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Solutions for Recycling and the Reuse of Ash and Slag Waste from Vietnam's Power Plants towards Sustainable Development

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Abstract- It is necessary to study on separating the ash and slag (waste) and the coal (reuse) in the boilers in the coal-fired power plants in Vietnam. In order to meet the increasing energy demand for annual economic growth of about 7-8% per year at a reasonable price, Vietnam is required to continue to build coal-fired thermal power plants. However, the amount of ash generated by the plants is very much. According to statistics data, coal-fired power plants across the country discharged nearly 7.6 million tons of ash and slag in 2020. The process of combustion of coal in boilers is always optimized but always exist a significant source of unburnt carbon. The major aim of this research is that collects data of ash and suggests one technology to treat the ash to get the unburnt carbon to reuse by separating the unburnt coal from ash. This will be an important source of raw materials for many industries.

Keywords- Thermal power plant (thermal power plant), ash, slag, unburnt coal, Triboelectricstatic separation and Froth flotation technology.

I. INTRODUCTION

In Vietnam, since the first unit of Pha Lai thermal power plant (1983), there have been many researches on recycling, storing and reusing its fly ash and slag. However, the actual amount of ash and slag reused in our country is still very limited.

According to the planning of the power industry, the electricity output from Vietnam's coal-fired thermal power plants from now to 2020 will continue to increase and accordingly the amount of ash and slag discharged every year will also constantly increase.

In 2008, there were 2.27 million tons of thermal power ash, of which fluidized bed ash was 0.61 million tons. It is forecasted that by 2025, there will be about more than 30 thermal power plants with a total capacity of about 35,000 MW and the annual amount of ash and slag discharged at that time will be about more than 60 million tons. The recycling and using ash and slag in Vietnam Ash and slag.

Coal-fired power plants in Vietnam have a very large capacity from 600 MW to 1200 MW even larger capacity plants, so the amount of coal used and the amount of fly ash generated is very large. This requires a large area to accommodate as seen in figure 1:

Fig 1. Large ash and slag dump of a coal-fired power plant.

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Ash and slag in coal-fired thermal power plants is divided into two typical types: boiler bottom slag and fly ash, boiler bottom slag collected in the bottom of the boiler, fly ash collected primarily from electrostatic precipitator (figure 2). The biggest difference between slag and fly ash is the size of the particles; the bottom slag particles are larger than the fly ash particles.

Depending on different combustion technology, the mass percentage of slag and ash is different, the slag mass percentage got by the circulating fluidized bed boiler ranges from 40-50% and the ash ranges from 50-60%. The slag mass percentage got by pulverized coal fired boiler ranges from 10-20% and ash ranges from 80-90%.

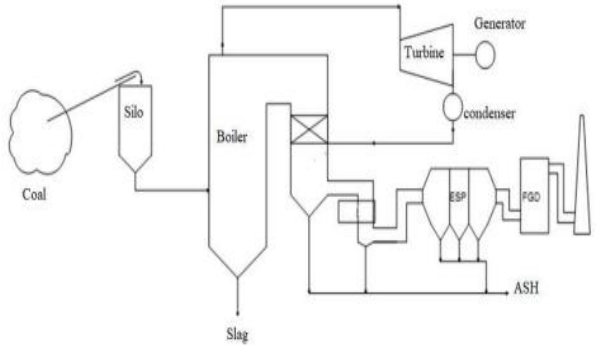

Fig 2. Ash and slag formation in coal - fired thermal power plants.

As the data from the table 1, the amount of fly ash and slag of all the Vietnamese coal – fired thermal power plants in the period 2005 to 2020 is very huge and the growing.

Table 1. Ash from Vietnamese coal – fired thermal power plants in the period 2005 to 2020.

No	Factory Names	Capacity, MW	Year of operation	Mass of coal (1000 tons per year)	mass of fly ash and slag (1000 tons per year) *
1	Cao Ngạn	100	2007	320	120
2	Uông Bí MR	300	2009	770	231
3	Sơn Động	220	2009	720	270
4	Hải Phòng I	300	2009	850	255
5	Hải Phòng I	300	2010	850	255
6	Cẩm Phả I	300	2009-Tổ 1	981	392
			2010-Tổ 2		
7	Quảng Ninh I	600	2011	1.700	510
8	Hải Phòng II	300	2013	850	255
9	Mạo Khê	220	2012	710	266
10	Nông Sơn	30	2015	96	29
11	Quảng Ninh II	300	2014	850	255
12	Hải Phòng II	300	2013	850	255
13	Cẩm Phả II	300	2011	981	392
14	Vũng Áng I	600	2014	1.530	459
15	Mạo Khê	220	2013	710	266
16	Uông Bí MR	300	2013	770	231
17	Mông Dương I	500	2015	964	386
18	Mông Dương II	600	2015	964	386
19	Quảng Ninh II	300	2014	850	255
20	Vũng Áng I	600	2015	1.530	459
21	Thăng Long	300			
22	Nghi Sơn I	300	2013	770	231
23	Vĩnh Tân I,	600	2015	1.530	459
24	Nghi Sơn I	300	2014	770	231
25	Mông Dương I	500	2016	964	386
26	Mông Dương II	600	2015	964	386
27	Vĩnh Tân I	600	2015	1.530	459

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(*) Estimated amount of ash and slag is based on coal quality standards used by thermal power plants.

Through the above statistics in the table 1, in the period from 2011 to 2015, the total installed capacity of coal-fired power plants has increased three times. That means the consumed amount of coal and the discharged amount of ash and slag also increased 3 times.

The amount of ash and slag discharged by coal fired thermal power plants in 2015 is about 8079 thousand tons of fly ash and slag, while reuse only accounts for about 20%, of which it is only used for small and not yet industrial scale. It is very waste and pollutes the environment.

Most of the coal-fired thermal power plants in Vietnam use Pulverized Coal Combustion technology and use anthracite coal fuel. Their study of fly ash and slag composition is almost the same. In the Hai Phong thermal power plant, we have the following chemical composition and characteristics in the Table 2:

Table 2. Ash and slag characteristics of Hai Phong Thermal Power Plant.

Compounds	Percentage	Values	Unit 1		Unit 2	
			Fly ash	Slag	Fly ash	Slag
SiO2	%	57,6	55,87	54,12	54,47	54,1
Al2O3	%	26,4	25,15	24,23	24,15	23,83
Fe2O3	%	7,7	6,05	4,65	5,45	4,05
CaO	%	0,8	0,63	0,51	0,59	0,41
MgO	%	1,2	0,77	0,54	0,7	0,44
Na2O	%	4,3	4,08	3,59	3,89	3,09
K2O	%	4,3	4,08	3,59	3,89	3,09
SO3	%	0,37	0,32	0,28	0,28	0,21
C slag	%			4,03		4,01
C fly	%		14,46		14,24	

II. SOME INDUSTRIAL APPLICATIONS USING ASH AND SLAG MATERIALS

This article evaluates the potential of ash and slag, their reserves as well as the ash and slag treatment technologies, technical guidance currently used in Vietnam and the world as bellow.

- Technical guidance: Fly ash facts for highways engineers (American Coal ash Association and Federal Highway Administration FHWA).
- ASTM C593-06 Standand Specification for Fly Ash and Other Pozzolans for Use with Lime for Soil Stabilization.
- Technical guidance of US Army: Soil stabilization for pavements TM5_822_14.
- 22 TCN 81-84: Process of using soil reinforced with inorganic binder in road construction.
- ASTM D5239-04 Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization.
- AASHTO TF 28-1: Guidelines and Guide Specifications for Using Pozzolanic Stabilized Mixture (Base Course or Sub base) and Fly Ash for In-Place Sub grade Soil Modifications.

Table 3. Hydroelectric power plant projects using roller compacted concrete technology in the period 2005 – 2015.

Name of plant	Number of units and capacity, MW	Place	Ash demand, tons	Time
Bản Vẽ	2 x 100	Nghệ An	200.000	2006 -2008
Sê San 4	3 x 390	Gia Lai	120.000	2006 -2008
Sơn La	2400	Sơn La	660.000	2007 -2010
Sông Tranh 2	2 x 190	Quảng Nam	142.000	2007 -2010
Bản Chát	2 x 100	Lai Châu	195.000	2008 -2010
Huội Quảng	2 x 280	Lai Châu	60.000	2008 -2012
Bắc Hà	90	Lao Cai	77.000	2008 -2010
Hua Na	180	Nghệ An	81.000	2008 -2013

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Making predictions about the amount of fly ash generated as well as select a possible ash and slag treatment technology for thermal power plants in Vietnam.

In Viet Nam, the factory premixed dry mortar production Da Cao Cuong produce products: red brick mortar plastering, plastering mortar concrete brick, plastered brick mortar lightweight AAC (Aerated Autoclaved Concrete).

Moreover, they can use fly ash as an additive in the production of Portland cement in the cement industry. There are essentially two main applications for fly ash in cement production, first as a raw material to produce Portland clinker and second as a pozzolanic addition. A large amount of ash and slag discharged from thermal power plants have been used to build hydroelectric plants using roller compaction technology (Table 3).

III. TRIBOELECTROSTATIC SEPARATION OF FLY ASH FROM COAL

The unburnt carbon in the fly ash shows that the quality of the ash depends very much on the composition of the unburnt carbon. In the ASTM C618 standards, it is limited to a maximum content of 12%. Fly ash with a high carbon content will have a large specific surface area. Therefore, the water demand of mortar or concrete using fly ash is more than usual.

Especially unburnt carbon affects very much the strength. In addition, the mixtures of mortar, chemicals and concrete can be absorbed onto the surface of carbon particles that will affect the properties of the mixture. Finally, the presence of carbon can affect the color of the ash. The increase composition of carbon will cause the gray color of minerals like magnetite.

So, we have to reduce the amount of carbon in the ash to fulfil all the technical requirements of these ash applications. There are currently many technologies in the world to separate unburnt carbon content in ash to ensure fly ash quality requirements for use in cement, concrete and other applications. These technologies are the centrifugal classifier method; Froth flotation method; Tribo electric static separation Method.

The fact shows that with Vietnamese tropical climate conditions and proximity to the sea, as well as avoiding the impact of clean water resources, the technology Tribo electric static separation is most appropriate when used in Vietnam. The Tribo electric static separation method will be described as in the figure 3:

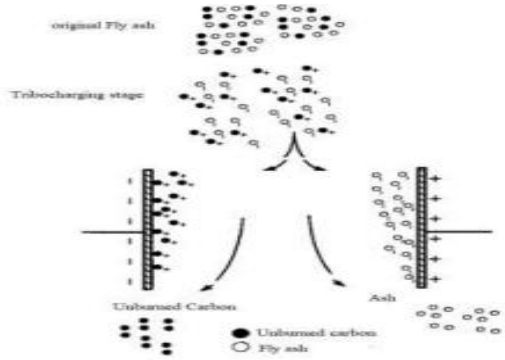

Fig 3. Principle of Triboelectricstatic separation technology.

The triboelectricstatic separation process consists of 3 principles stages: The 1st stage is the initial ash and slag obtained from the thermal power plant will be concentrated, collected and then, they are passed through a triboelectric charging surface to make these particles electrically charged. Finally, these charged particles are separated into separate unburnt coal and ash.

IV. CONCLUSION

In this article, the analysis and evaluation of Triboelectricstatic separation technology is discussed. The new method is triboelectrification phenomena that studied and have been briefly reviewed for separating bottom fly ash and unburnt.

This contributes to increase the amount of unburnt coal significantly to supply the coal market. This reduces the environmental impact of coal-fired power plants due to ash and slag emissions. Moreover, these wastes will be useful materials for other industries.

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