Boiler Case Study

"Coca-cola femsa san Fernando plant"

Group 4:

Asuncion, Arbyn

Fontanilla, Rose Ann

Hao, Kristine Lauren

Rivera, Alyssa

Simbulan, Rose Diane

INTRODUCTION

ABOUT THE COMPANY

Coca-Cola Bottlers Philippines, Inc. (CCBPI) is a Philippines-based company engaged in bottling and distribution of Coca-Cola soft drink brands. CCBPI is among the ten biggest Coca-Cola bottlers globally and one of the top 100 Philippine corporations. CCBPI operates 23 plants and 42 sales offices. Since 2013, CCBPI became jointly owned by Mexico-based Coca-Cola FEMSA, S.A. de C.V. and The Coca-Cola Company.

BACKGROUND

FEMSA's history in The Philippines began in January 2013, when FEMSA acquired 51% of Coca-Cola Bottlers Philippines, Inc. (CCBPI), from The Coca-Cola Company, and we established Coca-Cola FEMSA Philippines.

In 1979, a subsidiary of FEMSA acquired number of beverage bottling companies. At the time there were 13 distribution centers and with an output capacity of 83 million unit crates per year.

This initial operation became, 36 years later, the largest Coca-Cola products bottling in the franchise in the world, whereby they serve 351 million consumers, merchandising 3.4 billion crate units per in the 2.8 million points of sale we serve. All this thanks to the daily efforts of 83,000 plus men and women who work for them mainly in Latin America and the Philippines. Latin America has 45 bottling plants and for the Philippines, they have 19 bottling plants. Listed below are some of the Coca-cola FEMSA Bottling Plants.

BOTTLING PLANTS

Ilocos Bottling Plant: Brgy. Catuguing, San Nicolas, Ilocos Norte
Ilagan Bottling Plant: Brgy. Guinatan, Ilagan, Isabela
Calasio Bottling Plant: Brgy. Bued, Calasio, Pangasinan
San Fernando Bottling Plant: Bo. Saguin, Mc Arthur Hiway, San Fernando, Pampanga
Meycauayan Bottling Plant: Muralla Ind. Subd. Meycauayan Bulacan
Imus Bottling Plant: 122 NIA Road Buhay na Tubig Imus, Cavite
Santa Rosa Bottling Plant: Brgy. Pulong Sta Cruz, Sta Rosa City, Laguna
Canlubang Bottling Plant: Silangan Industrial Estate, Canlubang, Calamba City
Tacloban Bottling Plant: Fatima Village, San Jose, Tacloban City, Philippines
Iloilo Bottling Plant: VP Lopez Avenue, Ungka 2, Pavia Iloilo
Bacolod Bottling Plant: Mansilingan, Bacolod City
Cebu Bottling Plant: Natl Hiway Tipolo, Mandaue City, 6014
Tagbilaran Bottling Plant: Carlos P. Garcia Ave., Bohol Tagbilaran City
Naga Bottling Plant: 157 Concepcion Pequena, Naga City
Misor Bottling Plant: Barangay Katipunan, Villanueva, Misamis Oriental 9002
Davao 1 Bottling Plant: Mac Arthur Hiway, Ulas, Davao City
Davao 2 Bottling Plant: San Miguel Complex, Brgy. Darong, Sta. Cruz, Davao Del Sur
Zamboanga Bottling Plant: Maria Clara Lobrigat Hiway, Tetuan, Zamboanga City

Figure 1. Coca-cola FEMSA Bottling Plants

One of this bottling plants is the Coca-Cola Femsa San Fernando plant. It is located at Mac Arthur Highway Barangay Saguin City of San Fernando, Pampanga, Philippines.

NEED FOR BOILER

Coca-Cola FEMSA San Fernando Plant uses two boilers in their plant. Boiler 1-York Shipley has a model of MODEL- SPHV 150-6/94218 with a capacity or rating- 5049 lbs/hr (150 BHP). Boiler 1 is for back-up purposes. Boiler 2-Donlee has a capacity or rating of8625 lbs/hr (180BHP) and the model is sphv 200-6/200175. Boiler two is the main source of their steam in the whole plant. These two boilers are packaged fire tube boilers. The fuel for the boilers is SFO (special fuel oil) which has a composition of 70% diesel oil and 30% Bunker C. Figure 2 and 3 shows the actual boilers used in the plant of San Fernando Bottling Company.

Figure 2. Boiler 1- York Shipley

Figure 3. Boiler 2- Donlee

Boiler in Coca-Cola FEMSA San Fernando plant has a big role for the whole plant. These boilers are used in the 3 production line, for CO_2 vaporization, for water treatment plant and in CIP (Clean in Place) room. For production line, bottles are washed using steam and the boiler has a big role for this section. For CO_2 vaporization, their raw material for CO_2 is liquid. And the use of heat coming from the boiler is a great need to convert it into the gaseous phase. For water treatment plant and CIP room purposes, no further discussion where shared by the engineers and inspectors in the said plant.

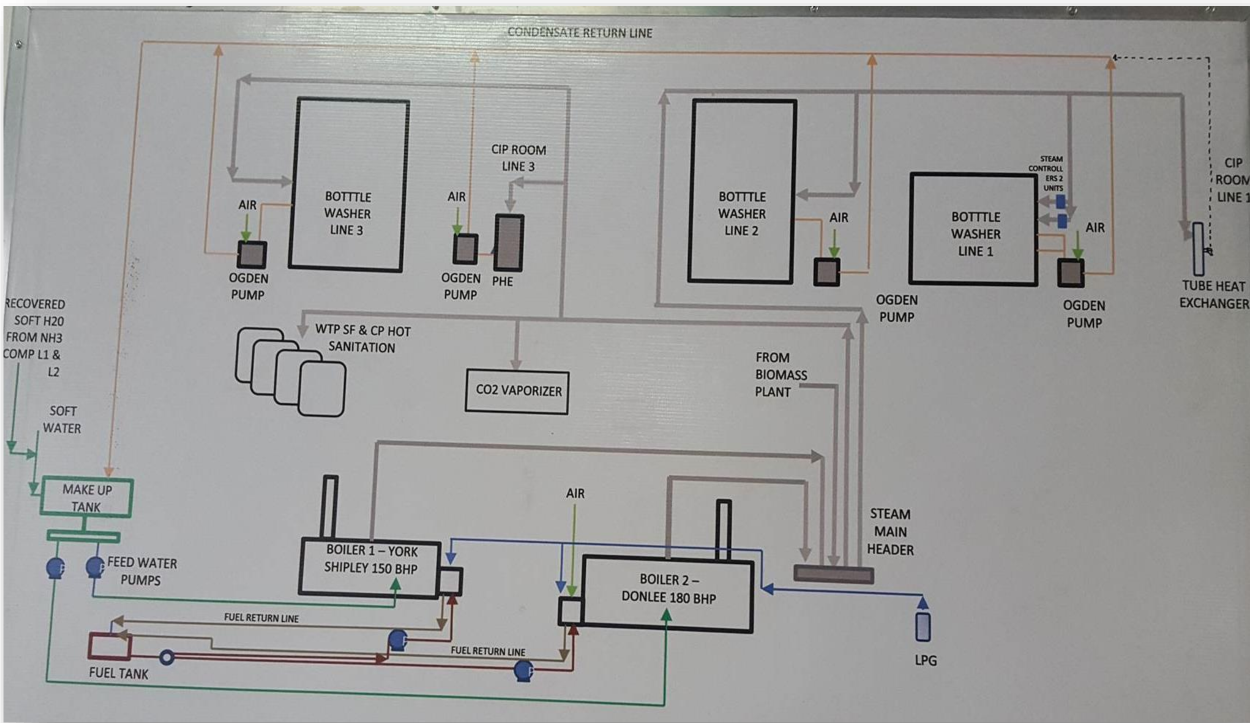


Figure 4. Schematic flow of the purpose of the boiler

Boiler Description

BOILER SPECIFICATION

Listed Below is the specification of the two boilers in the plant

Table 1. Boiler Specifications

Brand	**York Shipley**	**Donlee**
Model	SPHV 150-6	SPHV 200-6
Type of Boiler	Packaged Fire-tube Boiler	
Capacity	5049 lbs/hr	8625 lbs/hr
Type of Fuel	Fuel Oil	Fuel Oil

Set Pressure (Cut in/cut out)	30 to 60 psi	30 to 55 psi

FUEL CHARACTERISTICS

Listed Below is the fuel characteristics used in the two boilers in the plant

Table 2. Fuel Characteristics

Type of Fuel	**SFO 60**
Supplier	Petron
Density at 15°C, kg/m^3	876
Water Solubility	Insoluble
Odor	Characteristics of petroleum products
Appearance	Black liquid
Viscosity at 100°F, SSU	57.7
Stability	Normally stable at ambient temperature
Incompatibility	Strong oxidizing agents
Flash point, °C	71
Sediment and Water, % Vol	0.05
Sulfur, % wt	1.55
Ash, % wt	0.03
Carbon	85
Calorific Value, Kcal/kg	10,570

Boiler Operations

OPERATING CONDITIONS

Table 3. Operating Conditions of Boiler 1 and 2

	YORK SHIPLEY	DONLEE
Model	SPHVE 150 - 6 / 94218	SPHVE-200-6 / 200175
Capacity/Rating	5049 LBS / HR (150 BHP)	8625 LBS / HR (180 BHP)
Design Pressure	50 to 300 PSIG	
Set Pressure	30 - 60 psi	30 - 55 psi
Fuel	SFO 60	SFO 60
Burner Fuel	Pressure Atomized Fuel Oil	Atomized, Fuel Pressure
Electrical Motor	7.5 Hp	
Voltage	240/460 Volts	

RECORDED EFFICIENCY

The recorded efficiency of Coca-Cola FEMSA primary boiler is roughly around 60-70%.

OPERATIONAL ISSUE

On April 11, 2015 there was a recorded operational problem in the Donlee Boiler. The boiler failed to stop after it cut out when supplying steam in line 2 that results to delaying the production. The root cause of the malfunction was a loose ignition rod during the restarting of the boiler. The immediate corrective action to the problem is tracing the source of the failure; restarting the boiler and observing the individual component: fuel filters, electrical control, air and fuel line. Then inspect of fuel inlet and supply line. The preventive actions that should be done in order to handle the situations alike, the boiler controls and main burner should be restore and enhance personnel skills on trouble shooting and analysis.

Environmental Issues

Liquefied petroleum gas or LPG is flammable mixtures of hydrocarbon gases liquefied through pressurization. It comes from natural gas and oil refineries. Burning LPG releases several contaminants like particulate matter, carbon monoxide (CO), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Particulate matter is a complex mixture of extremely small particles and liquid droplets which is made up of number of components, including acids, organic chemicals, metals, and soil or dust particles that are dangerous to health when inhaled and can cause haze. Carbon monoxide (CO) is a colorless, odorless toxic flammable gas formed by incomplete combustion of carbon which can cause harmful health effects by reducing oxygen delivery to the body's organs. Nitrogen dioxide (NO_2) belongs to a group of highly reactive gases called Nitrogen oxides (NOx) that are formed when fuel is burned at high temperatures that can cause irritation and contributes to the formation and modification of other air pollutants, such as particulate matter, ozone and to acid rain. Sulfur dioxide is a toxic gas with pungent and irritating smell that reacts easily with other substances to form harmful substances, such as sulfuric acids, sulfurous acid, and sulfate particulates.

Coca-Cola FEMSA Philippines, Inc. San Fernando Plant hired the services of CRL Calabarquez Corporation to conduct ambient air sampling test within the location that was used to evaluate the actual concentrations of air pollutants during the plant's normal operation.

According to the test results shown in Table 3, the plant's average emission rate of particulate matter is 0.536kg/hr with an average concentration of 139 mg/Nm^3. Sulfur dioxide average emission rate is 3.718 kg/hr with an average concentration of 961 mg/Nm^3. It also emits 0.697 kg/hr of nitrogen dioxide with an average concentration of 180 mg/Nm^3; and 0.015 kg/hr of carbon monoxide with an average concentration of 4 mg/Nm^3. The table also presented that the concentrations of all air pollutants released are acceptable based on the DENR standard.

Table 4: Boiler Test Results

Parameters	Units	Run 1	Run 2	Run 3	Average Results	DENR standard
Particulate Matter	mg/Nm^3	150	129	137	139	150
Emission rate	kg/hr	0.572	0.503	0.533	0.536	--
Sulfur Dioxide	mg/Nm^3	971	911	1001	961	1500
Emission rate	kg/hr	3.708	3.565	3.882	3.718	--
Nitrogen Dioxide	mg/Nm^3	171	191	178	180	1500
Emission rate	kg/hr	0.654	0.747	0.691	0.697	--
Carbon Monoxide	mg/Nm^3	1	11	1	4	500
Emission rate	kg/hr	0.003	0.042	0.003	0.016	--

Based on the test results, there are air pollutants emitted by the plant's boiler. Even though the concentration of the said pollutants is acceptable by the DENR standard, they are still harmful not only to the environment but also to all living species. That is why there is a need for several pollutants control techniques to still lessen the emission of their boiler. The control techniques was not shared to our group because we were not able to talk to the right personnel however, we believe that they have some control techniques because they cannot have such good results if they do not have any control techniques used in reducing the emissions of the pollutants in their plant.

SUGGESTED BAT/BEP and REDESIGN OUTPUT using FIRECAD

SUGGESTE BAT/BEP

In order to reduce the emission of persistent organic pollutants from fossil fuel-fired utility and industrial boilers, the pathways for generation and release of such pollutants must be minimized in the design and operation of the process. This will be effectively achieved by conforming with the Best Available Technique (BAT) and Best Environmental Practices (BEP) for boilers.

The Coca-cola company did not reveal to us any BAT/BEP information for their boilers, but the following are recommendations that follows BAT and BEP:

1. BAT: Fuel quality

   BEP: Fuel specification was defined for key fuel parameters and to introduce a monitoring and reporting protocol.

   The fuel used is specialized fuel oil. Table 4 below shows the Fuel characteristics that agrees to the specifications of the required fuel type for the boiler.

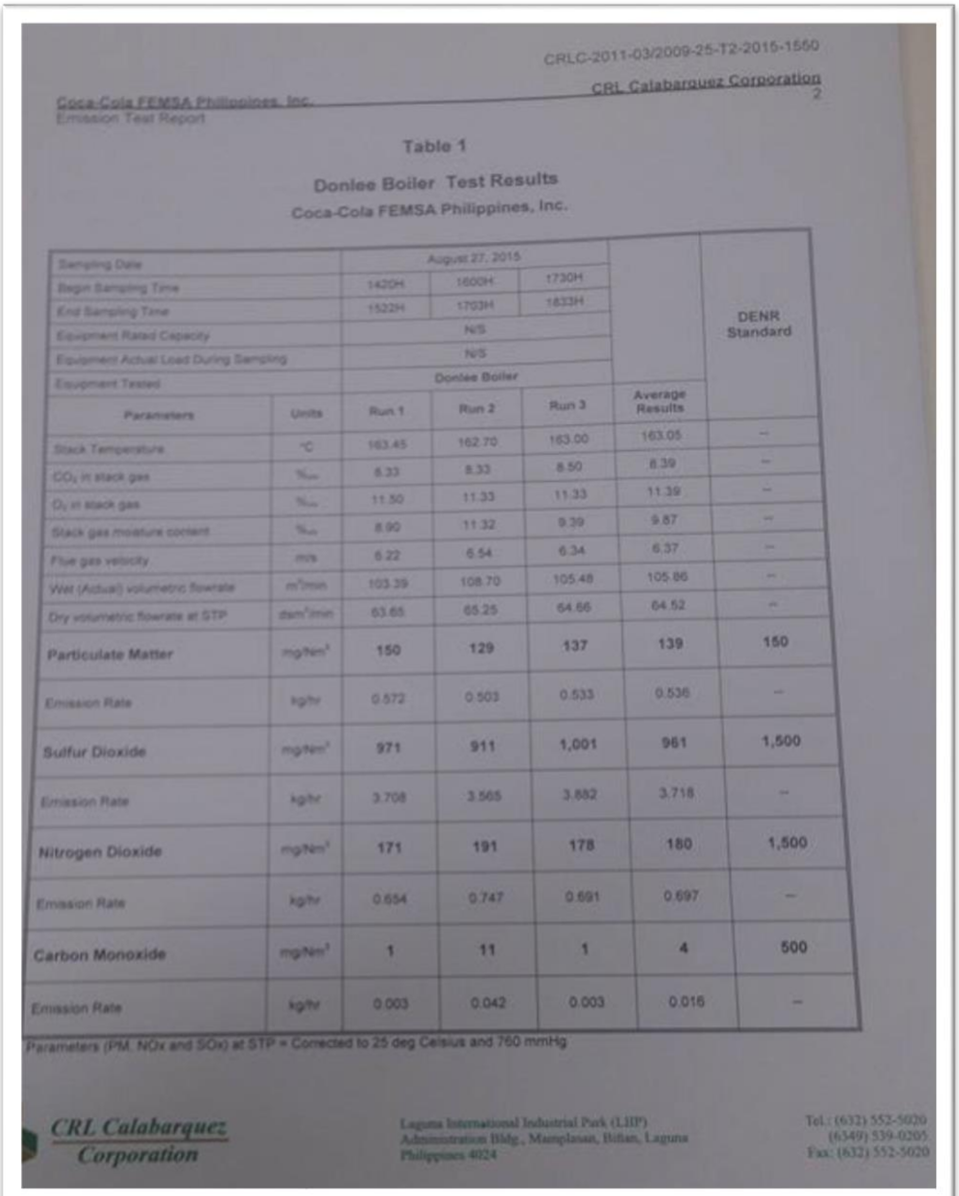
   Table 5. Fuel Characteristics and specifications

PROPERTY	TEST	SPECIFICATION	RESULT
Density at 15°C, kg/L	ASTMD1298	Report	0.8850
Viscosity at 100°F	ASTMD2161	60 MAX.	57

2. BAT: Combustion conditions
   BEP:
   - Identification of key process parameters, either from site-specific investigations or research undertaken on similar facilities elsewhere
   - Introduced measures that enable control of key process parameters
   - Introduced monitoring and reporting protocols for key process parameters
   - Introduced an environmental management system that clearly defines responsibilities at all levels

While environmental engineer of the company was able to provide measure-enabling control, monitoring and reporting protocols of the key process parameters for their boiler, the Department of Environment and Natural Resources (DENR) was the one responsible for the site-specific investigations and researches on the company's facilities.

The flue gas testing is being performed semi-annually by a representative from Petron and is analyzed and reported by the CRL Calabarquez Corporation shown in figure 5 below.


CRLC-2011-03/2009-25-T2-2015-1550

Coca-Cola FEMSA Philippines, Inc.
Emission Test Report

CRL Calabarquez Corporation
2

Table 1

Donlee Boiler Test Results

Coca-Cola FEMSA Philippines, Inc.

Sampling Date		August 27, 2015				DENR Standard
Begin Sampling Time		1420H	1600H	1730H		
End Sampling Time		1522H	1703H	1833H		
Equipment Rated Capacity		N/S				
Equipment Actual Load During Sampling		N/S				
Equipment Tested		Donlee Boiler				
Parameters	Units	Run 1	Run 2	Run 3	Average Results	
Stack Temperature	°C	163.45	162.70	163.00	163.05	--
CO_2 in stack gas	$\%_{v/v}$	8.33	8.33	8.50	8.39	--
O_2 in stack gas	$\%_{v/v}$	11.50	11.33	11.33	11.39	--
Stack gas moisture content	$\%_{v/v}$	8.90	11.32	9.39	9.87	--
Flue gas velocity	m/s	6.22	6.54	6.34	6.37	--
Wet (Actual) volumetric flowrate	m^3/min	103.39	108.70	105.48	105.86	--
Dry volumetric flowrate at STP	dsm^3/min	63.65	65.25	64.66	64.52	--
Particulate Matter	mg/Nm^3	**150**	**129**	**137**	**139**	**150**
Emission Rate	kg/hr	0.572	0.503	0.533	0.536	--
Sulfur Dioxide	mg/Nm^3	**971**	**911**	**1,001**	**961**	**1,500**
Emission Rate	kg/hr	3.708	3.565	3.882	3.718	--
Nitrogen Dioxide	mg/Nm^3	**171**	**191**	**178**	**180**	**1,500**
Emission Rate	kg/hr	0.654	0.747	0.691	0.697	--
Carbon Monoxide	mg/Nm^3	**1**	**11**	**1**	**4**	**500**
Emission Rate	kg/hr	0.003	0.042	0.003	0.016	--

Parameters (PM, NOx and SOx) at STP = Corrected to 25 deg Celsius and 760 mmHg

CRL Calabarquez Corporation

Laguna International Industrial Park (LIIP)
Administration Bldg., Mamplasan, Biñan, Laguna
Philippines 4024

Tel.: (632) 552-5020
(6349) 539-0205
Fax: (632) 552-5020

Figure 5. Flue gas analysis report

3. BAT: Installation of the most appropriate air pollution control devices
   BEP: Ensure the environmentally sound management of fly ash, coarse ash and flue gas treatment residues

   The fuel used was specialized fuel oil and therefore, there were no traces of fly ash and coarse ash. From the flue gas analysis in Figure 2, it was reported that the emission test results passed the standards of the DENR, although the particulate matter has the highest average result to DENR standards ratio. Therefore, from the article in Air & Waste Management Association entitled
   Fact Sheet: Air Pollution Emission Control Devices for Stationary Sources shown in Figure 6 below, the group recommends that fabric filters or bag houses be installed to the boilers to obtain higher boiler efficiency.

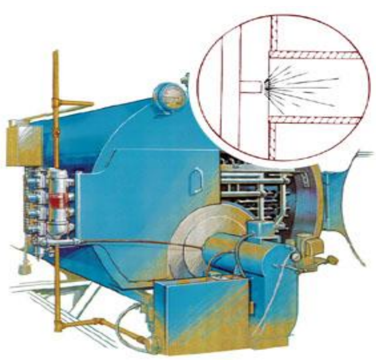
Common Control Devices	Pollutants	Examples Where Used
Packed towers, spray chambers, venturi scrubbers	Gases, vapors, sulfur oxides, corrosive acidic or basic gas streams, solid particles, liquid droplets	Asphalt and concrete batch plants; coal-burning power plants; facilities that emit sulfur oxides, hydrogen sulfide, hydrogen chloride, ammonia, and other gases that can be absorbed into water and neutralized with the appropriate reagent
Carbon adsorbers	Vapor-phase volatile organic compounds (VOCs), hazardous air pollutants (HAPs)	Soil remediation facilities, oil refineries, steel mills, printers, wastewater treatment plants
Fabric filters or bag houses	Particulate matter (PM)	Asphalt batch plants, concrete batch kilns, steel mills, foundries, fertilizer plants, and other industrial processes
Catalytic reactors, catalysts	VOCs, gases	Landfills, oil refineries, printing or paint shops
Cyclones	Large PM	Woodworking shops, pharmaceutical manufacturers, cotton gins, rock crushers, cement plants
Electrostatic precipitators (ESPs)	PM	Power plants, steel and paper mills, smelters, cement plants, oil refineries
Incinerators, thermal oxidizers, afterburners	VOCs, gases, fumes, hazardous organics, odors, PM	Soil contaminated with gasoline, landfills, crematories, inks from graphic arts production and printing, can and coil plants, hazardous waste disposal
Biofilters	VOCs, odors, hydrogen sulfide (H_2S), mercaptans (organic sulfides)	Wastewater treatment plants, industrial processes

Figure 6. Common Control Devices to Certain Polluants

4. BAT: Introduce and follow planning cycles, implement appropriate inspection and maintenance cycles
   BEP: Ensure all staff are appropriately trained in the application of the best environmental practices relevant to their duties

The Coca-cola company has a contract with Petron for their semi-annual flue gas emission testing. The company also selected competent engineers who perform their inspection and maintenance duties well.

Table 6. Suggested BAT/BEP

ISSUE (with suggested equipment)	**Best Environmental Practices**	**Best available techniques**	**Environmental benefit**
FUEL  *Sensors/utilities*	Fuel Sourcing Fuel Monitoring Fuel Specification	Control fuel input to meet specification by rejection, substitution, purification	Minimizing of POPs introduced into the combustion system
Combustion conditions  *Soot blowers*	Monitoring combustion condition, particularly -Temperature (>900C) -Time (>1 second) -Oxygen (in excess)	Automated or computerized combustion control system to maintain the ideal combustion conditions. -Maximized oxidation by maintaining ideal fuel/oxygen mix	Minimizing of formation of POPs during combustion

Collection  *Cyclone Separator*	Operation and maintenance of existing air pollution control device	Installation of air pollution control	Minimize Particulate Matters
Waste disposal  *Gas scrubber*	Collect solid and liquid wastes from the combustion process and air pollution	Safe disposal Assess potential for waste volume reduction and recycling	Minimize and control the release of POPs

REDESIGN OUTPUT USING FIRECAD

Through redesigning of the two boilers, the group aims to increase the efficiency using FireCad software.

1st Boiler: York Shipley

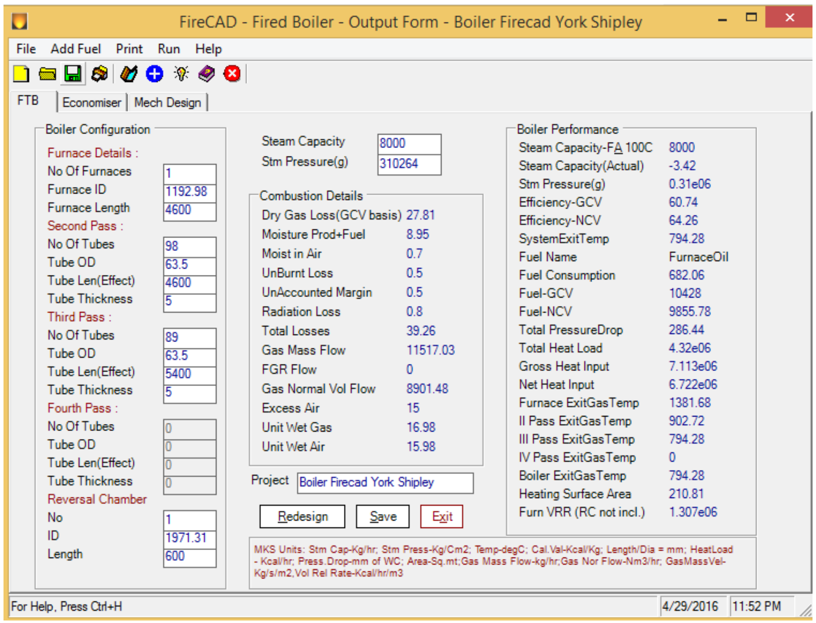


Figure 7. Actual efficiency for York Shipley

The Coca Cola Femsa Inc. Situated in Pampanga has two boilers. Both of the boilers used Special Fuel Oil No. 60 as the feed fuel for the evaporation of water.

Fuel Type used; Special Fuel

Carbon = 85.2

Hydrogen = 13.52

Sulfur = 1.16

Moisture = 0.06

Ash = 0.02

Calorific Value kcal/kg = 10752

For the York Shipley SPHV 150 – 6 / 94218, the steam capacity used is 5049 lb/hr or 150 hp and the set pressure are in the range between 30 to 60 psi. Using the calculations obtained from their data from the fuel analysis, capacity, pressure and others, the efficiencies in GCV and NCV obtained were 60.74 and 64.26, respectively.

2nd Boiler: Donlee

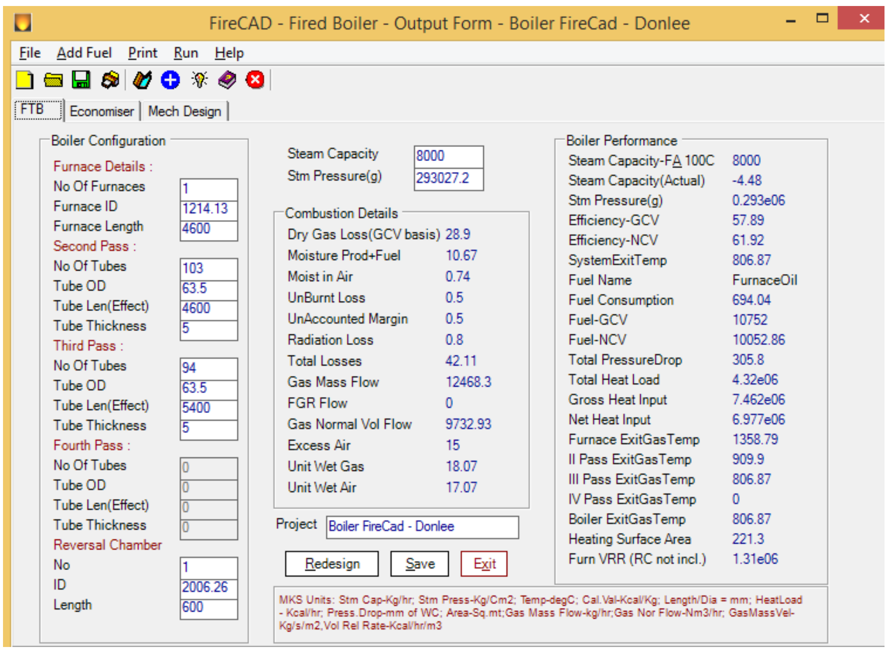


Figure 8. Actual efficiency for York Shipley

For the Donlee SPHV 200 – 6 / 200175, the steam capacity used is 8625 lb/hr or 180 hp and the set pressure are in the range between 30 to 5 psi. Using the calculations obtained from their data from the fuel analysis, capacity, pressure and others, the efficiencies in GCV and NCV obtained were 57.89 and 61.92, respectively.

The efficiencies of the two boilers are below the acceptable range of 80%. This is due to the large friction losses of the boiler which were adapted from its old age and ineffective maintenance, and the lack of economizer.

The efficiencies of the two boilers can be increased by installing the economizers, turbulators and soot blowers on both boilers.

1st Boiler: York Shipley

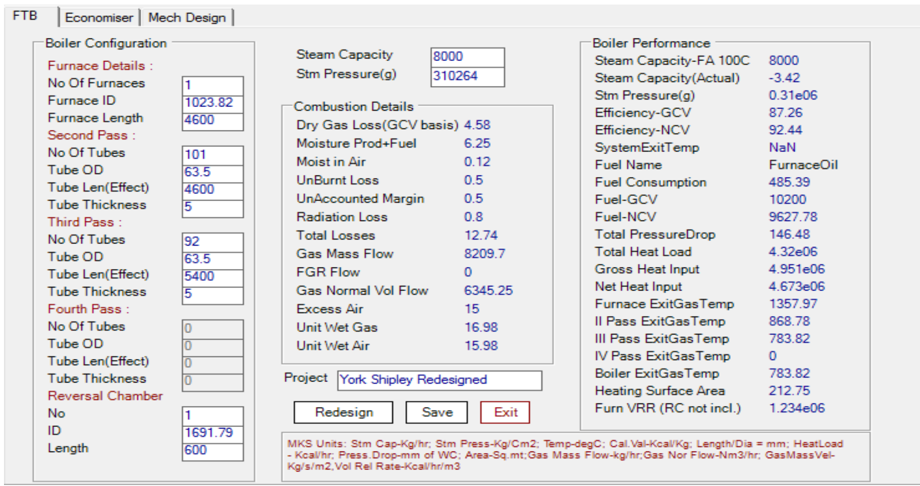


Figure 9. Redesigned of York Shipley

Through the installations of the add-on equipments for the York Shipley, the efficiency increased from 60% to 80%.

2nd Boiler: Donlee

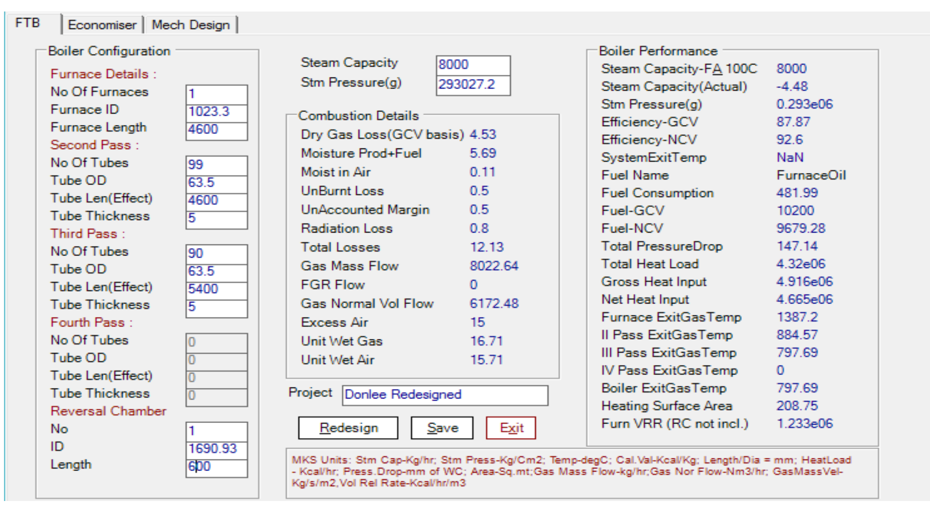


Figure 10. Redesigned of Donlee

Through the installations of the add-on equipments for the Donlee, the efficiency increased from 60% to 80%.

CONCLUSION and ACKNOWLEDGEMENT

CONCLUSION

For boiler operations, BAT/BEP should be a requirement. These are not only for the purpose of increasing the efficiency of the boiler but also for safety measures. These safety measures must be followed not just to pass the requirement for boiler operation but also to ensure the safety of human health especially during the combustion of fuel or boiler operation wherein emission of hazardous chemical like POPs are very critical.

- Coca-cola FEMSA uses 2 boilers which are York Shipley and Donlee.
- These are used for Production line, CO_2 vaporizer, Water treatment plant and CIP room
- SFO 60 is the fuel used that has a calorific value of 10,570 kcal/kg.
- They have an efficiency around 60-70% but can be improved to 80% by using different auxiliaries such as economizer, turbulators and soot blowers.

ACKNOWLEDGEMENT

My group and I want to give our deepest gratitude to those people who accommodated all are inquiries about the boiler in Coca-Cola FEMSA San Fernando Plant. To Engr. Vladimir who approved our boiler tour in the said plant, to Engr. Jade Ayuyang who discussed about the environmental impact of their boiler (emissions), and to Mr. Jerwin Reyes who gave the whole

tour and discussion about the boiler.