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Effect of Fuel Types on the Performance of Gas Turbines

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Abstract

In this paper we investigate the effect of the different types of fuels used during the same period in order to see how the efficiencies were affected. There are two types of fuels which can be used in the power plant station under consideration, one of them is liquefied petroleum gas (LPG) and the other is the light diesel oil (LDO). The efficiency of the plant is high while using liquefied petroleum gas (LPG) when compared to light diesel oil (LDO). This due to two reasons , the first is the high low heat value (LHV) of LPG , The second is the mixture of LPG and the air is more homogenous than LDO mixture during the combustion process.

Keywords: *Gas turbine, combined cycle, configuration system, Calorific value.*

1. Introduction

Gas turbines are increasingly used in combination with steam cycle, either to generate electricity alone, as in combined cycles, or to cogeneration both electrical power and heat for industrial processes [1], a wide variety of fuels, solid, liquid and gases can be used. A combined cycle featuring one or several gas turbines and a steam cycle is a power plant option commonly used for power production that offers high efficiency [2]. For any gas turbine-manufacturer, the fuels that will be used will have a profound effect upon both the machine design and the materials of construction [3]. When using natural gas, the combined cycle with unfired heat recovery steam generator can achieve the highest net plant efficiency (about 60%) of all fossil-fueled power plants used mid to upper output range, since the fuel heat is only supplied at a high temperature level to the working fluid in the combustion chamber of the gas turbine [4].

2. System configuration

The plant consists of two gas turbines with type of PG6581B and rated capacity of 38 MW, one unit of steam turbine with rated capacity of 36 MW and heat recovery steam generator (HRSG) is made by Harbin Boiler Works (China). Heat Recovery Steam Generator (HRSG) is the important component of combined cycle power plant used to recover waste heat from the high temperature of the exhaust of the gas turbines and generate steam .High efficiency; low energy losses and long expected life are the important factors which make combine cycle power plants unique in compression with other type of plants. The steam turbine type L36-6.70 is also the product of Nanjing Turbine & Electrical Machinery Group Co .Ltd Other main ancillary systems consist of air compressor system, firefighting system, potable water generation plant, waste water treatment plant, heating ventilation and air condition (HVAC) SYSTEM. DC system, uninterruptible power supplies system (UPS), etc. A schematic diagram of the plant is shown in Fig 1.

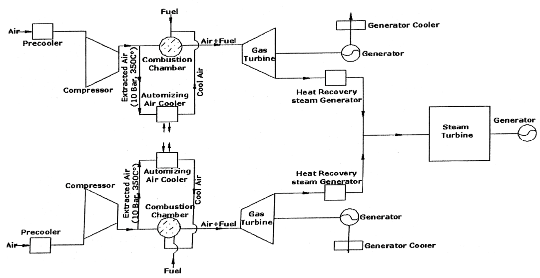

Fig. 1 Schematic Diagram of the Combined Cycle Power Plant

3. Parameters of Main Equipments

3.1 Gas turbine generator unit

The gas turbine generator unit was manufactured by Nanjing Turbine Group Company limited. The power output is 32.551MW under the following design condition:

Ambient temperature	40^oC
Atmosphere pressure	0.966 bar
Ambient humidity	38%
Inlet air pressure drop	100 mm H_2O
Exhaust pressure drop (under combined cycle)	350 mm H_2O
Fuel	Light diesel oil (LDO)
Power factor	0.80
Rated frequency	50 Hz

3.2 Heat recovery steam generator

The HRSG was supplied by Harbin marine boiler & turbine research institute. The HRSG output parameters are:

Maximum continues output	63.78 t/h
Output steam temperature	6.9 M Pa
Output steam temperature	468^oC
Exhaust gas temperature	<154^oC
Feed water temperature	$104\ ^oC$

3.3 steam turbine generator unit

Steam turbine also was manufactured by Nanjing Turbine Company limited. It is a single case, condensing type turbine. The main parameters are as followings:

Main steam pressure	6.7 M Pa
Main steam temperature	456^oC
Rated process steam flow	6 t/h
Process steam pressure	0.9 M Pa
Process steam temperature	244.3^oC
Rated main steam flow	127.56 t/h
Exhaust steam pressure	0.0099 M Pa
Generator power factor	0.80
Frequency	50 Hz

4. The Effect of Ambient Temperature on Efficiency

The data used for the analysis is obtained from the manufacturer data sheet of power plant [5, 6]. The output heat (Q_{out}), input heat (Q_{in}) and thermal efficiency η_{Th} is calculated by equation (1-3).

$$Q_{out}(KJ) = Q_{out}(MWh)\times 10^3 \times 3600 \qquad (1)$$

$$Q_{in}(KJ) = M_{LPG}\times Low\left(CV\right)_{LPG} + M_{LDO}\times\left(CV\right)_{LDO} \qquad (2)$$

$$Low\left(CV\right)_{LPG} = 45125Kj/Kg$$

$$Low\left(CV\right)_{LDO} = 42679.2Kj/Kg$$

$$\eta_{Th} = \frac{Q_{out}}{Q_{in}} = \frac{Q_{out}}{M_{LPG}\times Low\left(CV\right)_{LPG} + M_{LDO}\times Low\left(CV\right)_{LDO}} \qquad (3)$$

Where $(M)_{LPG}$ is the mass of liquid petroleum gas, $(CV)_{LPG}$ calorific value of liquefied petroleum gas, M_{LDO} mass of light diesel oil, and $(CV)_{LDO}$ calorific value of light diesel oil .

Table1: Effect of Fuel Types on Efficiency, Year (2007)

day	Mf(Tons)LDO	Mf(Tons)LPG	Heat input (KJ)	Heat output (KJ)	Efficiency %
15/2	103.66	-	4.426 E+10	1.188 E+10	0.26832
1/3	-	145.74	6.576 E+10	1.976 E+10	0.300526
25/3	-	202.03	9.117 E+10	2.859 E+10	0.313609
15/4	172.38	-	7.360 E+10	2.029 E+10	0.27565
15/10	190.15	-	8.119 E+10	2.199 E+10	0.27088
3/11	-	167.7	7.567 E+10	2.147 E+10	0.2837

From table 1 : the efficiency of the plant is quite high when using liquid petroleum gas (LPG) And the difference vary from 5 to 8%, which indicated the type of fuel being used has a significant effect on gas turbine thermal efficiency and consequently power output.

In comparison of using LPG and LDO as fuels for operating the plant it was found that the efficiency using small amount of LPG than LDO is higher, but due to shortage in the production of LPG locally it cannot be used continuously.

LPG is more pure than LDO which result in less failure of the turbine hot parts.

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