REVIEW OF SUPERCRITICAL FLUID WITH DESUPERHEATER ON RANKINE CYCLE FOR THERMAL POWER PLANTS

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Abstract
This paper presents a review of Supercritical Fluid for Rankine Cycle which operates on Thermal Power Plants as well as authenticate and studies the influence of Supercritical Fluid properties on cycle performance. This paper propose that the overall thermal efficiency of a Thermal Power Plant can be enhanced by using Supercritical Fluid with Desuperheater in Rankine Cycle which alleviates turbine and pump losses that occurs due to irreversibilities. The Rankine Cycle requires provoke and attention to work on thermal power plants with Desuperheater. Many of the practical embattlements associated with Carnot Vapour Cycle are eliminated in Rankine Cycle. The steam coming out of the boiler is usually in superheated state and expands in the turbine. After expanding in the turbine, the steam is condensed completely in the condenser in Rankine Cycle. But after many methods are adopted and aggrandizement done to increase Rankine Cycle performance it abolish almost all the ordeals suffer during its operation. The motivation of supercritical fluid in Rankine Cycle is to amend the cycle performance up to 49% which is not offer or not done by the methods adopted and development of Rankine Cycle, resilient all the practical difficulties occur and come through methods and aggrandizement previously adopted in Rankine Cycle. Desuperheater is benevolent to reduce the temperature of superheated steam procure from expansion of supercritical steam to superheated steam and restored it into the saturated steam which will help the working fluid (steam) to perform effectively in cycle for cycle progress. Therefore the efficacy of Rankine Cycle will be proved by research work if exist in future with invention to make new version of Rankine Cycle which mitigate or almost eliminate all the vulnerabilities of cycle.

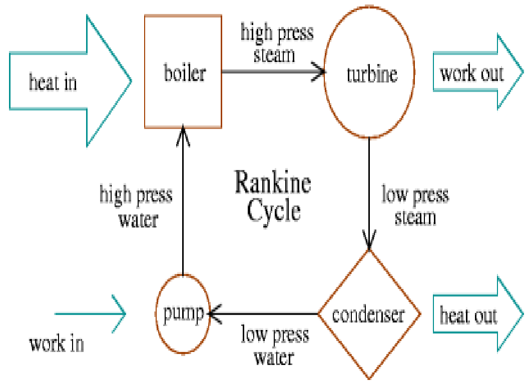
Index Terms: Desuperheater, Supercritical Fluid, Rankine Cycle, Thermal Power Plant.

1. INTRODUCTION

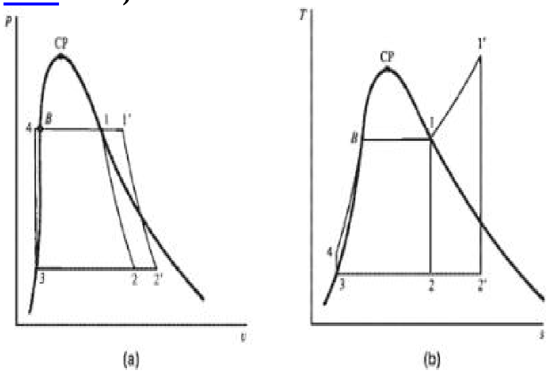
A Rankine Cycle works on Thermal power plants using water as a working fluid undergoes a change of phase. Heat is transferred to water in the boiler from an external source (furnace, where fuel is continuously burnt) to raise steam. The high pressure, high temperature steam leaving the turbine condenses into water in the condenser (where cooling Water circulate heat), and then the water is pumped back to the boiler. A Rankine Cycle was devised and accepted as the standard for steam power plants to generate a major fraction of electric power from plant produced in the world. However maximum portion of steam is lost in form of thermal energy due to irreversibilities and losses in Rankine Cycle. The research work introduces the use of expanded steam deployedly in Thermal power plant by using Supercritical Fluid. The review focus on Analysis of Supercritical fluid with Desuperheater on Rankine Cycle for thermal power plants to find the beat solution of steam procure from operated supercritical fluid from boiler and expands into the turbine which on evoke gives the amiable and aesthetic up gradation of Rankine Cycle with minimum liabilities and maximum efficiency of49% that will exist in future research work, rather than emphasized working on progressive methods of Rankine Cycle for its better performance further.

1.1DESCRIPTION OF RANKINE CYCLE

The description can be easily comprehended by seen in the block diagram of Rankine Cycle with its PV and TS chart.



"Fig1.1" (a) Block Diagram of Rankine Cycle (STC-System-backwww.theloveplan.org/stc/stc.system back).

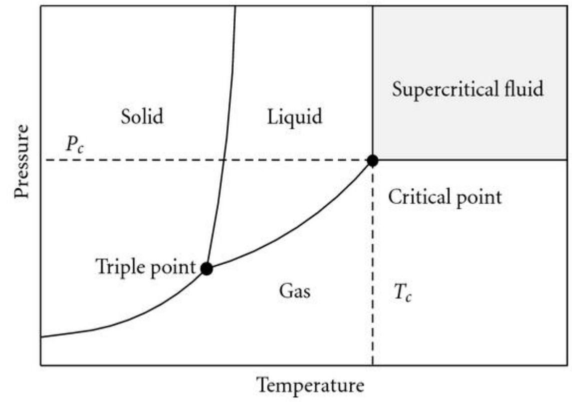


"Fig1.1" (b) PV and TS diagram of Rankine Cycle (Steam Power plants By – Philip Kiameh).

In above PV and TS diagrams the critical point is stated which shows that at this point the latent heat of steam is zero.

2.1 REVIEW OF SUPERCRITICAL FLUID

A SCF is defined as a substance above its critical temperature (T_C) and critical pressure (P_C). The critical point represents the highest temperature and pressure at which the substance can exist as a vapor and liquid in equilibrium.



"Fig2.1" PT curve of Supercritical Fluid (www.hindawi.com journals of nonmaterials Supercritical CO2 foaming).

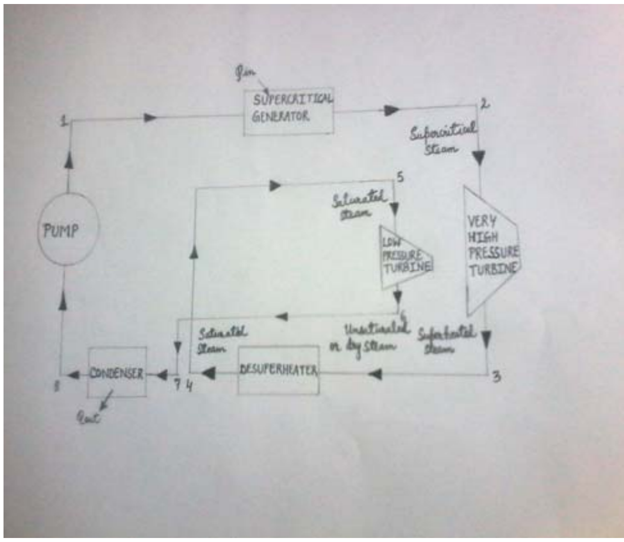
3. DESCRIPTION OF DESUPERHEATER

Desuperheater is a critical component used in the management of steam for power generation. Desuperheating is the process by which superheated steam is restored to its saturated state, or the superheat temperature is reduced. Most Desuperheater used to restore the saturated state produce discharge temperatures approaching saturation. When steam is used for mechanical power, such as driving the turbine rotor by expanding across turbine blades; it is most efficient when superheated. When steam is used for heating or other heat transfer or industrial process purposes, it is most efficient when saturated. A Desuperheater then, is a device that lowers the temperature of superheated steam and restores it to saturated steam so that it can be used effectively for industrial uses. Therefore Desuperheater is a device that injects a predetermined amount of water into a steam to reduce its temperature up to the requisite temperature.

4. CYCLE REVIEW

It is based on working operation of cycle in which Supercritical Fluid is introduced as a working fluid to work on cycle progressively.

The review can be seen aesthetically in Calculations of Cycle in which all the components work efficiently to give best evoke of Cycle performance that Cycle claims in review as a result.



“Fig 4” Supercritical Fluid Rankine Cycle with Desuperheater.

Working operation:-

1. Boiler (Supercritical generator) to Very high pressure turbine.
2. Very high pressure turbine to Desuperheater.
3. Desuperheater to Low pressure turbine
4. Low pressure turbine to Condenser
5. Condenser to Pump.
6. Pump to Boiler (Supercritical generator).

4.1 CALCULATIONS OF CYCLE

In Supercritical Generator

Heat supplied to Supercritical Boiler = h2- h1

In Condenser

Heat rejected from condenser = h8-h7

In Very High Pressure Turbine

Work Done = h3-h2 (1)

In Low Pressure Turbine

Work Done = h6-h5 (2)

In Pump

Work Done = h1-h8 (3)

Desuperheater performance

Enthalpy into process = Enthalpy out of process

$$\dot{m}_{cw}\, h_{cw} + \dot{m}_s\, h_s = \dot{m}_s\, h_d + \dot{m}_{cw}\, h_d$$

$$\dot{m}_s\, h_s - \dot{m}_s\, h_d = \dot{m}_{cw}\, h_d - \dot{m}_{cw}\, h_{cw}$$

$$\dot{m}_s(h_s - h_d) = \dot{m}_{cw}(h_d - h_{cw})$$

$$\dot{m}_{cw} = \frac{\dot{m}_s(h_s - h_d)}{(h_d - h_{cw})}$$

Where:

m_{cw} = Mass flow rate of cooling water (kg / h)

$\dot{m}s$ = Mass flow rate of superheated steam (kg / h)

h_s = Enthalpy at superheat condition (kJ / kg)

h_d = Enthalpy at desuperheated condition (kJ / kg)

hcw = Enthalpy of cooling water at inlet connection(kJ / kg)

Effective Work Done = Work Done by Turbines (Very High Pressure Turbine + Low Pressure Turbine) - Work Done by Pump
= [{(h3-h2) + (h6-h5)} - (h1-h8)]

Thermal Efficiency = Effective Work Done /Heat Supplied = [{(h3-h2) + (h6-h5)}-(h1-h8] / h2- h1

5. RESULT OF CYCLE REVIEW

It demystify the efficiency of Rankine Cycle can be progressed by using supercritical fluid with Desuperheater which explicates that supercritical steam of supercritical fluid can directly flash into superheated steam after expansion. The superheated steam is effectively used in Desuperheater which reduces its temperature up to the temperature of saturation steam before entering to condenser. Therefore from above calculations of cycle review it can be proved in future research work that the efficiency of Rankine Cycle using Supercritical Fluid with Desuperheater will increased up to 49% which is beat and optimistic for thermal power plants to work effectively with liberation of minimum emissions.

6.CONCLUSION

The research work if exist or done in future will augmented the thermal efficiency of Rankine Cycle by mitigating all the losses and clogs occurs previously from the amending methods of Rankine Cycle. It can only be possible if Supercritical Fluid is used in Rankine Cycle with Desuperheater for Thermal power plants cumulate the efficiency up to 49% and mollifying emissions at a greater extent as analogous to the emissions of prerequisite methods of Rankine Cycle. Hence it may widely find its applications unabortively in fields like-

1. Thermoelectric Power Generation. 2. Thermoelectric Refrigeration System.

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