure downstream safety are still very limited. Along with that, the operation, regulation and discharge of floods, as well as information on flood discharges of some reservoirs are still inadequate, making it difficult for response in the downstream area, causing huge damages. Therefore, inter-sectoral coordination in the operation of the drainage system is essential to minimize damage in the events of flooding.

4. Conclusion

The research results reveal that the drainage system on Southern bank of Huong River has been recently improved with aim to enhance the drainage capacity for urban areas via such project as the Japanese ODA funded project, ADB funded project or local funded projects. However, under the influence of climate change, the weather is becoming more and more extreme and the unseasonal rainfall is increasing, the sewer network is still not able to drain in time, causing flooding in many locations on the Southern bank of Huong River. In addition, according to the climate change scenarios, the annual average temperature in Thua Thien Hue province will increase by 1.9°C and 3.5°C for RCP4.5 and RCP8.5, respectively; and the annual rainfall tends to sharply increase 26-31% at the end of 21st century.

Therefore, in order to enhance capacity on prevention of flooding risks and effectively respond to climate change, a holistic and integrated approach is needed. Within the scope of the research, the authors propose a number of technical measures such as consideration of additional parameters in the design of sewers, use of flood warning software, and approaching sustainable drainage solutions to improve the management capacity of the drainage system, adaption to flood risks, minimization of damages to local people as well as ensuring the sustainable development of the City./.

Technical process of operation of bubbling...

(continued on page 67)

Make sure the meter or water level display element is working properly

Ensure the cleanliness of the filter installed at the pump suction

Make sure the pump surroundings are clean of foreign substances and no chemicals are spilled there, for safe operation purposes.

Periodically check the pump inlet pressure and the operation of the pressure reducing valve.

(20) Mechanical dust collector

Visually check to see if there is a leak at the mechanical dust filter output flange.

Check the corners of the ash hopper to see if there is a leak.

Assess the level of leak, if serious, plan to stop the incinerator earlier than usual for repair. Stopping early can reduce damage to the valves.

Check the temperature of the bearings, if high temperatures are detected use the recommended lubricant.

3.3. Procedure for stopping solid waste incinerators

Just like when starting the incinerator, the process of stopping the incinerator must strictly comply with the regulations stated in the National Technical Regulation on incinerators QCVN 61-MT:2016/BTNMT. At the same time, the operator needs to follow the basic steps shown in Figure 3.

Conclusion

Fluidized bed incinerator technology (BFB, CFB) to treatment domestic solid waste and convert it into energy is a modern technology that requires the construction of very strict and meticulous operating process. With 3 basic processes that have been detailed and clearly outlined by the research team for each level from starting, operating to stopping the incinerator, this will be the necessary content to proceed with the implementation of training for direct and indirect managers can apply it correctly in real-life conditions, ensuring the best operating efficiency of the incinerator system, following technical and safety procedures. Besides, the research results are also reference documents to serve in training and scientific research in the field of environmental engineering./.

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