ID: 1061

The Thermodynamic Study and Increasing the Efficiency of a Gas Turbine by Recovery of Exhaust Gases

FATIMA Bachir*, AHMED Hafaifa, NADJI Hadroug

Applied Automation and Industrial Diagnostics Laboratory LAADI, Faculty of Science and Technology, Ziane Achour University of Djelfa, Algeria

*Corresponding author's email: fatima.bachir@univ-djelfa.dz

ABSTRACT

Among the various means of producing mechanical energy, turbines are in many ways the most satisfying. The gas turbine is the most versatile item of turbo-machinery today. It can be used in several different modes in critical industries such as power generation, oil and gas, process plants, and aviation. The thermal efficiency of gas turbines, often referred to as the ratio of useful work output to the heat input, is a key performance parameter that directly impacts their economic and environmental viability. This paper presents an overview of the factor influencing the thermal efficiency of gas turbines, and the performance optimization strategy employed to enhance it. On this basis, the efficiency of the GT with regeneration will be evaluated to compare them and draw conclusions regarding the potential gains that can be made with regeneration. Furthermore, it highlights the significance of thermal efficiency improvements in reducing fuel consumption, greenhouse gas emissions, and operating costs.

Keywords: Gas Turbine, Thermal Efficiency, Exhaust Gases, Heat Exchanger.

1 Introduction

In the power generation sector, gas turbines have become the main technology for the conversion of fossil fuels into electricity. The gas turbines currently in the simple cycle in the associated gas compression unit operate with low efficiencies. The efficiency of the TITAN 130 is achieved through several design features and operational strategies aimed at optimizing the performance of the turbine throughout its operating range. Therefore, this study was carried out with the aim of improving the performance and efficiency of the TITAN 130 gas turbine, which was achieved in the use of exhaust gas by recovering part of this energy,

2 Research Methodology

This study was conducted to highlight the importance of understanding the effects of temperature on a solar gas turbine TITAN 130 operation and efficiency focusing on key parameters such as efficiency, power output, and emissions, to facilitate the development of robust and efficient renewable energy systems.

3 Theory and Calculation

The thermodynamic principle underlying any gas turbine power plant operation is based on the Brayton/Joule cycle [1]. This heat engine extracts energy from fuel and air after pressurized combustion by a turbine unit [2]. Therefore, A thermodynamic calculation was performed for each gas turbine transformation component to assess the turbine's performance.

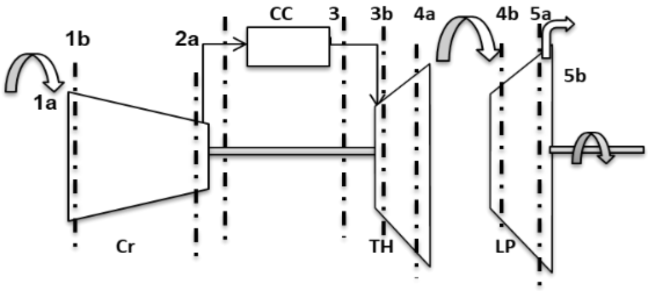

Figure 1: Schematic representation of TITAN 130 GT

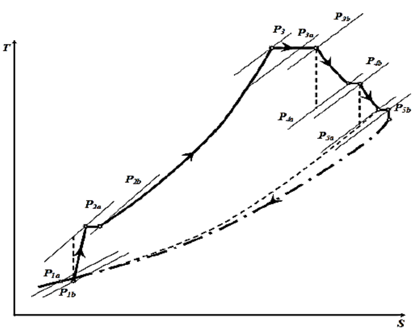

Figure 2: T-S diagram of the installation [3]

DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

The Thermal efficiency of the simple cycle of gas turbine is given by:

$$\eta_{th} = \frac{\Im_u}{Q_{cc}} = \frac{W_{TBP} \times G_g}{Pc_i \times G_c} \quad (1)$$

The thermal efficiency of the gas turbine and the useful power output are directly influenced by the inlet temperature. The option that was taken and applied for increase the thermal efficiency is the Regeneration. Therefore, it can be applied using a heat exchanger installed after the axial compressor. A process for the thermal sizing of a tubular shell-and-tube heat exchanger [4], designed for the installation of the TITAN 130 gas turbine, is presented with the aim of recovering part of the energy lost to the atmosphere.

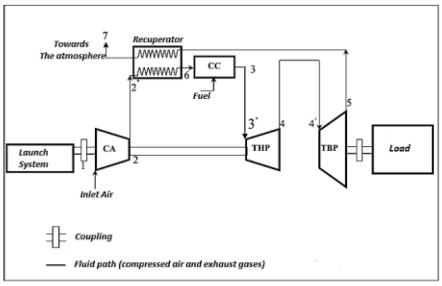

Figure 1: Schematic of GT with recuperator

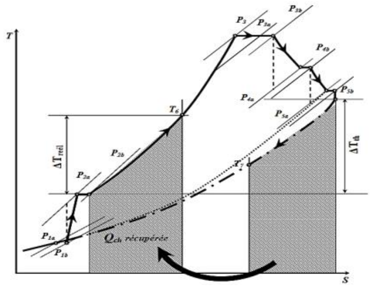

Figure 2: T-S diagram with recuperator [3]

The following equation represent the new relative masse flow rate of the fuel

$$qcn1 = \frac{(1 - qr - qf) \times Cpa \times (T3 - T6)}{\eta cc \times PCI - Cpc \times (T3 - Tc)} \quad (2)$$

The new mass flow of fuel will be provided as:

$$Gcn1 = qcn1 \,.\, Ga \quad (3)$$

Where the new thermal efficiency of the installation is provided as:

$$\eta_{th}' = \frac{\Im_u}{Q_{cc}} = \frac{W_{TBP} \times G_g}{Pc_i \times G_{cn1}} \quad (4)$$

4 Results and Discussion

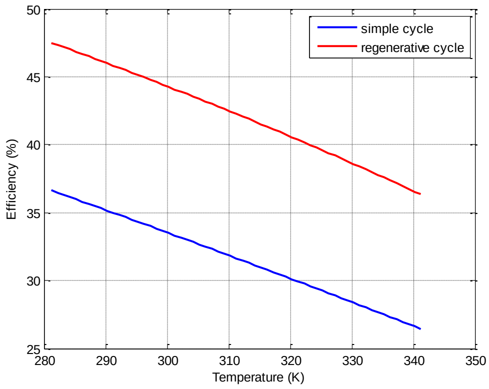

Figure 5: Effect of ambient temperature on thermal efficiency for simple and regenerative cycle.

As the ambient temperature increases, the thermal efficiency of the GT decreases. By the practice of regeneration, the calculations have shown that an efficiency improvement by 10%.

5 Conclusions

As a conclusion, the exhaust was exploited, and the problem of improving the performance of these turbines has been addressed, with a profit of the fuel flow of 0.15 kg/sec and an economic profit of 47304000 DA hence the efficiency of the plant increases of 37% to 47.5%. In addition, the recovery of exhaust calories would have a clear environmental advantage, when this improvement is applied; it follows a reduction in harmful emissive materials (flue gases) to the environment such as Nox.

ISBN: 978-81-970666-4-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.169

6 Acknowledgements

This work was supported by the Applied Automation and Industrial Diagnostics Laboratory at the University of Djelfa in Algeria. The authors express their sincere thanks to Station Manager and All the staff of gas compression station SC3/GG1 depending on the SONATRACH Company for their kind hospitality during the realization of this work.

References

[1] Ogbe, E., et al., Effect of regenerative effectiveness on the performance of simple gas turbine. Scientia Africana, 2023. 22(3): p. 247-260.

[2] Carbon Capture Technologies for Gas-Turbine-Based Power Plants HG Darabkhani, H Varasteh, B Bazooyar – 2022,

[3] Bedjou, Y., Belaid, M. Etude thermodynamique et amélioration du rendement d'une turbine à gaz: dimensionnement thermique d'un échangeur de chaleur de type: tubes-calandres. Editions universitaires européennes-2016,

[4] Andres ,B-,Pierre ,M,,,Echangeurs de chaleur (dimensionnement thermique) ,Techniques d’ingénieur (B2 342)-2021,