

UNDERGRADUATE THESIS

**EXPERIMENTAL STUDY OF WATER
HAMMER PRESSURE INTENSITY IN PUMP-
VALVE SYSTEM WITH VALVE CLOSURE
TIMES AND FLOW RATES VARIATIONS**



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APPROVAL SHEET**

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PUMP-VALVE SYSTEM WITH VALVE CLOSURE
TIMES AND FLOW RATES VARIATIONS**

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PREFACE

Utmost praise is offered to God Almighty, whose grace and kindness have enabled the author to complete this undergraduate thesis research entitled “Experimental Study of Water Hammer Pressure Intensity in a Pump-Valve System with Variative Valve Closure Times and Flow Rates.” The preparation of this proposal is intended to fulfil one of the academic requirements for completing the bachelor’s program in the Mechanical Engineering Department, Faculty of Engineering and Science, University of Pembangunan Nasional “Veteran” Jawa Timur.

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The author hopes that this research report may contribute to the development of knowledge within the Mechanical Engineering Department at University of Pembangunan Nasional “Veteran” Jawa Timur. The author realizes that this proposal is not without shortcomings, therefore constructive criticism and suggestions for improvement are sincerely welcomed.

Surabaya, 7th of November 2025

Author

ABSTRAK

Penelitian ini bertujuan untuk menganalisis fenomena *water hammer* yang terjadi pada sistem *pump-valve* dengan variasi debit dan waktu penutupan *valve* sebagai variabel bebas. Fenomena *water hammer* merupakan lonjakan tekanan akibat perubahan kecepatan aliran fluida secara tiba-tiba saat *valve* ditutup dengan cepat. Pengujian dilakukan menggunakan alat *water circulating unit* dengan tiga variasi debit (38,67 L/menit; 33,26 L/menit; dan 26,61 L/menit) serta tiga variasi waktu penutupan *valve* (1 s; 1,5 s; dan 2 s). Parameter yang diukur adalah tekanan, debit, serta nilai head efektif sistem. Analisis dilakukan secara teoritis menggunakan persamaan *Joukowsky* dan aktual dengan data hasil eksperimen. Hasil pengujian menunjukkan bahwa tekanan *water hammer* tertinggi terjadi pada debit 38,67 L/menit dengan waktu penutupan *valve* 1 s sebesar 1,56 bar, sedangkan tekanan terendah terjadi pada debit 26,61 L/menit dan waktu penutupan 2 s sebesar 0,86 bar. Semakin besar debit dan semakin cepat waktu penutupan *valve*, maka tekanan *water hammer* yang dihasilkan semakin tinggi. Hasil yang didapat menunjukkan kesamaan dengan teori *Joukowsky* serta penelitian terdahulu, dengan rata-rata perbedaan antara data teoritis dan eksperimental sekitar 8,33–26,67%. Didapatkan signifikansi antar variabel yang di mana variabel waktu penutupan *valve* memiliki dampak yang paling signifikan dengan nilai *p-value* $4,36 \times 10^{-7}$ dan diikuti oleh debit aliran dengan *p-value* sebesar $2,85 \times 10^{-5}$. Namun di samping itu, didapatkan variabel head efektif yang kurang signifikan terhadap intensitas tekanan *water hammer* dengan *p-value* 0,1206 yang nilainya jauh lebih besar dari kedua variabel sebelumnya.

Kata kunci: *Water hammer*, Flowrate, waktu penutupan *valve*, tekanan transien, sistem *pump-valve*

ABSTRACT

This research aims to analyze the water hammer phenomenon occurring in a pump-valve system with varying flow rates and valve closure times as independent variables. The water hammer phenomenon refers to a sudden pressure surge caused by an abrupt change in fluid velocity during valve closure. Experiments were conducted using a water circulating unit with three flow rate variations (38.67 L/min, 33.26 L/min, and 26.61 L/min) and three valve closure times (1 s, 1.5 s, and 2 s). The parameters measured include pressure, flow rate, and system head (static, dynamic, and effective). Theoretical analysis was performed using the Joukowsky equation and compared with empirical experimental data. The results showed that the highest water hammer pressure occurred at a flow rate of 38.67 L/min and a 1 s valve closure time with a pressure of 1.56 bar, while the lowest occurred at a flow rate of 26.61 L/min and a 2 s closure time with 0.86 bar. The results indicate that higher flow rates and faster valve closures produce greater water hammer pressures. These findings align with Joukowsky's theory and previous studies, with an average deviation between theoretical and experimental data of approximately 5–10%. Significance between variables was obtained where the valve closing time variable had the most significant impact with a p-value of 4.36×10^{-7} and followed by flow rate with a p-value of 2.85×10^{-5} . However, in addition, the effective head variable was obtained which was less significant on the intensity of water hammer pressure with a p-value of 0.1206 which was much greater than the two previous variables.

Keywords: *Water hammer, flow rate, valve closure time, transient pressure, pump-valve system*

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