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Designing Light Beam Transmittance Measuring Tool Using a Laser Pointer

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Abstract. A simple instrument used for measuring light beam transmittance percentage made of window film has been developed. The instrument uses a laser pointer of 405 nm and 650 nm ±10% as a light source. Its accuracy approaches 80%. Transmittance data was found by comparing the light beam before and after passing the window film. The light intensity measuring unit was deleted by splitting the light source into two beams through a beam splitter. The light beam was changed into resistance by a NORP12 LDR sensor designed at a circuit of voltage divider rule of Khirchoff's laws. This conversion system will produce light beam intensity received by the sensor to become an equal voltage. This voltage will, then, be presented on the computer screen in the form of a real time graph via a 2.0 USB data transfer.

1. Introduction

Window films are typically laminated polyester film layers modified with material that absorbs, scatters, or reflects ultraviolet and visible light. Most films are often impregnated with dyes or carbon particles or coated with a layer of magnetic sputter vapor deposited metal to accomplish the expected results. Metallic coatings, particularly aluminum, reflect incident light, thereby reducing the transmission of UV and visible light. Metallic coatings also create a reflective mirror-like surface from the exterior [1]. Window films can be installed to the interior of glass surfaces in automobiles, boats (marine application), homes and buildings. There are hundreds of different types of films available from a variety of manufacturers. To determine the amount of visible light that enters the automobiles used the term VLT (visible light transmission) levels, is the amount of visible light that is allowed to pass through a glazing system that is installed window film, which is measured as percentage. So when you see a window film being referred to as a percentage, this is, for example, the VLT with 20% dark smoke film has a VLT of 20%. In simple terms, the VLT is the percentage of light that the film allows to pass through. So a 20% VLT film is very dark as it only lets though 20% of visible light and a 60% film is very light as it lets through 60% [2].

Car window film application limits the entrapped radiation in car cabin and reduces peak cabin temperature. Hence, mobile air conditioning energy consumption will be reduced [3]. Automobile window film reduces the VLT through car windows. This can be problematic at night when motorists must be able to see through the windows of other vehicles in order to spot hazards which would otherwise be obstructed. Police may also want to identify the passengers in a vehicle. In many jurisdictions, the laws to ensure darkness of films do not present a danger to motorists.

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The tool used to measure the VLT is Tint Meter. There are many variations of this equipment in a vehicle variety store. Creating tools to measure the VLT can be done with the principles of reflection and refraction. If the beam of light is visible through a window film, then some light will be reflected and some will be transmitted. A tool which is able to split a beam of light is Beam Splitter. It can distinguish between reflected and transmitted lights. The light that comes into the glass will break down into two parts, namely transmitted and reflected lights. Beam Splitter is an essential part of the most of the interferometer [6].

Beam Splitter is used in laser systems, optical interferometer, fluorescence, and biomedical instrumentation. They come in three basic forms: plate, pellicle, and cube. All are made of a partially reflecting coating, but due to differences in construction, they differ in power handling. In this study, we use plate Beam Splitter. Plate Beam Splitter is made of a coated substrate, and thus exhibit beam offset and ghost reflections from the second surface [4].

The purpose of this study was to design a light beam transmittance measuring tools using a laser pointer. The used laser pointer has a wavelength of 405 nm and 650 nm± 10%.

2. Method

Tools and materials required in designing the light beam transmittance measuring instrument with laser pointer consist of a tool's sets, electronic kits, laser pointer, beam splitter, window film, sensors, interface device, and computer. Transmittance measuring instrument design is shown as in Figure 1. Figure 1 shows that the laser pointer as a light source is located in a distance of d from sensor 2 that captures light transmission, and the light is reflected by the beam splitter captured by the sensor 1. The sensor 1 and sensor 2 are connected to the computer through the interface. Measuring light intensity uses a light sensor LDR type NORP 12.

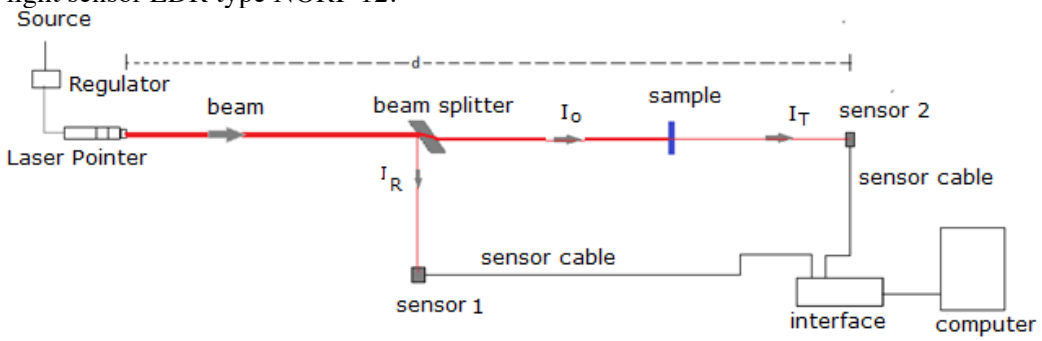

Figure 1. Design of Light Beam Transmittance Measuring Tool.

The light beam is changed into resistance by a NORP12 LDR sensor as designed at a circuit of voltage divider rule of Khirchoff's laws. This conversion system will produce light beam intensity received by the sensor into an equal voltage. Measurement data in the form of a voltage are equal to the intensity of lights which is then converted by the system interface with a resolution of 8 bits and the data displayed by the computer and stored in the form of graphs in excel [7, 8]. This voltage will, then, be presented on the computer screen in a form of a real time graph via a 2.0 USB data transfer.

To calibrate the transmittance measuring instruments of the light beam uses the rasio between the VLT from producers with an average T (T_a) is measurable, using the formula:

$$\% \text{ accuracy} = 100 - \frac{|VLT - T_a|}{VLT} \text{x} 100 \quad (1)$$

3. Result

Table 1 and Table 2 show the initial light intensity (I_o) and the light intensity after the sample window film (I_T), as well as comparisons between I_o and I_T are notated T or transmittance. Initial light intensity (I_o) is the intensity of the light beam before going through the sample window film, and I_T is the light intensity after going through the sample. I_o and I_T which are measured from these experiments have units of volts. Figure 2 looks a series of experimental equipment for laser pointer with wavelength 405 nm.

Table 1. The Measurement of Light Intensity with Laser Pointer 405 nm.

% Darkness	I_o	I_T	T (I_o/I_T * 100)	T_a
40	126	43	34.13	34.15
	138	45	32.61	
	126	45	35.71	
60	126	23	18.25	17.94
	138	25	18.12	
	126	22	17.46	

Table 2. The Measurement of Light Intensity with Laser Pointer 650 nm.

% Darkness	I_o	I_T	T (I_o/I_T * 100)	T_a
40	28	13	46.43	47.62
	27	13	48.15	
	29	14	48.28	
60	30	6	20.00	18.59
	27	5	18.52	
	29	5	17.24	

Figure 2. Experimental Equipment for Laser Pointer with Wavelength 405 nm.

4. Discussion

From Table 1 and Table 2 above, we can see that there is a difference between an average yield of T by % darkness. The greater the degree of darkness of window film sample, the smaller the average T. The percentage of accuracy of the tool is calculated using the formula (1) that can be seen in Table 3.

Average accuracy of 82 % indicates that the measuring instrument is in conformity with the specifications of the conditions set forth in the table guidebooks window film. With the accuracy, the

test is considered successful. Thus the light intensity measuring tool can be used to test the VLT of window film products that are used today's society. Measuring the VLT of window film is very important for the community because the function of diverse window film and has become a necessity in society. Window film has the function, among others, to protect the glass from impact, reducing the amount of sunlight coming into the car, and reducing energy consumption [3, 5].

Table 3. Accuracy of T average with VLT.

% Darkness	VLT	T_a	% Accuracy
40	37	34.15	92
40	37	47.62	71
60	22	17.94	82
60	22	18.59	85
Average			82

VLT figures listed in guidebooks window film do not necessarily indicate the actual situation. Based on our experiment, there is a lower transmittance but there are also higher than the VLT. Therefore, it is important to consider a window film choice to meet the needs. It is suggested not to buy it by virtue of brand, price, and darkness only. It is, however, to be careful to choose by a manual promise.

In tropical countries such as Indonesia, airy cabin is an absolute requirement. In addition to Air Conditioner (AC), coating the car window with a window film is quite important; it could reduce the coming sunlight into the cabin. For these reason, many car owners then apply a very dark film. In fact, it is not only considered the darkness of the outside in choosing a window film, but also the clear sight from inside of the car. It is also suggested to avoid installing a very dark window films, particularly when it is applied to the windshield. Although the very dark window films may not interfere with the visibility when driving in the daytime, they can be annoying at night. At this point, where there is no sunlight view it will be very bad from inside of the car, especially during the rain. As a result, the driver would be difficult to identify the stop lamp of the front car.

5. Conclusion

Results showed that measuring instruments draft of visible light beam transmittance was successfully built. The magnitude of the accuracy of the tool compared with the VLT level is 82%. This tool still needs to be developed since there are some shortcomings, mainly in design, that is still complicated. In addition, the ease of measuring beam is still imperfect.

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