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OPTICAL TOMOGRAPHY EXPERIMENTAL SETUP: A STUDY ON REFLECTION EFFECT

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Abstract. The selection types of material to be used as an obstacle or a sensor jig is really important before doing any decision about what material to be used in Optical Tomography. An experiment needs to be done to analyze the performance of each type of material. In this paper, the selection is between Aluminium and PVC (Polyvinyl chloride) whether they are suitable as an obstacle or more suitable for the sensor jig design. With the experiment, we can see the theory behind it, that showing the trustiness of the experiment that has been done.

Keywords: Sensor; projection; sensor jig; aluminium; PVC; reflection

Abstrak. Pemilihan jenis material untuk digunakan sebagai penghadang atau pemegang sensor adalah sangat penting sebelum melakukan sebarang keputusan tentang material apa yang akan digunakan dalam Optikal Tomografi. Ekperimen perlu dilakukan untuk menganalisa mutu setiap jenis material. Di dalam kertas kerja ini, pemilihan adalah di antara Aluminium dan PVC (Polyvinyl chloride) sama ada sesuai sebagai penghadang atau sesuai sebagai pemegang sensor. Dengan eksperimen ini, kita dapat melihat teori asas yang menunjukkan kebenaran dari eksperimen yang telah dibuat.

Kata kunci: Sensor; projection; pemegang sensor, aluminium; PVC; pembalikan

1.0 INTRODUCTION

Aluminium and PVC are always been used in instrumentation as a part to build the sensor jig. People always choose both without knowing the impact of the

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selection. Both have an effect to the light, whether fully absorb, fully reflect, half absorbs or half reflects and many other characteristics. We concentrate on the light because optical tomography always used light as a tool to know the performance of the system. To know the impact to the light, we must focus to the characteristic of aluminium and PVC first. For aluminium, as we know, it will reflect back if the light is given to it. But for PVC, it will reflect a little or absorb all the light.

PVC is a thermoplastic polymer which composed of organic compounds. In the case of PVC, basic building blocks are three parts hydrogen to one part chlorine for every two carbon atoms. PVC is cheap, durable, and easy to assemble [1]. The mass of Aluminium is roughly 35 percent that of iron and 30 percent that of copper [2]. The light reflectivity of Aluminum is over 80 percent, and widely use in lighting fixtures. Therefore in the optical tomography, the use of aluminium can increase the voltage of the receiver because of the effect of reflecting. Otherwise, the building that has Aluminum roofing will become cooler in summer because aluminium will reflects a high percentage of the sun's heat.

Therefore, as logic, people will select PVC rather than aluminium to avoid the effect of reflection of light. However, it is only the theory. To prove the theory, an experiment need to be done, therefore the selection has more meaning.

2.0 MODELLING

Previous research had shown that the using of alternate combination of transmitter and receiver will produce a good performance [3]. In this paper, the other effect will be considered when designing the sensor arrangement. Figure 1 shows the arrangement of sensors on a previous study [4-6]. San, Fea and Loon also make an assumption that refraction and reflection are neglected and only the attenuation is considered. This assumption is the same as other researchers such as Ruzairi [7] and Yan [8]. However, here the reflection is proven will have the influence to the voltage reading by some experiments that had been done.

As we can see on Figure 1, both receivers (Rx) will receive the signal from the reflection of the signal that come from the solid object. It's mean the solid object can become the reflector. Other thing is the signal will reflect to the sensor jig and the sensor jig itself will reflect the light to the object and the process will always continuous. Therefore both things, which are solid object and sensor jig will become the reflector. But, the amount of light reflected depends on the smoothness of the surface where smooth reflects better than rough[9]. Therefore, in this experiment the real material will not be used as we want to see the effect of object reflection to the voltage at adjacent receiver.

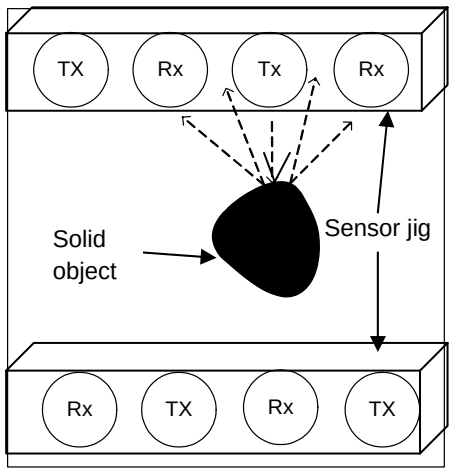

Figure 1 Effect of the light when it detects the solid

This phenomena of reflection can be divided into two categories, whether it is a specular reflector or diffuse (lambertian) reflector [10]. The solid object will always become the diffuse reflector because of the physical appearance that is a rough or granular surface and the sensor jig can be a specular reflector because the physical surface of the sensor jig that is very smooth[11]. Therefore, this is also the reason why we want to use a block of obstacle in this experiment rather than the real object that have a rough surface. In this experiment the object is in straight line shape, which is the block of aluminium and PVC. Figure 2 shows the experiment setup for showing the effect of adjacent receiver voltage towards the obstacle.

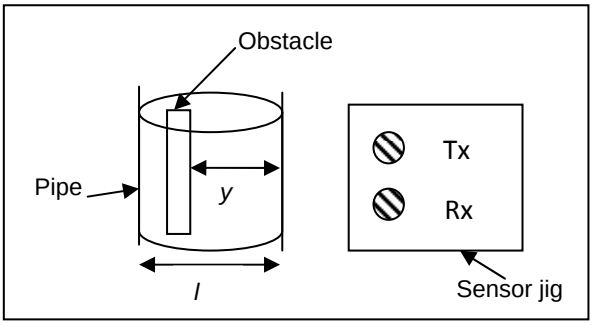

Figure 2 Experiment setup for showing the effect of adjacent receiver voltage

l = pipe diameter = 10cm
y = distance between object and pipe on the left
Tx = Transmitter
Rx = Receiver

The experiment setup as shown in Figure 2 is conducted to see the effect of the different type of obstacle towards the voltage value of adjacent receiver. The experiment also wants to evaluate the effect of the type of sensor jig towards the voltage value of the adjacent receiver. Therefore, we will know the suitable material that can be used as the object experiment and also the type of sensor jig that is suitable for optical tomography.

2.1 Obstacle Type Effect

Figure 3 shows the result of the adjacent receiver that will affect the reading using different types of obstacle which are aluminium and PVC. The sensor jig is aluminium type.

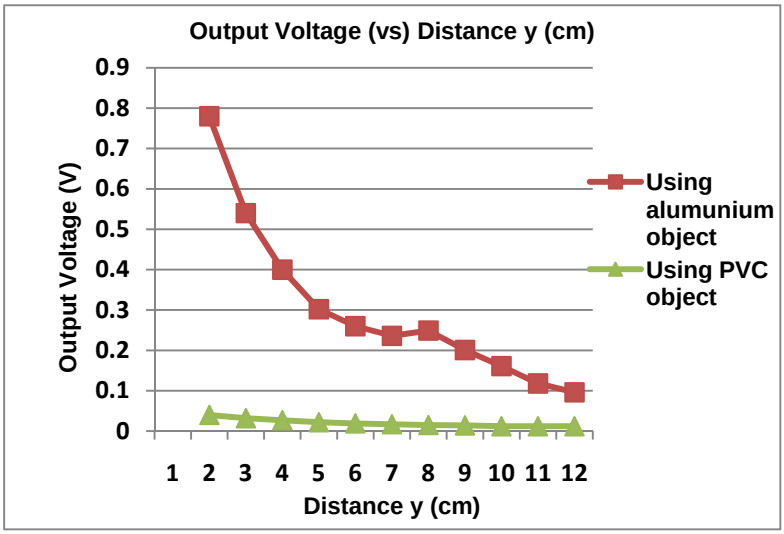

Figure 3 The voltage reading when using different material of obstacle where aluminium is a sensor jig

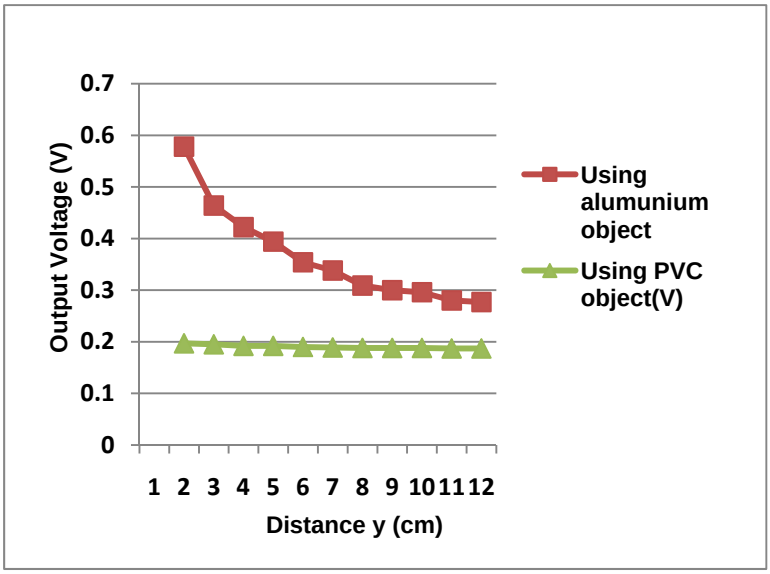

Figure 4 The voltage reading when using different material of obstacle where PVC is a sensors jig

As shown in Figure 3 and 4, by using different material of obstacle, it will affect the adjacent receiver. When using aluminium as an object the adjacent receiver shows the voltage is higher and this must be avoided in the optical tomography.

We also can see the trend for aluminium obstacle, where the bigger the angle, the more voltage the adjacent receiver will get.

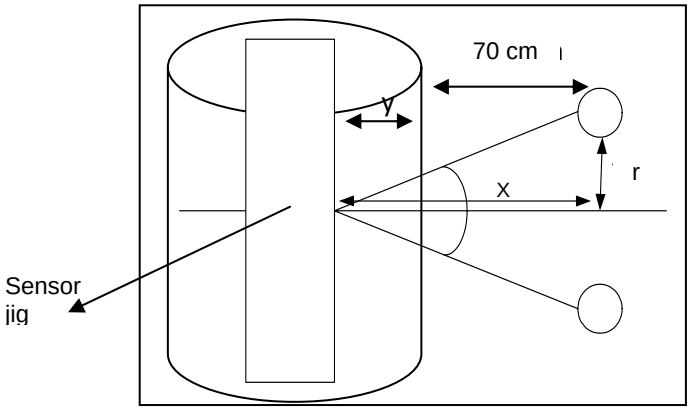

Figure 5 The relation between angle and voltage reading

$$\text{Tan } \alpha = r/x$$
$$= 1/72$$
$$= 0.88 \text{degree. (For 2 cm distance between pipe and obstacle)}$$

For 72 cm distance between the obstacle and the sensor, the voltage reading is 0.8V. For 3 cm onwards we can use Equation 1 where $y = 1.745x^{-1.06}$. y is equal to V in the graph and x is equal to distance y. Therefore if distance y = 3cm, the voltage is equal to $y = 1.745(3)^{-1.06} = 0.54$V. We get the relationship between angle and voltage value which is

$$y = 1E\text{-}07e^{17.64x}$$

and the graph is shown in Figure 6.

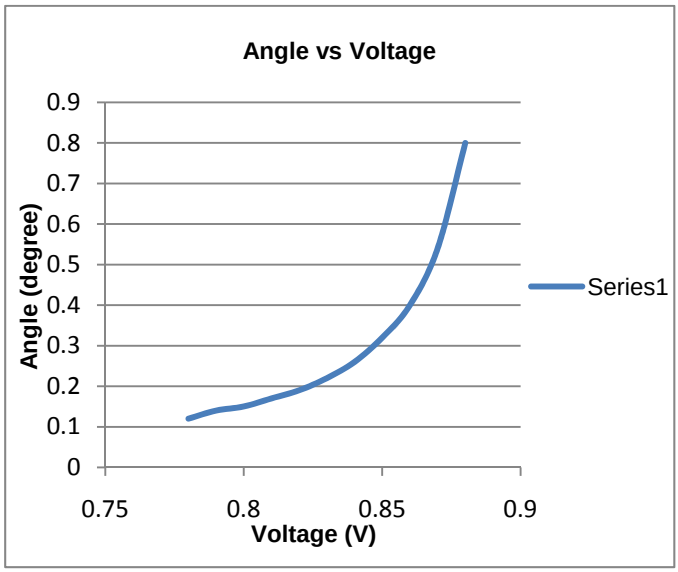

Figure 6 The relationship between angle and the value of voltage

The trend of the graph for aluminium obstacle is a power line where for Figure 3, the equation is

$$y = 1.745x^{-1.06} \quad (1)$$

for Figure 4, the equation is

$$y = 0.747x^{-0.41} \quad (2)$$

From Figures 3 and 4 it shows that the nearer the aluminium object to the wall of the pipe, the higher the voltage value for the adjacent receiver. This will affect the end result for the tomogram itself.

While for PVC obstacle, the graph trend is linear where;

for Figure 3, the equation is

$$y = -0.002x + 0.038 \quad (3)$$

for Figure 4, the equation is

$$y = -0.000x + 0.196 \quad (4)$$

2.2 Sensor Jig Type Effect

Another consideration also should be taken into account is about the feedback signal from the sensor jig itself. As mention above aluminium and PVC are two types of material that are used for the sensor jig. Figure 7 shows the different value of adjacent voltage when using different material of sensor jig.

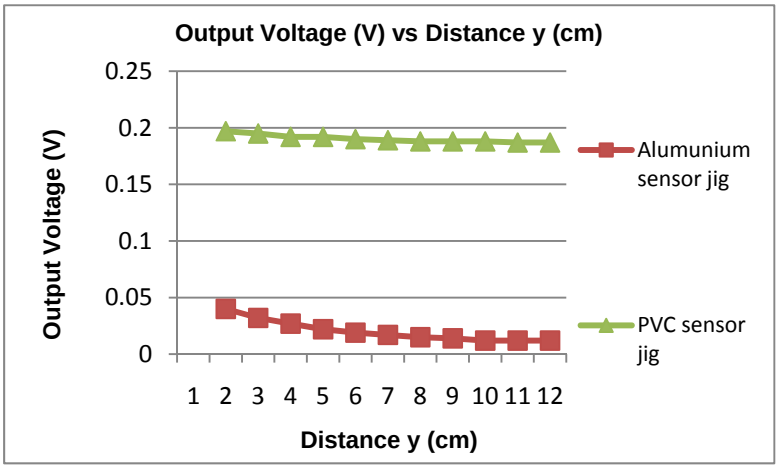

Figure 7 Output Voltage for adjacent receiver using different type of material in sensor jig

From Figure 7, it shows the aluminium types will give the lower voltage compared to PVC types for adjacent receiver. Therefore, aluminium type will be used as a sensor jig. To avoid the effect of voltage reading from the adjacent receiver, the

new arrangement will be used, which is to arrange the group of a transmitters in one place and the group of a receivers in the other side as shown in Figure 8.

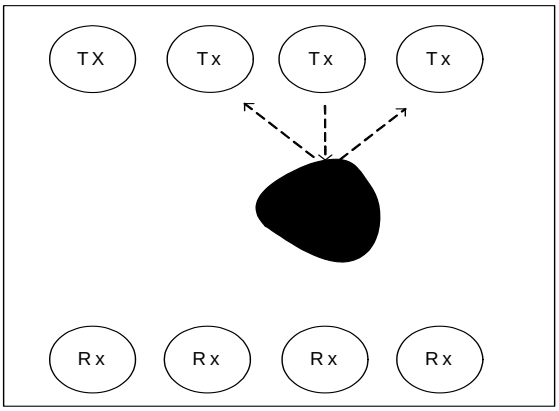

Figure 8 The modifying of sensor arrangement

With this arrangement, the reflection effect will not influence the transmitter function. Therefore, it will not interrupt the transmitter and also the receivers signal will have the correct signal. However, this configuration also has the disadvantage because the other receivers will response to the transmitter that transmitted the specific signal to its receiver pair although the collimator has been applied to the receiver sensor jig. This is proven by experiment that has been done to see the response of adjacent receivers as shown in Figure 8.

Figure 9 show that the farthest distance between Tx and Rx, will give the good result that will avoid the adjacent receiver to affect the result. However, this will need the big design for the sensor jig and this is not practical. The shortest distance which is the best design for the sensor jig, shows that the beam diameter is big and will affect the adjacent receivers to receive the wrong signal from the wrong transmitter.

To avoid this problem, each pair of sensor will be switched alternately, and this will avoid the incorrect signal. This also can easier the design of sensor jig where collimator will not be developed anymore. However, this project is planned to apply fan beam mode also. Therefore, the arrangement as shown in Figure 8 cannot be used. We will consider the arrangement as shown in Figure 1 and all the problem of this arrangement are solved by using switching mode.

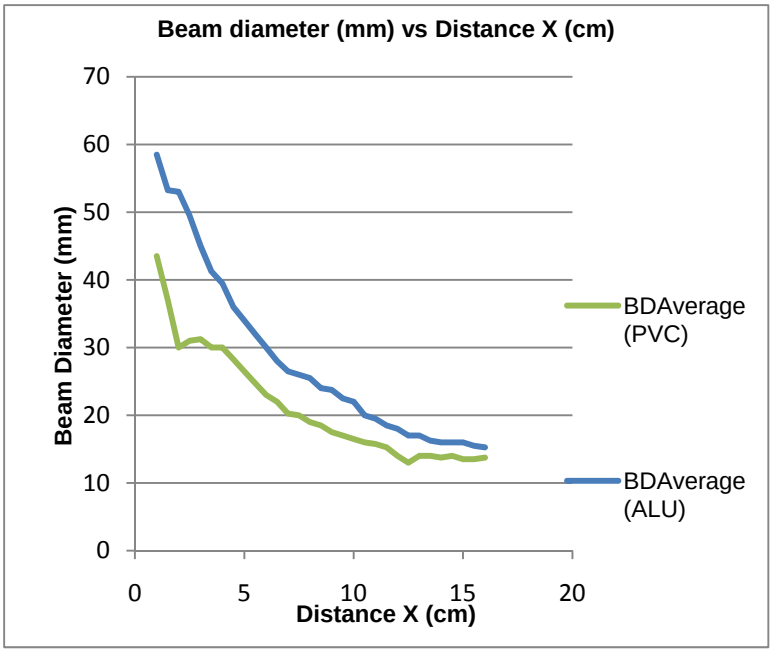

Figure 9 Beam diameter for distance between Tx and Rx is equal to 10 cm

3.0 CONCLUSIONS

There are many things that have to be considered before proceed to the actual development of the system. Reflection is the factor that will influence the performance of the system in optical tomography. By the experiment that has been done, it can be concluded that aluminium is suitable to be used as a sensor jig rather than PVC but aluminium is not suitable material for object obstacle

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