Journal of Advanced Mechanical Sciences (JAMS)
ISSN: 2583-3790 (Online)
"J. Adv. Mech. Sci., vol. 1, no. 4, pp. 108-113, December 2022"

Studies on Performance Assessment in Back Pressure Turbine

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Article received: 05/11/2022, Article Revised: 01/12/2022, Article Accepted: 10/12/2022
Doi: 10.5281/zenodo.7438348

Abstract

The backpressure turbine is used for supplying process steam to the facilities of power generation. This type of steam turbine not only produces electricity but also supplies low-pressure steam for various requirements. It can be a single or a multistage turbine which is generally used in industrial plants. Various bleeding points can also be incorporated where, the steam can be extracted at intermediate but constant pressures, or it can be used for process heating after fully expanding within the turbine.

Keywords: *Backpressure Turbine, Multistage Turbine, Bleeding points, Process heating, Power plants.*

1. INTRODUCTION

The steam turbines are widely used for generating electricity using the high enthalpy/energy steam and making it pass through a single or a series of turbines working at different pressures.Each of the turbine works at a different pressure which indirectly plays a role in the improvement in some of the parameters of a thermal/steam power plant. High energy steam experiences a pressure drop which is due to the utilization of that energy in rotating the turbine blades, which when connected to a large-scale generator, produces electricity. There are alternative ways to improve the performance of a steam turbine power plant. One of the ways of improving the performance is the usage of a backpressure turbine for regeneration. In regeneration, some amount of steam is bled from the turbine at intermediate pressures and passed through low-pressure heat exchangers. Regeneration brings down the work produced by the turbine but in turn, increases the efficiency of the thermal power plant Apart from regeneration; the backpressure turbine can be combined with heat and power-producing plants.The different combinations of the backpressure turbine can lead to the benefits of increased performance characteristics.

2. PERFORMANCE ANALYSIS OF BACKPRESSURE TURBINE

A power station from the United Arab Emirates was taken into consideration by Baghdadi et al. [1] for the study. Under the usage of 3 sets of backpressure turbines, which uses the moderate pressure steam available from the turbine. The steam was observed at 210 ^{o}C and 16 bar (abs) pressure. This steam generated could be passed on to the super heaters and then via backpressure turbines to the desalination plant. Around 68% of the steam produced can be considered as free.

In a study conducted by Jungwan et al. [2] PRV (Pressure reducing valve) was substituted by a backpressure turbine generator incorporating a radial outflow turbine (ROT). A three stage ROT (Radial Outflow Turbine) used in this study is designed for backpressure turbine generator systems. Performed using turbine blade tip clearances (1%, 3%, and 5%) and checked the performance. When the tip clearance varied, the rpm of ROT varied from nearly 9000 to around 11,000 rpm and output was in the range 8.68 kW to 12.79 kW. The best performance was obtained using 1% tip clearance.

In the thermodynamic study done by Naufal et al. [3] utilization of ORC (Organic Rankine Cycle) as the bottom cycle having different working fluids was aimed at extra electricity using backpressure turbine. The ORC was used to use squandered steam from 2 backpressure turbines. The best working fluids turned out to be C_5H_{12} and C_3H_4, having generated 2.25 MW & 2 MW. The working medium also attributed to the soaring thermal efficiency of around 10.50 % and 10.40 %.

Stepanova et al. [4] analyzed the steam turbine unit using a backpressure turbine for both heat and power generation. The optimization calculations for the usage of STU in 2 areas with varying climate conditions and cost of fuel were performed. Co-generation under consideration STU exhilarates the heat utilization coefficient value in the range from 0.91 to nearly 0.95, the coefficient of heating from 0.578 - 0.581. These are the range of the electricity cost for the tworegion from 2.9 to 4.2 cents/kW and 2.99 to 4.28 cents/kW.

In this research by Wang et al. [5] a 300 MW coal fired system which is a combination of heat and power was taken into consideration. Energy, exergetic parameters of large backpressure unit and conventional H and P setup combination are collated. Thermal energy magnitude and net energy of large backpressure system were greater than the ECS having around 18% and around 35% surge of the total thermal & generation efficiency. The available energy efficiencyof large backpressure unit was approximately 8% more as compared with ECS. The available energy efficiency for generation of large backpressure unit and usage of the condensing unit in the range of 40-50% respectively. The concept of wells using geothermal energy with elevated pressure by the usage of backpressure unit by [6] between 17 (bar) entry and 9.5 bar exit pressure. 7.75 MW of electric output of the unit was highly efficient and nearly 82% available energy efficiency in a backpressure unit with 85% reversible adiabatic efficiency. Gross maximum exergy energy in steam was nearly 90 MegaWatt, along with that, the available energy present in steam at exit of unit was nearly 80 MW and nearly 5 MegaWatt of available energy was wasted when passed through throttling valve [6].

The study by Samanta et al. [7] discusses 3E analysis of a naturally gas fired multi-generation unit is studied in the current study. A GT block having persistent 30 MW O/P, bottom backpressure steam turbine unit having varying electrical O/P & a beneficial high temperaturewater production unit were used. Initial performance of unit reveals that working unit is having nearly 35% electric efficiency which is considered having an energy-saving ratio of nearly 40 %. The gas turbine plant in combination with a backpressure steam turbine(CCGT-BP) is studied in this study by Antonova et al. [8]. The techno-economic efficiency of the above combination is studied. The efficient performance of the plant doesn’t vary with the combined gas turbine plant backpressure CCGT-BP heat efficiency. When the feed water temperature increases by 40 degree celsius, the usefulness of HRSG decreases by nearly 10 % and lessens magnitude of thermal energy by nearly 9 %, gross magnitude of CCGT-BP effectiveness is reduced around 4% [8]. This analysis focuses on of energy & maximum available energy thermal analysis of backpressure turbine unit in sugar-producing plant by Aijaz et al [9]. In this analysis, the efficiencies of energy, exergy and exergy loss, heat transfer rate of the turbine are evaluated at above 68% & 85% MCR of the backpressure unit. Results reveal that the considered unit at 85% MCR lead to heat transfer surge by nearly 17 KJ/kWh.

The study by Igor et al. [10] for backpressure turbine, heat and power combination plant and mechanical efficiency nearly to 98%, losses in a mechanical sense nearly 1935 kW and generation of approximately 6300 kW of power. A surge in the surrounding temperature for 10°C led to a change of turbine exergetic efficiency for lower than 0.5 % followed by with a meanincrease of turbine exergetic loss for 266 kW [10]. The analysis for the backpressure turbine used. A probabilistic method using Monte Carlo simulation. Geothermal wellhead generating unit (GWGU) is analyzed by Ahmad et al.[11]. The simulation method used for total power output calculation had done 50,000 iteration successfully. The output of the analysis is the probability for 3 different types of considerationsof total power output which are nearly 1.8 MW, 2.2 MW and 2.7 MW.GWGU backpressure isthe best way for greenfield development projects. The approach was focused upon thermo-analysis of HBP heat procedure of a 300 MW. Heat power combination by Xiao et al.[12]. The results showed that model encouraged the thermal efficiency of model nearly 6 % and reduced the coal intake by approximately 24 g/(kWh), contributing to the waste steam recovery effectiveness of around 60% and power production surge of nearly 25 MW.

A conventional two 350MW supercritical units were observed by Sun et al. [13]. A backpressure torrential heating method for 2 combined construction of a huge steam turbine power production systems is suggested. Mean coal requirement during the summer is around 206 g/kWh for the calculated heating of 52 g/kWh lesser, compared to the conventional heating mode. The coal intake rate of nearly 200 g/kWh was delivered for the largest thermal load value. Considerable savings in the energy and release of carbon dioxide drop is obtained. This analysis deals with reinstating low-pressure cylinder rotors and analysis of nearly 150 MW turbines is done by Ma et al. [14] whose exit steam was recuperated completely. A better mathematical model was utilized to analyze the effect of exit pressure on turbine power production efficiency. This experimental intake index for heat transfer is nearly 13 kgce/GJ, whose value is significantly lesser than the conventional system (20 kgce/GJ) where (kgce – Kg of coal equivalent).

The turbine’s exit stream of steam used for combined cycle as a bottom unit. Wijaya et al. [15] studied appending solar storage and storage of thermal form of energy as additional parts in the combined system. The combined system usage has slightly lessened thermal efficiency from nearly 11.4% to 11.3%. The combined system has somewhat surged the exergetic efficiency,from 44.15% to 44.40% [15].

3. CONCLUSION

- The backpressure turbine is most widely used in combined heat and power cycle.
- The pressure at the outlet of the turbine is taken advantage of and the regeneration used reduces the fuel consumption in a plant

- This concept is also popularly used in geothermal plants for power generation as well as the heat transfer.
- Probabilistic approach, Monte Carlo simulation and other such iterative techniques can be applied to find out the parameters.
- Parameters such as the fuel consumption, Exergy loss, Efficiency of the plants and the others were studied and the results were put out in a concise manner.

Acknowledgement/Funding Acknowledgement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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