Performance Evolution of 11.5 MW Steam Turbine of MSW based Power Plant

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Abstract - This study presents the performance evaluation of a steam turbine efficiency of 11.5 MW of MSW based power plant . The steam turbine efficiency at 11.5 mw, MSW based power plant has been evaluated and obtained with & without bleeding system used for regenerative purpose. It has been observed that the efficiency at turbine increases when number of bleed increases at specified inlet steam flow, pressure and temperature . Finally concluded that if double bleeding is used , the efficiency at turbine is increased by 1.2% with comparison of single bleed. also calculated the single bleed is increase by 1.9% with comparison of without bleed.

Keywords: MSW Power Plant, boiler, turbine inlet and exhaust temperature, turbine inlet and exhaust pressure, Rankine cycle, Regenerative cycle.

1.Introduction

This 11.5 MW is a waste to energy based power plant using municipal solid waste (MSW) as a fuel, procuring from Jabalpur and it's adjoining areas and approximately 900 tons of disaggregated municipal solid waste is used daily. Reducing approximately 37000 ton of carbon emission in Jabalpur annually. There are environmental benefits that can be derived from these plant. This most common MSW plant produces electricity and uses the heat of combustion to produce steam that rotates the turbine coupled with generator so producing electricity.

MSW Plant not only helps to treat the waste material but also produce electricity by incineration of various components having high calorific value.

MSW plant is designed to combust unrecyclable and simultaneously recuperates the energy and cleans the gases generated from combustion. By definition, waste incineration is carried out with surplus of air. This process releases energy and produces solid residues as well as a flue gas emitted into the atmosphere.

1.1Types of wastes categories:

1.1.1 Residential Waste:

- Vegetable waste – Peeling waste, discarded vegetables, food waste, discarded, food seeds, etc Paper – paper scraps, packing papers, discarded papers from student's bags, etc.
- Plastic – plastic articles, polyethylene, and other items made of primarily plastic Glass – scrap of glass, bottles, glass containers, broken kitchen items made of glass and ceramics, etc.
- Cardboards – non-recyclable paper, cardboards, cartons, etc.
- Others – metallic items, can, jars of metal, dirt and other inert materials.

1.1.2 Commercial Waste:

Amount of commercial waste included the wastes from the business centers such as restraints, hotels, community centers, shopping malls, offices, market place etc.

1.2Material Collection:

Collection and transportation by the Jabalpur municipal corporation Jabalpur one of the four major cities in M.P. with a population of approx 25 lakhs. Approx 1200 tons per day waste collection of JMC. The JMC is responsible for the collection of MSW. The MSW dumping in plant waste pit through waste transportation vehicle.

1.3Input and output of power plant

1.3.1Input:

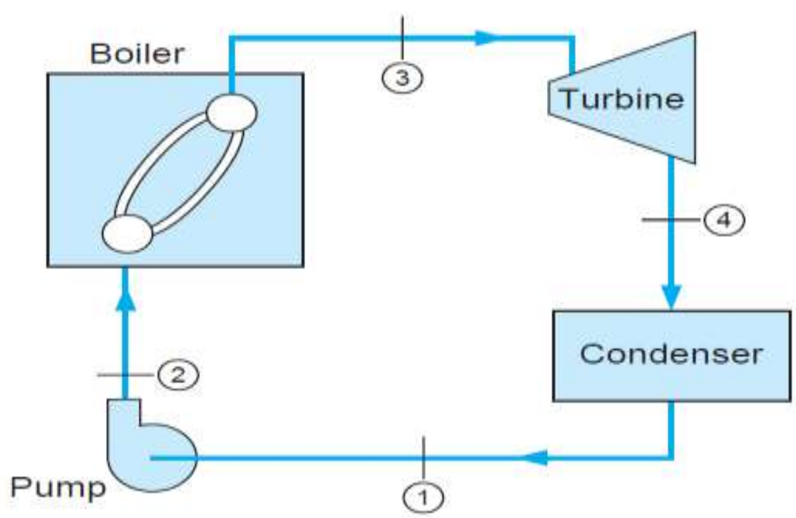
- MSW feed;
- Extra fuels assisting incineration (if needed);
- Energy used for air preheating;
- Energy used for feed water preheating.

1.3.2 Output:

- Electricity generated;
- Energy remained in exhaust steam;
- Energy remained in bottom ash;
- Energy remained in exhausted flue gas;
- Other energy losses during the process due to the radiation or efficiency of equipment.

1.4 Main component of steam power plant

- Turbine
- Boiler
- Condenser
- Feed Pump



1.5Using Cycle

- Rankine Cycle
- Regenerative Cycle

1.5.1Rankine Cycle

The steam turbine power plant is based on the rankine cycle which consists of five processes: two isothermals, two isentropic and one constant pressure.

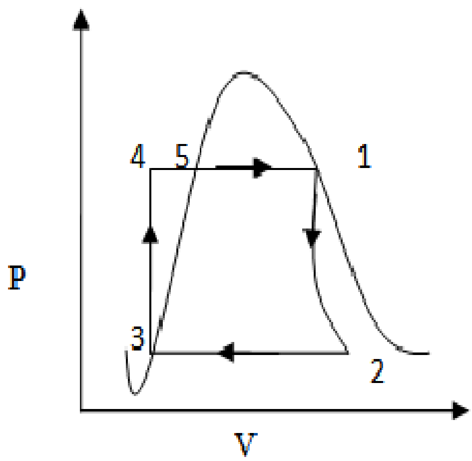


Fig.4 P-V diagram of rankine cycle

- Process 1-2: This shows the isentropic expansion of steam in the turbine from pressure P1 to P2.
- Process 2-3: At constant pressure P2 and temperature T2, the exhaust steam from the steam turbine is condensed in the condenser.
- Process 3-4: The water from the hot-well or the surge tank which is at low pressure is pumped into the boiler at high pressure P1. Here pumping process 3-4 is isentropic.
- Process 4-5: As the water enters the boiler, water is first heated up to the saturation temperature or evaporation temperature T1 called sensible heating and during this process the state point moves along curve 4-5. The heat supplied during this process is hf**5**-hf**4** and is called sensible heat of water.
- Process 5-1: At constant pressure P1 and temperature T1, water is completely evaporated into steam. The heat supplied in this process is equal to h1-hf5 and is called latent heat of vaporization.

1.5.2 Regenerative Cycle:

In this cycle, the feed water is preheated by means of steam taken from some sections of the turbine, before it enters the boilers from the condenser. This process of draining steam from the turbine at certain point during its expansion and using this steam for heating the feed water supplied to the boiler is known as “Bleeding.” The effect of this process is to supply the boiler with hotter water while a small amount of work is lost by the turbine.

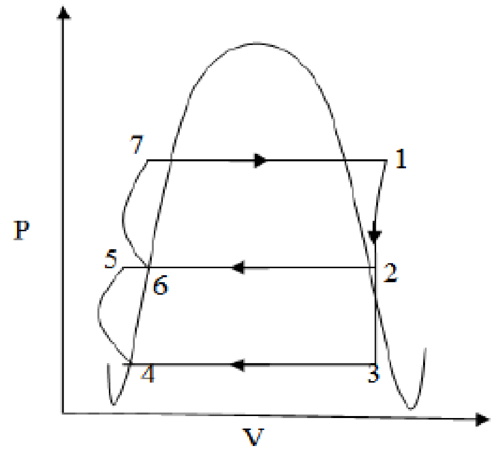


Fig.5 pv diagram of regenerative cycle

- Process 1-2: The steam is bled from the turbine and passed on to the heater.
- Process 1-3: This shows the isentropic expansion of remaining steam in the turbine from pressure P1 to P3.
- Process 3-4: At constant pressure P3 and temperature T3, the exhaust steam from the steam turbine is condensed in the condenser.
- Process 4-5: Here the feed water from condenser is pumped to heater.
- Process 5-6: In this heater (1-ms) kg of steam is heated.
- Process 2-6: In this heater ms kg of steam condenses.
- Process 6-7: The water from the heater which is at low pressure is pumped into the boiler at high pressure.
- Process 7-1: At constant pressure P1 and temperature T1, water is completely evaporated into steam.

2. Methodology

This Research paper is based on live data collection using two bleed steam at pressure of 5bar and 1bar respectively and find out the efficiency of existing turbine at these bleed stage.

Also find out the efficiency of the turbine based on the data given in the following table and respective calculation are based on three condition single bleeding, double bleeding and without bleeding. Following table show the collected from plant

2.1Performance data at different load

Sr.No.	Load In MW	Boiler			Steam turbine			Auxiliary Power Consumption	
		Pressure (kg/cm^2)	Temper ature ^oC	Flow TPH	Pressure (kg/cm^2)	Temperat ure ^oC	Flow TPH	Load KW	%
1	11.5	44.2	426	56	43.2	413	55.1	1084	9.42
2	11.0	43.3	418	53.9	42.5	407	52.7	1050	9.54
3	10.5	44.4	415	50.7	43.1	403	49.0	1016	9.68

4	10.0	42.5	421	50.0	41.7	406	48.5	1036	10.36
5	9.5	43.6	410	48.0	42.2	394	46.4	1065	11.21
6	9.0	42.1	414	45.4	40.9	400	43.8	1045	11.62
7	8.5	42	400	44.9	41.5	378	43	1020	12.0
8	8.0	42.6	414	42.1	41.7	395	40	970	12.13
9	7.5	42.4	393	42	41.4	382	41.2	965	12.87
10	7.0	41.5	400	37.2	40.8	393	35	950	13.57
11	6.5	43.2	402	33.6	41.8	396	32.1	928	14.28
12	6.0	41.8	395	33	40.1	377	32.3	895	14.92

2.2 Fuel Consumption

Sr.No.	Load	Approx Total fuel	Approx Fuel/mw
1	11.5 MW	900 TPD	3.26 T/MW
2	10MW	870 TPD	3.63 T/MW
3	9MW	830 TPD	3.85 T/MW
4	8MW	780 TPD	4.06 T/MW
5	7MW	720 TPD	4.25 T/MW
6	6MW	630 TPD	4.38 T/MW

3.Result

Chart 1 Compare Efficiency Versus Bleeding

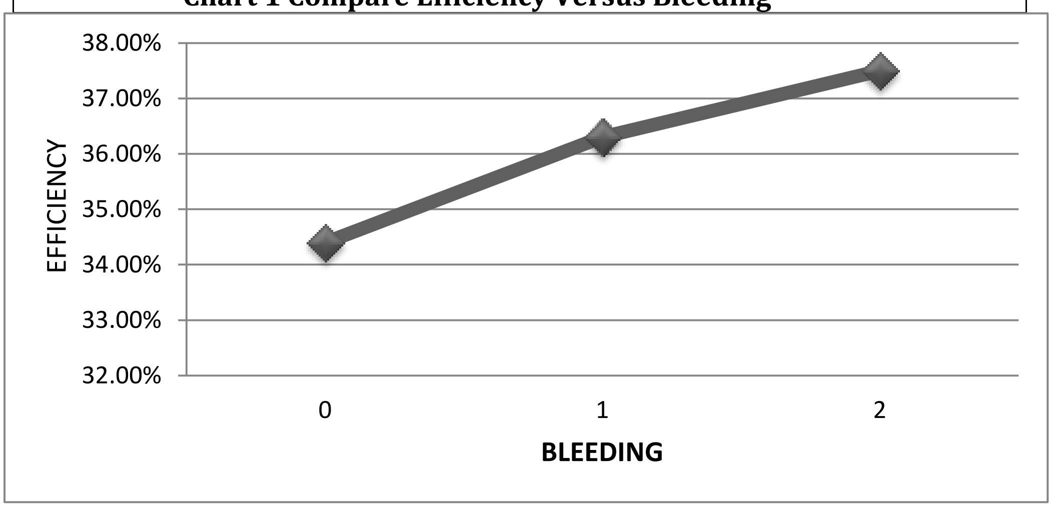
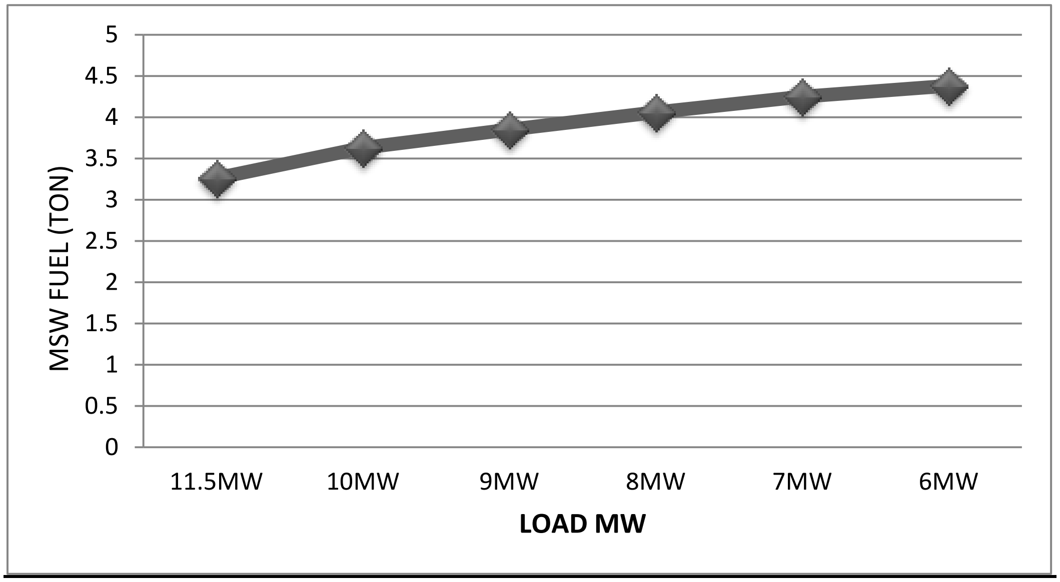


Chart 2 Fuel Consumption Ton Per day



4. Conclusion : As it's shown above that

1. if double bleeds are used the efficiency of the turbine is increase by 1.2% when both the bleeds works on full load.
2. If single bleed are used the efficiency of the turbine is increase by 1.9% when bleed works on full load.

If there is no bleeding the efficiency of turbine increase because of the amount of steam has not been taken out by bleeds which were passing to regeneration hence the enthalpy of the total steam, i.e. entering to steam inlet and exhaust outlet is totally converted work so isentropic is increase.

5. References

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