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Study of the Effect of Brightness After Penetration of Light from a Lens

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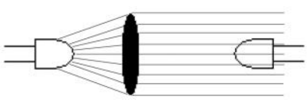
Graphical abstract



Abstract

There are many types of component that are able to produce light and the light is produced based on the angle and wavelength of the lens. Light penetration depends on the type of material used. The tests are done using basic electronic components which are able to produce light including the light emitting diode (LED), laser and infrared source. From the component, there are two types of light line, one with an angle and one without. It is known that the laser only produces a straight line light while the angle and thickness of light from both the LED, and infrared source increase with distance. The results show that the different types of light must use different types of lenses and they are suitable for use with all light properties.

Keywords: Electronic component; lens; angle; thickness

■1.0 INTRODUCTION

There are many applications of light, including making darkness brighter, medical diagnoses, scanning, jewellery, pointers and many more [1-3]. From the application (product), the user normally knows that only fix the application of lights from the product produced in the market. There are lights with many different features on the market. It is possible to distinguish between lights by looking at the wavelength. There are different types of lights that create the wavelength. Figure 1.1 shows the wavelength properties. Other than that, the advantages by using the light are that it is cheaper, safer (with no radiation), a reliable light source, low energy, and many more [4].

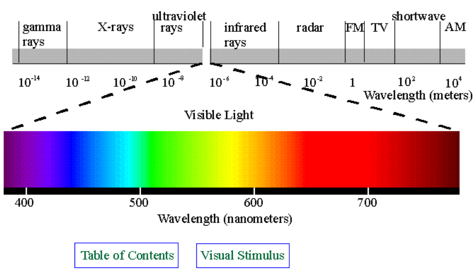


Figure 1.1 The wavelength of light

Another feature to consider is the source of light that will be used in the design to produce the light, and this is an important factor because the design will produce light based on the angle [5]. The normal projection for optical tomography is a fan beam for electronic components because the light angle will be produced from the components [6]. Researchers are using lasers to make the light focus at one point but the problem lies in the thin line which makes it impossible for light to cover the phantom. Based on the design, the light produced will be limited with regard to the angle covered by the light. The light is fixed if the measurement is taken directly from the component. However, the angle can be upgraded by the use of a lens.

There are a lot of types of lenses for example concave lenses, convex lenses and many more. All types of lenses have advantages and disadvantages. The different types of lenses may have different features and different types of applications for specific uses. Normally lenses are used to convert the properties of light, for example a lens can convert the angle of light, and so on. [7, 8].

Based on the type of lens, the experiment is setup to decide which lenses are suitable for use based on the light application. From the light features, the light will only go in a straight line, and then the normal lens can be used to make it focus or diverge.

Optical tomography is used as a light source of a medium to build the system. The light will be blocked if there are some particles [7, 9-11,33]. Optical tomography is normally used in medical environments to scan for diseases [1, 12-17]. This type of system can be used in soft tissue and hard tissue [18, 19]. Previous studies showed that only optical coherence tomography can perform the scanning of tissue [18-21]. Normal optical tomography, that is, the optical fluorescent tomography or optical coherence tomography, is use to scan biological tissue [18, 19]. The light will be produced with both types of devices above, are higher compared to the use of electronic components, and the light produce can scan the soft tissue [18]. Based on biological cell theory, cells normally consist of 70% water, and thus it is difficult for light to penetrate them. Normally the light will be refracted and for example if the light source is not 90 degree into the water. Thus, by using optical fluorescence tomography or optical coherence tomography, the tissue can be scanned to display the image [18, 19].

Based on previous studies, it was found that there were many ways to evaluate optical tomography technology,; one of which is by testing the effect of the resolution bandwidth on the wavelength. Tomography can also be used in the medical and industrial field. Optical tomography is also used in the particle sizing industry, the electronic industry, and many more. There are applications to check the blast [22]. From that we know that optical tomography can be used for lots of applications.

In a tomographic system, there are two types of projections:; parallel projection and the fan beam projection. Both of these projections have advantages and disadvantages. Generally, the projection will be selected when the system is able to detect the particles in the pipeline.

1.1 Light Frame

The table below shows the results of an experiment on the distance of light using three different sources: laser, infrared, and light-emitting diode (LED) [6, 23-26]. As we can see from the result, the light decreases when the light source is far from the sensor (detector) [27]. The penetration light into the air is one of the factors that reduces the voltage value[27]. The distance is also a major factor that makes the voltage drop smoothly.

Laser has advantages, especially for the projection of light over a greater distance, to parallel or straight line, this type of light source is designed to shed the light using a design with a lens at the front of the transmitter. Based on the previous study of laser design, the light will be produced at the centre of the laser body, and this is known as the module [23]. The module only releases light in two directions at the front and at the back. The lights are already at the centre of focus of attention so it is easy to make the laser concentrate the light and make the light go further.

An advantages of LED components is the angle;: a standard LED have 110 degree and there will be bigger light spot once the light source (led) is far from target [6, 25]. The projection of the LED is not far and it normally has a distance limit; above this limit, the distance makes the light become blurred [9, 25]. To make the LED more focused, the lens can be installed at the front of the LED so it is more focused at only one spot. Therefore, we can use this lens type (convex lens) to try to focus the LED light.

The infrared light type has disadvantages, especially when looking straight into the light (using the naked eye) from the source of its component [24]. Another way to see the light is by using a digital camera (digital camera or hand phone camera). We can see the light displayed by the component [28]. The wavelength of infrared light is between 800 nm and 0.08 cm, and the correct sensor that is suitable to capture the infrared wavelength must be chosen [19, 28]. An infrared detector cannot detect normal light (fluorescent light) [28, 29].

The first thing to consider when choosing a light sensor is whether the wavelength can be detected by the sensor. An infrared sensor only detects infrared light because of the wavelength which makes it different, and it can be proven with the design of sensor [28]. The advantage of an infrared sensor is, that it will not be disturbed by any surrounding light because the wavelength of the surrounding light is less than of infrared light.

There are various types of light sensors on the market; the, infrared sensor has been described in the paragraph above. Compared with the infrared sensor and the LED sensor are used, this type of sensor is sensitive to the surrounding light as the test report will be affected based on the surrounding light. The value of the surrounding light can be assumed to be zero (calibration).

2.0 EXPERIMENTAL WORK

Three types of light sources were used in this test method, namely laser, infrared and LED and each component have different properties of lighting for example angle of focus, the distance of the light wavelength and etc. This reduction of light (brightness) is not affected by the value of the wavelength of light when the distance detector is at a distance from the light source, and the brightness value will be reduced.

Based on the diameter of the pipe, the length range is limited and the maximum range of the diameter pipe is 12 cm [8, 30]. In this test, we use only a single light source and a single sensor to check the value captured by the sensor. The first method only uses two components:, the light source and the sensor. The objective of testing is to identify the quantity of light that can be captured by the sensor [26].

Figure 1.2 shows a diagram of the test. The light goes through the sensor and the sensor detects the light and displays a reading of the light. The sensor detects the brightness of the light that goes into it.

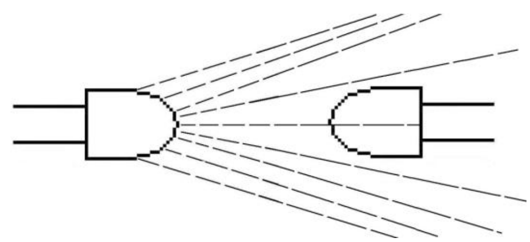


Figure 1.2 Basic diagram of the test

The first sensor tested detects normal light or visible light. This type of sensor generatesa problem and we should not consider the first reading detected by the sensor. The testing must be done in a dark room in order to ensure that the range has the correct value. The range of the sensor detector is too small, being between 0.09 mV to 3 V (using the mult-imeter).

As discussed above, these two types of sensors can detect normal light (solar and fluorescent light) and infrared light [28]. Some test can be done in a daylight situation because this type of sensor light is not function in visible light. Only a minor problem in the reading measurement is shown.

As we know, every component has specific functions and, for example, the light sensor for infrared can only detect infrared light [28]. Other light sensors can detect visible light. These types of light sensors are more sensitive than infrared light sensors. Because they can detect visible light they can further disturb the system when it is exposed to the environment (light).

For calibration, the first step is to check the voltage value with the light source turned off or in a dark room to ensure the value of light captured by the sensor. These values are considered as a zero light and it must be assumed that zero is the starting measurement. The test can also be done in normal conditions but there will be a lot of error from the surrounding light. When the test is done in a normal room the scale of detection decreases, which affect the efficiency of the sensor, and thus the error must also be reduced, so it is similar to the testing done in a dark room.

The second test is done using a lens to focus the outgoing light that goes through the sensor. As the previous study shows focusing cannot direct the light into one spot. The value of voltage detected by the sensor will decrease because indirectly increases the distance from the light source to the sensor. The distance is used to obtain more spot focus. Figure 1.3 shows the test done using the lens to focus the light.

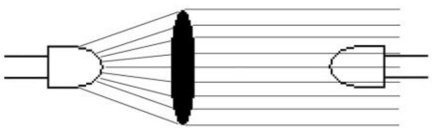
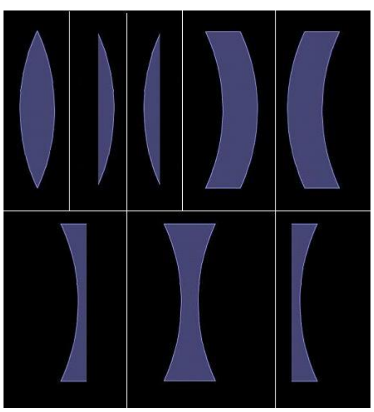


Figure 1.3 Diagram of the test using a lens

As we can see from Figure 1.3, the distance between the light source and the sensor has increased. The sensor can only be close to the lens. There is a gap between the light source and the lens because the gap has the best spot (focus length). The light will be broken and it will not be a very good spot if the distance is not suitable for the lens. So the distance between the light sources to lens is important in order to design the optical tomography jig. This distance makes the jig and the system smaller.

Before selection of the lens, a simulation is done to ensure the strength lines are produced after the light penetrates the lens. Figure 1.4 shows the lens shapes of eight different types of lenses. The results of the simulations are shown below.



Figures 1.4 Normal lens shapes

Other than this, there are other types of lenses with combinations of concave and convex lenses. The result of light refraction will be different. The light refraction is important to ensure that the beam of light coming from the lens is able to cover the distance required.

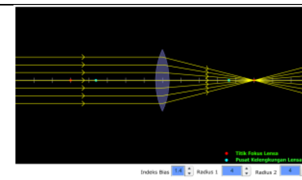
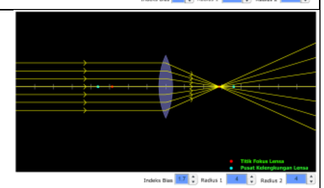
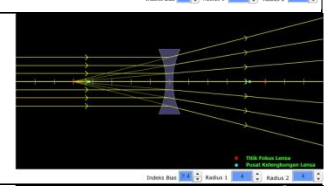
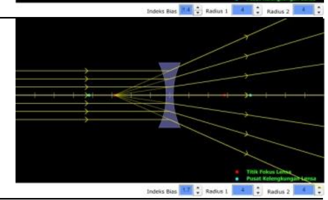
In this experiment, we use holders to hold the light source and the sensor. Researchers need to make sure that the height of the sensor (inside the light border) and the light source are in a straight line. The researchers need to take into consideration that the spot and the density of light are the same [7, 8].

Other than this, the test could also include the expansion of the diameter of the light. The measurement distance is the same as before, being 12 cm [7, 8]. The objective of this test is to confirm whether the diameter of the circle is maintained or increased. The step is almost the same as the experiment below but we did not use the sensor to measure the diameter of the circle. Based on the simulation result, the diameter will increase until it reaches a certain size and the size will then be maintained.

3.0 SIMULATION RESULT

Table 1.1 shows the result of the simulation of the use of a lens. The result shows the field of light after penetration of the lens. From that simulation, we chose to use a convex lens to make sure that the light travelled in one direction.

Table 1.1 Refraction index

No	Lens type	Refraction index	
1	Convex lens	1.4	
		1.7	
2	Concave lens	1.4	
		1.7	

Based on Table 1.1, the result shows that the convex lens is more suitable for this experimental test, as light penetration make the output of light have an angle after penetration of the lens [31]. After penetration of the lens the angle and pattern of light change to a bigger angle when a lens is not used. The input is a straight line light which goes through the lens, and we can see that the angle decreases and increases when the light passes through the focal point. The focal point depends on the type of material, curve, and distance of the lens. The focal point for the convex lens used in this experiment is 0.5 cm and the data are recorded and captured after the focal point. The simulation shows that only the convex type of lens has a focal point and it affects the output compared to a concave lens.

Based on the simulation, four lenses are chosen in this experiment: concave, convex, 90° convex and 100° convex. Figure 1.5 shows the shapes of the lenses, and all of the lenses have their own properties and different outputs of light. The lenses are made of plastic material, and normally the refractive index of plastic is 1.5917 [32].

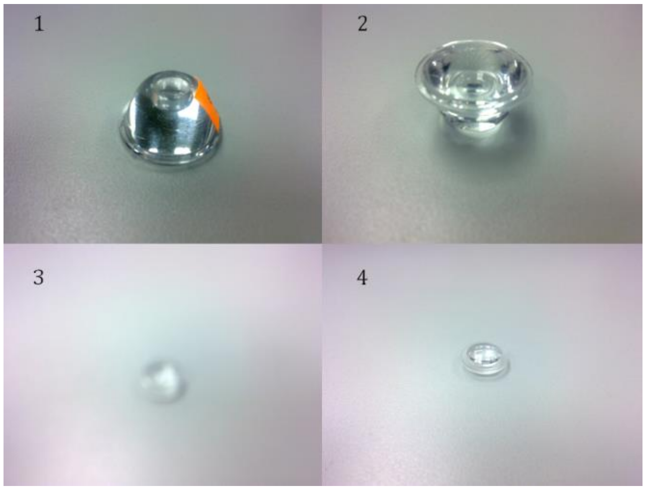


Figure 1.5 The lenses used in this test:,- **(1)** 90° convex lens:. **(2)** 100° convex lens:. **(3)** concave lens:. **(4)** normal convex lens

4.0 RESULTS AND DISCUSSION

In this experiment, we carried out a test without a lens for reference purposes. The result of using a lens should be smaller. The light sources (reference) directly penetrate the sensor without being blocked by the lens, which makes the readings higher compared to when a lens is used. Based on the picture, the experiment in which a lens is used needs a gap to make the light more focused. Based on the lens database, we chose to see whether the RX3 could capture more light, and thus it is more sensitive and captures more light although there is a little light surrounding the sensor. The RX3 sensor is more sensitive, and thus; this type of sensor can be used in a day light situation.

The SLD -70 2A and S 5973 sensors, are less sensitive and can only capture when it focused at the sensor (light go through into center of sensor). From that experiment, both sensors can capture accurate data but it is difficult to ensure that the data captured are accurate. The sensor shows its consistency when light goes through into centre of the sensor. The APEX 65 sensor has a flat surface and it can capture the light with a 120° angle. The APEX 65sensor is more suitable for use because it can detect the light coming from different angles [31].

4.1 Experimental Result Using LED Light Source

There are many types of photo sensors on the market, for example the APEX 65, SLD -70 2A, S 5973, and many more. From this result, the light penetration is very successful and we decided to consider using the APEX 65for the next experiment. For this experiment we used four lenses the convex lens, concave lens, 90° convex lens, and 100° convex lens.

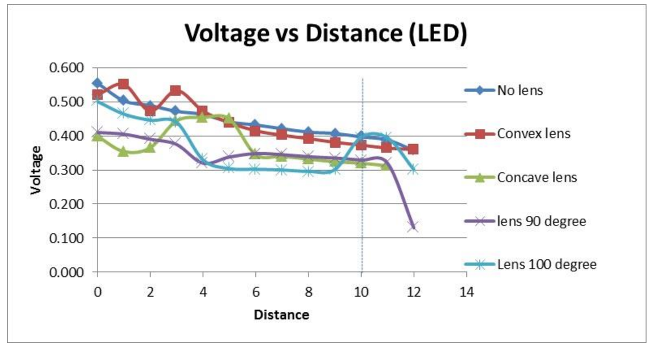


Figure 2.1 LED result for brightness versus distance. – using the concave lens : 0.35 V

From Figure 2.1, we can see that the results are slightly higher on the graphs with no lens and with the convex lens. Based on that, the intensity of light after penetration is still the same and does not modify the intensity but only modifies the light angle. The light decreases when the distance of the sensor from the light source increases. With the convex lens, the output is captured by the sensor and without the lens is still the same with a distance of 12 cm from the light source [30].

4.2 Experimental Result Using Laser Light Source

In this experiment we used a laser as the primary light source.

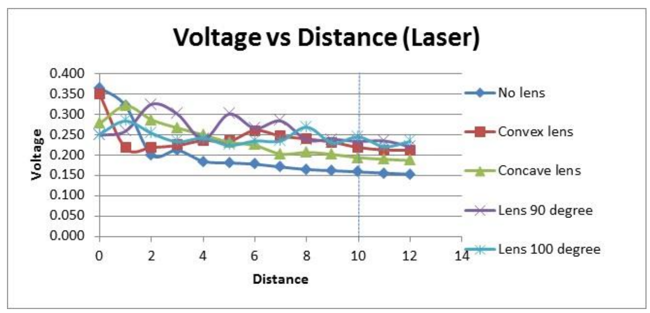


Figure 2.2 The laser result for brightness versus distance

The result shows that the reference has a higher reading compared to the case in which the lens is used. The simulation shows that the convex lens makes the output light more focused if the straight line light (incoming light) properties go through the lens. Figure 2.2 shows that the line on the graph rises slowly depending on the distance of the light source and it is quite stable compared to the cases of other lenses. Although the difference in the data (voltage) is quite small, the graph still shows changes in the value of data, and the value of the voltage is higher compared to the case with a light source (laser) without a lens.

4.3 Experimental Result Using Infrared Light Source

In this experiment an LED with 120° angle is used as the primary light source. The infrared component has the same 120° angle [24, 28]. The structure of the infrared component is almost same as that of the LED component, which means that the angle of light penetrating from the infrared component is the same as that of the LED output light [24]. Because the infrared wavelength is different from that of the light from the LED, special sensor is used to capture the value of the data [28].

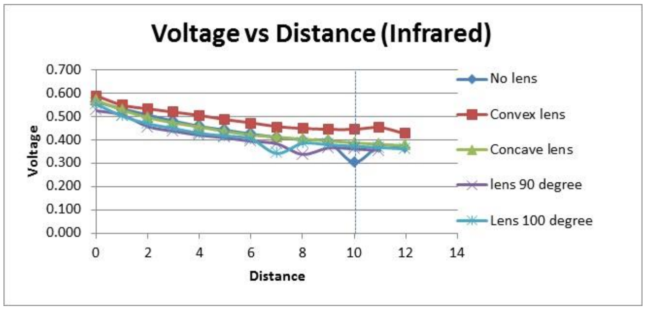


Figure 2.3 Infrared result for brightness versus distance – convex lens

Figure 2.3 shows that the reading drops sharply and stably when the distance increases from 3 to 12 cm. Based on the Figure 2.3, the first reading or starting point is higher, at around 0.588 to 0.446 V. a high voltage is given by the convex lens because this type of lens is focused when a straight line goes through it, and the refraction (refractive index) makes it focused when the lens is close to the sensor and will drop (referring to the refractive index) when the source and end are far from the focal point.

For the infrared source, the convex lens is more suitable. The graph shows that the convex lens is more stable compared with the other lenses.

4.4 Results and Discussion for Diameter Experiment

The LED and laser light sources can be measured by using a normal ruler or we just shot that light into the measurement graph. Figure 3.1 shows that the light circle after the light goes through into the lens or we call it penetration. The measurements are done by measuring the inner and outer circles.

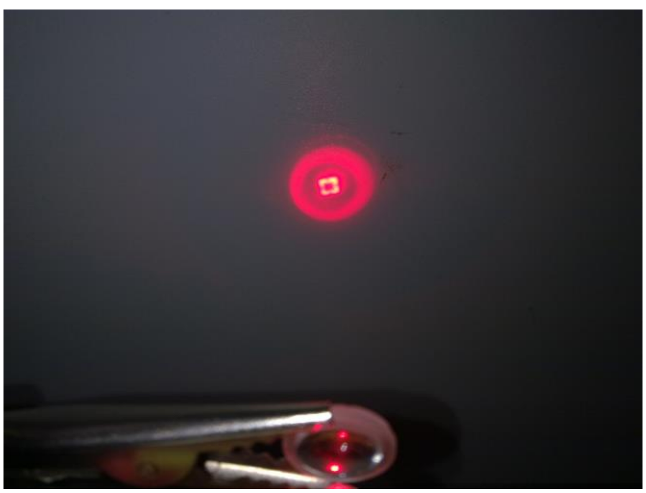


Figure 3.1 Circle of light after penetration of the lens

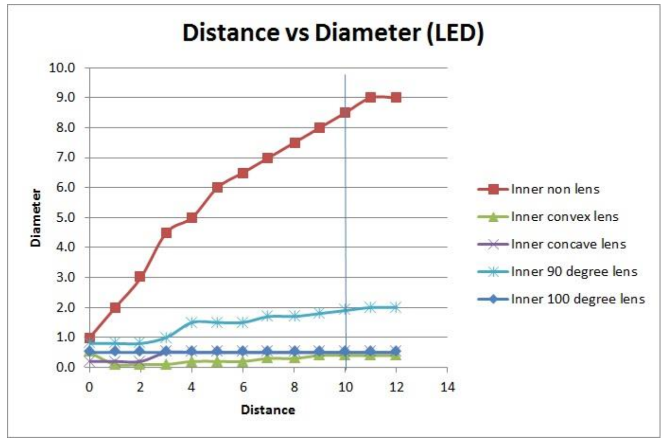


Figure 3.2 Result for inner circle for inner LED

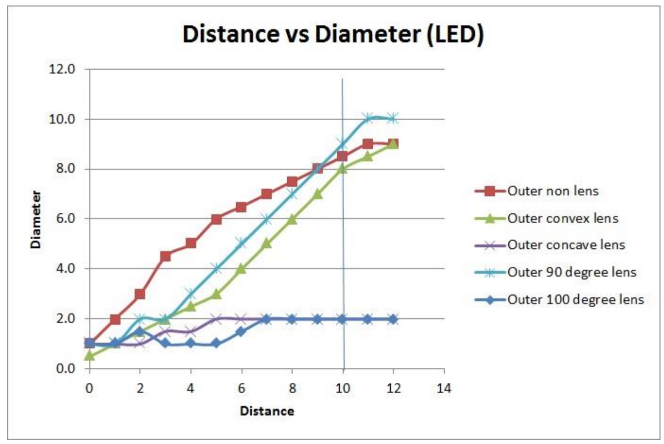


Figure 3.3 Result for outer circle with LED – concave 0.5

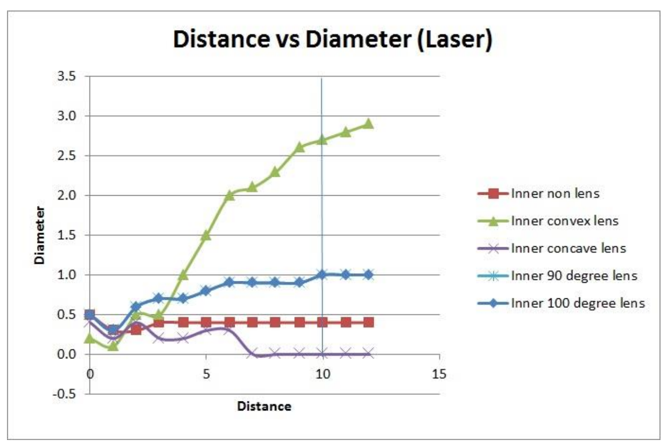


Figure 3.4 Result for inner circle with laser

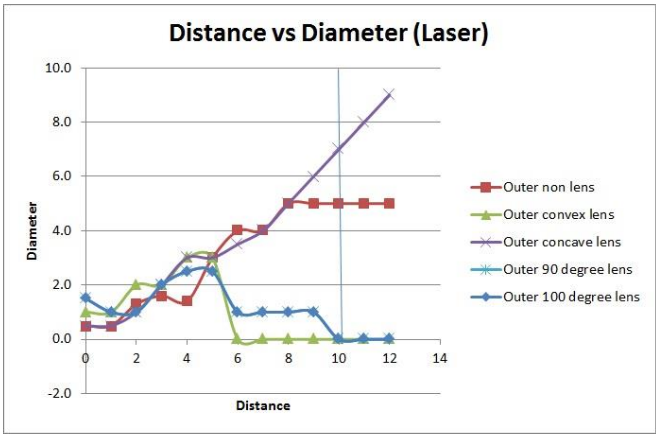


Figure 3.5 Result for outer circle with laser

As shows in Figure 3.2, 3.3, 3.4, and 3.5 the output after the lens has an eclipse property; that is, it has two points of light: a central (inner) one an outside (outer) and it shows on Figure 3.2, and 3.4 for inner circles and Figure 3.3, and 3.5 for outer circles. The diameters of both circles must be measured.

Based on the circle laser test result in Figure 3.4, and 3.5, most graphs of the laser experiment show low readings for the circle diameter. This is similar to the previous experiment; for the laser, only the concave lens is suitable, because the properties of light come from the laser, which is a straight line, and the light diverges depending on the value of the refractive index and the shape of the lens. Therefore, the laser already has eclipse properties even without the lens. Therefore, mostly laser graphs showing that the laser has a problem focusing the light, and only the convex lens can focus the laser light when it penetrates the lens. A comparison between the simulation and the test results shows that they are almost the same for the laser and it show at Table 1.1.

Based on the circle test result in Figure 3.2 and 3.3, the LED without an extra lens does not have an inner and an outer circle, unlike the laser. From that result, we assume that the inner and outer circle have the same value. Base on Figure 3.3 (outer circler) shows the eclipse properties are still existent when the lenses are put into the LED light source system. The graph of the LED test result is more stable compared with the case when the laser is used as a light source. Almost all graphs show that the increase is consistent and this graph (for inner circle for inner LED and Result for inner circle with Laser) includes the concave lens type.

5.0 DISCUSSION

Based on results shown in figure 2.1, 2.2 and 2.3, the bright of light detected is reduced when the distance of the sensor from the light source become large. This method can be used in optical tomography because by using this lens we know that the light can only go in a straight line. The important fact is that after 12 cm the light still has a value of 0.3 V, and this value can be used in the optical system. Generally the real answer is that the diameter of the pipe to be used in industry is 11 cm [30]. Other than the voltage value, the circle of light must be considered to know the coverage of the light in the site (room or pipe line). The brightness of the light will be reduced if something, for example a bubble, occurs in sensor or light source. Although the output of the light is reduced when the lens is applied in this light, it does not change the density or temperature of the light.

Based on the observations, the colour of light does not change, and if, for example the light is red the output after the lens remains red and does not change. By applying the lens to the laser, the fan beam projection is reflected in the optical tomography system by using a laser as the light source [31].

6.0 CONCLUSION

Based on the experimental results, the input of light must be considered when choosing the lens. If the input of light has an angle, the lens chosen must be a convex lens which causes the properties of the lens to be more focused after the penetration (after the lens). Other than that, the properties of light should be taken into consideration before determining the type of lens to be used in the system itself, if the line of light does not exist "and the angle of the laser (straight line) which" a better lens is chosen that is, the convex lens.

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