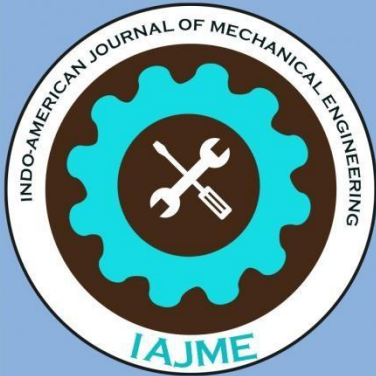


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ELECTRONIC HORIZONTAL FIRE TUBE BOILER DESIGN FOR INDIAN FOOD COMMERCIAL COOKING

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ABSTRACT

In order to facilitate the industrial preparation of Indian cuisine, this article seeks to provide the specifications for a horizontal fire tube two pass boiler. This boiler can produce 300 kg of steam per hour. Pure mild steel is used to construct the boiler tank. Boiler components including the fire tubes, furnace, and return chamber are made of mild steel. For this boiler, the fuel of choice is Indian coal. When heated at 1500 degrees Celsius and pressurized to 5 bars, the boiler produces dry saturated steam. Commercial kitchens, food processing plants, dairies, and restaurants may all benefit from this boiler's ability to cook Indian cuisine.

Key words: Fire tube boiler, Coal fired boiler, sake of the commercial cooking of Indian food, Indian food cooking.

1. INTRODUCTION

Commercial Indian cooking nowadays often makes use of open furnaces and stove burner systems to heat or prepare meals. Common fuels for these systems

to cook with include wood and liquid petroleum gas (LPG). There are a number of drawbacks to using open furnaces and stove burners.

Various disadvantages of the open furnaces and the stove burners are as follows:

- (a).High heat losses.
- (b).High fuel consumption.
- (c).High fuel cost.
- (d).Non uniform heating.
- (e).Pollution.
- (f).Bad effects on the health of the workers working around these systems.

All things considered, these drawbacks make steam an indispensable tool for industrial cooking and heating. Consequently, the heating process necessary for cooking requires steam,

which can only be produced by a steam boiler.

When the right size steam boiler is designed, it produces the most steam possible, eliminating all the drawbacks of

using open furnaces or stove burners for cooking. Reduced fuel use and costs are a direct result of this action, which lessens heat losses.

As a result, the plant's production is enhanced. Steam is an economical, practical, and dependable energy source that is necessary for the procedure to be

(b).Productivity of the plant gets improved.

(c).Uniform heating occurs in case of steam process heating.

(d).Heat losses are greatly reduced.

(e).Steam process heating does not have any harmful effect on environment or health of any worker.

(f).Burnt flue gases can be filtered in dust collectors. Thus, air pollution is greatly controlled.

(g).Convenient and reliable.

Figure ^[1] illustrates that the cost of energy consumption in a steam system is almost the entirety of the system's cost (based on the data for boilers with a high rate of capacity utilization over a 20 year life). It makes good business sense, therefore to run a energy efficient system.

carried out.

Advantages of using steam for process heating are:^[1]

(a).Fuel consumption is greatly reduced. Thus, cost associated with fuel consumption is reduced.

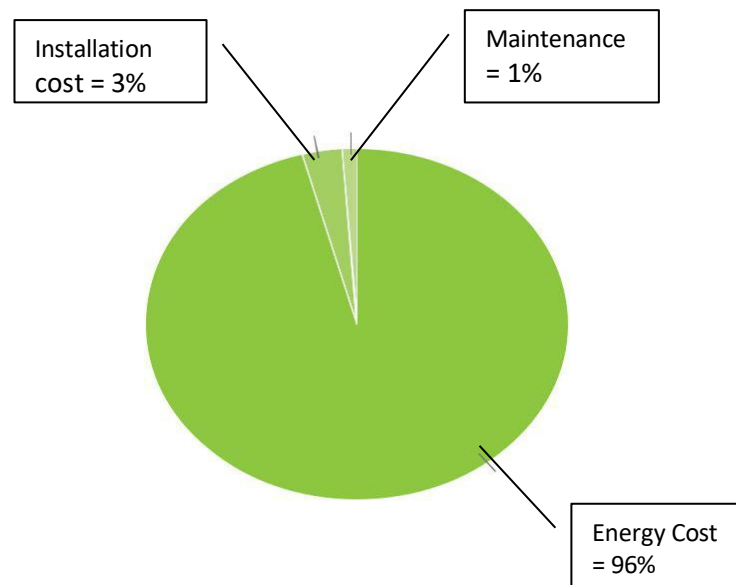


Figure 1 Life cycle cost of the Steam Systems^[1]

2. INDIAN BOILER REGULATIONS 1950

2.1. History^[2]

The first steam boilers appeared thousands of years ago. Steam plants underwent a dramatic transformation with the advent of the renowned James Watt's improved steam engine in the

years 1769–1775. Several people lost their lives in a terrible boiler disaster that happened in Calcutta in 1863. This explosion brought into sharp focus the need for boiler inspections, and the



Bengal Council eventually presented a measure to mandate such checks on steam boilers. The regulation of steam boilers and prime movers in Calcutta and its suburbs was established in 1864 by the Bengal Act VI of that year. Boiler laws in India were first introduced at this time. Following the 1864 Bengal Act, all of the other provinces passed their own laws. There were seven separate Acts and regulations in effect throughout that period. The Acts, regulations, and rules were quite different from one another. There were a lot of problems and slowed industrial growth because of these variations across India's many regions. This led to the 1920 establishment of the "Boiler Law Committee" by the Indian federal government, whose mandate was to investigate and report on the broad subject of boiler laws across the country.

In March of 1921, the "Boiler Law Committee" approved a report. The aforementioned discrepancies in the Acts, laws, and policies of various provinces were the target of criticism in this study. According to the study, all provinces should follow the same rules, and results from one province should be considered valid in another. Boiler materials, design, and construction should all adhere to predetermined standards, according to the committee's proposal. The central government of India should establish these rules, and they should apply throughout the country.

In 1923, a law was enacted that mandated the creation of standardized technical norms and administrative rules by the boiler committee. There was a clear delineation between rules and regulations. Questions about the Act's administration were addressed in the rules, while technical concerns were

dealt with exclusively in the regulations. Protecting people and their possessions against boiler explosions was the goal of the Boiler Act of 1923. The provision to establish the Central Boilers Board with regulatory power was included in an Act that was approved in 1937. In 1937, the Central Boiler Board was thus established.

2.2. Present Condition ^[2]

When boilers are being manufactured, inspected, tested, or operated, they must adhere to the standards and regulations set out by the Central Board of Boilers. The 35-pronged law is often referred to as "THE BOILERS ACT 1923" due to its 1923 passage. The 626 regulations are organized into 15 chapters. The rules are known as the "INDIAN BOILERS REGULATIONS 1950" since they were established in that year. Names like "THE BOILER OPERATION ENGINEER'S RULES 2011," "THE BOILERS ATTENDANT'S RULES 2011," "THE BOILERS APPEAL RULES 2013," and "THE CENTRAL BOILERS BOARD RULES 2008" are among the many regulations. Until the Central Board of Boilers decides to alter them, these statutes, ordinances, and guidelines will remain in effect. The legal definitions of boilers, their parts, pipelines, etc., may be found in several acts. Included in this data is information on the Boiler's technical advisor, application, certificates, registrations, inspection, costs, fines, and more.

The technical topic is referred to by regulations. Boiler regulations cover testing and selection of materials, design and drawing, fabrication, assembly, working pressure determination, valve selection, safety valves, water gauges, pressure gauge, flanges, feed water, erection, and commissioning. Boiler parts include the



main shell, furnace, tube plate, tube, nozzles, man hole, and others. Concerning matters pertaining to the execution of the Act, rules are used. Boiler operation, welder certification, boiler certification, approval, inspector selection, exam administration, exam method, and exam application are all governed by the rules that are formed. Boiler operation engineers, attendants, inspectors, and others are governed by regulations.

The government of India sets up boiler offices to oversee the production, installation, commissioning, operation, and maintenance of gas boilers. These positions appoint the chief inspectors and directors responsible for examining boilers. Every state has at least one boiler office. The Ministry of Industries has an adjacent office known as the boiler office. Maintaining and operating boilers safely is essential since they are both vital and potentially dangerous pieces of industrial equipment. A catastrophic loss of life and property may occur in the event of an accident caused by boilers that are poorly built, operated, or maintained. In addition to these, a pollution-free atmosphere, effective boiler performance, and smooth energy conservation are all necessary to guarantee product quality. These Acts, Rules, and Regulations are put in place to make sure that everyone involved with boilers is safe, and that the businesses mentioned above may keep producing smoothly. Inspecting, registering, and issuing certificates for boilers are major duties of the boiler inspector.

3. BOILER

“Boiler” means a pressure vessel in which steam is generated for use of external to itself by application of heat which is wholly or partly under pressure when steam is shut off but does not include a pressure vessel:

(1).with capacity less than 25 litres.

(2).with less than one kilogram per centimetre square design gauge pressure and working gauge pressure.^[2]

In simple words, Boiler is usually a closed vessel made of steel. Its function is to transfer the heat produced by the combustion of the fuel to water, and ultimately to generate steam. Steam produced is then used to carry out various industrial processes.



3.1. Classification of the boiler ^[3]

Boilers are classified as follows:

1. According to the contents in the tube:

Fire tube.

Water tube.

2. According to the position of the furnace:

Internally fired.

Externally fired.

3. According to the axis of the shell:

Vertical boilers.

Horizontal boilers.

4. According to the number of tubes:

Single tube boilers.

Multi tubular boilers.

5. According to the method of circulation of water and steam:

Natural circulation boilers.

Forced circulation boilers.

6. According to the fuel used:

Coal fired.

Diesel fired.

Agro waste briquettes fired, etc.

7. According to the pressure:

Low pressure boilers.

High pressure boilers.

8. According to the mechanism:

Dry back or wet back boilers.

Two pass or three pass boilers.

4. FIRE TUBE BOILER

The core of a fire tube boiler is a water-filled boiler shell that is perforated with tubes of various layouts, the most common of which being a horizontal layout. A portion of the water tank is filled with water, leaving enough capacity to hold the steam. The flues are long horizontal tubes that heat the water in the tank by transferring hot combustion gasses there. Through a series of tubes, the smokestack carries the heat generated by the combustion process to the boiler water. There are three main types of fire-tube boilers. One kind, known as a horizontal return tubular (HRT) boiler, has fire-tubes that run horizontally and are self-contained, with their own combustion chamber. The fire-tubes and combustion chamber of a Scotch, Scotch Marine, or shell boiler are contained inside the same shell. A firebox boiler uses three gas passages and has a firebox that is water-jacketed. A tiny, spherical combustion chamber is housed within the base of most contemporary fire-tube boilers, which have cylindrical outer shells. Because of their straightforward design,



fire-tube boilers are easy to build in a shop and may be transported completely completed. The number of passes each boiler has depends on the building specifications. There are a number of advantages to fire-tube boilers, including a reduced starting cost, improved fuel efficiency, and ease of operation.

Advantages of fire tube boiler are:

- (a).Low cost.
- (b).Fluctuations of steam demand can be met easily.
- (c).It is compact in size.

5. SCOPE OF THE RESEARCH

A basic model fire-lube boiler for commercial Indian cuisine preparation is detailed in the study. Aspiring engineers may use this design guideline as a starting point for learning about boiler basics, including how to determine an appropriate boiler size, material, and combustion heat. If you want your fire-tube boiler to work as efficiently as possible, you need to pay close attention to its design and the amount of heat it absorbs. Process requirements, economics, and other considerations might impact boiler design.

peace of mind. To ensure that the reader fully grasps the meaning of each word or parameter used in the guideline, a comprehensive definition section is provided.

6. METHODOLOGY

In the design of fire boiler in this paper includes various steps given below:

- Design requirement
- Design consideration
- Design specifications
- Dimensioning of the boiler
- Preparation of drawing.
- Mechanical calculations
- Heat balance calculations
- Efficiency and evaporation ratio calculation
- Fuel cost estimation during boiler's operation.

6.1. Basic Design Requirement

Criteria which govern the design and manufacture of fire-tube boilers include:

- (a).Compliance with the IBR 1950 code.
- (b).Compliance with the required safety and installation codes.
- (c).The ability to meet the required efficiency and other performance standards.
- (d).Ability to meet the required level of pollutants emissions.
- (e).Compliance with the requirements of the Central Boards of boiler and Pressure Vessel Inspectors.
- (f).The ability to meet the perceived needs of the customers in terms of operational performance, reliability and maintenance costs.

6.2. Design Considerations for Material Selection

For an intelligent design to be done, the knowledge of the materials available as well as the



properties they possess are very important. For the selection of the proper material to be used for the design of the fire-tube boiler, we shall consider the factors which affect the choice of material selected and used for design and these reasons.

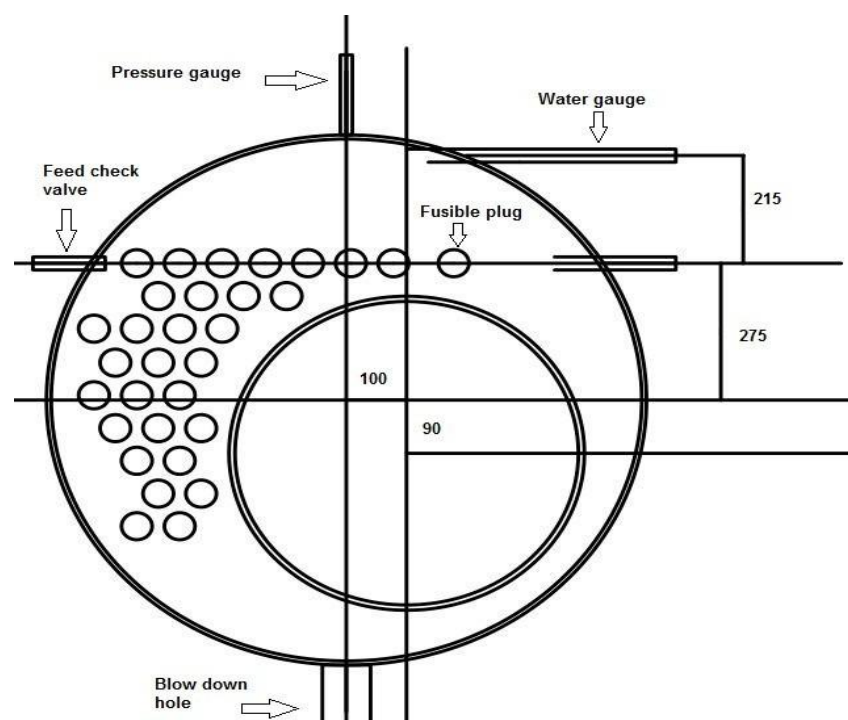
Choice of Material

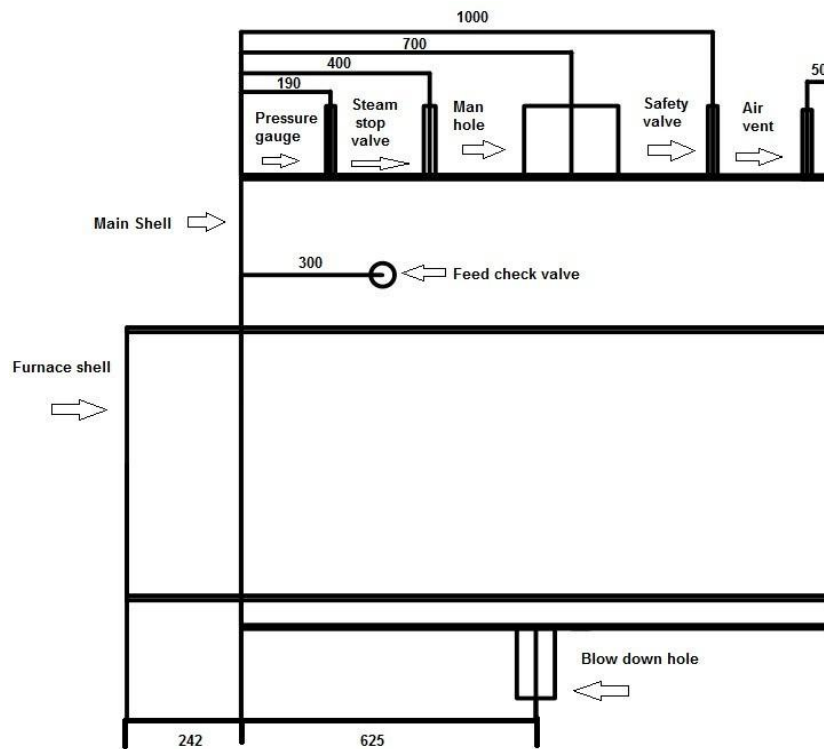
Based on the above considerations, the materials used for the design of the fire-tube boiler were thus selected and tabulated below:

Materials used and Reason

Parts	Material formally used or preferred and reasons	Material used and reasons
Furnace	Aluminum; good conductivity, high corrosion resistance but high melting point.	Mild steel; affordable, available, weldable, malleable, strength, high conductivity, and corrosion resistance.
Smoke-tubes	Copper; high thermal conductivity, better formability.	Mild steel; affordable, available, weldable, malleable, strength, high conductivity, and corrosion resistance.
Return chamber	Aluminum; good conductivity, high corrosion resistance but high melting point.	Mild steel; affordable, available, weldable, malleable, strength, high conductivity, and corrosion resistance.
Main shell	Wrought iron; toughness, malleable, and ductile.	Steel; low cost of fabrication, stronger, quick weldability, cheaper and less labor.
Front tubes	Copper; high thermal conductivity, better formability	Mild steel; affordable, available, weldable, malleable, strength, high conductivity, and corrosion resistance.

Drawing of the Boiler





(other details continued)

Nipples for safety valve, feed check valve, steam stop valve:

Size = 25 Nominal bore x 150 length (in mm)

Nipples for water gauge, pressure gauge, air vent:

Size = 20 Nominal Bore x 150 length (in mm)

Flange for the man hole = 20

0 NB class 150

Blind flange for the man hole = 200 Nominal bore
class 150

Flange for the blow down hole = 80 Nominal bore
class 150

Blind flange for the blow down hole = 80 NB class 150

Fusible plug = 51 OD x 40 length (in mm)

Mechanical Calculations

Mechanical calculations are performed for all the dimensions to check whether the dimensions provided are safe or not. All the mechanical calculations are performed as per the Indian Boiler Regulations 1950.

Mechanical calculations are necessary to ensure that the design of the boiler is safe.

Heat Calculations

Heat output = 100000 kcal / kg

Heat input = Mass of the fuel x Gross calorific value of Fuel

Fuel used = Indian coal

Gross calorific value of fuel = 4200 kcal / kg

Heat loss calculations are performed for:

- (1).Heat loss due to the dry flue gas (L1)
- (2). Heat loss due to the hydrogen in the fuel (L2)
- (3).Heat loss due to the moisture in the fuel (L3)
- (4).Heat loss due to the moisture in the air (L4)
- (5).Heat loss due to the incomplete combustion (L5)
- (6).Heat loss due to the convection and radiation (L6)
- (7).Heat loss due to the unburnt in fly ash (L7)
- (8).Heat loss due to the unburnt in bottom ash (L8)

7. RESULT

All mechanical calculations are performed as per the Indian Boiler regulations 1950, which ensures that all the dimensions provided to boilers are safe.

Thus, the design is safe.

Heat output = 100000 kcal / hr

Heat input = 147000 kcal / hr

7.1. Heat balance for this boiler ^[4]

Heat Losses		Kcal/ kg of fuel	%
Dry flue gas loss (L1)	=	339.42	8.08
Loss due to hydrogen in the fuel (L2)	=	183.02	4.35
Loss due to moisture in the fuel (L3)	=	196.8	4.68
Loss due to moisture in the air (L5)	=	12.07	0.28
Partial combustion of C to CO (L6)		95.53	2.27
Heat loss due the convection and radiation (L7)	=	For fire tube boiler it is taken as 2.5%	2.5
Heat due to the unburnt in fly ash (L8)	=	3.905	0.11
Heat loss due to the unburnt in bottom ash (L9)		62.136	1.77

Efficiency of the boiler by direct method = 71.42%

Efficiency of the boiler by indirect method = 75.96%

Evaporation ratio = 8.57

Cost of the coal per month required to operate

This boiler = 77000 Rs.

8. CONCLUSIONS

The information and studies presented in this article allow us to conclude the following conclusions. You can trust this fire tube boiler's design since it is completely safe. The mechanical calculations have been used to thoroughly evaluate all of the dimensions that are given to the boiler, which adds to its dependability. Mild steel is the material that was used for this fire tube boiler. In addition to being readily accessible, inexpensive,

malleable, weldable, and corrosion resistant, mild steel also has high conductivity.

The boiler can produce 300 kg of steam per hour.

This can generate 100,000 kcal/hr of heat, which is the necessary amount. Commercial kitchens, hotels, restaurants, and food processing plants all need this amount of thermal energy for their culinary procedures. The boiler is quite efficient, with an



efficiency level of about 75%. A month's worth of fuel for this boiler would set you back about 77,000 Rs. It is evident here

that this boiler's operation is quite economical. Any business kitchen that prepares Indian cuisine would benefit from this boiler, including but not limited to restaurants, dairies, and food processing plants. Standard methods for boiler design need to be implemented. Among these methods are:

- (1). Selection of material which should be conveniently accessible, inexpensive, corrosion resistant, high strength, malleable, weldable, etc.
- (2) The boiler's dimensions must be safe and in accordance with the heat, pressure, and steam production requirements.
- (3). All measurements must be in accordance with the 1950 rule that governs boilers in India.
- (4) Before the design may be considered safe, mechanical calculations must be carried out.
5. The boiler must to be economical, dependable, and efficient.

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