# VACUUM SYSTEM DESIGN FOR FRY DRYING

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This report is submitted as partial fulfillment of the requirement for the award of
Bachelor's Degree of Mechanical Engineering

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

MARCH 2008

‘I / we* admit that have read this
work and in opinion of me / we* this work was
adequate from the aspect scope and quality to the significance to awarded
Bachelor Degree of Mechanical Engineering (Design & Innovation)’

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"I declare that this report is done by my own unless the citation with the mentioned references for each."

Signature : ……………………………..
Author : MUHAMMAD LUTFI ABD. LATIF
Date : 12 MAY 2008

My immense gratitude goes to ALLAH s.w.t, the most merciful and gracious. Thank you to my parents; Abdul Latif Kasim and Kamariah Khalid, my friends and supervisor especially Prof Madya Ir. Mustafar Ab Kadir and Mr. Shafizal Mat for the guide on this report.

## ABSTRACT

Vacuum system has all along been applied in variety of techniques and technologies in related industry such as manufacturing and engineering. In cooking appliances, the vacuum system is used to minimize the pressure and heat that is applied to the food. This project is about designing a vacuum system for fry drying process with control, which needs detailed design and appropriate analysis. The vacuum systems to be carried out will be sighted in several fields of technology despite of the vacuum technology itself such as hydraulic, pneumatic, electrical and design process development. The knowledge in this field is used to construct the system circuit and types of components involved. The pressure and heat in the systems will be controlled by electrical devices and electrical circuits. The design software is used for designing the system circuit in detailed view and specifications of the system.

**ABSTRAK**

Sistem vakum telah lama diaplikasikan di dalam pelbagai teknik dan teknologi dalam industri berkaitan seperti pembuatan dan kejuruteraan. Di dalam peralatan masakan, system vakum digunakan untuk meminimakan tekanan dan haba yang dikenakan ke atas makanan. Projek ini adalah mengenai merekabentuk suatu sistem vakum berserta kawalannya, dimana ia memerlukan rekabentuk terperinci dan analisis yang berkaitan. Sistem vakum yang akan dihasilkan ini akan dilihat dari pelbagai bidang teknologi selain daripada teknologi vakum itu sendiri seperti hidraulik, pneumatik, elektrikal dan proses pembangunan rekabentuk. Pengetahuan dalam bidang ini diperlukan untuk membina litar sistem dan juga jenis – jenis komponen yang terlibat. Tekanan dan haba didalam system akan dikawal oleh peralatan elektrik dan juga litar elektrikal. Perisian rekabentuk digunakan untuk merekabentuk litar sistem dalam pandangan dan spesifikasi terperinci.

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| | | |
|---|---|---|
| Co. | = | Company |
| Inc. | = | Incorporated |
| MCB | = | Miniature Circuit Breaker |
| SSR | = | Solid State Relay |
| 2D | = | 2 Dimensional |
| 3D | = | 3 Dimensional |
| Pa | = | Pascal |
| Hg | = | Mercury |
| Psi | = | per square inch |
| Atm | = | atmosfera |
| LED | = | light emitting diode |
| PCB | = | printed circuit |
| PWB | = | printed wiring board |
| PCA | = | printed circuit assembly |
| PCBA | = | printed circuit board assembly |
| CAD | = | Computer Aided Design |
| CATIA | = | **C**omputer **A**ided **T**hree-dimensional **I**nteractive **A**pplication |
| abs | = | absolute |
| ltd | = | limited |
| A | = | ampere |
| AC | = | alternate current |
| DC | = | direct current |
| RTD | = | Resistance Temperature Detector |
| ITS | = | International Temperature Standard |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Nowadays, cooking equipment goes through lots of revolution in its design, from fire woods to the nano technology cooking. People are moving faster each day and this requires faster equipment to support today style of living including cooking equipment. Overheating or over-using the frying oil, or undue exposure to air while hot, leads to formation of oxidation products, polymers and other deleterious, unintended or even toxic compounds such as acrylamide. Researchers in many countries have found that, out of the three major market sectors, the most abused frying oils were those in the catering, domestic and industrial sectors.

Cooking under vacuum helps to significantly reduce the acrylamide formation; however this process is so far not widely used in the food industry due to the high investment volume involved. The design to be proposed is a vacuum piping and pumping system to minimize the heat needed in cooking and also reduce pressure on food while cooking.

## 1.2 Objective

The objective of this project is to design a vacuum system that suitable for fry drying by implementing the vacuum and heat energy approach.

## 1.3 Scope

This report will cover the design of the vacuum piping and pumping system and the application of this system to a vessel. Other than that, the items used in the vacuum system and their detailed specifications will be included in this report excluding the experimental parts.

## 1.4 Organization

This report begins by explaining the purpose of the design which is to achieve the main objective and followed by the design process of the vacuum system. The next step is the required process for the design and the parts or items that will be use in the system. Finally, the electric circuit and system detail design including how the system works will be explained.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

Literature review is the most important step to retrieve information related with the topic chosen. It can be done by searching the information from the internet, journals, books and other sources such as attending any seminars or courses offered outside or inside the university. It is important to make a study or research on the system before starting any development. This is to gain specific knowledge on the system and to ensure this project is on its scope. This chapter will elucidate on the details of the equipment and technology involved in this vacuum system design project.

## 2.1 Vacuum

A vacuum is a volume of space that is essentially empty of matter, such that its gaseous pressure is much less than standard atmospheric pressure. The root of the word *vacuum* is the Latin adjective *vacuus* which means "empty," but space can never be perfectly empty. The Latin term in vacuo is used to describe an object as being in what would otherwise be a vacuum. A perfect vacuum with a gaseous pressure of absolute zero is a philosophical concept that is never observed in practice, not least because quantum theory predicts that no volume of space can be perfectly empty in this way. Physicists often use the term "vacuum" slightly differently. They discuss ideal test results that would occur in a perfect vacuum, which they simply call "vacuum" or "free space" in this context, and use the term partial vacuum to refer to the imperfect vacua realized in practice [1].

In quantum mechanics, the *vacuum* is defined as the state with the lowest energy. However, even an ideal vacuum, thought of as the complete absence of anything, will not in practice remain empty. One reason is that the walls of a vacuum chamber emit light in the form of black-body radiation: visible light if they are at a temperature of thousands of degrees, infrared light if they are cooler. If this soup of photons is in thermodynamic equilibrium with the walls, it can be said to have a particular temperature, as well as a pressure [4].

Another reason that perfect vacuum is impossible is the Heisenberg uncertainty principle which states that no particle can ever have an exact position. Each atom exists as a probability function of space, which has a certain non-zero value everywhere in a given volume. Even the space between molecules is not a perfect vacuum. In quantum field theory and string theory, the term "vacuum" is used to represent the ground state in the Hilbert space, that is, the state with the lowest possible energy. In free (non-interacting) quantum field theories, this state is analogous to the ground state of a quantum harmonic oscillator [4].

What is vacuum? Imagine a closed container with nothing inside (figure 2.0). The space of the container with nothing in it is called a vacuum. Vacuum is the most prevalent state in the Universe, and on the average, most space qualifies as a very good vacuum. However, around the objects with sufficient gravity one can find a trapped gas mixture, and thus, the enormous variation of pressure exist. Therefore, vacuum is usually divided into ranges with somewhat arbitrary cutoffs.

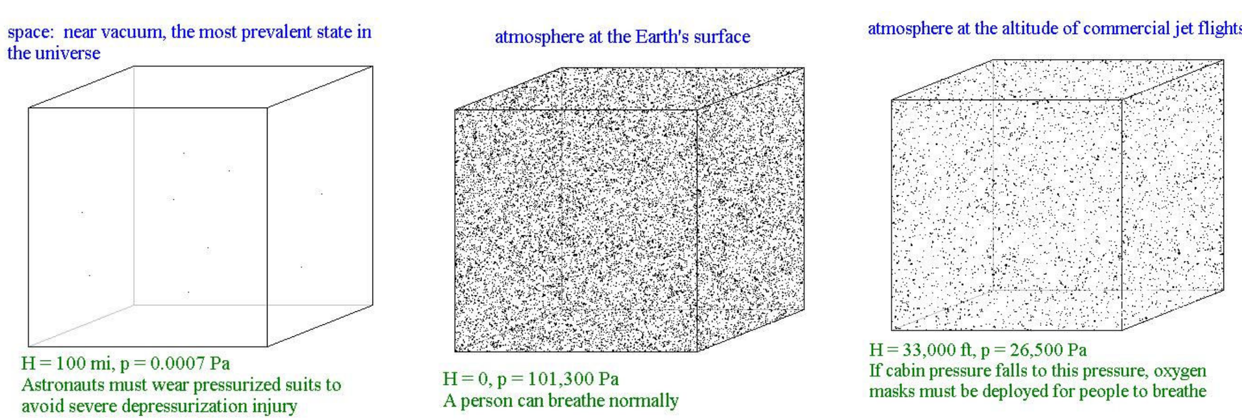

Figure 2.1: Vacuum State

(*Source*: *Ed. Rita G. Lerner and George L. Trigg. VCH Publishers, 1991*)

## 2.2 Vacuum Pumps

Any device which can induce a pressure difference between the two regions in the space is called a pump. The pump which creates the vacuum in the certain system is called a vacuum pump. The gas molecules are removed and will be maintain in a required degree of gas rarefaction in a gas filled volume from the gas phase using the vacuum pump. Pumps can be broadly categorized according to three techniques:

a) Positive displacement pumps use a mechanism to repeatedly expand a cavity, allow gases to flow in from the chamber, seal off the cavity, and exhaust it to the atmosphere.
b) Momentum transfer pumps, also called molecular pumps, use high speed jets of dense fluid or high speed rotating blades to knock gaseous molecules out of the chamber.
c) Entrapment pumps capture gases in a solid or absorbed state. This includes cryopumps, getters, and Ion pumps [2].
d) For this project the vacuum pumps that will be use would be under the positive displacement pump type which is the Liquid Ring Vacuum Pump.

### 2.2.1 Liquid Ring Vacuum Pump

Liquid ring vacuum pumps remove gases by means of an impeller rotating freely in an eccentric casing. The pumping is done by a liquid, usually water that is fed into the pump and thrown by centrifugal force into a moving ring along the internal casing wall. When gas or vapor enters the suction port of the pump, it is trapped by the whirling impeller blades and a liquid piston that expands in the eccentric lobe of the casing. As the impeller rotates, the liquid is then pushed inward by the narrowing space between rotor and casing, compressing the trapped pocket of gas. Finally, the compressed gas is released through a discharge port as the impeller completes the revolution [3].

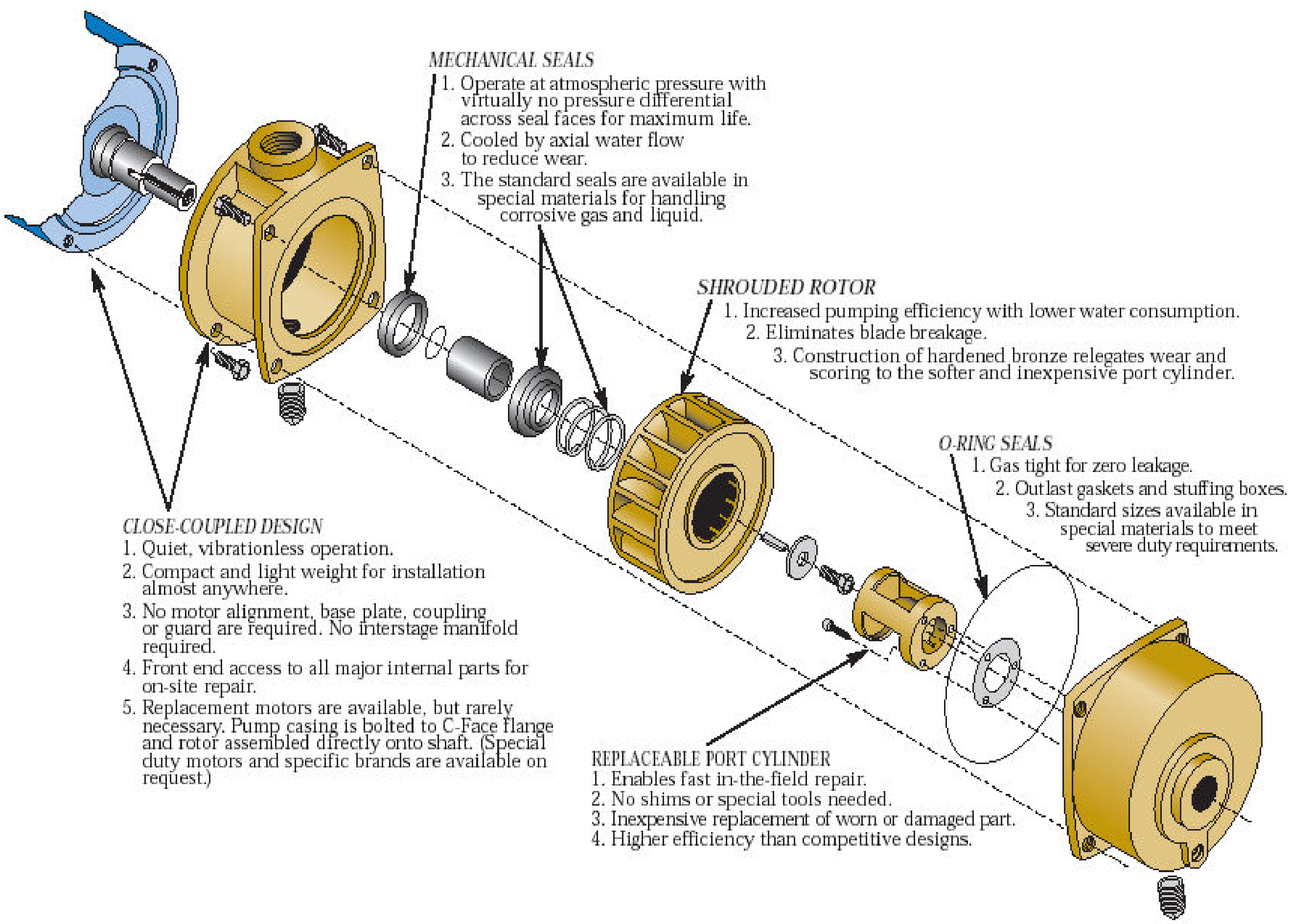


Figure 2.2: Parts of Liquid Ring Vacuum Pump

*(Source: http://vacuum.tuthill.com)*

### 2.2.2 Principle Operation of Liquid Ring Vacuum Pump

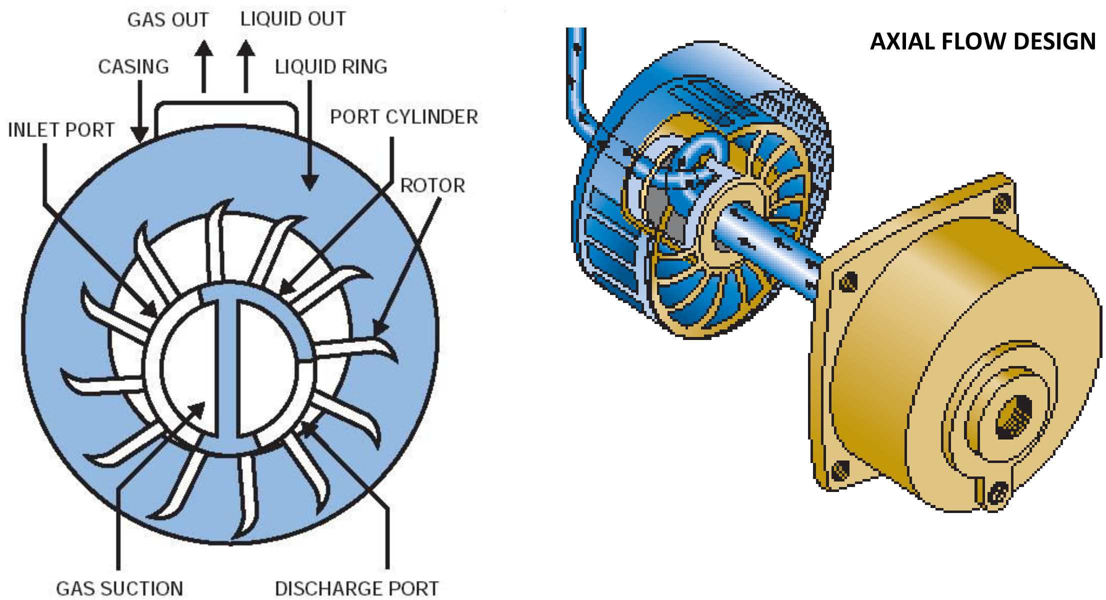


Figure 2.3: Cross Section of a Liquid Ring Vacuum Pump

*(Source: http://vacuum.tuthill.com)*

Liquid ring vacuum pumps consist of a shrouded motor rotating freely within an eccentric casing. There is no metal-to-metal Contact between the rotor and the casing. Centrifugal force acting on liquid within the pump causes the liquid to form a ring inside the casing. A fixed port cylinder concentric with the rotor directs the gas into the suction ports. Gas is trapped between the blades by the liquid pistons formed by centrifugal force as the liquid recedes from the port cylinder. It is trapped at the point of maximum eccentricity and is then compressed by the liquid ring as it is forced radially inward toward the central port cylinder. After each revolution the compressed gas and accompanying liquid are discharged. During the pumping cycle the gas is in intimate contact with the sealing liquid and compression is nearly isothermal. When handling saturated vapor-gas mixtures the liquid ring acts as a condenser, greatly increasing the effective capacity of the pump [3].