CHAPTER I
INTRODUCTION

1.1 Background

PT Pertamina Hulu Rokan (PHR) manages the Rokan Block, one of the largest oil fields in Indonesia, which since the transfer of operations from Chevron Pacific Indonesia in August 2021 has continued to develop its facilities to support the national production target of one million barrels per day by 2030. One of the main methods applied to maintain and increase production rates is water flooding, an Enhanced Oil Recovery (EOR) technique in which pressurized water is injected into the reservoir to push crude oil toward the production wells[1].

To support large-scale water flooding operations, PHR operates a Water Treatment Injection Plant (WTIP), a facility that treats and distributes injection water to injection well points through a piping system. The critical components of the WTIP are its centrifugal pump systems, which consist of two stages: the feed pump, which transfers water from the storage tank to the filter, and the injection pump, which provides high pressure to deliver water to the injection wells. These two pumps operate in series, so the performance of one pump directly affects the operating condition of the other [2], [3].

In the context of WTIP development and capacity expansion, the correct specification of centrifugal pumps becomes very important. Errors in specification can cause the pump to operate far from its Best Efficiency Point (BEP), which results in energy waste, cavitation risk due to inadequate NPSH values, and reduced reliability of the overall system[2],[4],[5]. Since the WTIP operates continuously at industrial scale, even a small difference in operating efficiency has a significant impact on energy consumption and operating costs in the long term.

Pump specification calculations by design engineers are generally performed separately for each segment of the system. Although this approach is valid for preliminary design, it does not necessarily provide an optimal picture of the interaction between the feed pump and the injection pump as one integrated system. A complete system analysis, covering the system curve, the actual operating point, and the distribution of pressure losses across the entire piping network, is required to verify whether the existing specifications are optimal or whether there are efficiency improvement opportunities that have not been utilized.

This study performs analytical calculations and simulations using PipeFlow Expert software to analyze the WTIP piping system as an integrated whole [6]. The analytical calculations are based on hydraulic principles (the Darcy Weisbach equation, head loss analysis, and NPSH analysis) with reference to the API 610 standard for centrifugal pumps in petroleum applications[4]. The software simulation is used to model the interaction of the entire system and to validate the results of the manual calculations. Through this approach, this study aims to produce centrifugal pump specification recommendations that are verified both analytically and by simulation, so that they can serve as a technical reference for WTIP development at PHR.

1.2 Problem Statement

In the development of WTIP capacity at PT Pertamina Hulu Rokan, correct centrifugal pump specifications are required to ensure that the piping system operates efficiently and reliably. Based on the background above, the problem statements of this study are::

1. What centrifugal pump specifications (head, capacity, power, and NPSH) are required to meet the operational needs of the WTIP piping system based on analytical calculations?
2. How do the PipeFlow Expert simulation results validate and complement the analytical calculation results in determining the system operating point?
3. How can the optimization of centrifugal pump specifications improve the overall efficiency of the WTIP piping system?

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1.3 Research Objective

The objectives of this study are:

1. To calculate the centrifugal pump specifications required for the WTIP piping system, including Total Dynamic Head, flow capacity, pump power, efficiency, and NPSH, based on analytical methods and the API 610 standard.
2. To validate the analytical calculation results through piping system simulation using PipeFlow Expert software.
3. To analyze the actual pump operating point against the pump curve in order to evaluate system efficiency and identify opportunities for specification optimization.

1.4 Research Benefits

The results of this study are expected to provide the following:

1. or industry: to provide a verified technical reference for determining centrifugal pump specifications in WTIP systems, which can be used as a basis for decision making in facility development.
2. For academia: to provide a case study of an integrated hydraulic calculation methodology that combines analytical and simulation approaches for series pump systems in EOR applications.
3. For operations: the recommended optimal specifications have the potential to reduce energy consumption and improve system reliability, which contributes to long term operating cost efficiency.

1.5 Scope and Limitations

To keep the discussion of this study focused, the following limitations are defined:

1. The analysis covers the piping system from the storage tank to the filter (feed pump segment) and from the filter to the injection wells (injection pump segment) as one integrated series system.
2. The analyzed fluid is injection water without chemical additives (non polymer flooding), with fluid properties based on the available design data.
3. The operating condition is assumed to be steady state with a constant flow rate according to the design data.

4. The parallel pump system is simplified into one representative operating train, with the assumption of balanced flow distribution between trains, based on the engineer design data.
5. The selection and verification of pump specifications refer to the API 610 standard (Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries).
6. The simulation is performed using PipeFlow Expert software.

1.6 Writing Structure

The writing structure of this study is organized as follows:

Chapter I Introduction, which contains the background, problem statement, research objectives, research benefits, scope and limitations, and writing structure.

Chapter II Literature Review, which contains the basic theory of water injection systems, the working principle of centrifugal pumps, system curves and pump curves, the theory of flow in pipes, and the concepts of pump power and efficiency.

Chapter III Research Methodology, which describes the system, the data and assumptions used, the hydraulic calculation procedure, and the method for determining pump specifications.

Chapter IV Results and Discussion, which contains the hydraulic calculation results, the system energy distribution analysis, the determination of pump specifications, and the evaluation of diameter and flow capacity variation scenarios.

Chapter V Conclusions and Recommendations, which contains the conclusions of the study and technical recommendations for further development.

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