شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

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جامعة عين شمس

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AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Mechanical Power Engineering

ANALYSIS OF OPTIMUM PERFORMANCE OF AIR VESSELS USED IN DAMPING WATER HAMMER PRESSURE WAVE

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Mechanical Engineering

(Mechanical Power Engineering)

by

Ahmed Ashraf Abdelfattah Abdelfattah

Bachelor of Science in Mechanical Engineering

(Mechanical Power Engineering)

Faculty of Engineering, Ain ShamsUniversity, 2004

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Cairo - (2021)

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Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

I would like to express my deep and sincere gratitude to my thesis supervisor, **Prof. Dr. Abdul-Aziz M. Abdul-Aziz** for giving me the opportunity to do research and providing invaluable guidance throughout this thesis. His dynamism, vision, sincerity, and motivation have deeply inspired me. He has taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under his guidance. I am extremely grateful for what he has offered me. I would also like to thank him for his friendship, empathy, and great sense of humor.

I would like to express my gratitude to **Prof. Dr. Kaddah Shaker** for his motivation and the incentive provided to me.

Many thanks to **Prof. Dr. Hany Ahmed Moneib** for his keenness to bring out this research in this scientific elegant order and his advice on the professional technical writing methods.

I express my thanks to **Dr. Ashraf Mostafa Hamed** for his support.

I am extremely grateful to my **Father and Mother** for their love, caring and sacrifices for educating and preparing me for my future.

I am very much thankful to my **Wife, Son and Daughter** for their love, understanding, and continuing support to complete this research work.

Finally, my thanks go to all the people who have directly or indirectly supported me to complete the thesis work.

Ahmed Ashraf Abdel Fattah

2021

ABSTRACT

Water hammer is a hydraulic phenomenon that causes severe changes in the hydraulic operating flow pressures. This phenomenon is caused due to an unexpected event in the flow such as sudden closing/opening of a valve or power failure of a pump installed along the pipeline system.

The **pressure increase, due to water hammer,** depends on the initial speed of the flow, length of the pipelines and the sound speed of the pressure waves. **Controlling** the water hammer pressure becomes indispensable, so a transient surge analysis is required to investigate the points of severe changes along with the pipeline system, and then the proper transient control device can be selected. Among the **transient control devices**, there is the **compressed air vessel (CAV)** which is a pressure control device that is used to control the positive and negative pressure changes. There are **two factors** that affect the sizing of the air vessel namely the initial trapped air volume (VFR) and the throttling aperture size of the air vessel. An experimental test rig composed of a long water pipe provided with a rapid closing valve and the essential pressure instruments is designed and used to create a water hammer pressure wave. The rig is also equipped with a compressed air vessel to test

its effect on depressing the pressure wave. A simulated computer program based on the solution of the one-dimensional unsteady flow equations is also written to model the water hammer phenomena and the performance of the compressed air vessel, both the experimental and the model results are compared and discussed.

Both the experimental and model results show the high capability of the air vessel to dampen water hammer pressure. The water hammer head could be reduced from 300m to 15-50m depending on the used orifice diameter and the initial air volume inside the air vessel.

The orifice diameter shows a high effect on the performance of the air vessel and that the air vessel should be throttled to control the upper and lower limit of water hammer pressure head.

The initial volume of the trapped air should be in the range of 53% to 78% of the total volume of the air vessel, so that the air vessel works effectively.

Keywords

Water hammer, transient flow, compressed air vessel, Method of characteristics.

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NOMENCLATURES

Symbols

Symbols	Description	Units
A_1	Pipe area of upstream air vessel	m^2
A_2	Pipe area of downstream air vessel	m^2
A_{CAV}	Area of the air vessel	m^2
$A_{orifice}$	Area of the orifice	m^2
a	Sound speed	m/s
C1, C2, C3	Coefficients of pump equation	
C_d	Discharge coefficient	
C_n	Courant number, $C_n = a * \frac{\Delta t}{\Delta x}$	
D	Diameter of the water coil pipe	m
D_c	Curvature diameter of the coil	m
E	Young's modulus for the pipe	Pa
e	Thickness of the pipe	m
f	Friction coefficient	
g	Gravity acceleration	m/s^2