A Survey on Coal Gasification Scenarios in Bangladesh

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***Abstract*— Coal gasification technology is an emerging technology to extract coal energy for using in many purposes including chemical production, thermal process and electrical power generation. This is comparatively a new technology for Bangladesh because of lack of financial investment, technical knowledge, support, experts and practical experiences. According to power system master plan (PSMP) of Government of Bangladesh, coal will get the highest priority as primary source of power generation. To generate clean electricity from coal, gasification is the highly efficient and environment friendly technology. Therefore, coal gasification technology has huge prospects in Bangladesh. This paper surveys the coal gasification scenarios in Bangladesh and presents the gasification technology adopted by different industries mentioning their present condition. In addition, coal gasification technology and the potential application of this technology in Bangladesh is discussed.**

Keywords—Coal Gasification, Gasification Survey, Bangladesh

I. INTRODUCTION

Considering global warming, it is important to adopt a sustainable energy conversion technology with a lower environmental impact [1]. The world energy scenario shows that, coal is the ultimate fossil fuel for thermal process and power generation to meet the continuously rising demand of power and thermal energy [2-3]. Among all the types of technology of coal energy conversion, Gasification is the smartest technique and provide higher efficiency [4,5]. Although, gasification is a high-cost technology and harder to implement in developing country, but this is an effective solution regarding the efficiency and environmental issues.

According to BP Statistical Review of World Energy and Power System Master Plan (PSMP-BD) report, Bangladesh is going to deal with huge amount of coal for power generation, brick and ceramic tile burning, running thermal system in steel industries, producing alternate of natural gas, etc. Therefore, this is the best time to adopt gasification technology for these purposes. But Bangladesh is very new in this field. Also there are no easily available data or information on present scenario of gasification in Bangladesh.

This paper surveys the coal gasification scenarios in Bangladesh by visiting existing gasification plants in Bangladesh and collecting their technical data. This report portrays the gasification technology adopted by different industries and their present situation. In addition, coal gasification technology is discussed shortly. Finally, the potential application of coal gasification in Bangladesh is mentioned.

II. BACKGROUND AND PURPOSE

According to Power System Master Plan (PSMP) 2010, the Government of Bangladesh (GoB) has embarked on fuel diversification attaching prime importance on coal. The government now has adopted an ambitious plan of increasing power generation to 24,000 MW by 2021 and to 39,000 MW by 2034 where 53% of electric power will come from coal [6]. However, the present fuel mix for power generation is like this, natural gas 65%, imported liquid fuel 25%, own coal 2.5%, hydro 2.5%, renewable, import and others 5% [7].

According to BP Statistical Review of World Energy 2016, and National Energy Technology Laboratory (NETL), Bangladesh Coal Consumption is at a current level of 0.8127 Mtoe, up from 0.6929 Mtoe one year ago. This is a change of 17.29 % just in one year [2]. In addition, Bangladesh continues to be one of Asia's most emerging markets in ceramics, steel, cement and power sector with growing need for technologies and raw materials specially for coal [8]. Therefore, coal energy conversion with low emission is an important issue to resolve in Bangladesh.

Dealing with coal is very complex because of its harmful content like carbon, sulfur, hydrogen, nitrogen etc. Also, coal energy conversion process has to deal with carbon mono-oxide and carbon di-oxide, which have adverse impact on environment. Coal gasification process makes it easy and safe to control the emission and increase the energy conversion efficiency. Gasification process makes it possible to produce clean gas which has huge potential in different industries in Bangladesh such as brick and ceramic tile burning, steel industries, alternate of natural gas and electrical power generation [3].

Many countries are introducing coal gasification technology to meet their future electricity demand with confirming the energy security and environmental issues. The capability to produce electricity, hydrogen, chemicals, or various combinations while eliminating nearly all air pollutants and potentially greenhouse gases, makes coal gasification one of the most promising technologies for clean power generation [3,9].

III. COAL GASIFICATION TECHNOLOGY

The gasification process converts solid or liquid hydrocarbon feedstock into synthesis gas that is suitable for use in electricity production or for the manufacture of chemicals, hydrogen, substitute natural gas (SNG), and transportation fuels [10-11]. Coal gasification has been

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commercially used for over 60 years in the production of fuels and chemicals [12].

In gasification process, combustible materials are partially oxidized or partially combusted. The product of gasification is a combustible synthesis gas, or syngas. Because, gasification involves the partial, rather than complete, oxidization of the feedstocks, gasification processes operate in an oxygen-lean environment [13-14].

As seen in Fig. 1, the stoichiometric oxygen-to-coal ratio for combustion is almost four times the stoichiometric oxygen-to-coal ratio for gasification of coal. The amount of oxygen used in gasification, however, is always far less than that used in combustion and typically is less than half. It is easy to purify any gaseous fuel before burning it. After burning the fuel, purifying the exhaust gas is more complex, emission full and expensive also. In this regards, coal gasification process is becoming popular more and more.

Due to the reduced environmental impacts and the high efficiency obtained from integrated gasification combined cycle (IGCC) processes, coal gasification has recently received increased attention [15-16]. In addition, coal gasification process can be adopting for so many purposes like, burning bricks and ceramics, generation of H_2, CO, Ammonia, Methanol (can be converted into LNG for use as a fuel in the transport sector), production of synthetic natural gas. Also, the modern technology and research making gasification process more efficient, economical, environment friendly and suitable for versatile applications.

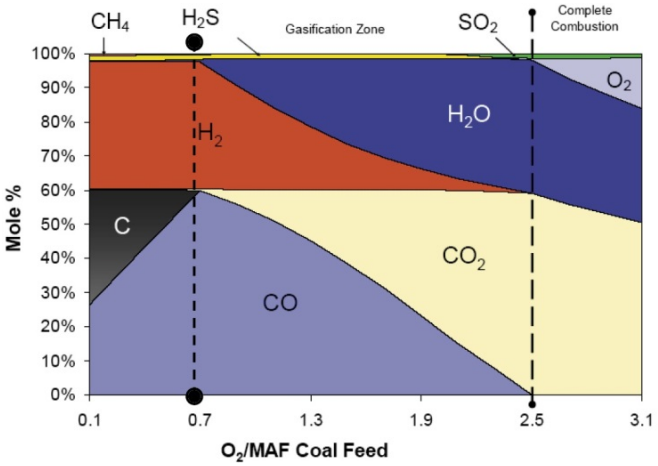


Fig. 1. Diagram showing the products of reaction as a function of oxygen-to-coal ratio [17].

IV. Coal Gasification Scenario in Bangladesh

Coal gasification is a newly introduced technology for Bangladesh. Few industries have gained experience on coal gasification technology mainly imported from China and India. There is no complete study on coal gasification scenario in Bangladesh. So it was very difficult to do a massive study within limited time. However, this report is produced by communicating with different industries, energy experts and visiting existing gasification plants in Bangladesh. Table I shows the basic information gathered from industries using coal gasification technology.

TABLE I. CURRENT SCENARIO OF COAL GASIFICATION TECHNOLOGY IN BANGLADESH

Sl.	Company	Location	Application	Commissioning year	Capacity	Comments
1	Tamanna Ceramic Ltd.	Rajendrapur, Gazipur, Dhaka	Bricks burning	2010	Max 400 kg/hr	After 11 months of operation, project failed due to low volume and pressure of produced syngas
2	X-Ceramic Ltd.	Dhaka	Bricks burning	2012	Max 200 kg/hr	Project failed due to lack of technical support
3	AB Ceramic Ltd.	Dupchancia, Bogra	Tiles burning	2013	Max 500 kg/hr	Project is running successfully till now

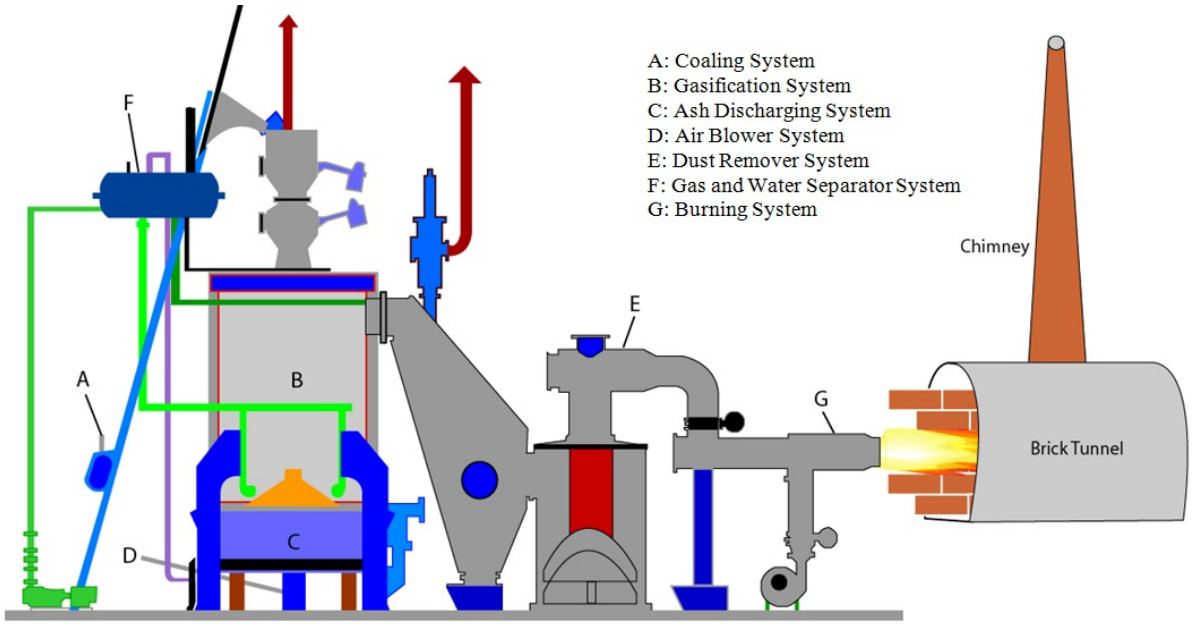


Fig. 2. Complete setup of brick field of Tamanna Ceramics.

A. *Tamanna Ceramic Ltd.*

The first use of coal gasification process in Bangladesh occurred in the end of 2010 at Tamanna Ceramic Ltd. near Rajendrapur, Gazipur, Dhaka. A small sized coal gasification unit was established for the purpose of burning bricks. But unfortunately that project failed at 11th months of its operation due to some technical issues. Tamanna Ceramic Limited established on the year 2000 at Rajabari, Sreepur, Gazipur, Bangladesh with the aim of producing high quality ceramic Bricks and Tiles. For better burning efficiency and emission less production they adopted coal gasification technology at the end of year 2010. The gasifier was designed and manufactured by an Indian company. Two engineers from India were employed for leading the operation and maintenance of the site.

1) Prime operational sections : The gasification plant consists some main sections mentioned below.

- Gas generation system : This system consists of Coal feeding system (Coal Bin, Slide valve, Buffer banker connection, Stocker), Steam
- Gasified furnace system: the water jacket furnace (or half water jacket furnace), the furnace roof, cloth coal fire detection hole, the water loop, the steam loop.
- Ash system: grate device, ash tray (or closed) gray structure, drive mechanism.
- Blast system: hearth fan, flapper valve.
- Instrument: control cabinet, thermal test instrument.
- Dust Reduction System: ash bucket, cyclone , wet disc valve , box-type dust collector.

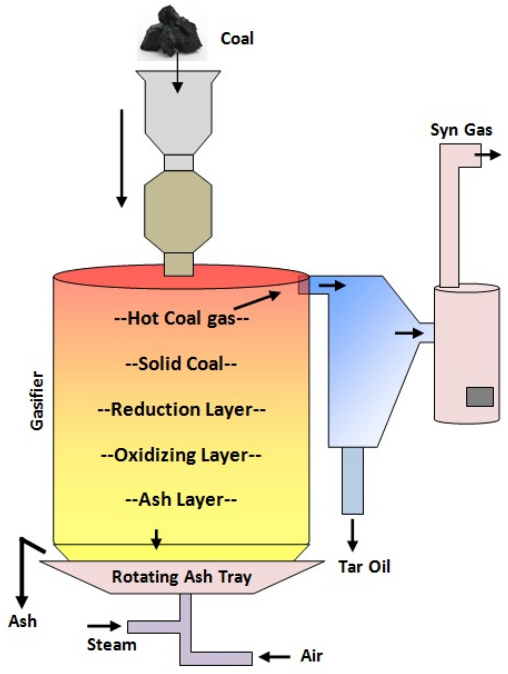


Fig. 3. Different layers of gasification chamber.

Process Flow Operation : The gasifier equiped the bucket to left coal, double bell jar feeding mechanism, and better the sealing effect, its adjustable pocket flap and conical coal unit can be used combinable, coal distribution uniformity. Basically same thickness in cross-section fuel, so as to improve coal gasification efficiency, put an end to occur the flaming phenomenon of partial furnace.

The furnace adopts full water jacket, self-produced steam, not outside for steam, pressure stability, favorable gasification in hearth, good cooling effect in furnace, water jacket inner sleeve deformation. Double bell coal feeder bring better sealing.

Wet rotary ash disk system adopt a tower type pyramid pentagonal grate, material is made by the steels casting. Design of small ash knife push slag, which add the mechanism of slag, broken slag structure, which enable uniform distribution and operation of gasifying agent.

Fig. 4. Main units of gasification plant of company-1.

With isolation of water seal dust catcher, during the outage boiler stop, which can improve water closed height, cut off the gas generator and thermoelectrical furnace between gas and make sure have no pressure, put an end to happen the tempering explosion. Use the special burner, this gas furnace are based on different specifications, different using conditions, equipped with a special "ejector type" burner, which can bring some usages, such as sufficient fuel combustion, stable operation, long life and other characteristics.

2) Technical issues of failure : Due to some technical issues and limitation of resources, the gasification unit had to shut down on 11th month of its operation. An expert team visited that unit and gave some recommendations to recover these issues. Unfortunately, the recommendations did not work properly. Some important issues behind the failure of first coal gasification unit in Bangladesh, are mentioned below.

- Following the gasifier, the produced coal gas temperature should be minimum 300-450^{o}C, but

some time it increased more than 500°C due to less effective system of temperature control. That was a design limitation.

- Burning layer speeded quickly upwards, so fire climbed in dry layer of gasifier. Height of the gasifier was not sufficient to combining individual chemical reaction in each separate layer.
- Produced syngas pressure was not sufficient to continue burning process.
- More than 30% of coal wasted because of very small sized (less than 10 mm) coal.

B. AB Ceramic Ltd.

AB Ceramic Ltd is one and only industry in Bangladesh, whih is successfully running the gasification plant, since 2013. They are manufacturing and marketing ceramic floor and wall tiles across the country. Their gasification plant is in Dhupchachiaa, Bogra, Bangladesh. The plant was imported from India and running by Bangladeshi and Indian engineers. The produced syngas is used for burning process of ceramic tiles.

1) Prime operational sections: The gasification plant of AB-Ceramic is divided into five main sections, as mentioned below.

- Coal preparation system : This system consists of Belt conveyers, Electric Hoist and Suspending coal bin.
- Gas generation system : This system consists of Coal feeding system (Coal Bin, Slide valve, Buffer banker connection, Stocker), Steam generation by Water Jacket, Ash tray.
- Purification system : This system consists of Electrical tar Precipitator, Wet Disc valve, Cyclone Dust Collector, Natural Air Cooling Device, Gas Bipolar Intercooler, Drop Catcher, Novel Phenol Water Evaporator and Cut-off Water Seal.
- Pressurized System : This system consists of Centrifugal motor and pressure sensing controlling system.
- Electrical System : This system consists of Switching control, Switchgear Protection, Scada control.

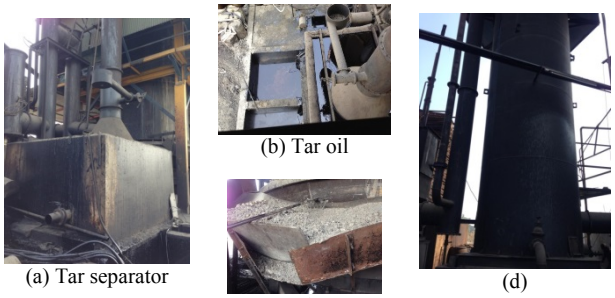
Process Flow Operation : Refined coal processed granularity 30 to 80 mm by crashing. Then coal is kept in coal bin. Each furnaces have two coal filling channels, each channels equipped by two coal filling valve. In between two groups there is a buffering coal bin. Coal filling are automatically controlled by the programmed controller from the control room. The upper gas outlet temperature is higher than 125^0C. At first valve 1 remains open and some amount of coal is feeded into the gasification chamber, during this time valve 2 remains closed. After closing valve 1, valve 2 opened and some coal fills into the buffering bin and then valve 2 will be closed. In this procedure, each valve is opened for 6 seconds and closed for 1 seconds, and one cycle is 14 seconds. The time can be adjusted to complete the coal filling action and it is also available to fill the coal under manual mode.

Belt conveyers - Coal loading system

Suspending coal bin

Coal Buffering Unit

Fig. 5. Coal feeding system.



(a) Tar separator (b) Tar oil (c) Ash tray (d)

Fig. 6. Purification system and ash collection.

(a) Electrical tar Precipitator, (b) Water sprayer (c) Air Cooling Device

Fig. 7. Coal syngas purification systems of AB Ceramic Ltd.

Coal is converted to gas in gasifier chamber. In the carbonization process, the volatile components in bituminous coal will produce tar which will leave the gas generation furnace in the form of mist. The upper gas outlet temperature is 120°C and pressure is 1500 Pa. After carbonization the coal became volatized in gasification stage. In this stage the burned gas temperature is up to 600°C. The produced gas is discharged to the cyclone dust filter where outlet pressure is 2000 Pa and temperature is 400°C.

The gas then goes to primary stage electrical tar precipitator. Here tar is removed by electrostatic shot and stored at bottom of the system. Then the gas goes to cooling system for discharging heat to the cooler directly or indirectly. The gas cooled by two stages 80°C to 120°C and 35°C to 45°C. And then, the gas passes through the Cut-off Water Seal to remove the steam from syngas. At the end of the purification process produced gas pass through the Drop-Catcher, where fine dust are removed by gravitational forces. Finally, the gas is ready to use. Before using this gas, it is required to increase the pressure by centrifugal motor in pressurized unit. According to requirement of tiles burning

process, produced coal syngas pressure are controlled by electrical system attached with pressurized unit.

V. Discussion

This survey observed that, presently only one industry in Bangladesh is running coal gasification plant successfully. They are using this technology for burning tiles. Other two industries had failed to use coal gasification technology because of lack of technical support, expert engineer and inadequate design.

Brick manufacturing industry is among the largest industrial polluters of Bangladesh. According to Bangladesh Brick Manufacturing Owners Association (BMOA), more than 8,000 brick fields consuming around 3.5 million tons of coal for manufacturing bricks and tiles. Brick kilns are major sources of greenhouse gas in Bangladesh, emitting annually 6 to 9 million tons of CO_2 and so many harmful gases. Hence, cleaned syngas can be used in firing process. The main advantage will be the reduction of dependency on natural gas. In addition, the emission of harmful contents can be controlled by gasification process. A pilot plant can feed required syngas to the ceramic tile kiln.

Conversion of coal to Synthesis Natural Gas (SNG) is an industrially proven technology and SNG can be a substitution of natural gas due to rising demand & prices of natural gas [18]. Another promising application of gasification is power generation through IGCC technology. The net efficiency of five coal-based IGCC power plants currently in operation worldwide is in the range of 39%-43% with electricity generation capacity in the range of 250 MW – 430 MW [19-20]. Bangladesh is now capable to adopt IGCC technology for upcoming coal power plants. Gasification is a commercial manufacturing technology that has been used around the world to produce chemicals, fertilizers, transportation fuels, substitute natural gas, and electricity for many years. There is huge scope for Bangladesh to adopt Coal-Gasification technology and get the advantages from direct product and co-product.

VI. Conclusion

In this paper, it is clearly presented that, Gasification could become a clean and smart solution for coal energy conversion in Bangladesh. Although, Bangladesh has less experience in this field, but it can be recovered by technology and experts sharing with neighbor country India, technical training, technological support from BUET and logistical and policy support from Bangladesh Government. Bangladesh has high prospects in coal gasification industry. Also, it is the best time to adopt gasification technology in power generation through IGCC technology. Finally, we strongly recommend, Bangladesh Government to take necessary action to employ this environment friendly technology in ceramic industries and power generation industries.

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