

# Energy, Exergy and Simulation Analysis of Steam Driven High Pressure Pumps of Cogeneration Plants

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**Abstract:-** High-pressure pumps are centrifugal pumps that increase the feed water pressure before it enters the boiler. The performance of the Kaduna Refining and Petrochemicals Company Power Plant has been impacted by their decline from their design output. Adopting strategies that will boost pump performance and enhance the plant's functionality is essential. A mathematical model for the KRPC HP Pump was established, and a simulation program for energetic and exergetic analysis of the pump was created. The program was validated in free and open-source literature with a benchmark percentage error of 10% or less. It is based on Python programming code. The program used in the analysis had a maximum percentage error of 1.42%, demonstrating the validity of the simulation program. The results showed that the energy efficiencies of HP Pumps 1 and 2—which were each 82.03% at design conditions—were lowered to 67.14% and 61.33% at operating conditions, and the exergy efficiencies—which were each 25.6% at design conditions—were reduced to 21.2% and 19.36%. Exergy destruction increased from 5.0410 MW each at design condition to 5.0649 MW and 5.1827 MW at operational condition, and energy losses increased from 1.1368 MW each at design condition to 1.9573 MW and 2.3033 MW at operating condition. An analysis has found that HP pumps are more energy and exergy efficient under design settings than under operating conditions. Leaks or insufficient insulation are the causes of these losses. It is recommended that the power plant be run at design conditions, in the absence of this, the control system of the plant should be in good condition.

**Keywords:-** Energy; Exergy; Efficiency; Simulation;

## I. INTRODUCTION

Cogeneration plants are highly efficient systems that generate electricity and useful thermal energy from a single fuel source. High-pressure pumps, which include reciprocating pumps, centrifugal pumps, and diaphragm pumps, are pumps that produce high-pressure outputs in order to transfer fluids at high pressures. [1]; [2]. It is essential that people today are aware of how to regulate their energy, so it is important to conduct study like this. Energy and exergy analysis are based on first and second law of thermodynamics. Deterioration in performances of HP Pumps also affects the thermal performance of a plant as a whole [3]. Thermal performance of a typical power plant is primarily due to efficient pressure boost through the HP Pumps. Therefore, the effectiveness of these pumps has a

substantial influence on the whole performance of the plant [3]; [4].

To the delight of her clients, Kaduna Refining and Petro-chemical Company (KRPC) refines crude oil into premium petroleum products and produces petrochemical and packaging goods. [5]. The power plant and utilities (PPU) department, comprises of utilities and power plant sections. The HP Pumps as shown in figure 1 are faced with the problem of deterioration from its design output, which lead to less performance of the power plant. Through the identification of losses, destructions, and efficiencies, the simulation program hopes to address these issues and disclose the extent of losses that occur in HP Pumps. It will also serve as a guide for the company's management regarding the maintenance schedule for the plant. Energy and exergy analysis is a process that not only assesses performance but also optimizes and recommends changes to be made to the power plant to increase performance. [6]; [7]. Python is a strong and well-liked programming language that is extensively utilized in many industries. It is known for being straightforward, readable, and adaptable, making it an excellent option for novice and seasoned programmers. Python's ability to be directly executed rather than being translated into machine code as an interpreted language is one of its key characteristics [8].

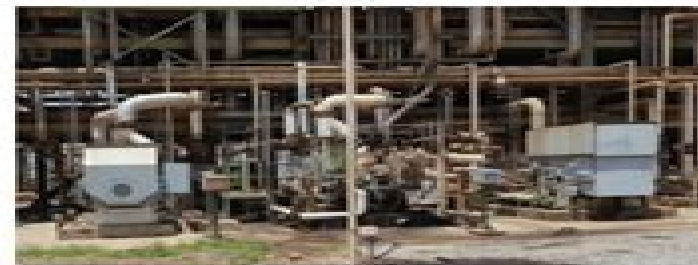


Fig. 1: KRPC HP Pumps

The analysis of energy and exergy in thermal power plants and its constituent parts has been the subject of numerous studies. A physical model was transformed into a python-based simulation program and validated based on literature data [9]. The results revealed high qualitative and quantitative conformity with literature data. It was revealed that boiler has the maximum exergy destruction of 490.76 MW when the performance of a 250 MW thermal power

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## **Table of Contents Cogeneration Sourcebook**

1. Understanding the eBook Cogeneration Sourcebook
  - The Rise of Digital Reading Cogeneration Sourcebook
  - Advantages of eBooks Over Traditional Books
2. Identifying Cogeneration Sourcebook
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Cogeneration Sourcebook
  - User-Friendly Interface
4. Exploring eBook Recommendations from Cogeneration Sourcebook
  - Personalized Recommendations
  - Cogeneration Sourcebook User Reviews and Ratings
  - Cogeneration Sourcebook and Bestseller Lists
5. Accessing Cogeneration Sourcebook Free and Paid eBooks

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- Cogeneration Sourcebook Budget-Friendly Options
- 6. Navigating Cogeneration Sourcebook eBook Formats
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  - Cogeneration Sourcebook Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Cogeneration Sourcebook
  - Highlighting and Note-Taking Cogeneration Sourcebook
  - Interactive Elements Cogeneration Sourcebook
- 8. Staying Engaged with Cogeneration Sourcebook
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Cogeneration Sourcebook
- 9. Balancing eBooks and Physical Books Cogeneration Sourcebook
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Cogeneration Sourcebook
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Cogeneration Sourcebook
  - Setting Reading Goals Cogeneration Sourcebook
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Cogeneration Sourcebook
  - Fact-Checking eBook Content of Cogeneration Sourcebook
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development

- Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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