The Study of Green Hotel Chains Use Green Power in Heating or Boiling System by Environmentally Friendly Technology

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ABSTRACT

Nowadays economic business chain hotels are developing vigorously in China. To comply with the national standard on green hotel, they have also participated in the construction of green hotel actively. Therefore, it is a significance study about how to mitigate the pollution caused by the room hot water system in economic business hotels, make them develop towards the green hotel under the condition of affordable investment. No big changes on the main equipment and create the brilliant sales performance based on environmental protection and ecological conservation. The application of the refined environmental protection fuel oil in the hot water supply system of green hotels-economic business hotels can effectively reduce the air pollutant emissions in the research. Through the use of the clean renewable fuels, it can achieve the expectation of green hotels for energy saving and carbon reduction. In addition, matching the refined environmental protection fuel oil with B14G catalyst is at low cost. In terms of the combustion efficiency, due to its good liquidity and cleanness, it can be directly used in the equipment without modification, so the green hoteliers have no risk and burden to modify the equipment. For the green hotels-economic business hotels, the long-term fuel cost is still a very high burden. However, the cost of hot water produced by Model-3 refined fuel oil-fired boiler in the research reduces to USD $0.085 per MJ. Thus, it effectively reduces the operation cost of the fuel-fired boiler. Therefore, it is quite feasible for the green hotels-economic business hotels to apply the refined environmental protection fuel oil in the hot water supply system.

INTRODUCTION

The tourism and hospitality industry has been listed as the important economic policy and key development project promoted for national development in mainland China, Taiwan, Hong Kong and Macao in recent years. However, due to the difference in the customer bases and their demands, the development of the hotel industry has also become polarized between large international star hotels with over 500 rooms and small economic business hotels with only 30 rooms. In large
international star hotels, the hot water supply has had a certain scale and the hot water consumption has been in certain demand. In order to answer the call of energy conservation and pollution reduction and effectively promote the corporate image, they always make considerable efforts and investment in energy conservation equipment to build the green hotel. Economic business hotels adopt the style of low cost and simplicity in the business strategy, so they must strictly control the operating costs. Nevertheless, they continue to transform towards the green hotel. The hot water supply equipment there is limited by small scale, scattered and inconsistent consumption. In this case, most of them use the small oil-fired boiler and the investment in the relevant environmental protection and pollution prevention equipment is less than that of large international star hotels. Now economic business chain hotels are developing vigorously in China. To comply with the national standard on green hotel, they have also participated in the construction of green hotel actively. Therefore, it is of great significance to study how to mitigate the pollution caused by the room hot water system in economic business hotels, make them develop towards the green hotel under the condition of affordable investment and no big changes on the main equipment and create the brilliant sales performance based on environmental protection and ecological conservation. [1,2,7]

In the tourism hotel industry, the energy consumption in the operation process is quite striking. Therefore, all countries in the world have posed the concept of environmental protection and ecological conservation—constructing the green hotel. How to effectively reduce the pollution emissions in the operation process, use the environmental protection fuels, reduce the overall operation costs and enhance the overall competitiveness through the corporate image of green hotel is the focus. Economic business hotels have a small number of guest rooms, so the demand for hot water is much less than the standard and scale of international star hotels, but in terms of the unit hot water production, their pollution emissions, energy consumption and operation cost are much more than those of international star hotels. In addition, due to the imperfect pollution prevention equipment, the energy consumption is considerable and the impact on the ecology is huge in the operation process. [3,4]

Green hotel is built based on effective and less use of electricity, water, gas and related chemical products. The tourism industry itself maintains a highly symbiotic relationship with the natural environment, so green hotel is not only the new trend of the tourism and hospitality industry in the future. Moreover, it successfully makes the hotel industry maintain the high competitiveness in the competitive tourism industry through the discussion of green hotel. Generally speaking, the hotels mostly use the boilers to supply the hot water for guest rooms. The chain hotels adopt the style of economy and simplicity, so they are located between the first and second-grade cities and other sub-grade cities. Currently, not all regions in China can supply abundant electricity for the hotel operators to use. And, the chain hotels don’t have enough funds to invest on the high-tech heat pump system and environmental protection products for hot water supply. Therefore, they have no option but to improve the oil-fired boiler. The boiler fuels include coal, diesel oil, fuel oil, gas, etc. Large hotels mostly use the large coal-fired boilers due to large demand for hot water. Small hotels always use the diesel or fuel oil as the fuel, because their demand for hot water is little, irregular and discontinuous. Thus, the operation characteristics of the coal-fired boiler do not conform to the economic business hotel. [4,7]
It can be clearly understood from the survey on the hotel industry in Taiwan that hot water boiler plays a quite important role in providing hot water and producing steam. For the hotels, leisure clubs and bath centers at all levels and heated swimming pools, a certain proportion of hot water is supplied by the hot water boilers. The energy consumption accounts for about 20% to 30% of the energy costs of the main cause. The fuels for heating the boilers include natural gas, fuel oil and diesel oil. The survey in 2013 showed that the greenhouse gas emissions were up to 8 metric tons per year. Only 30% of PM2.5 in Taiwan was from China and over 70% was from Taiwan Island, in which 31% was from restaurants, hotels and others. The long-term exposure of fine suspended particulate matters may cause cancer and cardiovascular system diseases. Therefore, the Environmental Protection Department has launched a six-year plan in Taiwan in 2015 with the goal of making 100 hotels use the natural gas boiler for hot water supply, helping the operators improve the existing hot water boiler equipment and strengthening the inspection, so as to improve the air quality.

Take the energy-saving measures of Regent Taipei Hotel as an example. It can reduce the emissions of carbon dioxide by about 3,200 tons every year, which is equivalent to the carbon uptake of 100 Da-an forest parks in a year. The Chinese government also began the complete prohibition of the use of coal-fired boilers under 10 ton in coastal cities and other important first and second grade cities since 2010. In addition, due to the drastic fluctuations of the crude oil market, the hoteliers begin to think about the feasibility of alternative energy sources. Alternative energy sources can not only achieve environmental protection but also reduce the overall operation cost of the hotel. For the large coal-fired boilers, the biomass RDF (refuse derived fuel) has been adopted to replace the coal for heating. Its calorific value is up to 5900 kcal/Kg. Thus, it can completely replace the anthracite coal. At the same the RDF is odorless, tasteless and stable without sulfur molecules in the combustion process. Thus, it can significantly reduce the pollutant emissions in the air and make an effort in environment protection and ecological conservation. Kai Wang; Meng-na Li; Quan-sheng Ge described the profit motives, pressure of environmental regulations from the government and other stakeholders are the main hotels’ environmental behaviors driving factors. However, the biomass RDF is not applicable for small oil-fired boilers. Therefore, it is the top priority to choose the new alternative energy sources which are environment friendly for oil-fired boilers. The hotels and dormitories in the Greater China region also have a big demand for hot water. Under the limited resources, there are still a large number of public and private units adopt the environment friendly oil-fired boilers. Take Tajen University as an example, the hot water in student dormitories is supplied by the oil-fired boilers whose emissions conform to the provision of relevant rules and regulations. However, the fuel cost is too high, which is a big burden for the universities. At present, the heat pump water heater is the mainstream high-tech environmental protection equipment for new hotels, hospitals and schools in Taiwan, but under the restriction of funds, it is impossible to replace all oil-fired boilers with the heat pump water heater immediately. In order to prevent air pollution, it is necessary to effectively reduce the pollutant and carbon emission and take the responsibility to protect the environment and conserve the ecology, so as to achieve the sustainable development with nature. [5,6,7,8,9,10]
RESEARCH METHODS

Sources of Green Environmental Protection Fuel Oil. The green environmental protection fuel oil in the research is the regenerative fuel oil produced through thermal cracking of waste rubbers and plastics. The waste plastics and rubbers are recycled by the department of environmental protection. After being crushed and grinded, they are transported in low temperature for gasification and thermal cracking in absence of oxygen at 280 to 410°C. The produced oil and gas are treated through cooling, condensation, letting stand and oil-water separation to produce the primary green environmental protection fuel. [5,6]

Mixing of Green Environmental Protection Fuel Oil. Primary green environmental protection fuel oil contains sulfur molecules and mercaptan molecules, so it has a pungent and bad odor. In addition to its characteristics of high ash and colloid contents, it fails to be directly used in the diesel engine unit, electronic diesel boiler or electronic fuel-fired boiler. Therefore, it is necessary to remove the sulfur molecules and mercaptan molecules in the primary green environmental protection fuel oil in the way of mixing and then get rid of the colloid through the special catalyst formula, so as to reduce the problem of carbon deposit in the combustion process.

Selection of The Catalyst Formula. There are quite a few kinds of catalysts for use in the actual business circle, including organic nitrogen series formulas, petroleum series formulas, solvent-based formulas, etc. This research adopts the inorganic formula which is non-toxic. It can be reused through regeneration. Although each time of activation will reduce 3% of the catalytic ability, it can catalyze about 120000L of primary environmental protection fuel oil due to its characteristics of long-term effect and stability. Thus, it is very competitive and economic. The catalyst is prepared in the lab. It uses the inorganic material, its special adhesive and chemically modified starch to make the particles with the diameter of 6 mm or powders as the catalyst for the subsequent use. The performance of three kinds of catalysts is shown in Table 1.

| TABLE 1. CHARACTERISTICS OF CATALYSTS. |
|---------------------------------------|
| Product No. | X135A | X503X | B14G |
| Category | Nonorganic material blend Chemically modified starch Series | Nonorganic material blend Chemically modified starch Series | Nonorganic material blend Chemically modified starch Series |
| Mineral | Nonorganic material blend Chemically modified starch Series | Nonorganic material blend Chemically modified starch Series | Nonorganic material blend Chemically modified starch Series |
| Crystalline structure | Type A | Type X | Non-Crystalline |
| Density | 0.87 | 1.13 | 0.93 |
| Appearance | Fine particles | Powdery | Granules |
| Recycle | Yes | No | Yes |
| Characteristics | Color: Ivory white | Color: Snow White | Color: Aurora White |
| Producers | ZKHN LTD. | ZKHN LTD. | The laboratory's own |

Processing and Production of Environmental Protection Fuel Oil. The waste plastics, rubbers or other waste derivative petrochemical products are decomposed through thermal cracking to make them become tar, gas with low calorific value, fuel, carbon and other related derivatives. Among them, fuel oil has the largest output.
Thus, the effective application and marketization of fuel oil is still a very important subject. The primary environmental protection fuel oil produced by thermal cracking of the waste petrochemical products is characterized by odor, high contents of colloid and ash, high viscosity, low calorific value, poor fluidity and high acid value, so the primary environmental protection fuel oil cannot be directly used in the business but in red brick kilns, asphaltum factories or charcoal production factories as the auxiliary fuel. In the combustion process, it produces black smoke, stench, PM10, PM2.5 and other pollutants. Its compositions of sulfur oxide and nitrogen oxide seriously affect the ecological environment and far exceed the standard set by the governmental regulations. Therefore, the untreated primary environmental protection fuel oil can only be used as the auxiliary fuel oil rather than being the main fuel.

Many studies have pointed out the secondary thermal cracking, distillation, desulfurization and deodorization can significantly improve the quality of the environmental protection fuel. The fuel oil is colorless. Its performance has almost reached the super diesel level and its quality has met the commercial use standard. The fuel oil products can also be directly used in diesel engines. However, the processing cost is too high and a lot of wastes are produced in the process. Thus, relevant technologies are mostly confined in the lab research and only a small part is formally put into commercial production. The effectiveness needs to be improved.

The research adopts the physical and chemical ways to effectively improve the problems of high contents of sulfur and colloid, stench and high viscosity of the primary environmental protection fuel oil through the catalysis of the catalysts. Then, it reduces the content of ash and increases the total base price through mixing and physical and chemical ways. Although the refined environmental protection fuel oil still cannot be directly used in diesel engine, it has complied with the environmental regulations and emission standards to be used in the fuel-fired hot water boiler and other related emissions and operations.

**Basic Physical Property Analysis of Refined Environmental Protection Fuel Oil.**

Through the appropriate physical processing and mixing technology, the refined environmental protection fuel oil in the research has complied with the relevant environmental regulations and government laws. In addition, its quality is far beyond that of the traditional fuel oil. Thus, its direct use in the hot water boiler to replace the original fuel oil not only meets the requirements of green energy on clean energy but also reduces the environmental pollution and ecological damage. The research adopts three kinds of catalysts to refine the environmental protection fuel. Its basic physical properties are as follows:

| Basic Properties | Model-1 Refined Fuel Oil | Model-2 Refined Fuel Oil | Model-3 Refined Fuel Oil | Primary Fuel Oil | CNPC Fuel Oil |
|------------------|--------------------------|--------------------------|--------------------------|------------------|---------------|
| Catalyst Producers | X135A ZKHN Ltd | X503X ZKHN Ltd | B14G The laboratory's own | Na ZKHN Ltd | Na CNPC Oil |
| Density at 15°C (Kg/L) | 0.93 | 0.92 | 0.87 | 1.03 | 0.97 |
| Flash point (°C) | 61 | 57 | 69 | 36 | 88 |
| Pour point (°C) | 1 | 2 | 1 | 6 | 13 |
| Kinematic viscosity | 3 | 4 | 2 | 84 | 7 |

919
at 40°C, cSt.

|                      | 0.07 | 0.08 | 0.02 | 6.33 | 0.89 |
|----------------------|------|------|------|------|------|
| Sulfur content, %    |      |      |      |      |      |
| Carbon residue, micro wt.% | 0.31 | 0.34 | 0.23 | 18.59 | 0.37 |
| Water Content (mg/Kg) | 0.04 | 0.05 | 0.04 | 13.73 | 0.58 |
| Heat value (Kcal/Kg)  | 10310| 8870 | 9560 | 12870| 9100 |

RESULTS AND DISCUSSION

Analysis of the economic benefits of the refined environmental protection fuel oil for the hot water boiler combustion

The hot water supply system in X chain economic business hotel has three fuel oil-fired boilers. The first one is a horizontal boiler which is set for operation and opening. The second one is a vertical fuel oil-fired boiler which was added in 2011 due to the increase of the guest rooms. In addition to the fuel oil as the main fuel, it also accepts ordinary diesel. The third one is a vertical boiler which is set due to the requirement of the government’s environmental protection policy and after the intense inspection of old boilers by the district government. Its fuel oil and combustion condition is automatically controlled by the microcomputer. Moreover, it has a strict requirement on the fuel and only accepts low sulphur fuel oil or high-grade diesel oil. Due to its automatic control device, it has better performance in the combustion efficiency and pollutant emissions compared with other traditional boilers. Therefore, the research makes comparison on the benefit. The relevant data are shown in the table.

The feasibility of applying the refined environmental protection fuel oil in the hot water supply system boiler in green hotels-economical business hotels: according to the actual pollutant emission data and economic feasibility evaluation of the hot water boiler, the application of the refined environmental protection fuel oil in the research in the hot water supply system of green hotels-economic business hotels can effectively reduce the air pollutant emissions. Through the use of the clean renewable fuels, it can not only achieve the expectation of green hotels for energy saving and carbon reduction, but also effectively resolve the disposal of waste petrochemical products. Moreover, after being catalyzed by the catalyst, physical treatment and mixing, the refined environmental protection fuel oil has lower sulfur content than the traditional fuel. In the combustion efficiency, due to its good liquidity and cleaness, it can better refine the oil molecules in the atomization process to make the fuel-fired boiler burn more completely and effectively and indeed improve the combustion efficiency of the fuel-fired boiler. At the same time, it can be directly used without modifying the equipment, so the green hoteliers have no risk and burden to modify the equipment.

From the perspective of economic cost, the cost of hot water produced by the coal-fired boiler is about USD $0.010 per MJ and that by the traditional fuel-fired boiler is about USD $0.013 per MJ. The latter is over 30% higher than the former. Although the fuel-fired boiler has the characteristics of cleanness and its operation technology and the cost for pollution prevention and treatment is far lower than that of the coal-fired boiler, for the green hotels—economic business hotels, the long-term fuel cost is still a very high burden. The cost of hot water produced by Model-3 refined fuel oil-fired boiler in the research reduces to USD $ 0.085 per MJ. Thus, it effectively reduces the fuel cost. If the fuel-fired boiler adopts Model-3
refined fuel oil as the fuel, the fuel injection system needs to be maintained, repaired and cleaned every 2000 to 2500 h, but the cost of the cleaning agent is low. Its operation cost is still lower than that of traditional fuel-fired boiler. Therefore, it is quite feasible for the green hotels- economic business hotels to apply the refined environmental protection fuel oil in the hot water supply system. At the same time, it can promote the hotels to the rank of green hotel and make them undertake the social and environmental protection responsibility.

**TABLE 3. COMPARISON OF THE ECONOMIC BENEFITS OF BOILER 1.**

| Boiler 1 | CNPC | Model-1 | Model-2 | Model-3 |
|----------|------|---------|---------|---------|
|          | Fuel Oil | Refined Fuel Oil | Refined Fuel Oil | Refined Fuel Oil |
| Actual fuel consumption (Kg/h) | 70.2 | 66.2 | 68.3 | 65.1 |
| Actual combustion efficiency (%) | 85.7 | 90.8 | 88.1 | 92.4 |
| Actual Output power (MJ) | 2160 | 2288 | 2220 | 2328 |
| Fuel cost (kg/USD) | 0.40 | 0.316 | 0.316 | 0.305 |
| Cost per MJ (USD) | 0.0130 | 0.0091 | 0.0097 | 0.0085 |

**TABLE 4. COMPARISON OF THE ECONOMIC BENEFITS OF BOILER 2.**

| Boiler 2 | CNPC | Model-1 | Model-2 | Model-3 |
|----------|------|---------|---------|---------|
|          | Fuel Oil | Refined Fuel Oil | Refined Fuel Oil | Refined Fuel Oil |
| Actual fuel consumption (Kg/h) | 15.3 | 14.1 | 14.9 | 13.8 |
| Actual combustion efficiency (%) | 84.2 | 91.3 | 86.4 | 93.3 |
| Actual Output power (MJ) | 455 | 479 | 453 | 490 |
| Fuel cost (kg/USD) | 0.40 | 0.316 | 0.316 | 0.305 |
| Cost per MJ (USD) | 0.0135 | 0.0093 | 0.0104 | 0.0086 |

**TABLE 5. COMPARISON OF THE ECONOMIC BENEFITS OF BOILER 3.**

| Boiler 3 | CNPC | Model-1 | Model-2 | Model-3 |
|----------|------|---------|---------|---------|
|          | Fuel Oil | Refined Fuel Oil | Refined Fuel Oil | Refined Fuel Oil |
| Actual fuel consumption (Kg/h) | 46.2 | 45.9 | 46.1 | 44.9 |
| Actual combustion efficiency (%) | 88.6 | 89.2 | 88.8 | 91.2 |
| Actual Output power (MJ) | 1595 | 1606 | 1598 | 1642 |
| Fuel cost (kg/USD) | 0.40 | 0.316 | 0.316 | 0.305 |
| Cost per MJ (USD) | 0.0116 | 0.0090 | 0.0091 | 0.0083 |

*Boiler 3 is the new generation of electronic boiler automatically controlled by the microcomputer and Boiler 1 and 2 are the traditional mechanical boilers.

**CONCLUSIONS**

The tourism and hospitality industry has been listed as the important economic policy and key development project promoted for national development in mainland China, Taiwan, Hong Kong and Macao in recent years. However, due to the difference in customer bases and their demands, economic business hotels adopt the style of low cost and simplicity in the business strategy. They must strictly control the operating costs and move towards the green hotel in the case of no big change in the main equipment. They can also create the brilliant sales performance based on environmental protection and ecological conservation. However, the tourism industry is closely related to the natural environment. They both are inseparable and symbiotic, so green tourism and green hotel are not only the development axis of the tourism industry at present but also the embodiment of their responsibility of environmental protection and ecological conservation.
The application of the refined environmental protection fuel oil in the research in the hot water supply system of green hotels-economic business hotels can effectively reduce the air pollutant emissions. Through the use of the clean renewable fuels, it can achieve the expectation of green hotels for energy saving and carbon reduction. In addition, matching the refined environmental protection fuel oil with B14G catalyst is at low cost. B14G catalyst can also be recycled through activation. After physical treatment and mixing, its sulfur content is lower than that of the traditional fuel oil. In terms of the combustion efficiency, due to its good liquidity and cleanliness, it can be directly used in the equipment without modification, so the green hoteliers have no risk and burden to modify the equipment.

From the perspective of economic cost, the cost of hot water produced by the coal-fired boiler is about USD $0.010 per MJ and that by the traditional fuel-fired boiler is about USD $0.013 per MJ. The latter is over 30% higher than the former. For the green hotels-economic business hotels, the long-term fuel cost is still a very high burden. However, the cost of hot water produced by Model-3 refined fuel oil-fired boiler in the research reduces to USD $ 0.085 per MJ. Thus, it effectively reduces the operation cost of the fuel-fired boiler. Therefore, it is quite feasible for the green hotels-economic business hotels to apply the refined environmental protection fuel oil in the hot water supply system. At the same time, it can promote the hotels to the rank of green hotel and make them undertake the social and environmental protection responsibility.

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