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An Experimental and Fabrication of Miniature Steam Power Plant

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ABSTRACT: This paper describes a miniature steam power plant made with the boiler and the water pump from an old starch iron. It uses boiler as vaporizer to vaporize the water it receives from the water pump. Then the steam is injected on the turbine fan making it twirl. The voltage generated by the fan is enough to lighten a couple of LEDs. A wooden case with a chimney encloses all the referred devices. Today, most of the electricity produced throughout the world is from steam power plants. However, electricity is being produced by some other power generation sources such as hydropower, gas power, bio-gas power, solar cells, etc. This paper deals with steam cycles used in power plants. Thermodynamic analysis of the Rankine cycle has been undertaken to enhance the efficiency and reliability of steam power plants. The thermodynamic deviations resulting in non-ideal or irreversible functioning of various steam power plant components have been identified. Steam power plants are located at the water and coal available places. Steam is utilized to run the turbines, in turn gives the power to generator and generator produces the electricity, the electricity is utilized for lighting, running the industries, for lighting of offices, schools, etc. Boiler is an important component of the power plants, it produces the steam.

I. INTRODUCTION

The steam turbine has been in use for the past century and is available in virtually any capacity ranging from a few (hp) kW to a several hundred (hp) kW. It is highly reliable, needs little maintenance and extremely long service life. Steam turbines are custom built, hence efficiency and operating characteristics can be optimized for each application. Retrofitting a steam turbine into a facility's steam system can be done quite easily, minimizing installation costs. Most facilities that have a steam plant usually are unaware of their potential to cogenerate.

This paper will provide brief theory and operation of steam turbines with particular focus on backpressure turbines; it will analyze the steam turbine being the preferred choice for electrical production and present sensitivity analysis based on varying plant operating conditions. This information can then be used to provide an indication for distilleries and facilities in the Caribbean to cogenerate, since the cost of electricity in the Caribbean islands is generally high.

1. ADVANTAGES OF STEAM POWER PLANT

- High efficiency at full load.
- Mechanical simplicity and hence potential reliability.
- Conventional reciprocating steam locomotives give a varying torque through the cycle, resembling a sine characteristic. This makes wheel slip at starting much more likely.
- Conventional steam locomotives have substantial reciprocating masses such as connecting rods and valve gear.

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2. ENERGY IS EASILY TRANSFERRED TO THE PROCESS

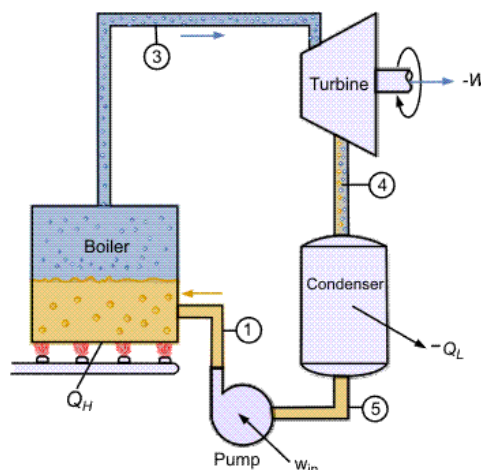
Steam provides excellent heat transfer. When the steam reaches the plant, the condensation process efficiently transfers the heat to the product being heated. Steam can surround or be injected into the product being heated. It can fill any space at a uniform temperature and will supply heat by condensing at a constant temperature; this eliminates temperature gradients which may be found along any heat transfer surface a problem which is so often a feature of high temperature oils or hot water heating, and may result in quality problems, such as distortion of materials being dried. Because the heat transfer properties of steam are so high, the required heat transfer area is relatively small. This enables the use of more compact plant, which is easier to install and takes up less space in the plant. A modern packaged unit for steam heated hot water rated to 1200 kW and incorporating a steam plate heat exchanger and all the controls. In comparison, a packaged unit incorporating a shell and tube heat exchanger would typically cover an area of two to three times that size.

3. THE STEAM PLANT CYCLE

The simplest steam cycle of practical value is called the Rankine cycle, which originated around the performance of the steam engine. The steam cycle is important because it connects processes that allow heat to be converted to work on a Continuous basis. This simple cycle was based on dry saturated steam being supplied by a boiler to a power unit such as a turbine that drives an electric generator. Dry saturated steam is at the temperature that corresponds to the boiler pressure, is not superheated, and does not contain moisture. The steam from the turbine exhausts to a condenser, from which the condensed steam is pumped back into the boiler. It is also called a condensing cycle. This schematic also shows heat (Q_{in}) being supplied to the boiler and a generator connected to the turbine for the production of electricity.

Heat (Q_{out}) is removed by the condenser, and the pump supplies energy (W_p) to the feedwater in the form of a pressure increase to allow it to flow through the boiler. Higher plant efficiency is obtained if the steam is initially superheated, and this means that less steam and less fuel are required for a specific output. Superheated steam has a temperature that is above that of dry saturated steam at the same pressure and thus contains more heat content, called enthalpy, Btu/lb. If the steam is reheated and passed through a second turbine, cycle efficiency also improves, and moisture in the steam is reduced as it passes through the turbine. This moisture reduction minimizes erosion on the turbine blades. When saturated steam is used in a turbine, the work required rotating the turbine results in the steam losing energy, and a portion of the steam condenses as the steam pressure drops. The amount of work that can be done by the turbine is limited by the amount of moisture that it can accept without excessive turbine blade erosion.

This steam moisture content generally is between 10 and 15 percent. Therefore, the moisture content of the steam is a limiting factor in turbine design. With the addition of superheat, the turbine transforms this additional energy into work without forming moisture, and this energy is basically all recoverable in the turbine. A reheater often is used in a large utility.

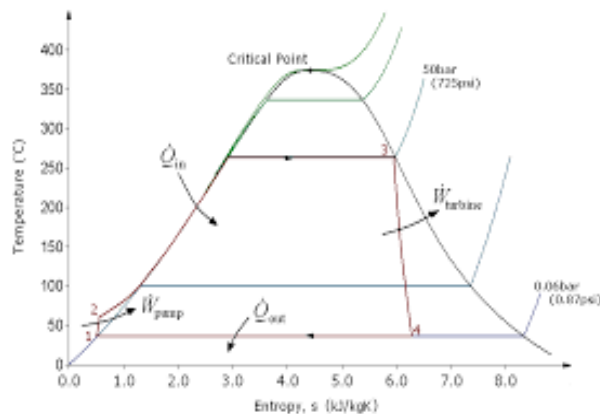


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4. THE FOUR PROCESSES IN THE RANKINE CYCLE



1. Process 1-2: The working fluid is pumped from low to high pressure. As the fluid is a liquid at this stage, the pump requires little input energy.
2. Process 2-3: The high pressure liquid enters a boiler where it is heated at constant pressure by an external heat source to become a dry saturated vapour. The input energy required can be easily calculated using mollier diagram or h-s chart or enthalpy-entropy chart also known as steam tables.
3. Process 3-4: The dry saturated vapour expands through a turbine, generating power. This decreases the temperature and pressure of the vapour, and some condensation may occur. The output in this process can be easily calculated using the Enthalpy-entropy chart or the steam tables.
4. Process 4-1: The wet vapour then enters a condenser where it is condensed at a constant pressure to become a saturated liquid.

5. BOILER EFFICIENCY

1. Combustion Efficiency indicates the burner's ability to burn fuel measured by unburned fuel and excess air in the exhaust.
2. Thermal Efficiency - indicates the heat exchangers effectiveness to transfer heat from the combustion process to the water or steam in the boiler, exclusive radiation and convection losses.
3. Fuel to Fluid Efficiency - indicates the overall efficiency of the boiler inclusive thermal efficiency of the heat exchanger, radiation and convection losses - output divided by input.

6. GROSS CALORIFIC VALUE

This is the theoretical total of the energy in the fuel. However, all common fuels contain hydrogen, which burns with oxygen to form water, which passes up the stack as steam. The gross calorific value of the fuel includes the energy used in evaporating this water. Flue gases on steam boiler plant are not condensed; therefore the actual amount of heat available to the boiler plant is reduced. Accurate control of the amount of air is essential to boiler efficiency Too much air will cool the furnace, and carry away useful heat. Too little air and combustion will be incomplete unburned be carried over and smoke may be produced.

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GAS TYPE	GROSS CALORIFIC VALUE
NATURAL	38.0
PROPANE	93.0
BUTANE	122.0

OIL TYPE	GRADE	GROSS CALORIFIC VALUE
Light	E	40.1
Medium	F	40.6
Heavy	G	41.1
Bunker	H	41.8

7. NET CALORIFIC VALUE

This is the calorific value of the fuel, excluding the energy in the steam discharged to the stack, and is the figure generally used to calculate boiler efficiencies.

1. Net calorific value $\approx$ Gross calorific value -10%
2. Accurate control of the amount of air is essential to boiler efficiency.
3. Too much air will cool the furnace, and carry away useful heat.
4. Too little air and combustion will be incomplete, unburned fuel will be carried over and smoke may be produced. In practice, however, there are a number of difficulties in achieving perfect combustion.
5. The conditions around the burner will not be perfect, and it is impossible to ensure the complete matching of carbon, hydrogen, and oxygen molecules.

Some of the oxygen molecules will combine with nitrogen molecules to form nitrogen oxides (NO). To ensure complete combustion, an amount of 'excess air' needs to be provided. This has an effect on boiler efficiency. The control of the air/fuel mixture ratio on many existing smaller boiler plants is 'open loop'. That is, the burner will have a series of cams and levers that have been calibrated to provide specific amounts of air for a particular rate of firing. Clearly, being mechanical items, these will wear and sometimes require calibration.

II. WORKING PRINCIPLE

This type of project is used to steam storage areas. When the high pressure of steam flow through the turbine in that turbine will be rotate the rotating speed is depends upon the pressure of stem flow. For this tank we are using pressure gauge it is maintain the tank or steam pressure. heater using heat water Dynamo is coupled with turbine it is a permanent magnate with a coil arrangement whenever the turbine is rotating the moving coil in the dynamo also rotate. Due to that alternating voltage is generated. Then AC voltage is given to rectifier circuit to convert the DC voltage. After that the rectified voltage is fed to filter circuit in order to filter the AC ripples. Then the filtered DC voltage is stored in the Battery. This steam power converts to inverter and activate the CFL lamp. This stored DC voltage used to different

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application. Through this way electric power is generated and compensated to the electric demand. So this project is steam power plant.

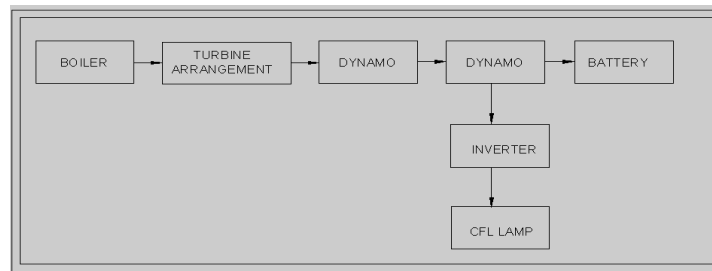


Fig.3 Block for Steam Power Plant

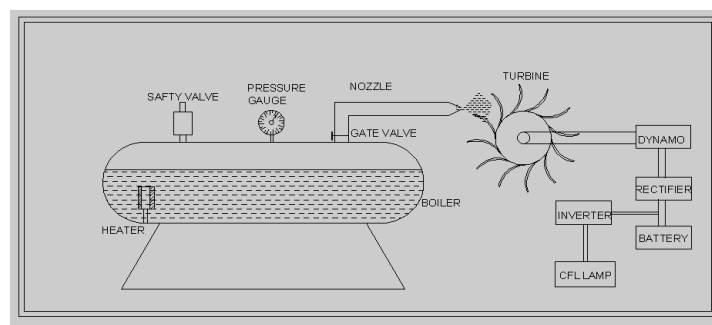


Fig.4 Drawing for Steam Power Plant

1. STEAM TURBINES

Steam turbines extract heat or Btu's from steam and transform it into rotational energy by expanding the steam from high to low pressure, resulting in mechanical work. Small and intermediate-sized steam turbines are used for a wide range of applications, including power generation, drivers for mechanical services. When coupled with gears they can be used to drive fans, reciprocating compressors and other classes of low-speed machinery. The largest turbine applications are generator drives in utility and other central power stations.

2. BOILER

A boiler is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. The heated or vaporized fluid exits the boiler for use in various processes or heating applications including water heating, central heating, boiler-based power generation, cooking, and sanitation.

3. STEPPER MOTOR

Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. Since the shaft of the motor moves only the number of degrees that it was designed for when each pulse is delivered, you can control the pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current sent to the stator and the number of turns in the windings.

4. DYNAMO

Dynamo is a device that makes direct current electric power using electro magnetism. It is also known as a generator. It is an electrical generator that produces direct current with the use of a commutator. Dynamos were the first

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electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. Today, the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons. A dynamo has the disadvantages of a mechanical commutator. Also, converting alternating to direct current using power rectification devices is effective and usually economic.

5. PRESSURE GAUGE

Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure pressure are called pressure gauges or vacuum gauges. A manometer is an instrument that uses a column of liquid to measure pressure, although the term is often used nowadays to mean any pressure measuring instrument. A vacuum gauge is used to measure the pressure in a vacuum which is further divided into two subcategories, high and low vacuum and sometimes ultra-high vacuum. The applicable pressure range of many of the techniques used to measure vacuums have an overlap. Hence, by combining several different types of gauge, it is possible to measure system pressure continuously from 10 mbar down to 10^{-11} mbar.

6. SAFETY VALVE

A safety valve is a valve mechanism which automatically releases a substance from a boiler, pressure vessel, or other system, when the pressure or temperature exceeds preset limits. It is one of a set of pressure safety valves (PSV) or pressure relief valves (PRV), which also includes relief valves, safety relief valves, pilot-operated relief valves, low pressure safety valves, and vacuum pressure safety valves. Safety valves were first used on steam boilers during the Industrial Revolution. Early boilers operating without them were prone to accidental explosion. A gate valve also known as a sluice valve, is a valve that opens by lifting a round or rectangular gate wedge out of the path of the fluid. The distinct feature of a gate valve is the sealing surfaces between the gate and seats are planar, so gate valves are often used when a straight-line flow of fluid and minimum restriction is desired. The gate faces can form a wedge shape or they can be parallel.

7. APPLICATION

1. Thermal Efficiency of a Steam Turbine is higher than that of a Reciprocating Engine.
2. The Steam Turbine develops power at a uniform rate and hence does not require Flywheel.
3. No internal lubrication is required for Steam Turbine as there are no rubbing parts inside.
4. No heavy foundation is required for Turbine because of the perfect balancing of the different parts.
5. If the Steam Turbine is properly designed and constructed then it is the most durable Prime Mover.
6. Much higher speed may be developed and a far greater range of speed is possible than in the case of Reciprocating Engine.

III.CONCLUSION

A miniature steam power plant was presented. Construction and operation details were explained. The voltage generated by the power plant is enough to lighten two LEDs. Energy efficiency is very low. This is because the built miniature power plant is far from being optimized like a real world one is. From the description presented is the text although the working principle is the same there are profound differences between a real steam power plant and the model described in this paper that directly affect efficiency. The major difference is the steam temperature difference between steam going to and existing the turbine. In a real world plant steam enters the turbine at 550°C and exit at a relatively low temperature although higher than ambient temperature. In this model the steam enters the turbine at about 120°C and leaves the turbine still very hot ;steam temperature was not measured but it is hot enough to burn the skin. Despite very poor efficiency the device is very eye-catching and especially suitable for science fair events.

REFERENCES

- [1] boyes, walt (2008). instrumentation reference book (fourth ed.). butterworth-heinemann. p. 1312.
- [2] hills, richard l. (1989). power from steam. cambridge university press. p. 33. isbn 0-521-45834-x.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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- [3] hewison, christian h. (1983). locomotive boiler explosions. david and charles. p. 12. isbn 0-7153-8305-1.
- [4] fluid power, naval education and training command, navetra 12964, july 1990, 0502-lp-213-2300
- [5] http://www.tpub.com/content/engine/14105/css/14105_87.htm
- [6] thermal power station –wikipedia, the free encyclopedia
- [7] asme boiler and pressure vessel code, section i, pg-5.5, american society of mechanical engineers (2010)
- [8] bs en 14222: "stainless steel shell boilers"