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AUTOMATED SYSTEM OF OIL LEVEL CONTROL IN THE HORIZONTAL SEPARATOR

Introduction

The oil and gas industry plays a key role in the global economy by supplying energy and driving technological progress. The efficient operation of oil separators, which separate oil, water, and gas, is a crucial aspect of this sector. In this regard, the development of a liquid level control system for a three-phase oil separator has become a pressing issue, as it would optimize phase separation processes and enhance the efficiency of oil and gas production.

Leading research institutes, universities, and companies are actively conducting studies in the field of oil and gas engineering, highlighting the importance of developing effective control systems for phase separation in oil separators. Issues related to process optimization, energy efficiency improvement, and equipment reliability remain relevant and require further scientific research.

Methodology

The methodology of this research integrated a comprehensive literature review of separator designs and control strategies with industrial standards (API, ISO) to establish optimal operational parameters, followed by the development of a detailed technological process flow for the three-phase separator that outlined the fluid dynamics from the gas-liquid-steam mixture inflow to final stratification. A structural block diagram was designed using KOMPAS, incorporating critical sensor networks (TE for temperature, FE for flow rate, LE for level) and control actuators, while dynamic system modeling simulated the separator's self-balancing mechanism as a negative feedback control system, deriving transfer functions to characterize fluid behavior and valve response. PID tuning via PID Tuner optimized controller parameters, yielding a stable response with 10 % overshoot and a 27.5-second settling time, validated through transient analysis under operational disturbances. Gaussian analysis of sensor data assessed measurement consistency, ensuring level and temperature variability adhered to predictable distributions.

Results

The automated oil level control system for the horizontal three-phase separator was successfully modeled and optimized using PID control. Through simulation and tuning, the system demonstrated stable and efficient performance with the following key characteristics:

- Control Stability: The PID controller effectively maintained the liquid level at the desired setpoint, ensuring smooth operation of the separator.
- Transient Response: The system exhibited an overshoot of approximately 10 %, indicating a well-balanced control action that prevents excessive fluctuations.
- Settling Time: The liquid level stabilized within 27.5 seconds, confirming the system's rapid response to disturbances while maintaining operational reliability.
- Negative Feedback Mechanism: The self-balancing process, governed by negative feedback control, ensured continuous adjustment of the valve position to maintain optimal separation conditions.

These results validate the effectiveness of the proposed automated control system in optimizing oil-water-gas separation, enhancing process efficiency, and ensuring stable operation under varying conditions. The developed model provides a foundation for real-world implementation in oilfield separation systems.

Conclusions

This study successfully developed an automated oil level control system for a horizontal three-phase separator, optimizing the separation process and enhancing operational efficiency. The research encompassed the design of the technological process, the working principle of the separator, and the implementation of a robust monitoring and control system. Through modeling and PID tuning, the system demonstrated stable performance with an acceptable overshoot (10 %) and settling time (27.5 seconds), confirming its reliability in maintaining optimal liquid levels.

The negative feedback control mechanism ensures self-balancing, while sensor networks (temperature, flow rate, and level sensors) enable precise process adjustments. Future research should focus on real-world implementation under varying operational conditions, including extreme temperatures and fluctuating flow rates, to further validate system robustness. Additionally, exploring advanced control algorithms, such as adaptive or AI-based PID tuning, could further optimize separation efficiency and energy consumption in industrial applications.

Recommendations

For engineers and researchers working on automated oil separation systems, adopting a systematic approach to design and optimization is crucial. Implementing advanced sensor networks (temperature, flow rate, and level sensors) ensures precise monitoring and control, while integrating PID tuning enhances system stability. To mitigate performance issues in low-temperature conditions, heating systems should be incorporated to maintain optimal separation efficiency.

Educational institutions and industry partners should emphasize hands-on training in control system modeling and separator design to bridge theoretical knowledge with practical applications. Universities should integrate simulation tools into engineering curricula to familiarize students with dynamic process control. Additionally, workshops on PID tuning and system troubleshooting can enhance technical proficiency.

For industrial implementation, companies should prioritize regular maintenance of separator components (valves, pumps, and sensors) to ensure long-term reliability. Further research should explore adaptive control algorithms and machine learning techniques to optimize separation efficiency under varying operational conditions. Finally, collaboration between academia and industry should be strengthened to facilitate knowledge transfer and innovation in oilfield automation technologies.

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