GE-International Journal of Engineering Research
Vol. 3, Issue 11, Nov 2015 IF- 4.007 ISSN: (2321-1717)
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Website: www.aarf.asia Email : editor@aarf.asia , editoraarf@gmail.com

ECONOMIC NEBULIZER FOR ASTHMA TREATMENT

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ABSTRACT

An atomic nebulizer is an atomized air machine that is used to convert the liquid phase into gaseous phase, also known as atomizers. These are substitutes to the metered dose inhalers and therefore a lot more convenient to use for any age group. Nebulization is a term referring to formation of aerosol and is widely used to treat lung diseases at home itself. The aim of our work was to build an economic nebulizer out of basic household things & at the same time, make the atomizer a bit different from the generally available nebulizer in the market. Our equipment has the capacity and specifications which have been carefully designed to convert the liquid medicine into aerosol almost immediately thus avoiding any possible amount of delay in the administration of drug. The reason behind this is that there has been no significant up gradation in this device for a long time and still takes a little start-up time before the aerosol conversion. Since it is practically made out of used and recycled materials which can be easily found in daily life, it is significantly cheaper than the products available in market with better output and much lesser power consumption.

Keywords- Nebulization, Atomisation, Aerosol Formation, Nebuliser, Respiration

I. INTRODUCTION

Nebulizer has been there in the medical industry for more than quite a few hundred of decades and serves a very crucial technique of drug delivery. The main idea behind the establishment and development of a nebulizer as a device, was to serve the purpose of drug delivery to those patients who had difficulty in intake of medicinal dosage or drugs in the conventional manner such as intravenous, oral, external application, also it had the main & a highly specific advantage of immediate drug and body interaction ratio due to its aggravated dissolvability factor with the blood.

The term 'aerosol' was not into existence until 1920 but inhaled therapy for medicinal purposes are dates back at least 4,000 years ago. The origins of inhalation therapy for asthma and other lung complaints may have arisen in the traditional Ayurvedic medicines in India around 2000 BC [1]. The compounds which were used to smoke included herbal preparations, most notably datura species, which had potent alkaloids with bronchodilating properties. The roots of datura were powdered together with other materials preferably ginger and pepper, made into a paste for smearing on a reed that could be dried and smoked through a pipe [2]. Though the technology is to centuries old but there has been no significant changes in the device or the mechanism i.e. it still uses the same compressed air and either ultrasonic energy or the mechanical energy to pressurize and breakdown the drug and finally covert it into aerosol form to be a better discharger and release of drug action.

II. HISTORY OF NEBULIZERS

History of nebulizers starts from smoking of datura preparations in India 4000 years back. In the late 18th and in the 19th century, earthenware inhalers were popular for the inhalation of air drawn through infusions of plants and other ingredients. Atomizers and nebulizers were developed in the mid-1800s in France and were thought to be an outgrowth of the perfume industry as well as a response to the fashion of inhaling thermal waters at spas. Around the end of the 20th century, combustible powders and cigarettes containing

stramonium were popular for asthma and other lung complaints. After the discovery of the utility of epinephrine, an adrenaline extract for treating asthma, hand-bulb nebulizers were developed, as well as early compressor nebulizers. The marketing of the first pressurized metered-dose inhaler for epinephrine and isoproterenol, by Riker Laboratories in 1956, was a milestone in the development of inhaled drugs [2].

One of the earliest devices which served as inhalators is design attributed to Hippocrates (Greece 460-375BC) that primarily consist a simple pot and reed in the lid, through which vapors could be inhaled. In 1190 AD, a famous Spanish physician and philosopher Maimonides wrote *Treatise on Asthma* and acknowledged that inhalation of fumes generated from herbs thrown on a fire, can prove to solve lung complaints. [3]

A. Evolution of ceramic inhalers

Variations on Hippocrates's pot-and-reed design were used in the late 18th and early 19th century. The first person to use the term "inhaler," was Dr. Mudge and he describes using his device for inhaling opium vapor for the treatment of cough [4]. Numerous models followed the same design and came into existence in late 19th century. The design caused air to be drawn through warm water prior to inhalation; one of the most popular models, the Nelson's inhaler, was manufactured by S Maw and Sons in London, it is well described in a *Lancet* article in 1863 [2]. Dr Scudding, in 1895 stated on inhalation therapy, that "the most efficient apparatus for the inhalation either of simple steam or of medicated vapors is that which is known by the name of Nelson's Inhaler: it is constructed of earthenware, and, in addition to its complete adaptation to the purpose for treating asthma, it possesses the triple recommendation of cleanliness, portability, and cheapness." [5]

B. Early atomizers and nebulizers

Atomizers which later came to known as nebulizers were developed in France, in the mid-1800s were thought to be an outgrowth industry in fashion in the form of perfume. In 1849, Dr Auphon Euget-Les Bain invented the atomizer, and in 1858 Jean Sales-Girons introduced a portable nebulizer as shown in figure 1.

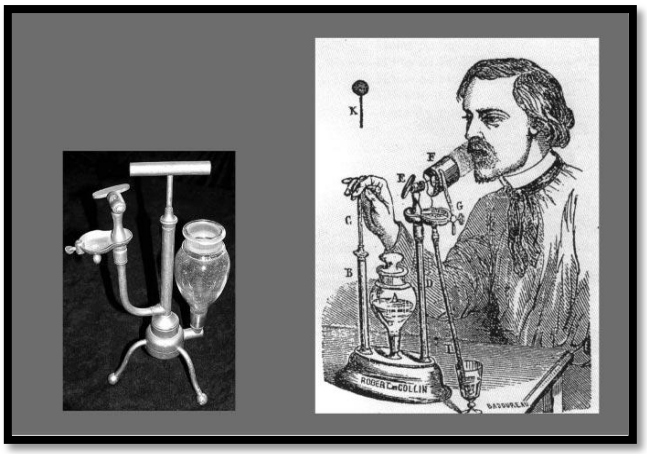

Figure 1. The Sales-Girons pulverisateur [4]

In 1858 Paris Academy of science awarded Dr Sales-Girons with the silver prize for his invention, which used a pump handle to draw liquid from the reservoir and force it through a nozzle against a plate. [6] [7]

At that time, spa therapies were very popular in France for therapeutic purposes. And the Sales-Girons "pulverisateur" was invented to allow those patients who could not attend the thermal baths to benefit from treatment. In the thermal spas in France and elsewhere in Europe the waters were inhaled as aerosols as well as ingested [8] [9].

More improvements were done Sales-Girons device and has been attributed to Bergson of Berlin, who designed a new apparatus consisting 2 glass tubes with capillary opening adjusted perpendicular to each other. The more open end of the perpendicular tube is immersed in the medicated fluid, and, as the compressed air is forced through the horizontal tube, the air in the perpendicular tube becomes exhausted, and the medicated solution then rises in it, and, when it arrives at the capillary opening, it is dispersed in very fine spray by the force of the compressed air passing along the other tube [10] [11]. This was a very early description of *Venturi system* that is being employed by today's jet nebulizer.

C. Asthma paper rolls and cigarettes

In the early 20th century combustible powders and medicated cigarettes were common for the treatment of asthma and other lungs related diseases and problems. The method of using these powders was very simple, a spoonful of powder was taken into the saucer was wrapped and then smoked. The smoke was taken deep into lungs, was hold there for a while and then exhaled. The cigarettes primarily consisted of *Datura stramonium*, tea leaves, belladonna and lobelia as shown in figure 2.

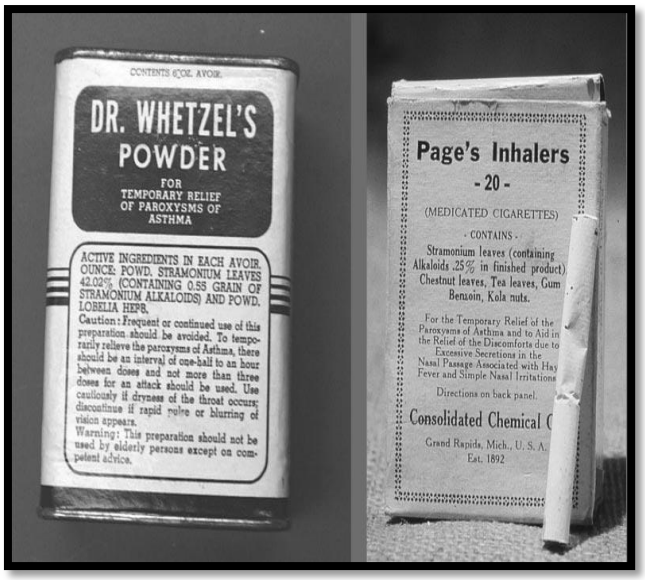

Figure 2. Asthma powder and cigarettes. [8] [12]

D. Rise of manual and electrical nebulizers

Various other advances were made around the turn of 20th century for converting atomizers to nebulizers and was recognized that epinephrine, an adrenal extract can be used as bronchodilator. In 1899, epinephrine was named by Abel, and this was followed by its synthesis by Stolz and Dakin. [13] [14]

The most effective among these seem to be the ones that contain stramonium leaves and saltpeter in the form of a powder, the fumes of which, when burned, are inhaled for the relief of the paroxysm. The antispasmodic action of fumes cause rise of thick sputum after the inhalation and temporary relief results [15]. In the early 1930s, a compressor nebulizer, the Pneumostat, was manufactured in Germany [16]. Availability of electrical supplies made possible to manufacture such a product. In 1910 G.Zuelzer published a paper stating that adrenalin could be administered through Spiess's drug nebulizer, made by Dräger in Lübeck, Germany, with either compressed air or oxygen. [17] .During that time only adrenalin chloride solution was supplied and taken in the form of bronchodilator via glass bulb nebulizer such as Parke-Davis Glaseptic and in 1940s through plastic bulb nebulizers also known as AsthmaNefrin. [18]

The Pneumostat had a rheostat for the power supply which gives the provision to control the input voltage of the compressor. Also around that time, the London Inhalatorium provided a room for treatment that utilized a nebulizer powered by a cylinder of compressed oxygen, for inhalation of adrenalin, menthol, eucalyptus, turpentine, and other ingredients. [19] [20]

E. Inhalers and rise of nebulizers

In 1948 Abbot Laboratories developed inhaler (also known as aerohaler that time) for penicillin G powder. It consists of a sifter cartridge which can have upto 100,000 units of penicillin powder which were inserted in the inhaler. The inhalation air intake caused a metal ball to strike the catridge and shake out an airstream of medicinal formulation. Later for treatment of asthma in 1950s Abbot used norisodrine powder. This revolutionized the idea for metered drug administration (MDI). Researchers at Riker Labs worked with DuPont, which manufactured propellants to produce an alcohol-based solution MDI developed a metered-dose valve. In March 1956, new drug applications were approved for Medihaler-Epi (epinephrine) and Medihaler-Iso (isoproterenol). After three months, these products were packaged for marketing [2].

Since 50 years there have been remarkable advancements in the technology inhalers and therefore it lead to the world of nebulisation. In 1960s the ultrasonic nebulizers came into picture and were using piezoelectric transducers but were not as successful as jet nebulizers.

III. ELEMENTARY and NOVEL NEBULIZERS

The elementary nebulizers include the conventional nebulizers which are ultrasonic nebulizer and jet nebulizer. *Ultrasonic nebulizers* generate aerosol by rapid movement of piezoelectric crystal as shown in figure 3.

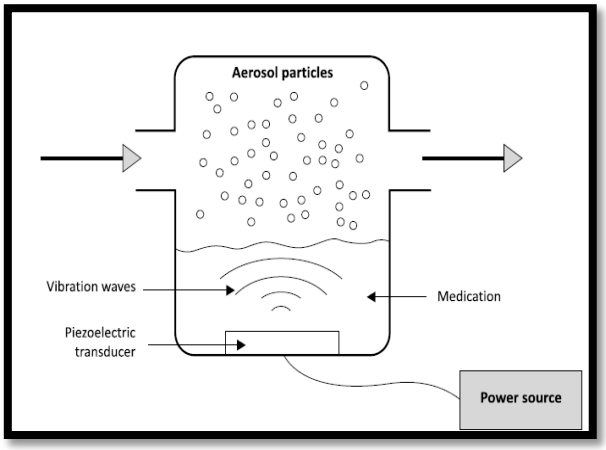

Figure 3. Aerosol formation [21]

In these kinds of nebulizers the medicine is lying just above the piezoelectric transducer and as soon as the power source is turned on, the transducer vibrates at a very high speed changing electric energy to mechanical energy and therefore forming aerosols. However, heat generated by the crystal can sometimes denature many drugs, particularly proteins, and the crystal may break, a fact that is often difficult to be detected. [22]

In *jet nebulizer* aerosol formation is based on the principle of Bernoulli. Airflow is passed through a very tiny orifice and expands in the dispenser, therefore suddenly lowering the pressure and increasing the velocity at a very high rate. And by Bernoulli's principle the medication within the nebulizer dispenser is sucked out giving rise to aerosols as shown in figure 4.

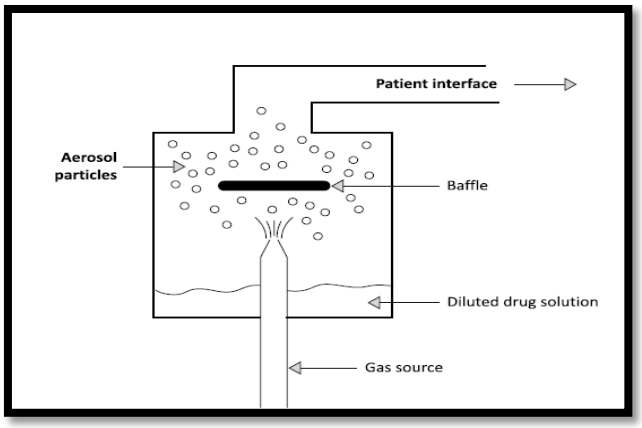

Figure 4. Jet dispenser [21]

The *novel nebulizers* include Breathe-enhanced nebulizers (BEN). The effectiveness of conventional nebulizers varies on certain parameters such as: motor power, dispenser fill volume, flow and humidity of driving gas and may be on brand usually. Therefore to increase the aerosol deposition of medicines towards lungs, nebulizers need to improve further and used breathe actuated dispensers. BEN has an inspiratory valve that allows the patient to inhale additional air during inhalation, in addition to recycling medication in the reservoir when the patient is not inhaling. These are more efficient than old devices that do not have this recycling system (continuous nebulization).Approximately 70% of the drug is lost to the atmosphere during expiration in the conventional nebulizing systems. The only disadvantage of these devices is increased nebulization time. [23]

IV. METHODOLOGY

The idea of making this device was to make it more convenient to the patients who were not able to afford. This is completely on the principle of jet nebulizers and having breathe enhanced dispenser.

The basic components used are as follows and there assembly is shown in figure 5.

1. A plastic box

2. A step down transformer

3. A DC motor

4. Power cord

5. Tough plastic tubing

6. A fuse and a fuse holder

7. A two way switch

8. A medicine dispenser

9. A face mask

A. Components Assembly

(a) A step down transformer is screwed in a plastic box and through it a DC motor is attached in series.

(b) The DC motor should be encased in such way that it has one inlet and one outlet for air.

(c) The plastic tubing is joined on both the ends of inlet and outlet of air.

(d) At the outlet join the medicine dispenser through which mask is attached for the patient and on the inlet end join a filter like cotton layer for increasing the shelf life of the nebulizer.

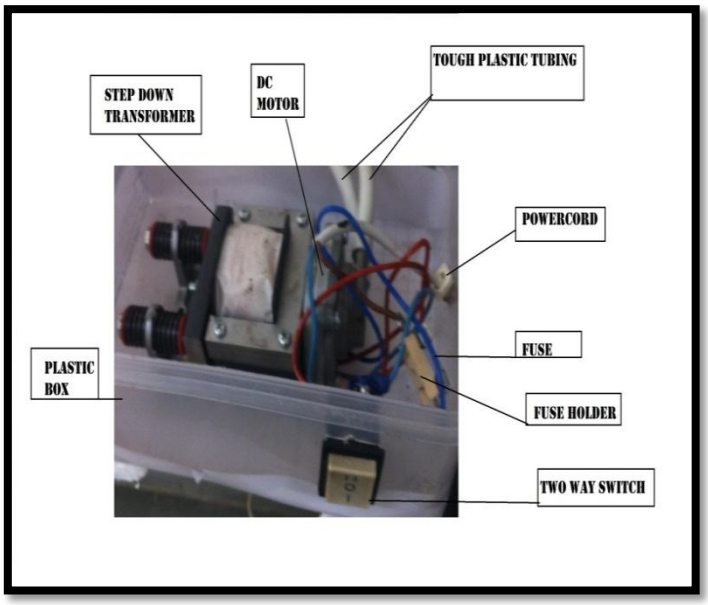

Figure 5. Nebulizer assembly

(e) Connections of two way switch are made along with the main power cord to give it a provision of working on two modes with a fuse of suitable reading in series with a power cord to prevent the device from fluctuations.

(f) Put the desired medicine in medicine dispenser and start using the nebulizer.

B. General instructions for using the nebulizer

- The correct amount of medicine should be measured as prescribed by a physician and poured into the medicine dispenser.
- Either the mouthpiece or the face mask should be attached to the dispenser depending upon the patient. Mouthpiece is considered ideal for the young patients as the need more medicine.
- The mask should be tightening properly on face or mouthpiece should be inserted into the mouth properly and lips should be sealed.
- Machine should be powered on after all adjustments are done.
- Hold each breathes for about 1-2 sec and then release.
- Continue its use until there is no more medicine left in dispenser.
- Device should be clean after every use.

C. Cleaning of device

- The face mask or mouth piece should be rinsed with warm water after every use for about 1 minute. Distilled or sterilized water should be used preferably.
- Tubing should not be put in water.
- After rinsing with water, excess water should be shaken off. Let the pieces be dry on any clean cloth or on paper.
- Reconnect the mask and mouthpiece and run the machine for about 20 seconds to dry the parts completely.
- Disconnect the parts after drying and store them in zip lock bag to prevent them from any dust.

D. Precautions

- The inlet filter should be checked every month. If it is found dirty it must be replaced.
- The device must be kept in a zip lock bag when not in use.
- Device should be clean after every use.
- A tight seal should be used over the mask for children.
- Never put the whole machine under the water.
- Clean the surface of the device with damped cloth.
- Keep the device out of reach of children.
- Do not use the device above 40°c.
- Accessories like mouthpiece and mask should be replaced for each patient.

Table I

Specifications of the device

Type	Non heating compressor nebulizer
Electrical	230 V and 50 Hz
Nebulizer rate	0.4 ml/min
Operating Temperature	+10°c to +40°c
Particle size	Mass median diameter approx 5µm
Weight	800-900grams(approx)
Dimension	8X6X10 inches(approx)
Transformer Type	Step down transformer

V. CONCLUSION

The main idea and purpose behind building and reventuring this product was to make some effective and efficient contributions to the medical industry, the product designed by the team is completely marketable and effectively operational. Our product clearly meets all the criteria of a commercial nebulizer hence can be easily chosen and commercialized above of that , the product meets up all the significant features mentioned above from low-cost to efficiency, the prototype has been tested and verified by the users and is completely capable of universal drug transformation (liquid to aerosol). Although it lacks the sophisticacy of a commercial product due to noice produced by the compressor but the usage and immediate drug discharge supports and surpasses all the other available products of much higher costs of some major superior brands. The project was made out of general household products and all the other specifics such as plastic masks and tubing, which endorses what we preach i.e. low cost efficiency. The product is completely user friendly and easily operable with low volume to high efficiency ratio since maximum amount of vapors can be obtained via nebulization

technique with the provision of two way switch through which the amount of aerosol formation can be controlled.

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