

IMPROVING THE NIGERIAN POWER SUPPLY WITH COAL GASIFIER COMBINED CYCLE POWER GENERATION SYSTEM

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Abstract

This paper tries to introduce and recommend the combined cycle power generation (CCPG) for Nigerian dwindling power system since there is a general outcry for both improved power supply and diversification of our energy sources to meet the power demands of Nigerian populace. It outlines the principle of CCPG with its necessary control systems.

Keywords: combined cycle, control system, power generation, gas, turbine.

1.0 Introduction

Combined cycle power generation (CCPG) is the method of power generation where the exhaust fuel of the first generating set is used to drive a second (or more) turbines: thus having two or more power generations from one fuel supply. It causes a lot of savings in fuel as depicted in fig.1.

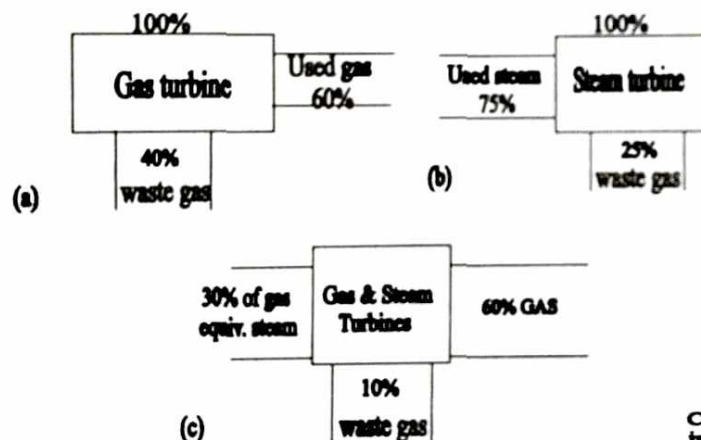


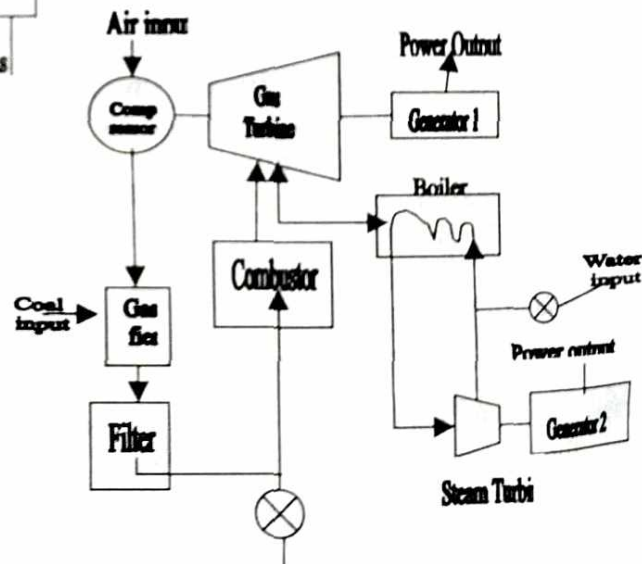
Figure 1: Fuel saving in CCPG

Fig1 (a) shows when only one source of fuel (gas) was in use and there was a loss of 40% (60% efficiency). [1]

Fig1 (b) Shows an isolated steam power generator at the efficiency of 75% (a loss of 25%) and fig1 (c) the combination of steam and gas generation modes and a loss of only 10% was envisaged instead of 40% when only one gas power generator was in use: hence giving the savings of not less than 30% in fuel (gas). [1,2]

1.1 Fluidised Bed in CCPG

The coal fluidised bed power generator is used in the combined cycle power generation. Coal is first gasified and the gas is applied to a gas turbine as usual. The exhaust gas from the turbine is then used to boil water; the steam of which is used to drive a steam turbine. See fig. 2. In other to use a larger steam turbine, two or more gas turbine generators can be used in the cycle as shown in fig.3. [3]



Auxiliary gas input

Fig. 2: Single line diagram for basic steam reheat Coal Gasifier CCPG system with special arrangement for auxiliary gas source. [4]

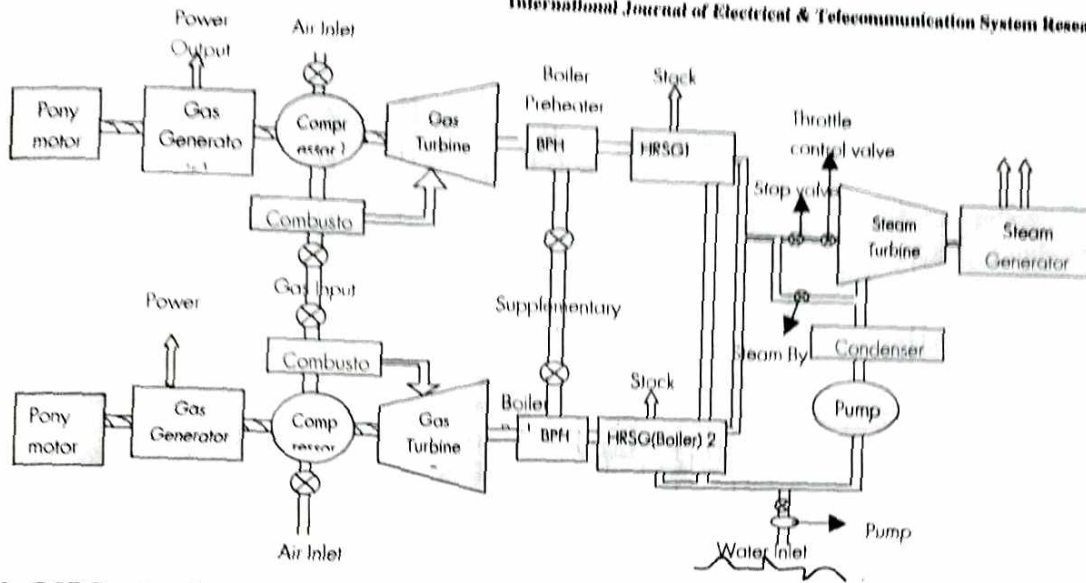


Fig.3: CCPG using 2 gas turbines and one big steam turbine

2.0 Choice of Coal Gasifier for Nigeria

Although gas can be obtained from our refineries, but since Nigeria has abundant coal reserve coupled with the need to diversify our energy sources as a result of shortage of gas supply to our gas power stations as a result of the activities of Niger delta militants, it becomes imperative that coal gasification is given priority attention in reinforcing the national power supply. [4]

2.1 The Gas Power Generation

Compressed air is fed into a combustor to enhance gas combustion. Heated gas from the preheater is fed into a gas turbine for power generation. The temperature of the hot gas is controlled by the combustion rate, which in turn is regulated by the variation of input air to the compressor by the control system described later

2.2 Gasification of Coal

One method of coal gasification involves two fluidised beds (B1 & B2) in figure 4. The first bed, B1, is a pressurised fluidized bed where coal particles are mixed with compressed air, at a rate dependent on the

velocity of the compressed air, on a grid bed made with fine materials to enhance combustion. At critical velocity, there is turbulence in the pressurised mixture and any other input coal particles are mixed efficiently. Heavier particles sink down the bed while lighter ones float. At a critical point the turbulent mixture bubbles and looks like boiling water. At this stage, the bed is said to be **fluidised** and the fluid (gas) is transferred into another vessel – the second bed, B2, and is supplied to gas turbine of a power generating set. Solids from the first bed, which escaped with gas, are used to heat water in the second bed in conjunction with its produced heat, before being returned to the first bed through a special filter. The first vessel, B1, is usually a shell pressure fluidised bed while the second, B2, can be a normal atmospheric fluidised bed. See fig. 4

2.3 The Steam Turbine

High powered steam from the boiler is fed to a steam turbine which drives power generator at a rate determined by the controls.

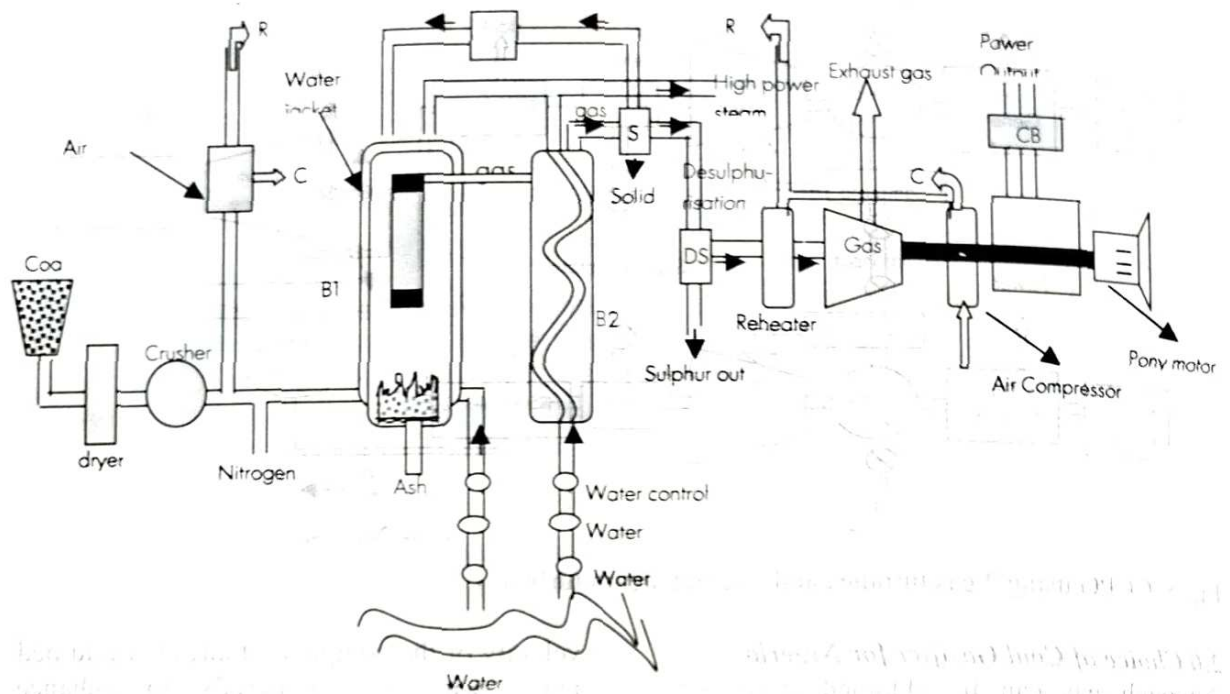


Fig.4: Typical Coal Gasifier System

3.0 Control System For Combined Cycle Power Generation

The control system starts each item in the combined Cycle Power Generation (CCPG), accelerates and synchronises the turbine generators and shuts them down when required. Gas turbine blade temperature, steam pressure control valve, compressor air inlet valve etc are continuously monitored and regulated. Meters, indicators, recorders, push button-switches are some of the display instruments necessary for the monitoring and control of the process in a closed loop. The control system consists of the combined cycle General Control Board (GCB) consisting of the Automatic Control Unit (ACU), the remote control Unit (RCU), the Central Processor Unit (CPU) and the local unit control (LUCS) as shown in fig.5. The CPU receives signals from both ACU and RCU to regulate the limits, run backs and other special features, e.g. Regulating the following valves; compressor air inputs, pre-heater's out put and its temperature, stop valves, steam by-pass valves, gas input valves, steam control valves and water inlet valve. The position of these valves determines the output of the boilers and the associated turbine generators. Thus, the

monitoring systems effect the real-time control of the plant. There are three basic modes of control, through the Central control system (CCS), for the CCPG. These are the automatic control system (ACS), the remote control system (RCS) and the local unit control system (LUCS). See figs 5, 6 & 7

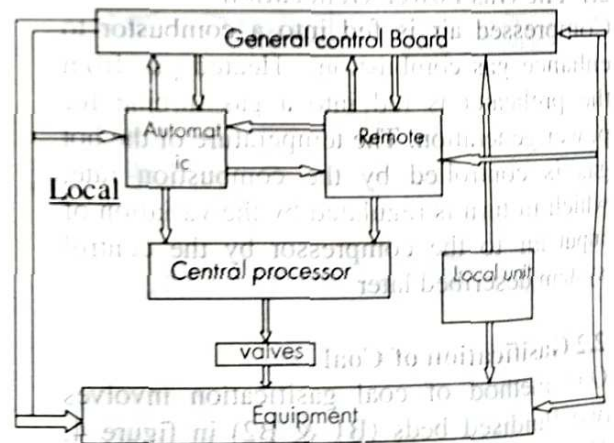


Fig 5: Basic control system for CCPG

At the first mode (ACS), the dispatch engineer can operate any equipment and may decide to start all the machines simultaneously after selecting the flow rates for both gas and steam and the power output of each generator. The control system automatically starts up the machines in

proper sequence, accelerates and synchronises the generators before picking the loads at the preset rate. The general shut down of the plants can also be done from the central control system through a reverse process. At the second mode, (RCU), the dispatch engineer starts up each unit independent of the other by selecting appropriate controls remotely at the console. The machine automatically starts, runs up, synchronises and picks up the load at the rate set by the dispatch engineer. The shutdown is also effected through remote control. The third mode of control, the local control, (LUCS) is a back-up mode which is usually used when the first and the second modes have failed. This involves using the local controls at the equipment locations to operate the particular equipment one after the other independently. [5,6]

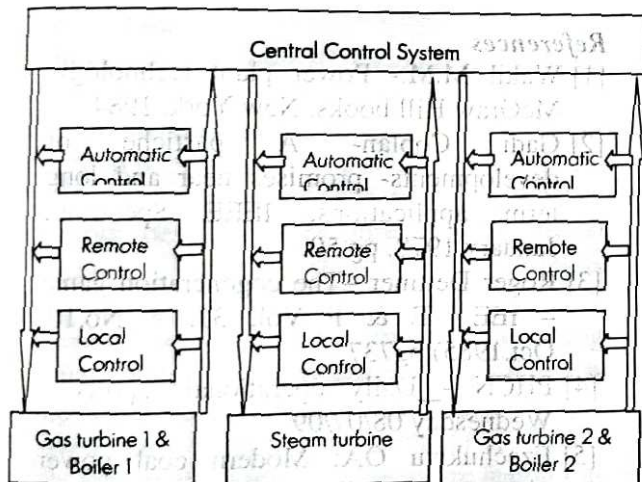


Fig 6: Control Modes in CCPG for (fig.3)

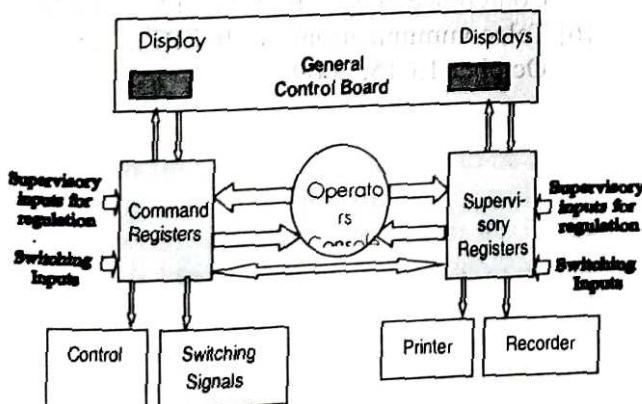


Fig7: Automatic Control Block Diagram

3.1 The Concept

The concept of combined cycle power generation may have started in Britain in the early 19th century. In 1898 the first industrial combined heat and power (CHP) plant was commissioned in singer industry in Clydebank. In 1911, the government owned Bloom Street (DC) station came up with a large plant, which supplied heat to nearby shops, offices and other establishments in Manchester. Today there are not less than 250 CHP plants of rating ranging between 1 and 60MW privately owned in Great Britain. So one can not see why Nigerian Industries cannot set up their own CCPG plants for their private electricity power generation since PHCN has failed to meet the power demands; more so when the federal government has broken the monopoly in electric power generation and supply. Nigeria is called the giant of Africa and the earlier she starts, the better. One thing with Nigerians, is that they always expect the government to provide every amenity. After all, many countries of the world have been on combined cycle power generation for decades. Table 1 shows the status of CHP in some IEA countries about, 20 years ago.

Table 1: Status of CHP in some IEA countries as back as 1980

	Country	CHP- Installed Capacity (MW)	CHP Actual generation (TWH)
1.	USA	8800	44.0
2.	Austria	1300	2.9
3.	Denmark	2500	8.6
4.	Germany	15100	41.2
5.	Italy	5700	20.9
6.	Netherlands	1900	6.7
7.	Spain	700	2.0
8.	Sweden	3200	9.3
9.	UK	2800	10.0

Source: © ECD/IEA, 1982 *Energy Policies and Programmes of IEA Countries - 1981 review* (Roger Dettmer - *The cogeneration game - IEE E & P Vol. 31, No.10, Oct.1985*).

4.0 Viability In Nigeria

The combined cycle power generation will be viable in Nigeria now because there is gross short fall in power generation and distribution as a result of the activities of the Niger Delta militants who vandalised gas pipe lines supplying the 17, out of about 20, generating stations we have in this country; and other factors. Secondly there are abundant coal reserves in various mines in Nigeria that are abandoned since the discovery of oil:

The energy demand of this country is far not met by PHCN and there is need for diversification of our power sources. See table2

Table 2; Composition of Nigeria's power generating stations.

TURBINE FUEL	CONTENT %
Gas	80.9
Hydro	14.3
Diesel	4.8
Coal	0

The attractive features of the CCPG include:

- ❖ Low capital investment per KW generated;
- ❖ Capabilities to be used at both base load and peaking hours with fast starting capabilities.
- ❖ Low daily operational cost.
- ❖ Usage of coal, which is abundant and abandoned at various sites in the country.
- ❖ It requires simple and compact controls that may require simple programmes that monitor its environment; and
- ❖ Since clean gas is derived (from coal gasifier) acid rain and other pollutants are eliminated.

5.0 Conclusion

The combined cycle power generation saves fuel cost and has low capital investment per KW generated. It has low daily operational cost and the coal gasifier CCPG will not only help to utilize our abundant coal reserve but will also help to diversify our energy sources – yet without any pollutant emission. The application of coal gasified CCPG will expose Nigeria to the modern technology in coal fired power generation.

6.0 Recommendations

The federal government should encourage private ownership of coal fired combined cycle power generation and the likes in Nigeria by providing enabling environments, technologies, subsidies and collaterals between local firms and foreign construction companies in the area of modern coal-fired power generation.

References

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