FUZZY LOGIC CONTROL FOR NEGATIVE PRESSURE WOUND THERAPY

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Special thanks to

My beloved family members who always there for me,

My friends, who assists, accompanying me now and then,

And also to

My supervisor who guide me through the research's hardships

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ABSTRACT

Negative Pressure Wound Therapy (NWPT) has been successful treated the acute and chronic wound by promoting the wound healing. Many medical techniques like NPWT are available in this world but not approachable for many patients due to high in cost and lack of devices. In order for most of the patients accessible to NPWT, an inexpensive NPWT system is explored in this study. Aim of this work is to design a fuzzy logic conntrol of NPWT system that can generate negative pressure and the negative pressure can be regulated within the range. A NPWT system consists of vacuum pump, drainage tubes, wound dressing, fluid collecting canister and adhesive film dressing. Therefore, in this thesis, a miniature vacuum pump, canister and Arduino micro-controller were used in order to build up a functional NPWT system. The system has been designed to supply negative pressure from 0 mmHg to 200mmHg and negative pressure can be controlled. The fuzzy logic control system performance is compared and proven that it has better performance compared to boolean logic control. In conclusion that this system is able to function according to the require specification and suitable for home healthcare wound healing device with safety precaution implement and system stabilization is improved in future.

ABSTRAK

Tekanan negatif Luka Terapi (NWPT) telah berjaya merawat luka akut dan kronik dengan memperceptkan penyembuhan luka. Banyak teknik perubatan seperti NPWT boleh didapati di dunia ini tetapi tidak dapat dinikmati bagi banyak pesakit kerana tinggi kos dan kekurangan peralatan. Dalam usaha untuk sebahagian pesakit mendapat rawatan NPWT, sistem NPWT murah telah diterokai dalam kajian ini. Tujuan kajian ini adalah untuk mereka bentuk prototaip sistem NPWT yang boleh menjana tekanan negatif dan tekanan negatif boleh dikawal dalam julat. Sistem NPWT terdiri daripada pam vakum, tiub saliran, balutan luka, cecair kumpulan kanister dan filem pelekat kulit. Oleh itu, dalam kajian ini, pam vakum kecil, kanister dan Arduino mikropengawal telah digunakan untuk membina sistem NPWT berfungsi. Sistem ini telah direka untuk membekalkan tekanan negatif daripada 0 mmHg untuk 200mmHg dan tekanan negatif boleh dikawal. Sebagai kesimpulan, sistem ini dapat berfungsi mengikut spesifikasi yang diperlukan dan sesuai untuk kegunaan rumah preanti dengan melaksanakan langkah-langkah keselamatan penyembuhan dan penstabilan sistem bertambah baik pada masa akan datang.

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LIST OF ABBREVIATION

DC	–	Direct Current
LCD	–	Liquid Crystal Display
MUHC	–	McGill University Health Centre
NPWT	–	Negative Pressure Wound Therapy
PU	–	Polyurethane
PWM	–	Pulse Width Modulation
VAC	–	Vacuum Assisted Closure

LIST OF SYMBOLS

A/D	–	Analog to digital

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CHAPTER 1

INTRODUCTION

1.1 Background

Negative-pressure wound therapy (NPWT) is a therapeutic technique using a vacuum dressing to promote healing in acute or chronic wounds and enhance healing of first and second degree burns. Since 1947, Russia used suction for the post-operation exudates by using gauze and wall suction.

Basic suction method of negative pressure therapy used for treatment is from China’s cupping therapy been for thousand years ago [1]. Cupping therapy is used to cure the diseases by circulating the blood flow was recorded earliest in *Bo Shu* (an ancient book written on silk) which was discovered in an ancient tomb of the Han Dynasty in 1973 [2].

In 1980’s, Bier’s Hyperemic Treatment using vacuum suction apparatus and method was introduced [3]. Since that, the technique of using negative pressure wound therapy (NPWT) had been triggered and began to be researched by many researchers. The more advance use of NPWT has been studied by Chariker and Fleischmann in late 1980’s and early 1990’s [4,5]. In 1997, the first device for

NPWT was cleared by the Food and Drug Administration and marketed in the United State.

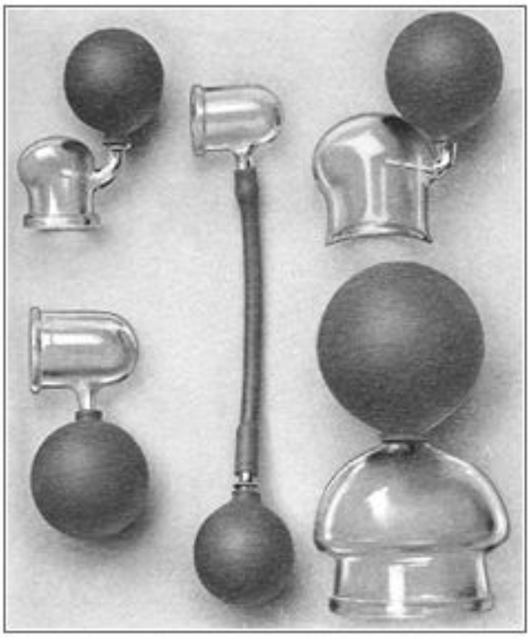

Figure 1.1: Suction apparatus for induction artificial hyperemia [3].

The method of using NPWT for open wounds was arisen in Germany and United States and has been widely spread throughout Europe, North America and other parts of the world. NPWT also known as vacuum assisted closure (VAC) therapy, vacuum therapy, vacuum sealing therapy, topical negative pressure therapy and sub-atmospheric pressure therapy. Recently, NPWT has become a very important part of modern wound treatment and is implemented in most of the surgical discipline such as general surgery [6], gynecologic surgery [7], plastic surgery [8], orthopedic surgery [9], thoracic surgery [10], trauma surgery [11] and pediatric surgery [12]. Treatments of acute, chronic and complex wounds routinely have been using NPWT in hospitals.

NPWT use the concept of Physics mechanics by controlling the subatmospheric pressure that induces mechanical stress to tissues. The subatmospheric pressure means the pressure that is lower than the atmospheric pressure (760 mmHg). By induces mechanical stress to tissues, the division of cells (Mitosis) is stimulated. Therefore, new blood vessels are grown, and the wound is drawn closed [13].

The level of pressure to the wounded tissue is small, but when whole parts of the wound press in an effort to close toward the center point, the effect of negative pressure becomes impressive and results in faster healing and resolution. NWPT aids in wound healing by increasing blood flow rate at wound [14,15,16], promoting the growth of granulation tissue[14], providing a humid, shielded surrounding[17], decreasing interstitial oedema [18,20,21], contracting wound edges[18,19] and reducing bacterial and infectious [21].

1.2 Problem Statement

Nowadays, diseases such as diabetes and cardiovascular diseases increase in number. This has activated the growth of NPWT market. According to the American Diabetes Association, nearly 4 million people with diabetes experience foot ulcer in their lifetime and NPWT is recommended as a novel therapy for them.

The NPWT devices in the market are high in cost. Based on McGill University Health Centre (MUHC), the average cost of NPWT in fiscal year 2009 to 2010 was US$36.30 per treatment day or US$254.13 per week. The NWPT product of KCI Company is cost US$20-30 per day for rental and available for purchase that cost about RM70000 per unit in Malaysia.

The demand of using NPWT has been raised for promoting wounds healing in hospital due to the increase in the number of diabetes, cardiovascular diseases and peripheral vascular diseases and caused the NPWT devices inaccessible for most of the patients who need the NPWT. In addition, the price of NPWT device is high in market give rise to hospital inability to supply the treatment for most of users and the cost of therapy is also much costly that cause middle or low income family unable to receive the therapy.

In addition, the duration of NPWT treatment last for 22 days and above for one patient. Therefore, a stable and regulated negative pressure is needed during treatment.

1.3 Objectives

To design a fuzzy logic control system and regulated pressure feedback system for NPWT.

1.4 Scope

The main hardware used for this project are Arduino Uno R3, pressure sensor IC and dc motor suction pump while software used for writing the program to control Arduino micro-controller board is Arduino version 1.0.6.

A prototype of NPWT device is designed in this project that can be functioned to supply negative pressure in the range from 0 mmHg to -200 mmHg and regulate negative pressure within the range using fuzzy logic control.

1.5 Report Layout

This report consists of 5 chapters. The first chapter includes introduction with background, problem statement, objective and scope of the research.

Chapter 2 presents the literature review of research. It gives an overview of mechanisms of action, negative pressure level, modes of negative pressure, wound filler, NPWT Devices in Market and fuzzy logic system.

Chapter 3 discusses the methodology of research. The NWPT design specification and fuzzy logic design is described, schematics and block diagram is drawn in this chapter. Besides, the uses of components are being lists out. Moreover, the flow chart, project flow and are being brought up in this chapter.

Chapter 4 shows result and follow by discussion. The project management is also discussed in this chapter with project schedule and project budget are being tabulated and listed out.

Last but not least, conclusion and future work will be discussed in chapter 5.

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