INSPECTION OF DRILL BIT POINT ANGLE USING IMAGE PROCESSING METHOD

by

AMIRA SYUHADAH BINTI AHMAD YUSNI

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ENDORSEMENT

I, Amira Syuhadah Binti Yusni @ Ahmad Yusni hereby declare that all corrections and comments made by the supervisor and examiner have been taken consideration and rectified accordingly.

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(Signature of Student)

Date:

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(Signature of Supervisor)

Name:
Date:

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(Signature of Examiner)

Name:
Date:

DECLARATION

This thesis is the result of my own investigation, except where otherwise stated and has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any other degree.

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(Signature of Student)

Date:

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Primarily, I would like to express my deepest gratitude to Allah SWT for giving me the life and the opportunity to write this report. Without the guidance, it will be a hard time for me to complete this report and may not finish within time.

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INSPECTION OF DRILL BIT POINT ANGLE USING IMAGE PROCESSING METHOD

ABSTRACT

This research presents the inspection of drill bit point angle using a digital microscope and based on computer measurement which is by using image processing method. This project is to support Spirit Aerosystems Sdn. Bhd. in determining the lifespan of a drill bit and to provide a system that can detect wear or changes in the drill bit geometry specifically, point angle. Images of wear drill bit are captured and later on analyzed using MATLAB software to measure the point angle. There are two lighting setups used in this project which are focused light and ring light. Both setups are set to create backlight effect in order to enhance the edges of the drill bit. Besides having two setups of lighting, two methods of analyzing the data also presented in this thesis. The first method is binarization method and the other one is by using Sobel filter method. Both methods showed a similar trend of results where the system is capable of detecting the changes in point angle. This project is divided into two parts which are the hardware and software part. For the hardware, a close setup is designed and fabricated meanwhile for the software part, the images need to be imported into MATLAB software to be analyzed by both methods. The algorithm used is being referred to an example given by Math Work and being adapted into this project to suits the objective of this project. Within this project, we could observe the changes in the drill bit point angle by using both binarization and Sobel filtering methods.

PEMERIKSAAN PENJELASAN BIT POINT MENGGUNAKAN KAEDAH PEMPROSESAN IMEJ

ABSTRAK

Penyelidikan ini membentangkan pemeriksaan sudut titik bit gerudi menggunakan mikroskop digital dan berdasarkan pengukuran komputer dengan menggunakan kaedah pemprosesan imej. Projek ini adalah untuk menyokong Spirit Aerosystems Sdn. Bhd. dalam menentukan jangka hayat gerudi dan untuk menyediakan satu sistem yang boleh mengesan haus atau perubahan dalam geometri bit gerudi secara khususnya, sudut titik. Imej-imej bit gerudi yang telah haus diambil dan kemudian dianalisis dengan menggunakan perisian MATLAB untuk mengukur sudut titik. Terdapat dua cara pencahayaan yang digunakan dalam projek ini iaitu cahaya tertumpu dan cahaya gegelung. Kedua-dua tetapan ditetapkan untuk menghasilkan kesan lampu latar untuk meningkatkan kualiti sudut tepi bit gerudi. Selain mempunyai dua pencahayaan, dua kaedah menganalisis data juga dibentangkan dalam tesis ini. Kaedah pertama adalah kaedah 'binarization' dan kaedah kedua adalah dengan menggunakan kaedah penapis Sobel. Kedua-dua kaedah tersebut menunjukkan kecenderungan hasil yang sama di mana sistem itu mampu mengesan perubahan sudut titik bit gerudi. Projek ini dibahagikan kepada dua bahagian iaitu bahagian perkakasan dan perisian. Untuk perkakasan, tetapan tertutup direka dan untuk bahagian perisian, imej perlu diimport ke perisian MATLAB untuk dianalisis oleh kedua-dua kaedah. Algoritma yang digunakan dirujuk daripada contoh yang diberikan oleh Math Work dan disesuaikan dengan projek ini mengikut kesesuaian dengan objektif projek ini. Dalam projek ini, kita dapat melihat

perubahan sudut titik bit gerudi dengan menggunakan kedua-dua kaedah ‘binarization’ dan penapisan Sobel.

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LIST OF ABBREVIATIONS

Bhd.	:	Berhad
CCD	:	Charge-coupled Device
CFRP	:	Carbon Fiber Reinforced Polymers
D	:	Dimensional
DBMS	:	Drill Bit Monitoring System
DEFROL	:	Deviation from Linearity
FLE	:	Fixed Leading Edge
HSS	:	High-speed Steel
JPEG	:	Joint Photographic Experts Group
LED	:	Light-emitting Diode
mm	:	Millimeter
PNG	:	Portable Network Graphics
rev	:	Revolution
RGB	:	Red, Green, and Blue
rpm	:	Revolution per minute
Sdn.	:	Sendirian
SOP	:	Standard of Operation
USM	:	Universiti Sains Malaysia
V-RAM	:	Video Random Access Memory

LIST OF SYMBOLS

$^\circ$	:	Degree
θ	:	Angle
μ	:	Mean
N	:	Number of iteration
σ	:	Standard Deviation

CHAPTER 1

INTRODUCTION

1.1 Research Background

In aviation industries, Carbon Fiber Reinforced Polymers (CFRP) composite has been widely used and it is getting wider. The use of composite materials has stood out due to their outstanding mechanical properties in which they are highly specific in strength and stiffness which almost as same as metal. Holes need to be drilled in order to join and fasten the composites during the assembly process.

Drilling is the most common material removal process in composite machining. Even small jet aircraft requires 245,000 holes to be drilled and the number increases for large aircraft. The tool used which in this case a drill bit will be wear when hundreds of thousand holes are being drilled. Tool wear eventually leads to material degradation issues such as delamination, fibre fracture, fraying, and burr formation. Many research has been done regarding on the development of the techniques in measuring tool wear because tool wear will affect the condition of the material.

Generally, there are two methods for measuring the tool wear which is a Direct and Indirect method. It is known as a direct method because the cutting edge of the tool wear is being measured using a vision system such as digital microscope which the image is processed (image processing). Noted that by using direct method, the tool needs to be detached from the machine during the measuring process.

Meanwhile, the indirect method measures the tool wear by processing the signal during the drilling process. As mentioned previously, tool wear will affect the condition and quality of the material, hence, a proper inspection system is needed to prevent from using wear tool that leads to cost increments such as time and money.

1.2 Problem Statement

In Spirit AeroSystems Malaysia Sdn. Bhd., there is an issue regarding drill bit usage where there is no proper benchmark or manual to prove that the drill bit usability. The drill is used until something happen to the material, usually delamination, then only it will be changed. This is obviously not a good way to determine whether the drill is still useable.

Cost spend for drilling process increases due to damage material since one material used to make part of the aircraft is expensive. Imagine having approximately twenty materials in just one part of the aircraft, giving example, the wing. However, sometimes the drill is changed even before the wear occurs in which it is considered a waste of money. The drill might go up to thousand more holes but instead, it is being thrown because no standard of operation (SOP) says so.

A system ought to be developed to overcome this situation that can help in terms of inspecting the degree of tool wear. The previous study had been done regarding monitoring system for drill bit wear such as a digital microscope is placed facing the drill and image is captured from the top. The image is then being processed to obtain a percentage of wear.

This new developed system is built to provide alternative in the inspection method. The drill bit wear not only can be monitored from the top, but also from side view. Moreover, measuring drill bit wear from side view (point angle) have its own importance as point angle affects the composite. Normally, drill bit with 135° point angle is used to drill composite. Once the point angle reduces, it affects the composite integrity which can lead to delamination. Hence, it is important to monitor the drill bit wear from point angle view.

1.3 Research Objective

The objectives of this research are:

i. To develop a system to inspect drill bit wear specifically point angle.
ii. To obtain point angle by applying image processing method during the inspection of the aircraft assembly line drill bit.
iii. To test performance and capability of the inspection system of the aircraft assembly line drill bit.

1.4 Thesis Outline

There is a total of five chapters in this thesis that includes an introduction, literature review, research methodology, results and discussions and finally conclusions and recommendations. Chapter 1 introduces the main idea of the project which is briefly described and some information regarding the method used. Besides, the motivation of this project is also explained in the problem statement and objectives of this project also being pointed out to have a clear view of the path of this project heading toward to. Then, in thesis outline, each chapter is being defined to give the reader of flow of the project.

In Chapter 2, the nomenclature of the drill bit is explained in detail and where usually wear occurs. Also, what are the effects of point angle towards the drilling process itself and the workpiece material. Previous studies regarding inspection system tool wear were presented too. This gives a whole idea on how to improve from existing design.

Meanwhile, Chapter 3 describes the method and technique used throughout the study of how fabrication of hardware is used, how the data is collected and how data is analyzed. The method used is based on the previous study.

In Chapter 4, the results were explained in two graphs where the comparison between Binarization and Sobel filtering method are made. Then, discussions on why such graphs are obtained and which method is the most suitable to be used in this project is being presented. Finally, Chapter 5 concludes and recommend some improvements that can be done in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Drill bit

2.1.1 Drill Bit Parameter

Drill bit or cutter is a tool that is used in the making of circular cross-section which is known as holes and the process is called drilling. In the market, there is a vast option of the drill bit to choose from and it is usually depending on what material to be drilled and what are the desired outcomes; pilot hole, true hole or etc.

Since drilling is the most major machining process in the industry, apart from drilling parameters, drill bit geometry plays a vital role in making sure that hole produced is within requirement. Using worn drill bit will just damaging the workpiece material. Once the workpiece is damaged, there is nothing can be done except for pay for a replacement which will obviously lead to cost increment.

The twist drill is a rotary cutting tool that usually has two cutting edges and two flutes which are grooves formed in the body to provide cutting lips. The flutes will help in the removal of chips and allow coolant or cutting fluid to reach cutting section. Few basic features of a twist drill are point angle, main cutting edge, chisel edge, flute profile, and helix angle as shown in Figure 2.1.

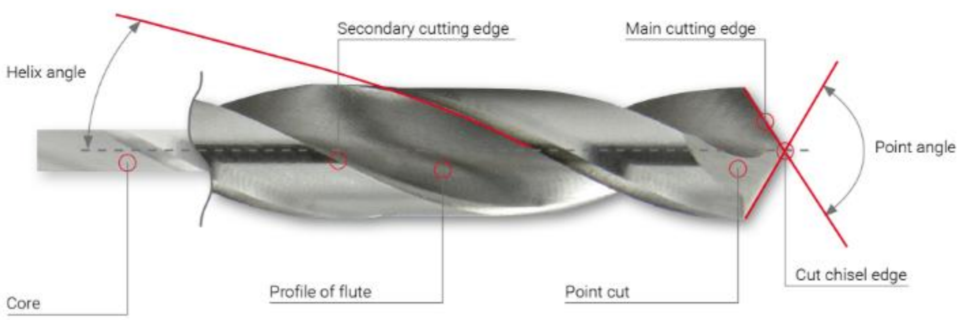


Figure 2.1 Drill bit nomenclature.

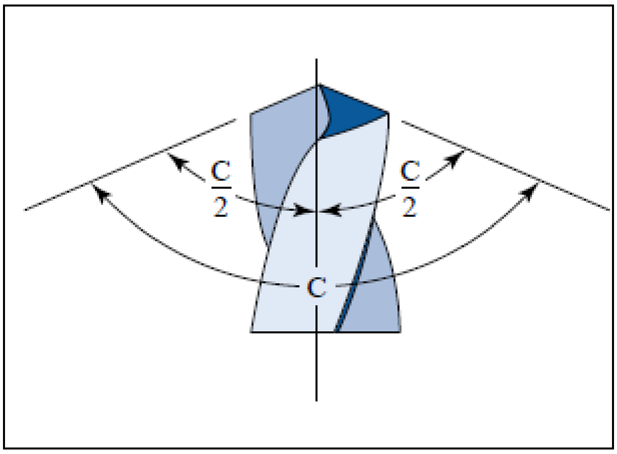


Figure 2.2 A drill bit should have an equal angle on both sides.

Point angle is located at the tip of the twist drill and the angle is measured between the two main cutting edges. A drill bit should have the same angle for both sides as shown in Figure 2.2 and the cutting edges should be equal in length (Schneider *et al.*, 2002).

Before the drilling process starts, point angle is used to center the twist drill in the material. Small point angle makes it easier for centering process. Besides, the small point angle also helps in reducing the risk of slipping on curved surfaces. Meanwhile, a larger point angle has a shorter tapping time. Tapping is the action that creates a thread onto the side of the hole. Centering in the material gets harder and a higher contact pressure is required.

The actual drilling process is done by the main cutting edges. A drill with long cutting edges has a higher cutting performance compared to short cutting edges, even if the differences are very small.

Chisel edge depicted in Figure 2.3 is located in the middle of the drill tip and gives no cutting effect. It connects two main cutting edges and responsible for entering the material and exerts pressure and friction on the material. These properties can lead to increase in heat generation and power consumption.

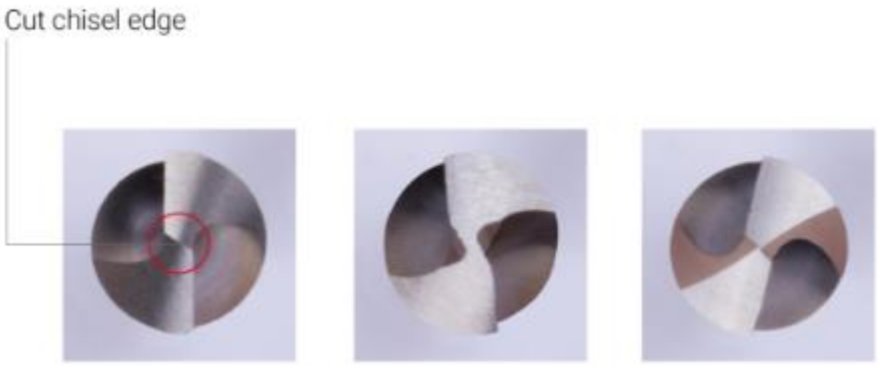


Figure 2.3 Chisel edge located on the tip of the drill bit and connecting two cutting lips.

The profile of flute responsible is to promote chip absorption and removal. The wider the groove profile, the better the chip absorption and removal. Wide groove profiles are flat while thin groove profiles are deep. The drill core thickness is determined by the depth of the groove profile. Flat groove profiles allow thick core diameter and deep groove profiles allow thin core diameters.

Helix angle is the angle between the leading edge of the land and the drill axis that decides the chip formation process. Larger helix angles contribute to the effective removal of soft, long-chipping materials. On the other hand, smaller helix angles are used for hard, short-chipping materials.

2.1.2 Drill Bit Wear

The drill bit starting to wear as soon as the cutting process begins. Therefore, it does not need to wait until a number of holes produced. Even though the drilling process is at a constant rate, wear does not progress at a constant rate too. Instead, it accelerates continuously.

Kim *et al.* (2002) studied the tool wear measuring technique by using a carbide-coated end mill as a tool. It is found that the wear can be categorized into two parameters; the mechanical and chemical parameters. The mechanical parameters such as abrasion and adhesion occurred due to the thermally loaded motion acting between the tool and the workpiece. Chemical parameters such as diffusion and oxidation occurred due to rise in temperature that leads to activation of chemical responses. Oxidation exists due to the oxide between the coating layer and the workpiece. Meanwhile, adhesion is caused by excessive wear of flank face of the cutting edge. When the flank wear reaches a specified dimension, the tool is considered to end its useful life (Zhang *et al.*, 2013).

Flank wear has been proven to have unfavorable effects on surface integrity where it hardened the surface layer due to residual stress and microstructure changes. Central wear and flank wear usually showed at the ball end mill while flank wear is displayed at flat end mill.

As for twist drill, shown in Figure 2.4, the wear starts at the sharp corner of the cutting edges and works its way along the cutting edges to the chisel edge and up the drill margins as mentioned by Schneider *et al.* (2002). The clearance is reduced as wear progresses while heat is generated due to the abrasion and this induces to a faster wear. The degree of wear actually indicated by the wear that occurs on the drill margins but normally, it is not as obvious as wear lands. Wear lands appear behind the cutting edges and is not the best indicator of wear.

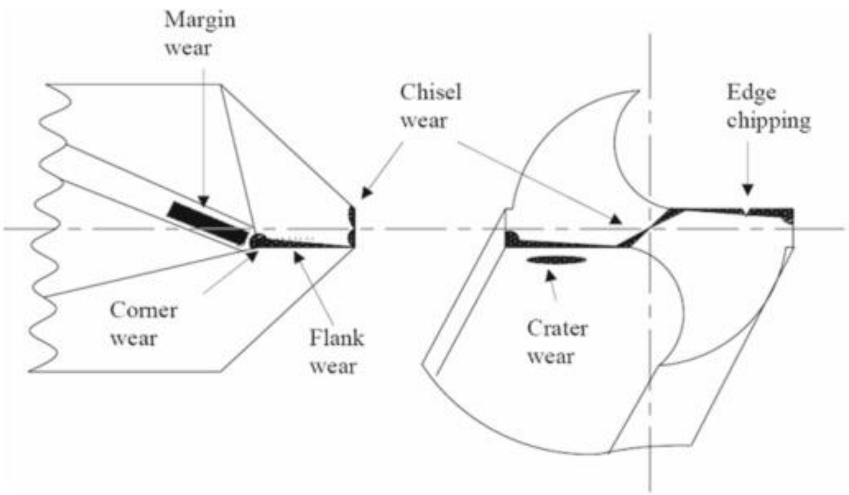


Figure 2.4 Type of drill wear.

2.2 Point Angle Effect

2.2.1 Drilling Parameter

There are many types of the drill bit in the market nowadays and each drill has its own purpose and function. Some drill type is made specifically for its material and function such as plug cutters, masonry, augers and etc. There is a common drill bit which can be used in daily drilling and can almost drill any material which is known as twist drills. There are a variety of point angles can be found for the twist drill but the commons are 118º and 135º.

Choosing proper point angle is vital since different point angle will give a different effect on the material and affect drilling parameter. The point angle affects the feed force and drilling torque characteristics. Not only that, thrust force also is affected by point angle. Smaller point angle can reduce the thrust force at different feed rate. However, larger point angle has no major difference in the thrust force due to full diameter engagement occurred between drill tip and composite laminates.

2.2.2 Delamination

Drilling onto a composite material introduces a major concern in aerospace industries and that would be an interlaminar delamination in the composite. This failure affects the structural integrity and long-term reliability severely (Hocheng *et al.*, 2006).

Delamination can occur at two places which are at the exit and the entrance of the holes. It is also known as push out and peel up respectively. It has been proven that point angle has great influence on the delamination factor when at a constant feed rate and cutting speed. Persson *et al.* (1997) studied shows that hole machining defects have significantly reduced the strength and fatigue life of composite laminates. Maoinser *et al.* (2014) did an experiment to test three different point angle of drill bits which are 85º, 118º and 135º. It is found that smaller point angle shows less delamination compared to larger point angle at high feed rate. Meanwhile, larger point angle shows less delamination at lower feed rate.

2.3 Inspection System

2.3.1 System Setup

Basically, the experiment setup depends on the wear parameter to be analyzed. Different setup is needed to assess different parameter so that the best outcome could be obtained. An experiment was done by Pfeifer *et al.* (1990), the camera is set to be linear to the drill bit because it was the flank wear that to be analyzed. Since flank wear occurs at cutting edge, the linear setup would be appropriate for the experiment. This study is supported by Azhar (2017) where the camera is set to be also linear with a drill bit to allow its wear to be detected and measured. On the other hand, Atli *et al.* (2006) mentioned that they were measuring the drill bit tip shape. Therefore, a 90º view towards the drill bit is more appropriate.

2.3.2 Lighting

When capturing images, lighting is a crucial parameter as it is to provide the correct amount of illumination to the image. As mentioned by Lambrecht *et al.* (2011), there are five different sources of light in a common portrait studio which are the key light, fill light, rim light, backlight and kicker illustrated in Figure 2.5. Different purpose of the images may require a different source of light or maybe a combination of two or more sources.

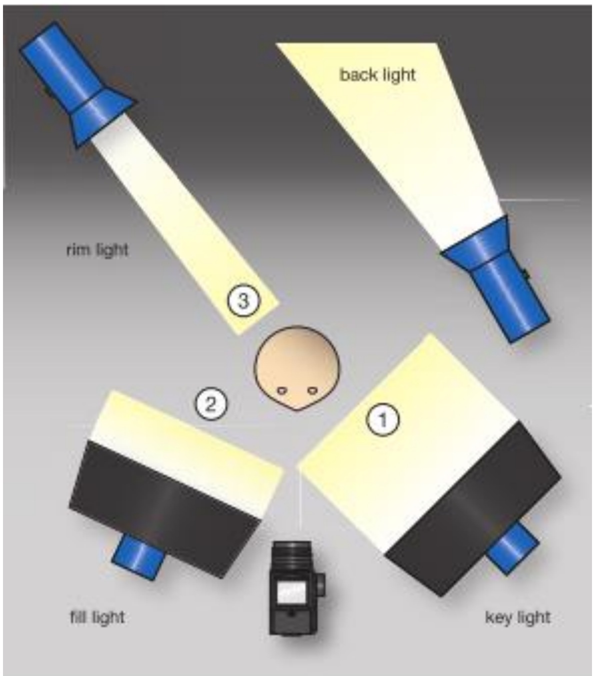


Figure 2.5 Different sources of light in a common portrait studio.

In a tool wear monitoring system, the main requirement of the system is to provide sufficient contrast between the worn region and the background. The intensity and the angle of the illumination source should be adjusted to emphasize the tool region of interest. Besides selecting an appropriate light source, consideration must also be given to the technique which will give optimum results. There are three techniques that have been used extensively for various machine vision applications including front lighting, backlighting, and structured lighting.

The light source is needed to create a clear contrast between the tool flank and the background in the image (Zhang *et al.*, 2013). In this study, light-emitting diode (LED) light from the charge-coupled device (CCD) camera is used to help capture the wear region. This means that the light source is facing the object. The wear area can be identified by the gray level of the image captured by using only the naked eye. The gray level is higher compared to the unworn tool area and the background to detect wear region. The change of the gray values is large at the nearby edge of the tool wear region, Ramzi *et al.* (n.d) use lighting from the digital microscope and two additional LED strips to add illumination for a better image quality. There are two servo motors used to control the angle of the lighting and also a light barrier to limit the lighting from hitting the drill bit. This also supported by Atli *et al.* (2006), where a light source was located near the camera location pointing towards the cutting tool to provide sufficient illumination.

A number of light source also affects the quality of the image. More than one source of light also helps in terms of capturing clearer images. The different images could be observed by changing the lighting angles. The tool bit becomes shady when the light comes from left and right sides and since wear is going to be measured, it is not favorable to have an image with shade. Only the bright part could be monitored and measured but not the shady part (Kim *et al.*, 2002).

However, there is also research regarding different lighting setup which is by using backlight effect. Backlight separates a dark subject area from a dark background by illuminating the background directly behind the subject with a small reflector. Lim *et al.* (2012) studied how various lighting condition affect scanned images. In one of the conditions, they applied backlight effect in scanning the tool insert and found out that the outcome images have the best contrast and uniform illumination.

This is supported by the gray level histogram plotted and is shown in Figure 2.6 (e). It shows that backlight has a peak value concentrated at a higher gray level value compare to other lighting conditions which signify good illumination condition. Therefore, in this project, backlight effect is used as lighting setup as the objective is to detect the wear edge. It is great to notice that source of light or lighting setup is depending on the type of cutting tool to be monitored and what are the desired outcomes.

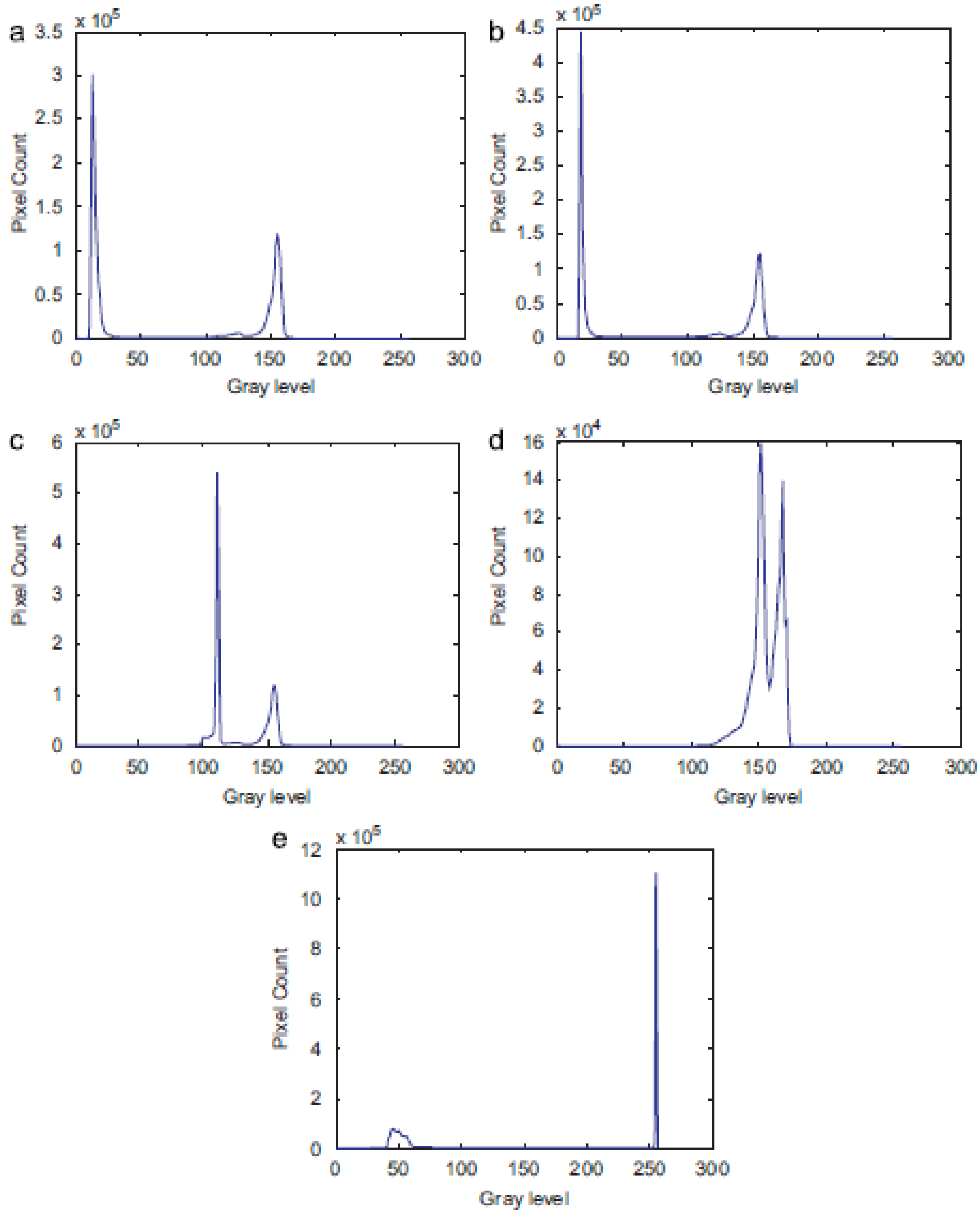


Figure 2.6 Gray level histogram of scanned images: (a) open, (b) controlled black, (c) controlled white, (d) controlled gray and (e) backlight.

2.3.3 Online/Offline

There are two methods for measuring and analyzing drill bit wear which is online and offline methods. Referring to the word online, it means something that it is always going on, always in the move and something that can be used directly. Meanwhile, offline means that the system needs to be shut down or turned off, then the tool needs to be detached from the drill gun.

As indicated by Azhar (2017), the drill bit is detached from the machine to be analyzed under the camera. García-Sanz-Calcedo *et al.* (2016) in their study used an online method where drilling experiments were performed on a vertical drilling machine. Tool life was estimated by monitoring signals acquired during machining. Hall current sensors were used to measure current signals from the machine.

According to Zhang *et al.* (2013), using an online method shows that there are two possible working principles for their measurement and monitoring design. The first mode is known as a real-time mode where the measurement and monitoring system capture and detect the tool wear during the milling operation is ongoing. The other mode is known as an in-process mode where the machine tool is stopped from operating for capturing and detecting purposes. However, they only focus on in-process mode because of a more precise measurement of tool wear can be achieved from this mode.

2.3.4 Wear Detection

Atli *et al.* (2006) mentioned that Canny edge detection is used in his experiment to detect the edges encountered in an image. This method able to detect the best edge pixel by marking the high threshold value and then continuing with neighboring locations which its gradient magnitude is above the low threshold value. Note that this method only considers neighboring pixels that are located along a line normal to the gradient magnitude direction to further speed up the process.

The author also proposed a deviation from linearity (DEFROL) metric illustrated in Figure 2.7 where each side of the tool tip was separately processed. Points were placed at each side's top and bottom tip and DEFROL metric counted a total number of pixels lying between these lines. Worn tool portrayed significantly higher DEFROL values then sharp tools. Supporting that, it obtains a very low value for a sharp tool every few frames and it showed that it is very easy to differentiate between worn and sharp tool using this method.

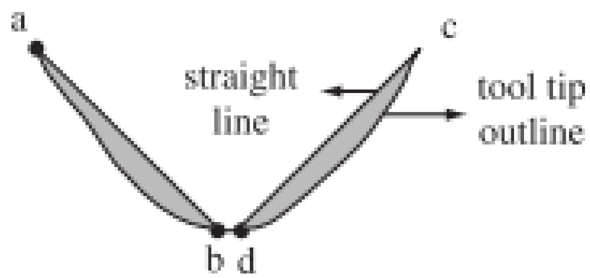


Figure 2.7 DEFROL method used in detecting the edges of the tool.

A 3×3 convolution-matrix can be used to manipulate the grey-scale image of the CCD-camera which is stored in the Video Random Access Memory (V-RAM) (Pfeifer *et al.*, 1990). This operator calculates new grey-scales for every pixel with a mathematical formulation. This convolution filter is often called a Sobel filter. The result shows the boundary lines of the High-speed Steel (HSS) drill. Angle position of the cutting edge with the help of Hough-transformation. According to Kim *et al.* (2002), an image measuring program called 'Image-Pro Plus' was used in measuring the tool wear.

In the measurement and monitoring system, it is discovered that besides image processing, wear also could be detected by using sensor and it can be categorized into two; direct and indirect sensors (Kurada *et al.*, 1997). Direct sensors are able to measure actual dimensions of the worn area or detecting the condition of tool's cutting edge. The most common direct sensors are a proximity sensor, radioactive sensor and vision sensor. Proximity sensors are used to measure the change in the distance between the tool's edge and the workpiece. Electric feeler micrometers and pneumatic touch probes are used to measure the distance. Radioactive sensors detect tool wear by measuring the tool directly where a small amount of radioactive material is implanted on the flank face of the cutting tool. Vision sensors are applied directly to measure tool wear which utilizes the cutting tool itself.

Indirect sensors measure a parameter that can be correlated with tool condition and the most common indirect sensors are cutting force sensors, vibration sensors, and acoustic emission sensors. In cutting force signals, a dynamometer is attached to a tool holder to monitor the cutting force in one or two orthogonal directions. The increase in the cutting force required as a progressively wearing tool is forced through the material is indicated by the force sensor signal. When the machining process is done by using the worn tool, the fluctuation of forces on the cutting tool will increase and hence causes vibrations to occur in the system. The vibration sensors allow us to assess tool wear by monitoring the level of vibration. Last but not least, monitoring tool wears by using acoustic emission. The emission signal is normally detected by contacting a piezoelectric transducer mounted on the machine tool.

CHAPTER 3

METHODOLOGY

3.1 Overview

In the making of this project, it is consisting of two parts which are hardware setup and software development. The hardware part is more on how the setup is built, what influence it to be that shape, dimensions and some limitations. Some of the material is used from existing apparatus from another laboratory which is borrowed just for the purpose of this project. On the other hand, software part is more on how the code in MATLAB was edited to suits this project's purpose and to obtain the desired result.

3.2 Overall Process

The project flows shown in Figure 3.1 starts with the development of the ideas by studying the previous drill bit wear system, finding the research gap and throwing some ideas on improvement process. The setup is designed based on the objective of this project. Next, the fabrication process is done based on the design earlier. All dimensions of the materials need to be accurate so that it can fit one another. Making sure that the setup can be used for the project is crucial, therefore, a testing is needed. A setup such as heights and positions need to be determined and set. Then, the setup is ready to be used. If not, the design testing procedure has to be reiterated.

In the algorithm development process, a program is created and then is used to test method functionality in inspecting and analyzing procedure. Once the result obtained is satisfied, then the overall process ends.

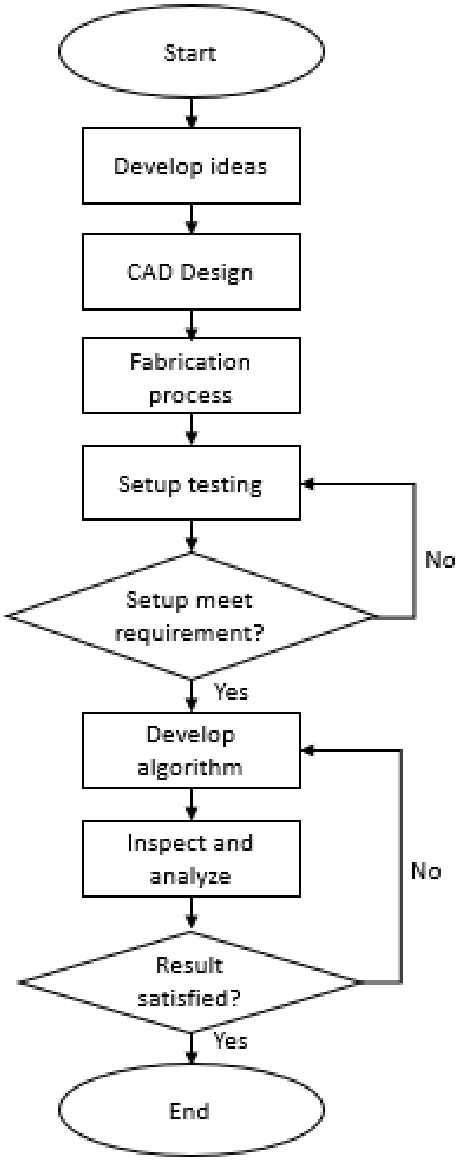


Figure 3.1 Overall process for this project including hardware and software setup.

As for the purpose of capturing satisfactory images, a digital microscope camera is used. This digital microscope is then connected to a computer that acts as a monitor.

3.3 Hardware

3.3.1 CAD Design

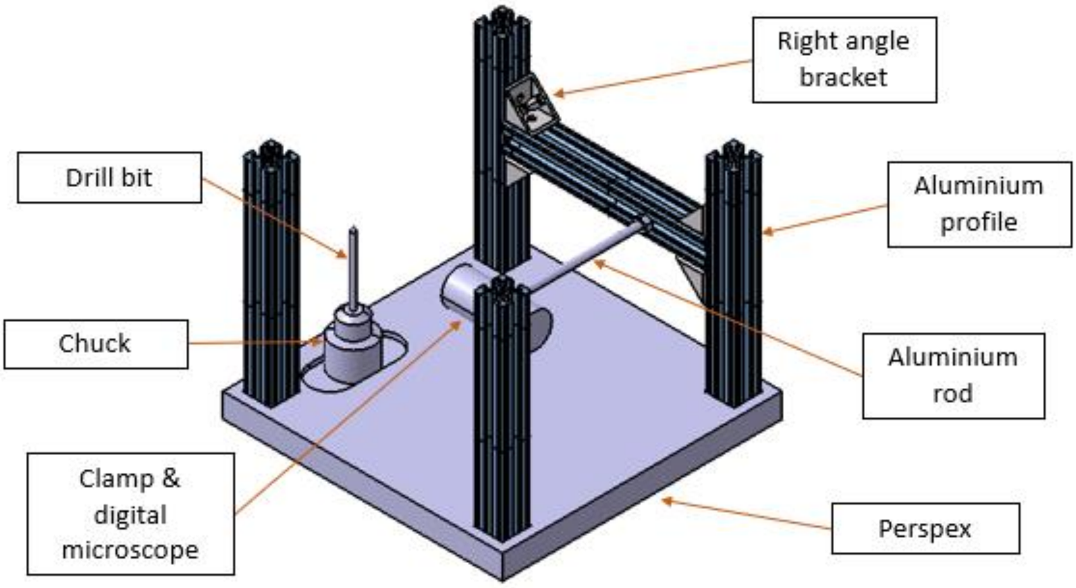


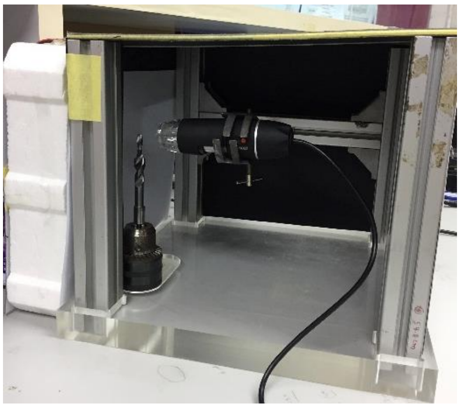
Figure 3.2 CAD design by using CATIA V5.

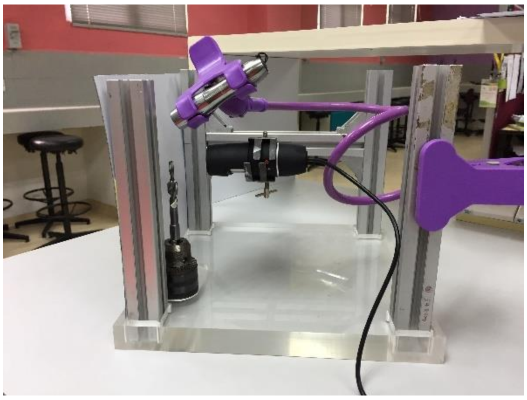
From developing ideas process, the design in Figure 3.2 is drawn to have a better view on how the design should be. Roughly, setup idea by Atli *et al.*(2006) was being used as a reference where the camera is 90º facing the drill bit. This will enable the camera to capture the drill bit tip section and eventually will support in calculating the point angle in software algorithm discuss later.

The aluminium rod that is connected to the aluminium profile is able to move front and back to alter focus length of the camera in order to obtain sharp images. Meanwhile, the slot on the Perspex enables the chuck to move left and right to make sure the drill bit is located at centre of the camera.

3.3.2 Setup Fabrication

A new setup had to be designed to properly measure the point angle. The camera and drill bit had to be aligned perfectly at the angle of 90º shown in Figure 3.3.





(a) (b)

Figure 3.3 Proposed setup for the experiment. (a) Ring light. (b) Focused light.

The process starts with machining of aluminium profiles from various of length to 4 pieces of 190 mm and 1 piece of 210 mm. The length of the aluminium profile is influenced by the length of aluminium rod used to hold the camera. The rod used is an existing rod from a retort stand shown in Figure 3.4. Therefore, the rod is the reference length and since the aluminium profiles are longer than the rod, the profiles were designed as per the rod length. Holding the camera has already been easy as the rod came with a clamp that can fit the camera. In addition, the clamp can be manually adjusted according to the size of the camera and can be locked.

Figure 3.4 Retort stand used in the laboratory.

As for the base of the system, a Perspex block of 25×25 mm is used. Four slots of 3×3 mm are milled to lock the aluminium profiles onto the base depicted in Figure 3.5. However, an existing tool in School of Mechanical Engineering, USM could not mill the slots into a perfect rectangle shape. The slots will not be having a perfect 90º angle. Additional holes need to be drilled separately from the machine to allow edges of the aluminium profiles to fit the slots.

(a)

(b)

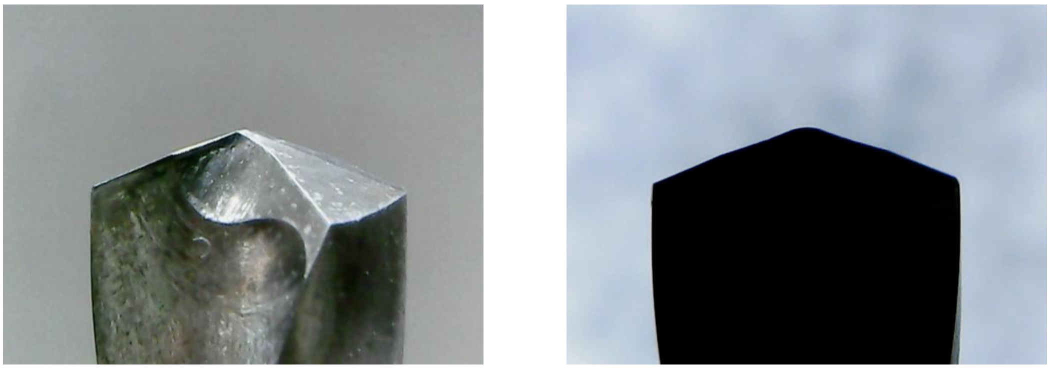
Figure 3.5 Perspex base fabrication process; (a) cutting (b) milling.

By using a milling machine, another slot with the depth of 5 mm is milled. This slot is used to place chuck that holds the drill bit. Besides, the slot enables the chuck to move on the x-axis and enables the drill bit to be captured perfectly center.

3.3.3 Lighting

The source of light affected the image to be captured. It depends on the type of image that needed to be achieved. In a photography studio, they use reflectors and additional stand studio lamp to achieve perfect lighting. Good lighting will provide good, sharp image. Without a good source of lighting, the image will become a blur and low quality.

In this project, there are two ways that were used to create backlight effect. It is known as backlight due to the source of light is coming from behind the object. The object is placed between camera and source of light. When the light source hits the object from behind, the side of the object that facing the light is brightening while on the other side becomes darken as shown in Figure 3.6. An easy example can be given is through natural phenomenon which is during eclipse where a black Moon can be seen from Earth due to the Moon is located in between the Earth and the Sun.



(a) (b)

Figure 3.6 Image produced with back light on.

Backlight setup was introduced due to the importance of the object edge rather than the object itself. Figure 3.6 (a) shows when the light hits the object from in front or top, the object can be seen clearly and the 'true' shape or characteristic of the drill bit can be described in detail. However, this type of lighting setup is not favorable in this project. Moving on to Figure 3.6 (b), despite the object cannot be seen as clearly as Figure 3.6 (a), the edges of the object can be seen distinctly. This method can help to achieve this project's objective as the edges will be used in measuring the point angle.

One way of creating backlight effect is by using a reflector. As can be seen from the Figure 3.7, a white cardboard is used to reflect the light from a 45º mini torchlight. Besides functioning as a reflector, the white cardboard also helps in diffracting the light so that uniform amount of light hits the drill bit. This helps a lot in terms of enhancing and getting sharp edges since every single light particle reaches the object.

This method can be done under room light condition because the mini torch light acts as a focused light and with the help of white reflector, it is capable of creating excellent backlight effect.

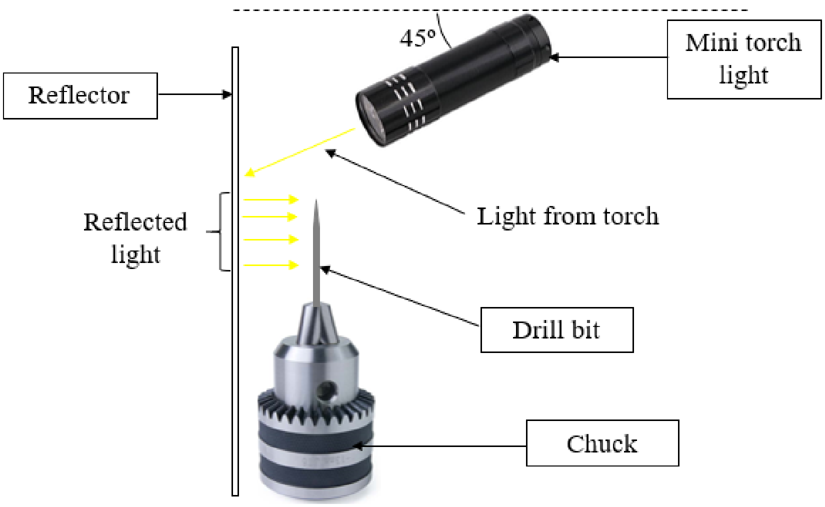


Figure 3.7 Backlight effect using a reflector and a torchlight (focused light setup).

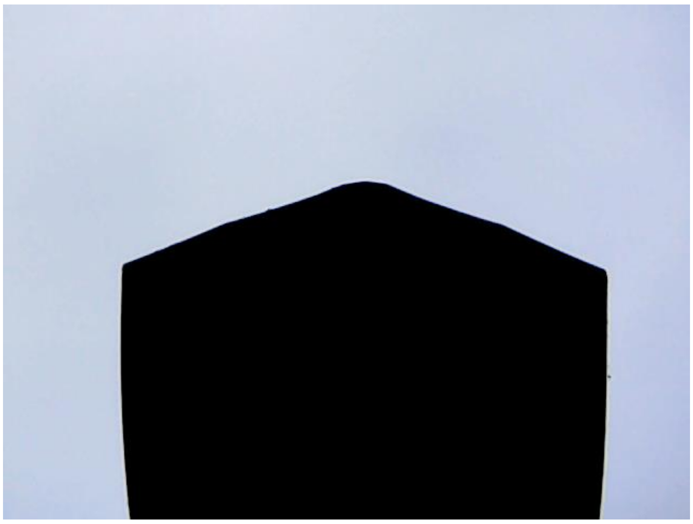


Figure 3.8 Image captured using focused light setup.

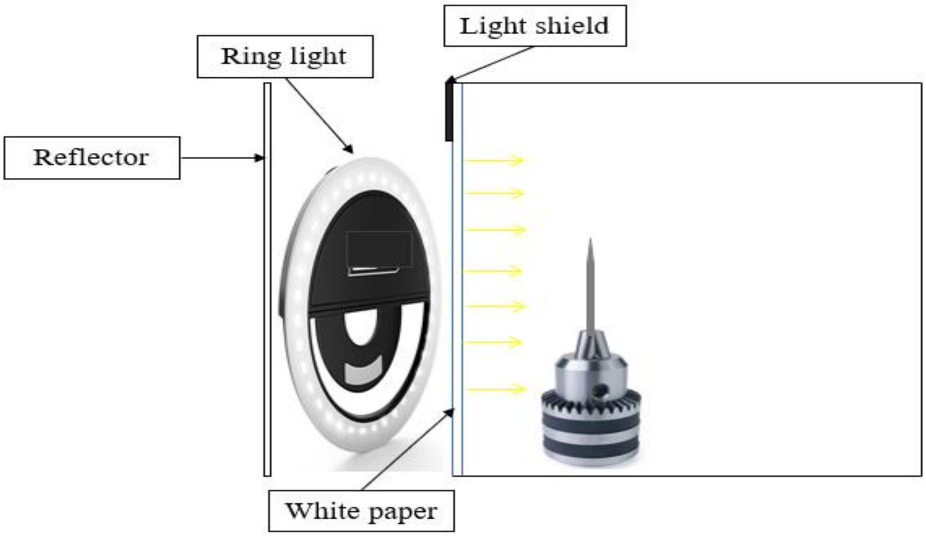


Figure 3.9 Backlight effect using a reflector and ring light (ring light setup).

Figure 3.10 Image captured using ring light setup.

Another method to create backlight effect for this project is by using direct light from behind the object, which is the ring light as the source as illustrated in Figure 3.9. White papers were used to diffract the light from the source to allow an equal amount of light to hit the object. Just on top of the ring light, behind the white paper, there is a black matte paper that functions as a light shield. The light that passes through the white paper is well distributed that it can reach the drill bit from the top causing blur edges. This is when the light shield comes in, to ensure the light only passes through the white paper