



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم



MONA MAGHRABY



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Ain Shams University

Faculty of Engineering

Acoustic and vibration diagnosis of cavitation for centrifugal pumps of different materials

Thesis Submitted to the Faculty of Engineering Ain Shams University

For Partial Fulfillment of the Degree of Master of Science in Mechanical Power Engineering

By:

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July 2020



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STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirement for the M.Sc. Degree in Mechanical power engineering. The work included in this thesis has been carried out by the author in mechanical power engineering department, Ain Shams University. No part of the thesis has been submitted for a degree or a qualification at other university or institute.

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NOMENCLEATURES

ACE	Acoustic cavitation emission
BPF	Blade pass frequency, Hz
c_1	Fluid velocity at impeller inlet, m/s
c_s	Flow velocity at the pump suction , m/s
DST	Dempster-Shafer theory
g	Gravitational acceleration, m/s^2
H	Pump total head, m
H_f	Friction head loss, m
L	Average sound level, mPa
N	Pump rotation speed, rpm
$NPSH_A$	Available net positive suction head, m
$NPSH_R$	Required net positive suction head, m
P_d	Absolute discharge pressure, bar
P_s	Absolute pressure at the pump suction, related to the pump centerline, Pa
P_v	Absolute vapor pressure at the fluid temperature, Pa
Q	Discharge, L/h
RF	pump rotational speed frequency, Hz

SPL	sound pressure level, mPa
SVM	Support vector machine
u_1	Peripheral speed of impeller inlet, m/s
v_{r1}	Fluid velocity at impeller inlet relative to the impeller peripheral speed, m/s
z	Potential elevation, m
<u>Greek</u>	
β_1	Inlet blade angle, degree
$\Delta\beta_1$	blade shift angle at blade entrance, degree
ρ	Density of fluid, kg/m ³
σ	Thoma's cavitation number

ACKNOWLEDGMENT

- We thank the almighty ALLAH for his mercy and grace, which enabled me to complete this work.
- Also, We wish to express my sincere thanks and gratitude to Prof. Abdulaziz Morgan, for providing me moral, psychological and scientific support. Also, he gives me all the necessary facilities. I am extremely grateful and indebted to him for his patience, valuable guidance and encouragement extended to me.
- We would like to express my deep appreciation to Dr. Ashraf Kotb for editing corrections for the thesis. I thank him for his effort, concern and time he spent in helping me.
- We appreciate all the faculty members of the department of mechanical engineering staff for their help and cooperation.
- We thank my parents for their unceasing encouragement and support.
- Last but not least, my sincere gratitude to my family specially, my wife, my son and my girls, for their continuous support and encouragement.
- We are also grateful to all who, directly or indirectly, have lent helping hand in this research.

Mostafa Swelam Mahmoud Swelam

2020

ABSTRACT

Cavitation has destructive effects on pumps. It causes mechanical damage, decreases discharge and efficiency, and increases noise and vibration. Therefore, it must be detected during pumping operations to find a way to eliminate it.

This study concentrates on the effect of the impeller blades material of a centrifugal pump on cavitation and its impact on vibration and acoustic emission levels. Using an in-house pump system, number of experiments were performed on a centrifugal pumping system using three different impeller materials; stainless steel, brass and plastic.

Cavitation could be detected by vibration and acoustic spectrum analysis. When cavitation commences, the flow conditions change and the noise and vibration of the pump increase. Since vibrations and noise are transmitted from the pump through its housing, the signal is not uniformly distorted due to the loss of transmission and the structure of the housing. Noise and vibration are steadily increasing, but the signal is more pronounced in certain frequency ranges than in other parts of the spectrum.

The experimental results show that the plastic impeller gives the lowest level of sound and vibration compared to the stainless and brass materials. It is also evident that the amplitudes of the high frequency range of the sound spectrum are affected by the impeller material during normal operation of the pump. Cavitation results in further increase in the sound amplitudes in the high frequency range.

Keywords: Centrifugal pump; Cavitation; noise; vibration.

CHAPTER 1

INTRODUCTION

1.1 Problem Definition

Although the cavitation phenomenon in pumping systems is known to have problems, there are still many questions to be resolved. Cavitation causes deterioration in both efficiency and performance, physical damage as well as increased vibration and noise. It occurs if static pressure drops under real fluid pressure at the current temperature in a very pump. Then the liquid begins to vaporize and many bubbles of vapour emerge. The bubbles are growing in size and number as the cavitation grows. Bubbles pass by the fluid pump, and in the end, they fall quickly to a high-pressure area. Forces, generated during the collapse, will have terribly damaging ramification. If the bubbles implosion takes place near a solid wall, the wave of shock reaches and erodes the surface. This damages the pump surfaces, which cause un-flow conditions and may cause the pump to become useless after a certain period of time. The detection and prevention of cavitation must occur as quickly as possible. There are several utterly other ways for cavitation observance which can be accustomed forestall damaging consequences of the cavitation within the pump and systems [1]: Fixable speed and constant flow rate of determination of the net positive suction head (NPSH) visual picture of the flow inlet at the impeller blades, erosion paint on blades of impeller, static pressure mensuration within the flow, vibration mensuration of the structure of pump and noise measure inside the pump. Acoustic measurement is known for ultrasound measurements inside the centrifugal pump, but not well known for audible noise measurements in the pump proximity. While operating, a pump has to overcome a pressure difference, which arises by pipe resistance, height difference between the fluid levels and the pump in containers, and the pressure above the fluid levels. In some circumstances the given pressure difference is just too high for the pump to be capable of pumping the fluid, which implies that the NPSH value is insufficient [2, 3].