
A NOVEL WEARABLE HUMIDIFIER SPECTACLES FOR DRY EYES SYNDROME

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ABSTRACT: Tears are necessary for maintaining the health of the front surface of the eye and for providing clear vision. Dry eye syndrome (DES) or keratoconjunctivitis sicca (KCS) is a common disorder where a person doesn't have enough quality tears to lubricate and nourish the eye. Dry eye is a common and often chronic problem, particularly in older adults. There are lot of consequences related to this disease such as ocular surface and tear film problem, age and gender, indoor environment, and computer vision syndrome (CVS). In this paper, we propose a novel idea to design a prototype of a wearable humidifier glasses for patients suffering with Dry Eye Syndrome. The system is designed using a microcontroller, sensors such as temperature and humidity ,a mini micro pump ,and an ultrasonic transducer. The glasses are fixed with sensors to make it as an active device. The proposed system continuously monitors the dryness of the eye and can self-regulate the moisture for the eyes based on the humidity level in proximity to the eye.

Keywords: Dry Eye Syndrome, Keratoconjunctivitis Sicca, Computer vision Syndrome, Sensors, Wearable Humidifier, Health care technology.

1. Introduction

Tears are essential to provide protection to the eyes, to see clearly and to maintain the health of your eyes. Dry eye is a disorder of the tear film which occurs due to tear deficiency or excessive tear evaporation; it causes damage to the inter palpebral ocular surface and is associated with a variety of symptoms reflecting ocular discomfort. Dry eye disease is a chronic ocular pathology and a major global health problem that manifests as a plethora of symptoms such as burning,

photophobia, tearing, and grittiness. Patients with dry eye disease experience difficulties in daily routine activities thus compromising their quality of life. If the disease is severe, it may lead to partial or total loss of vision. Dry eye syndrome, is a common condition reported by patients who seek ophthalmologic care and is characterized by inflammation of the ocular surface and lacrimal glands.

In general, dry eye syndrome can be divided into two main types. The first type is due to tear deficiency in dry eye and the second type is evaporative dry eye. The tear deficiency type is divided further into two categories, known as Sjogren Syndrome dry eye and Non-Sjogren Syndrome dry eye. Both types are autoimmune diseases that are closely related to problem with lacrimal gland and salivary gland. Meanwhile, for evaporative dry eyes, it can be divided into Meibomian Gland Disease (MGD), mucin deficiencies and exposure related dry eyes factors such as low blink rate and low surrounding humidity.

The DES is thus closely associated with ocular surface disease where most DES patients face problems with abnormalities of their tear film. Problematic tear film can cause insufficient supply of tears to the ocular surface that will then contribute to inflammation of the ocular surface. At present, there is no cure for dry eye disease. However, there are variety of treatments that are designed to reduce the irritation and discomfort caused by dry eye conditions.

The treatment varies with the severity of the diseases. For slightly dry eyes, the use of artificial tear supplement in form for eye drop should be sufficient, and it needs to be applied regularly. For those who suffer from moderate dry eyes, the use of gels is recommended, as these gels will last longer than the eye drop. Finally, patient with severe dry eye problem might need to use lubricant ointments or undergo minor surgery to occlude the tear duct.

Apart from the above mentioned treatments, moistening the air surrounding the eyes was found to be very effective in healing the symptom of dry eyes. This study hence proposes to implement a wearable humidifier glasses that can improve the air moisture close to the eyes

2. Literature Survey

Dry eye is more prevalent in older patients and among them more marked in women than men. Guillon and Maissa[1], found that the increase in dry eye with aging is traditionally thought to be associated with a decrease in tear production enhanced by hormonal changes. Clinical evidence of an abnormal lipid production system in older patients, in particular women is established. It is therefore postulated that the greater prevalence of dry eye problems in an older population has an evaporative component. Tear film evaporation was

measured with the Oregon Health Sciences University Evaporimeter at 30% and 40% humidity. 160 subjects less than 45 years old and 57 subjects aged 45 years or more formed the study population. The results revealed a significant effect of age ($p < 0.001$), gender ($p < 0.001$) and their interaction ($p < 0.001$): (i) the rate of evaporation was higher in the older age group at both humidity's; (ii) the rate of evaporation was overall higher for women; and (iii) the synergic effect of age and gender was very marked: the rate of evaporation of older women was 34-80% higher than that of older men and 36-69% than younger women. Aging of the tear film includes a significant evaporative component characterized by higher tear film evaporation for the over 45 compared to younger people. Further, in the over 45 years of age, a significantly greater tear film evaporation was recorded in women than men. The findings have significant implications for the management of presbyopic dry eye sufferers.

M.L.Schwebel[2], proposed a mask to improve the comfort and eye health of individuals suffering from dry eye syndrome including a substantially vapor impermeable shell with a unitary structure having a substantially planar portion and two eye recesses. Each eye recess forms a generally concave dome shaped region on one side of the substantially planar portion. The shell is adapted to be worn on the face of the dry eye subject. An absorbent material can be positioned in at least one of the eye recesses; so that the absorbent material extends less than the maximum depth of the eye recesses to present the absorbent material to the face in the vicinity of the eyes of the dry eye subject without extending beyond the edge of the substantially planar portion. The invention may also include securing member to secure the shell to the subjects head.

Generally, currently available mask products are expensive. The expense of the currently available products encourages repeated reuse of the mask as well as the absorbent moisture reservoirs by users. Because the mask and moisture reservoirs are in close contact with the skin, the mask and/or moisture reservoirs may become contaminated with bacteria or other pathogens over time. The presence of bacteria or other pathogens creates a possibility of infection in or about the skin and the eyes. It is well known that a moist, dark environment provides a favorable environment for the growth of bacteria, fungi and other pathogens. Dry eye disease (DED) is common; its prevalence around the world varies from 5% to 34%. Its putative pathogenetic mechanisms include hyperosmolarity of the tear film and inflammation of the ocular surface and lacrimal gland.

Dry eye is clinically subdivided into two subtypes: one with decreased tear secretion (aqueous-deficient DED), and one with increased tear evaporation (hyperevaporative DED). MessmerEM [3] proposed based on pertinent

publications retrieved by a selective PubMed search and on the authors' own clinical and scientific experience. The diagnostic evaluation of dry eye disease should include a detailed patient history, thorough split-lamp examination, and additional tests as indicated. Few randomized controlled therapeutic trials for dry eye have been published to date. Artificial tears of various kinds are recommended if the symptoms are mild. Lid hygiene is helpful in the treatment of hyperevaporative dry eye, while collagen or silicon plugs can be used for partial occlusion of the efferent lacrimal ducts to treat severe hypo secretory dry eye.

The benefit of long-term topical anti-inflammatory treatment of moderate or severe dry eye disease with corticosteroids or cyclosporine A eye drops has been documented in clinical trials on a high evidence level. Orally administered tetracycline derivatives and omega-3 or omega-6 fatty acids are also used. Dry eye disease is defined as a "multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by increased osmolarity of the tear film and sub acute inflammation of the ocular surface".The ocular surface (cornea, conjunctiva, accessory lacrimal glands), meibomian glands (specific sebaceous glands of the eyelid margin, which produce the outer lipid film of the tear film), the main lacrimal gland, and the innervation between them form a functional unit. Any or all of these structures may be affected in dry eye disease .

Recent studies have shown that dry eye is an inflammatory disease that has many features in common with autoimmune disease. Stress to the ocular surface (environmental factors, infection, endogenous stress, antigens, genetic factors) is postulated as the pathogenetic triggering mechanism. Dry eye is a common eye disease. In the US, as many as 6% of the population over the age of 40 and more than 15% of the population over the age of 65 suffer from dry eye. According to a survey locally conducted, there is nearly 20% of the population with some dry eye symptoms. Clinically, symptoms associated with dry eyes can include ocular burning, foreign body sensation, stinging sensation, pain, photophobia or blurred vision. The precorneal tear film is an essential structure of the ocular surface. This tear film can be divided into the anterior lipid layer, the middle aqueous layer and the innermost mucin layer which is secreted by the meibomian glands, the lacrimal gland and the goblet cells of the conjunctival epithelium respectively. Its use is to lubricate the eye, maintain nutrients and oxygenation of the ocular structures, act as a part of the refractive surface and help to remove debris from the ocular surface.

DJ.C. Pong[4] said Patients with the dry eye syndrome can show signs of punctate epitheliopathy and even corneal abrasions. As the dry eye syndrome can be associated with a large range of causes, it is important for clinicians to perform a careful clinical examination of the eyes before proceeding to treatment. A careful history taking to illicit the patient's medical history such as diabetes, thyroid disease and other connective tissue diseases is necessary. A thorough contact lens history is also useful. Previous eye diseases and eye surgeries such as Laser refractive surgeries like LASIK are important considerations for the cause of the dry eye syndrome

R. Vee [5] developed similar one which consists of an eyewear frame, lens and seal that is removable and can easily be attached to other eyeglasses or even sunglasses. A filter known as HEP A filter is being used together with the seal.

A special eyewear for relief of computer vision syndrome (CVS) was also developed [6]. As aforementioned, CVS occurs due to long hours of staring and glancing at the monitor. High amount of light reflected into the eyes can cause eye problem. Therefore, this invention is designed to block some light from entering the eye. It has its own housing surrounding the user's face and a forehead portion. The interior and the exterior surface of the housing are made out of opaque material.

Thus the only idea is to propose a wearable humidifier spectacles that can achieve better therapeutic effect, i.e. releasing moisture only when necessary. For such active humidification, an electronic control unit would be required that is explained in the following section.

3. Methodology

3.1. Objective

The main aim of this paper is to propose a wearable humidifier glass for the dry eye disease.

3.2. Block diagram

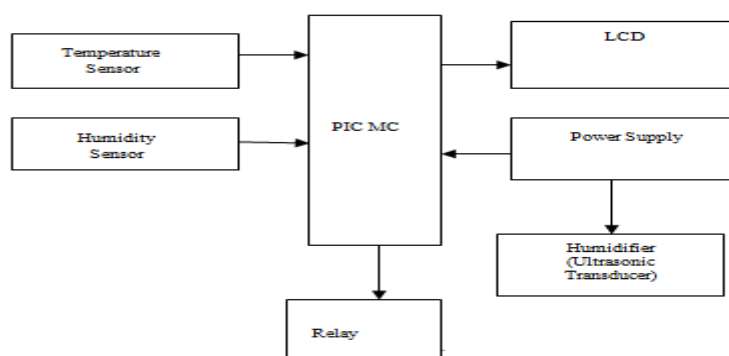


Figure 1. Block diagram

3.2. Proposed System

The proposed system comprises three modules for sensing, mist generation and control. While the ultimate goal is to produce a wearable device, the design at this stage is aimed to prove the concept of localized humidification at a system level. In addition, the use of microcontroller was considered to offer programmability for clinical studies and personalized eye care. The following describes each module in detail

3.2.1.Sensor Module

Air humidity level is the main aspect in reducing Dry Eye Syndrome. In this module, we are using Temperature sensor (LM35) and a Humidity sensor(DHT22) to measure ambient temperature and humidity level near the eye. The temperature and humidity levels are measured continuously. Based on the threshold value of the sensors, the microcontroller module will activate or deactivate the mist generation module.

3.2.2. Mist Generation Module

This module comprises of Ultrasonic mist transducer, Micro pump and water reservoir. The ultrasonic mist transducer unit converts the water droplets to mist particles. The produced mist particles is sent to the lateral part of the glasses to cool the eye using a Micro pump. Micro pump is used to control the flow of mist which is driven by ULN and Relay. The ON/OFF of the pump is controlled by the microcontroller module using a relay. ULN is a high voltage, high current transistor array IC which we are using it with microcontroller to switch ON/OFF a relay.

3.2.3. Microcontroller Module

The microcontroller used is PIC16F877A which acts as main control unit for both the sensor and the mist generation module. The sensor module is connected to the Microcontroller module through which the temperature and humidity levels are measured. When the measured humidity level decreases beyond the threshold value, the micro pump will be activated to produce mist particles near the eye with the help of ultrasonic mist transducer. If the humidity level is normal the mist generation will be deactivated automatically. In our proposed prototype LCD is connected to the microcontroller where the measured temperature and humidity levels are displayed.

4. Results

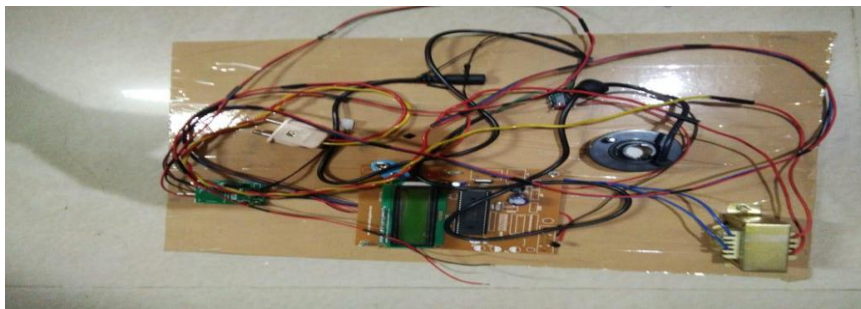


Figure 2. Designed Prototype

The functionality of the prototype in moisturizing a small area was assessed. A humidifier glass was worn that has the humidity and temperature sensors fixed in order to measure the changes in air humidity throughout the experiment. A closed container with water, ultrasonic transducer module and micro pump integrated with microcontroller and sensors are taken. Upon continuously monitoring the humidity level, when it decreases, the ultrasonic transducer module produces moisture to the eyes. The efficiency level of our humidifier would reduce if the area in proximity to the eye were not partially enclosed. Further experiment is hence required to quantify the effect of airflow.

5. Conclusion and Future Scope

The developed prototype proposed in this paper has been successfully tested. The experiment results of the prototype humidifier design is working as intended. For the dry eye patient the developed wearable glass moistens the eye by producing the mist particles. The future enhancement will be to transform the prototype working wearable humidifier glass to a real time compact portable glass by combining all the three modules into a single monolithic integrated circuit device inside a wearable device.

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