Waste Heat Treatment from Wood Seasoning Plant

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Abstract—***At Present in India and all over the world,wood is the first choice to make furniture for houses, offices and for industry. To make a good furniture wood should be dry and chemically treated to protect from termite. This treatment is done at wood seasoning plants where first, wood is chemically treated in chemical tank for 1-2 days and second, chemically treated wood is placed in seasoning chamber to dry it for 2 weeks. Saturated steam is used in chamber to dry the wood. This steam is produced by a baby boiler in which water used to produce steam and wood scrap is used as fuel. Steam is passes through the pipes and fins in chamber where fans circulate heated air in chamber evenly and remove moisture from wood. During this process they burn lots of fuel and use temperature and pressure of steam above their need. In this paper we steam turbine between boiler and seasoning chamber to use this extra temperature and pressure to produce electricity for the plant. The steam exhausted from the turbine will have sufficient temperature and pressure that can be used to dry the wood in chamber. Wood Seasoning Plants have generator as backup of electricity. They usually run generator 2-3 hrs per day. If they generate their own electricity they won't need the generators that will reduce the pollution due to generators and can save their daily p.u cost of electricity.***

KEYWORDS: Steam Turbine, Wood Seasoning Plant, Waste Heat Treatment, Electric Power.

INTRODUCTION

Wood seasoning is going to be a great business today. At present in my town Sardarshahr, Situated in Churu District, Rajasthan, there are 20-25 seasoning plants. Basically wood seasoning plant is established to dry the moisture present in wood. Now this wood is used for making furniture. The basic principle of this plant is to use the steam, which is generated by the baby boilers. This steam is highly heated and pressurized and used to raise the temperature of air present in seasoning chamber, now this air is used to remove the moisture from the wood. The temperature used in this process is about 100^{o} – 120^{o}C and pressure is about 50-70 psi.

The actual heating capacity of boiler (Baby boiler) is 200-220^{o}C at 120-160 psi. Generally these boilers run on their maximum capacity but heat and pressure losses between boiler and seasoning chamber are quite high. So the extra fuel (wood scrap) goes waste. These boilers do not have any provision to check the quantity of fuel supplied. Huge quantity of wood scrap is available there. So the plant owners do not care about fuel consumption.

Our idea to run the small capacity steam turbine using this waste heat and pressure. This turbine would be coupled to an alternator to generate the electricity. The basic principle of this arrangement is to use the turbine before the seasoning chamber to use the maximum capability of boiler and then supply the exhaust steam to seasoning chamber which still has sufficient heat to season the wood.

BOILER USED IN THE PLANT

Boiler is a pressure vessel, which is used to convert water into steam at high pressure and temperature. Generally to supply heat fuels like coal, diesel, wood, etc are used. Here in seasoning plants wood scrap is used as fuel. This wood scrap is available in their handicraft workshops in huge amount. Generally the boiler that is used for the plant is baby boiler and its temperature and the pressure is 200-220^{o}C and 10 bar respectively. The pressure can be raised up to 15bar by some suitable arrangements. Evaporation capacity of boiler is 500Kg/Hr at 100^{o}C. The boilers run 24 Hrs continuously for 8-10 days in summer and 15- 20 days in winter for one lot of wood. This process may be revised twice in a month. So we can get the steam regularly for this time period.

Specification of Boiler used in Wood Seasoning Plant:

Evaporation capacity: 500 kg/hr. at 100 degree Celsius
Steam condition: saturated
Operating pressure: 12 bar
Safety valve set pressure: 10 bar
Design pressure: 16 bar
Hydraulic test pressure: 10 bar
Max steam temperature: 200- 220^{o} C

Fig 1 Baby Boiler

SEASONING CHAMBER

This is the chamber where seasoning process of wood takes place. This chamber possess pipes with aluminum fins over their outer surface and fans to circulate air over the wood. Steam passes through these pipes and heat of steam is released in chamber surrounding through the fins.

The temperature required for this purpose is 80-90^{o}C and this temperature could be maintained by the exhaust steam of turbine. Pressure is not a subject of their interest.

IMPULSE STEAM TURBINE

Steam turbine is a mechanical device which converts heat energy of steam into mechanical energy. Steam from boiler is passed through the rotor blades of turbine and blades start to rotate by the high impact of steam about their axis. A drop in temperature and pressure of steam takes place during this process. The rotor is connected to the alternator shaft. Generally the steam turbines used in power plants are large in size and capacity and uses steam at high pressure of 50-70 bar and temperature of 350-500^{o}C but here in this arrangement we require a small capacity up to 10kW which require steam at approximate pressure of 10 bar and temperature 200^{o}C. For this purpose we consider impulse turbine.The impulse steam turbine have bucket shaped rotor blades and rotates by pressure exerted by the jets causes the rotor to rotate and the velocity of the steam to reduce as it imparts its kinetic energy to the blades. These blades change the direction of flow of the steam however its pressure remains constant as it passes through the rotor blades since the cross section of the chamber between the blades is constant. Impulse turbines are therefore also known as constant pressure turbines. Impulse steam turbine has series of alternate moving and fixed blades. The next series of fixed blades reverses the direction of the steam before it passes to the second row of moving blades. So the direction of rotor remains same and we will have steam from outlet at constant pressure and with loss of some temperature but still sufficient for seasoning chamber. At present impulse turbine are available only for utility purpose which is not compatible for our purpose. We can change number of series of moving and fixed blades as per our requirement which is possible. To maintain the temperature, insulation is required during all arrangement because if loss of temperature will high than it will not usable for seasoning chamber.

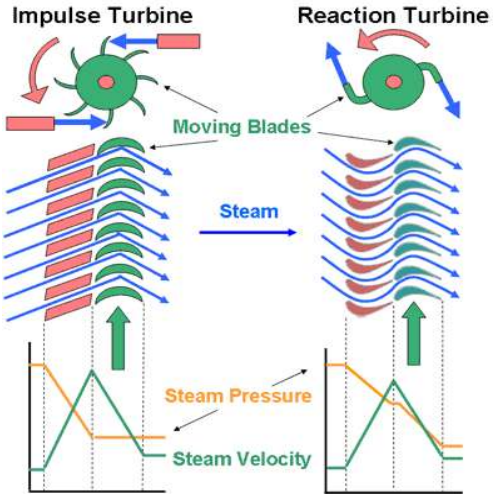

Fig. 2

In some wood seasoning plant they use two or more than two baby boilers as per their requirement. So we can use high capacity turbine with two nozzle jets so we can get good pressure to run blades. To control the pressure at nozzle end we can use automatic pressure control system because some time in factory workers uses more fuel than required which increases pressure and temperature and can damage the arrangement. So with automatic valve system we can control the pressure.

CALCULATION OF STEAM TURBINE

In a standard steam turbine, there is a 70% loss in steam pressure during expansion of steam. So we take 3 bar of pressure of exhausted steam from steam turbine.

Input Quantities to Turbine:

i/p Pressure: 10 bar

Steam Temperature: 200^{o} C

Evaporation Capacity (mass flow), m : 500 kg/hr (0.14 kg/s)

For P=10 bar and Temperature T=200^{o}C

h_1 = 2778.1 kJ/kg

S_1 = 6.587kJ/kg-K

V_1 = 0.194 m^3/kg

For P = 3 bar, we need to find the properties for s = 6.586 kJ/kg*K

S_{f2} = 1.672kJ/kg-K

S_{fg2}= 5.320 kJ/kg-K

Assumption, Inlet Mass Flows equal Outlet Mass Flow

$S_1 = S_2$

$S_1 = (S_{f2} + X_2 * S_{fg2})$, where x is the quality of the vapor

$6.587 = (1.672 + 5.320X_2)$

X_2 = 0.923

The enthalpy of this mixture can be calculated using the saturated liquid properties

H_{f2}= 561.5 kJ/kg

H_{fg2} = 2163.8 kJ/kg

$H_2 = (H_{f2} + X_2 * H_{fg2})$

H_2 = (561.5+ 0.923 * 2163.8) = 2557.949 kJ/kg at the exit

The isentropic work (or more accurately, the power) is therefore

$W_t = (H_1 – H_2) = m * (2778.1 – 2557.949)$ = 0.14 kg/s * 220.151 kJ/kg

W_t = 30.82 kJ/s = 30.82 kW

This calculation is done for loss of 70% at exhaust point but we can't reduce pressure to this level as required by seasoning plant. So we remains pressure of exhaust steam at 5 bar.

At pressure of 5 bar, with this calculation we will get 18 kW of power from Steam Turbine. With the losses in Alternator we can get 10-12 kW of electricity that will be sufficient for the plant.

ALTERNATOR

A device which converts mechanical energy into electrical energy, generally using electromagnetic induction. Basic principle of alternator is when a rotating magnetic field is cut by the coil, as per the Faraday's law if there is change of flux in the field, an e.m.f produces in the coil. Here source of mechanical energy may be given to the alternator by using steam turbine through shaft. We can generate up to 10kW of electricity by the pressure of 150 psi steam produced by baby boiler.

BENEFITS TO PLANT

This whole arrangement can be used to generate electricity. By using this whole arrangement an appreciable amount of electric power can be developed which can be used in seasoning plant itself. It will lead to save electricity and money.

BLOCK REPRESENTATION OF ARRANGEMENT

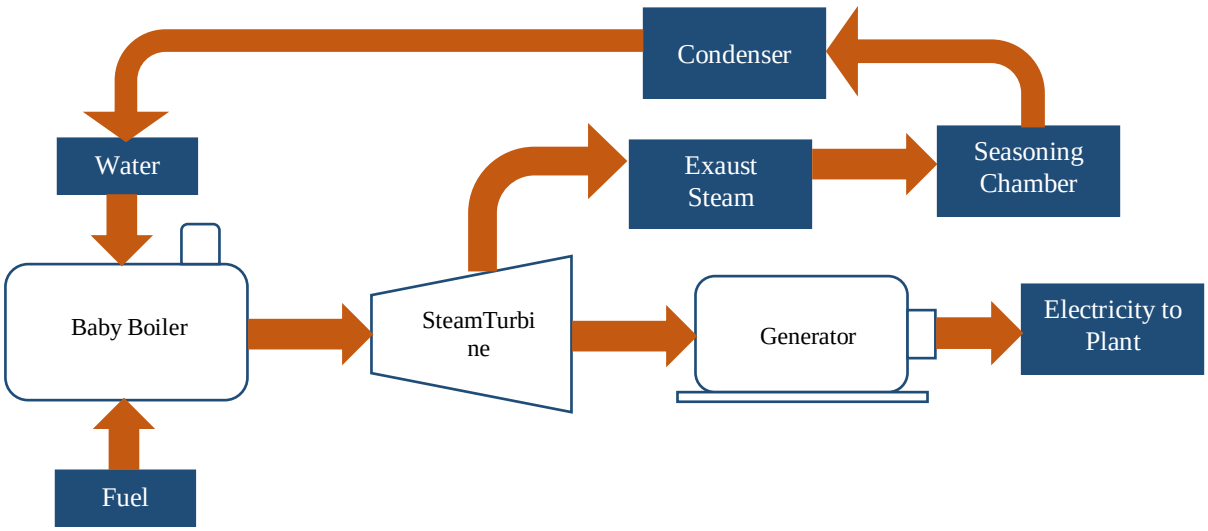

Fig. 2

As shown in fig steam is produced by the baby boiler using wood scrap, used as fuel, at temperature and the pressure is 200- 220°C and 10 bar respectively. Pressure of steam can be increased and controlled by nozzle and automatic pressure controller system at required level and further send to stream turbine using insulated pipes, to maintain temperature, to run turbine blades. Turbine is connected to generator through a shaft. When generator will run at rated rpm of alternator, electricity will be generated. At outlet of steam turbine we will get exhaust steam with little bit loss in temperature but still has enough temperature that can be used in seasoning chamber of the plant. This steam further circulated in pipes with aluminum fins over their outer surface which raise the temperature of chamber. Fans will circulate heated air over the wood and remove all the moisture from wood.Exhaust steam from seasoning chamber than passes through a condenser where it converts into water and can be reused in babyboiler.

CONCLUSION

In this paper I have found that we can generate sufficient electricity upto 10 kW from waste heat and pressure of baby boiler that will be very useful for the plant itself to run their machines and daily uses appliances. This energy can be stored in battery and used whenever plant will be in maintenance mode. In some factories who have two or more than two boilers they can generate upto 50 kW of electricity and can be distribute to nearby domestic customers and factories.

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