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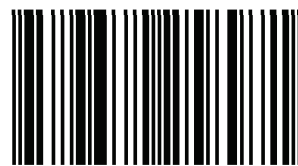
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IMMEDIATE REDUCTION OF BONE AEROSOL DURING AUTOPSIES USING AUTOPSY SAW WITH AUTOMATIC VACUUM

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ABSTRACT

Particulate matter (PM) emitted during autopsies can serve as a vector for numerous viruses or bacteria and can lead to infections. Reducing the exposure of those particles in indoor working environments is, therefore, an important issue. Even short-term exposures with high concentrations have a harmful potential and can lead to an increase in cardiovascular and respiratory mortality. The aerosol of PM needs to be cleaned by vacuuming during and after the autopsies process. An autopsy machine is a single-user machine. The most common practice in Malaysia, such as observed in Hospital Besar Ipoh, Perak is to use an autopsy saw and vacuum machine separately with two staff members simultaneously cutting and vacuuming. There are autopsy saws that came with a vacuum attachment, but the vacuum still needs to be operated manually. This project's purpose is to develop and implement modern autopsy saw prototypes that meet the needs of forensic pathologists and other medical examiners. This autopsy saw is equipped with an automatic vacuuming function that can be singlehandedly operated. The design is ergonomic and specially crafted for easier cleaning of the machine's tanks after the autopsy procedure. Tested in the simulation of the autopsy process, the machine instantly reduces the number of particulate matter PM_{2.5} during the cutting process.

Keywords: Autopsy saw machine, 3D printing, DC Motor, Small Fan and Blade Saw

1. INTRODUCTION

An autopsy is a process that takes place in the forensic unit of every major hospital. An autopsy involves an external and internal examination to determine the cause of death and its characteristics. Whether it was caused by a disease, chemistry, radiation, accident or other injuries. The autopsy is divided into two, the first being a medicolegal autopsy. A medicolegal autopsy is a case of death to be dissected and directed by the police. While, a clinical autopsy, is an autopsy in which the attending doctor needs to obtain the permission of the next of kin. The next of kin has the right not to allow the autopsy of the body to be performed or allow an autopsy to be performed on a specific part only. In any case, an autopsy is crucial in identifying the cause of death.

The main part of an autopsy is dissection. One of the important procedures is dissecting the cranial using a chainsaw swing. The swinging saws used to open cranial vaults are potentially dangerous for three reasons. First, the electrical equipment is used in wet environments. An

improperly maintained swinging saw poses an electrocution risk. Secondly, the dissection process produces aerosols of bone dust and bodily fluids. Therefore, they must be used with an exhaust system that collects these aerosols into closed containers. Third, it has been suggested that prolonged use of the device may be the cause of white finger vibrations (a long-term condition that causes numbness or tingling in the fingers, which is often accompanied by whitening (or blanching) of the fingertips) in anatomical pathological technologists. While these chainsaws are very effective at cutting bones, they pose little danger of cutting the handler.

This paper is suggesting a solution for the danger of bone aerosol produced during the use of an autopsy saw. We recommend the use of a modified swinging saw machine for user optimization. The swinging saw machine was modified to a smaller size compared to a regular autopsy saw commonly in use but has approximately the same cutting power. It was specially designed to be used for cutting cranial or bones that have the same hardness as cranial. The machine was also designed to have a small tank for a shorter cleaning cycle. Therefore, this machine will reduce the bad smell and bacteria on the machine and the user will be able to use it safely. More importantly, this machine only requires one user to operate.

2. LITERATURE REVIEW

2.1 HUMAN SKULL

During the surgery of a human body, various parts need to be dissected, among which are the skull, brain, heart, liver, and other parts found throughout the body. The focused part is the skull. The skull is the bone structure that forms the head in the vertebrae. It supports the structure of the face and provides a protective cavity for the brain. The skull forms an anterior-most skeletal part and is a product of brain cephalization, housing some sensory structures such as the eyes, ears, nose, and mouth. So, let's find out that the skull part is a little complicated to dissect.

In addition, the skull has a front bone and consists of two main parts. This is the squamous part and the orbital part. The squamous part marks the vertical, flat part, as well as the largest part and the main region of the forehead. The orbital part is the horizontal region between the second and third largest front bones. It enters the formation of the roof of the orbital cavity and the nose. Sometimes the third part is inserted as the nasal part of the frontal bone, and sometimes this is accompanied by a squamous part. The nasal part is between the eyebrow ridge and ends up in a serrated nasal notch articulated with the low nasal bones and with the lacrimal and maxilla bones laterally.

In short, the skull has a large structure to be dissected carefully as well with a higher risk in the surgical process. A lot of strength is needed to cut off the skull. Thus, the force of the chainsaw causes the skull to crack, which can cause the saw blade to break. Blades also tend to rupture or crush the skull, causing pieces of bone to fly in and around the operating area.

2.2 BONE AEROSOL

Aerosols typically appear in specific climates or as a result of pollution from sources like automobile exhaust, garbage incinerator fumes, industry emissions, and so forth. As a result of the unstable air quality, individuals may have health effects. Although aerosols in the open are detrimental to people. There are measures to prevent them, including wearing a mask, staying inside, and limiting the use of motor vehicles. Blood and bone aerosols, however, are produced in an operating theatre or autopsy room. Blood and bone aerosols together may form harmful microorganisms that can infect anyone in the vicinity.

Concerns over exposure to blood and other human fluids prompted an investigation into the potential production of blood-containing aerosols during orthopaedic surgical procedures. To imitate the aerosols normally produced during routine orthopaedic operations, standard surgical power equipment was used in the lab. Blood trickled over the surgical surface while a bone saw, a Hall drill, a Shea drill, and electrocautery were employed on bone or tendon [4]. A low-pressure cascade impactor was used to measure the particle size distribution, and a midget impinger was used to measure the amount of haemoglobin in inhalable particles. Depending on the type of power tool utilised, the particle size distribution varied, but the majority of the particles were in the respirable range. In every sample, haemoglobin was found.

In cervical spine surgery, high-speed cutters are employed. Such quick machines can create an aerosol cloud. A patient can act as a reservoir for infections that can spread through aerosols, therefore every aerosol used during surgery must be considered a possible source of infection for both the patients and the medical staff present.

2.3 OPERATION OF AUTOPSY SAW COMMONLY USED IN MALAYSIA HOSPITAL

When sawing during autopsies on human remains, fine dust is produced, which consists of particles of sizes that may fall within the human respirable range, and can act as vectors for pathogens. To eliminate the hazard, vacuuming is needed during and after the cutting process. There are several models of autopsy saw that came with vacuum attachments, that need to be operated separately by an assistant during autopsies. Furthermore, the equipment is massive and heavy, as well as expensive. The machine usually has a large suction tank and a long cleaning cycle. As a study case, the autopsy saw currently used at the Hospital Besar Ipoh in Perak needs two staff for cutting and vacuuming at the same time. The equipment is enormous and heavy, and it comes at a hefty price. It also has a big vacuum tank and requires a lengthy cleaning cycle, hence making the machine stink, and infecting it with harmful microorganisms. This results in an unpleasant smell as part of the machine which is very uncomfortable for the operating staff. As a solution, a small, low-cost autopsy saw that cuts and vacuums at the same time are needed. With an easier and shorter cleaning cycle, the machine will be more hygienic.

3. METHODOLOGY

3.1 BLOCK DIAGRAM

Figure 3 shows the block diagram our autopsy saw. The input is the power supply that will function to channel power to the entire machine. Then the output is the saw blade and vacuum. Saw blade to cut to the bone. Vacuum to suck the particle of bone simultaneously during the cutting of the bone.

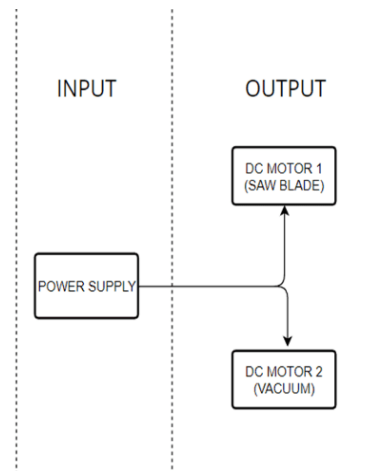


Figure 3: Block Diagram

3.2 OPERATION PROCEDURE

Figure 4 shows the flow chart of the standard operation procedure of this machine, it was designed with easy-to-use features without compromising safety for the user. The ON switch will turn on the motor of the saw and the vacuum at the same time.

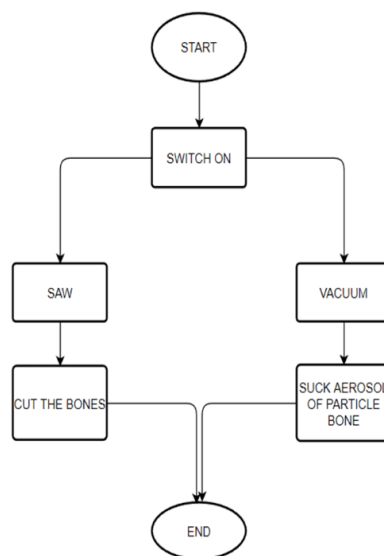


Figure 4: Flow Chart

3.3 PROJECT DESIGN

Figure 5, Figure 6 and Figure 7 show the housing design of the machine. The Solid Work was used in the design process. The design takes into account the ergonomics of hand-held power tools while at the same time making sure it will be able to execute the two main functions of cutting and vacuuming. The small tank is part of the strategy to reduce the cleaning cycle; this tank only can hold residue for one autopsy at a time. The machine body that the user needs to hold during the cutting is wrapped with a durable but easy-to-grip material made out of synthetic polymer; the same type used for a tennis racket handle tape.

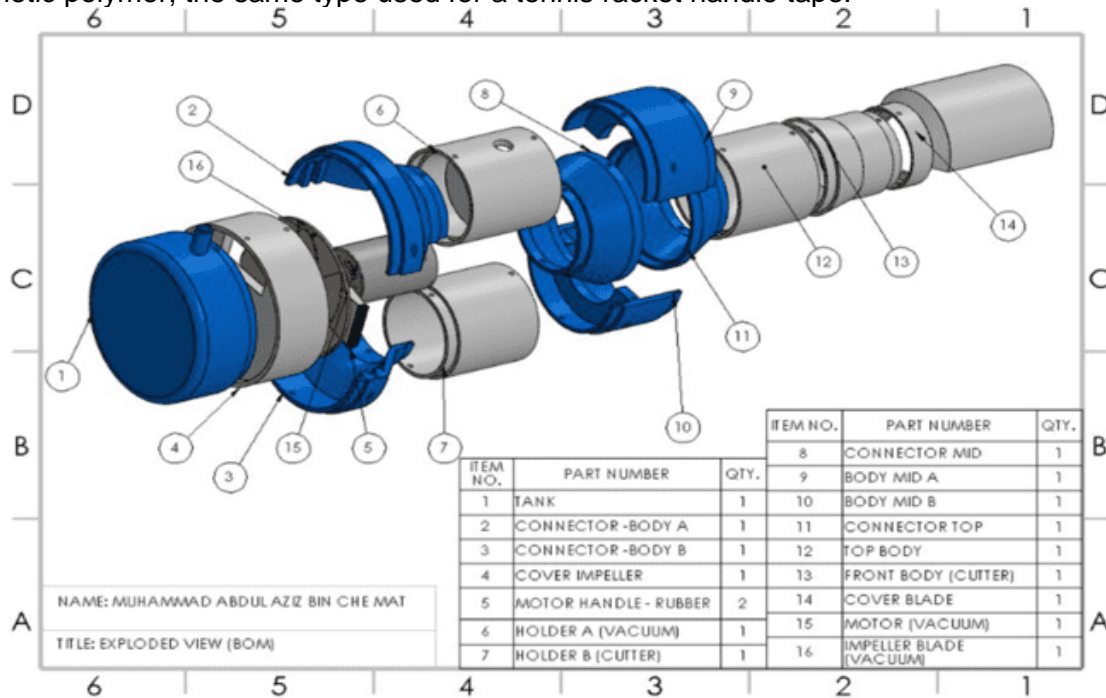


Figure 5: Exploded View

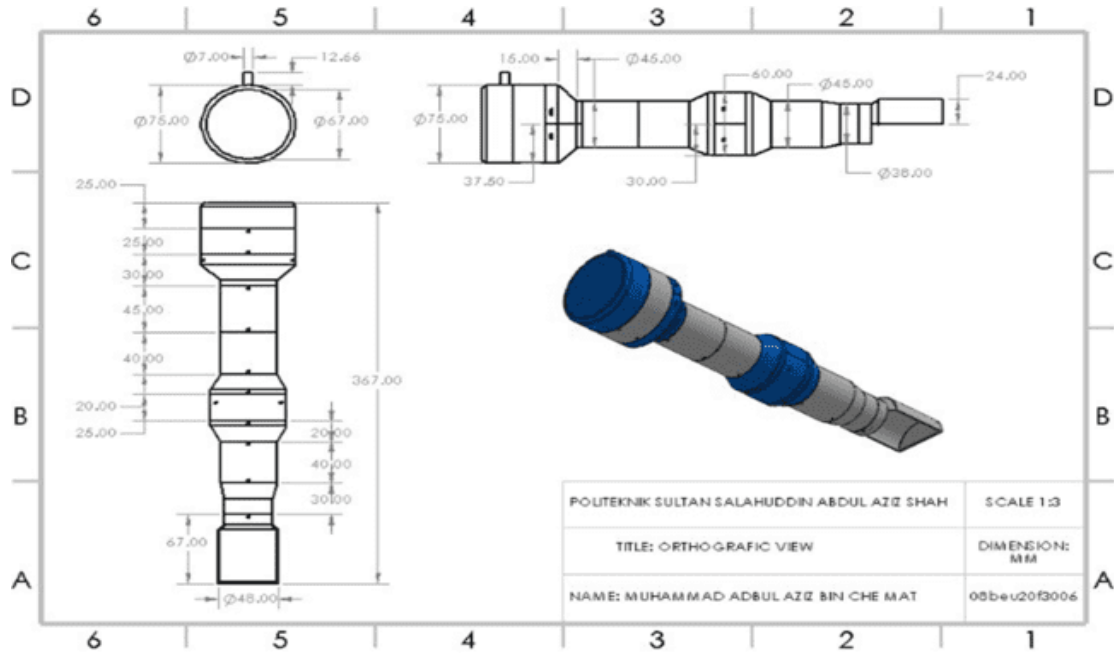


Figure 6: Orthographic View

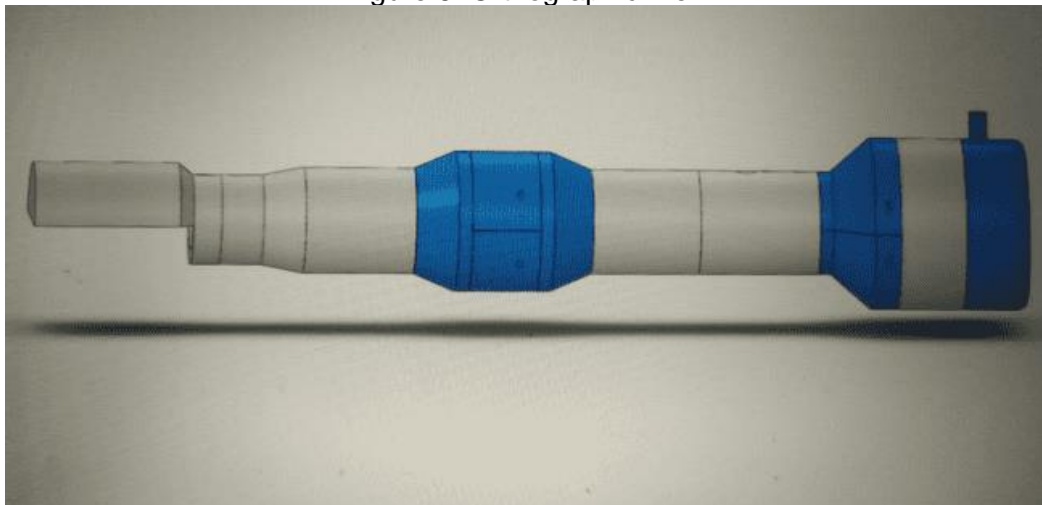


Figure 7: Full Design

4. RESULT AND ANALYSIS

4.1 DEVELOPMENT OF PROJECT



Figure 8 depicts the whole design of this project. To get this machine going an adaptor is needed. It is possible to alter the voltage strength of the adapter when it is plugged in. It has high- and low-speed adjustments. One metre of adapter wire is split into two equals 0.5 metres. If the adapter is operating, a blue light will be emitted from it to indicate that it is doing so. The project's length is 31 cm, and its various diameters make up that length. The tank and DC motor chamber are located at the bottom, each measuring 7 cm in diameter. Between 3.5 cm and 6 cm in diameter for the mid section of the machine. Then there's the apex, which has a 4 cm and 3.5 cm diameter.



Figure 8: Result Full Design

4.2 RESULT ANALYSIS

An air quality sensor is used to check the air quality during the bone cutting process by detecting particles (PM2.5). A light indicates three levels of air quality – green (good), yellow (okay), and red (not good). Bovine bones were used in the experiment. The table below compares an autopsy without a vacuum versus an autopsy with a vacuum. The table adds to the analysis for this project.

AUTOPSY SAW WITHOUT VACUUM	AUTOPSY SAW WITH VACUUM
<div data-bbox="240 751 784 1094" data-label="Image">  </div> <div data-bbox="380 1108 646 1140" data-label="Caption"> <p>Figure 9: Red colour</p> </div> <div data-bbox="224 1207 800 1476" data-label="Text"> <p>Figure 9 demonstrates that if you do not apply a vacuum, the release of aerosols throughout the whole room area will result in poor air quality. The colour then shifts from green to orange, then to red. This will jeopardise the user since bone aerosols, nasty germs, and a terrible odour from the bones will be present.</p> </div>	<div data-bbox="1003 751 1214 1121" data-label="Image">  </div> <div data-bbox="946 1140 1276 1171" data-label="Caption"> <p>Figure 10: Orange colour</p> </div> <div data-bbox="824 1220 1390 1423" data-label="Text"> <p>This change from red to orange is shown in figure 10. This is because the vacuum is working to keep the aerosol from getting into the room air. It will lower the chance that aerosols will hurt people who use them or are near them.</p> </div>

5. CONCLUSION

In conclusion, the portability of an autopsy machine, from big to little, is essential in the modern-day to ease moving it without the assistance of others. Since it is light in weight and simple to transport and store in a compact space, it is not exposed to harmful microorganisms and may avoid damage from falls and other accidents. The smaller tank reduced the cleaning cycle which is the problem in old-style autopsy saw. Most important, the bone-cutter needs to have a vacuum that turns on and off automatically along with the blade motor so that bone aerosols are immediately reduced in the air around the room. All these features are present in the prototype of the autopsy saw that we design. This is a good base for the actual design that will need to take into account the actual power tools force needed.

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