Microstructure and Hardness Analysis of Silicon Emulsion & Graphene Oxide Coating Material for Helmet Visors

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Abstract:- Coatings generally have materials in the form of liquid or solid. Coating has been known since ancient times to protect objects or buildings. Coating can be applied to almost the entire substrate surface with the aim of coating and protecting the surface. Coating is an important process to maintain the durability of a component which has a direct impact on increasing the useful life and operational reliability of a product. The coating process is an increasingly important production step. Coatings can protect and beautify the surfaces of many objects, increasing their value – from homes, to manufactured products, to bridges and other structures. Polycarbonate helmet visors are the material used today. Plastic (Polycarbonate) helmet visors have advantages and disadvantages, the first advantage of plastic helmet visors is that they are flexible. Its flexibility makes it more resistant to impact when an incident occurs.

Keywords:- *Coating, Silicone Emulsion, Polycarbonate, Helmet Visor.*

I. INTRODUCTION

As time and technology develop, coatings can be applied to almost all substrate surfaces with the aim of coating and protecting the surface. Coatings generally consist of materials in the form of liquids or solids. Coating has been known since ancient times for protecting objects or buildings. Coating is an important process to maintain the durability of a component, which has a direct impact on increasing the useful life and operational reliability of a product. It's worth remembering that today, the components used are much more complex than they were a decade ago, and at the assembly level, the processes have also evolved. Therefore, the coating process is an increasingly important production step. Coatings can protect and beautify the surfaces of many objects, increasing their value – from homes to manufactured products, to bridges and other structures. There are various variations of coatings, but in general, they can be divided into three categories: Architectural Coatings, Industrial Coatings, and Special Coatings. The coating is in the form of liquid silica oxide, which can harden or crystallize so that it looks like a thin layer of acrylic when it dries. This layer will keep the paint from being easily scratched.

The process of applying the coating involves spraying it onto the visor/helmet visor. One method to prevent scratches on the visor is by using coating. Coating serves as a protective layer of material and finds applications in the automotive industry. Additionally, coating offers numerous advantages, such as high resistance, ensuring that the color and shine of a specimen can endure longer compared to not using coating. It provides high durability, is dust-proof, and is resistant to scratches. The application of this coating demands special skills and tools. If the application process is not careful enough, it can result in a subpar appearance and may even reduce its functional value. The application process takes a considerable amount of time to ensure the drying process produces perfect results and achieves maximum effectiveness. To achieve optimal coating results, the costs and processes involved in this coating can be considered high due to the relatively expensive coating materials required.

Silicone polymers constitute a class of hybrid organic/inorganic polymers that exhibit desirable surface properties, including low surface energy and high flexibility. These characteristics enable even very high molecular weight chains to achieve optimal orientation at the interface. Silicone polymers also possess excellent physical properties such as water repellency, heat stability, and high resistance to chemical attacks and UV rays. Graphene and graphene oxide have attracted tremendous interest over the last few decades due to their unique and excellent electronic, optical, mechanical, and chemical properties.

II. MATERIAL AND METHODS

A. *Material :*

The materials used for the research were liquid silicone oil (100ml), sodium silicate (100ml), graphene oxide (100ml), glycerin (50ml), distilled water (500ml), visor/helmet glass, polycarbonate glass with dimensions of 30 x 30 cm and 2 mm thickness, and aftermarket coating.

B. *Methods*

➢ *Research Methods and Data Collection*

This research and data collection method will discuss the combination of manually made coating liquid and aftermarket coating liquid. The liquid will be applied to the test material, namely polycarbonate glass. Subsequently, several tests will be conducted, including the hardness test, scratch test, and examination of the microstructure to determine the strength of the polycarbonate glass before and after applying the coating liquid. The polycarbonate glass will undergo a scratch test to assess its strength, and the coating liquid must be applied beforehand to differentiate the test results between coated and uncoated polycarbonate glass. The final test involves a microstructure examination to observe the detailed structure of both the coated and uncoated polycarbonate glass.

➢ *Process of Applying Coating Liquid to Polycarbonate Glass*

The process of applying liquid coating on polycarbonate glass begins by preparing three pairs of polycarbonate glass with dimensions of 30 x 30 cm and a thickness of 2 mm. The coating is carried out using two pairs of polycarbonate glass, each treated with two different coating fluids: aftermarket coating and coating made independently.

To create the coating liquid, start by making a silicone emulsion. This involves combining several ingredients, namely silicon oil, sodium silicate, glycerin, and distilled water. Mix 15 ml of silicon oil, 15 ml of sodium silicate, 10 ml of glycerin, and 65 ml of distilled water. Stir the mixture until it is even, then add 50 ml of graphene oxide liquid and stir again until evenly mixed. Afterward, prepare the polycarbonate glass specimens according to the testing procedure.

The application of the coating liquid involves two methods: using an applicator pad and spraying. Apply the coating liquid to the specimens slowly and evenly over the entire surface using either method. After applying, let the specimens sit for 24 hours to allow the coating liquid to be absorbed and completely dry on the surface. This process is also repeated using the spray method, evenly spraying the surface of the specimens and leaving them for 24 hours until the coating liquid is completely absorbed.

➢ *Vickers Hardness Test Process*

Vickers hardness test on polycarbonate glass using the ASTM E92 method. ASTM E92 is a standard method for testing the knoop method made from polycarbonate material. Polycarbonate glass that has been coated and which has not been cut to the size specified in ASTM E92 is used as a Knoop hardness test specimen. When the specimen has been designed, the knoop hardness test process can be carried out.

The formula for calculating the Vickers hardness value is as follows:

$$VHN = \frac{1.854.F}{d^2}$$

In the formula:

- VHN is Vickers Hardness Number.
- F is the test load applied to the material in kilograms (kgf).
- d is the diagonal of the indentation action in millimeters (mm).

The Vickers testing process involves loading the material to be tested with a certain load (usually 1 kgf to several hundred kgf), and the resulting indentation measured is the length of the diagonal created by the diamond pyramid on the surface of the material. This diagonal is then used in the formula above to calculate the Vickers Hardness Number value.

➢ *Micro Structure*

After all the tests have been carried out, microstructuring is then carried out so that the micro elements that have occurred in the specimen can be identified and differences can be seen before the test is carried out and after the test is carried out. From this micro structure, you can find out the micro elements of this polycarbonate glass before coating and after coating is applied. Specimens that have undergone several tests are then tested using a microscope to see the condition of the specimen after testing.

➢ *Bending Test*

Bending test or flexural test is a method for measuring the strength and stiffness of materials when subjected to bending or bending forces. When applied to polycarbonate, this testing provides important insight into how well the material can withstand loads and its flexibility when stressed. The theoretical basis behind bending tests on polycarbonate involves material mechanics concepts which consider the behavior of the material when subjected to bending forces. In bending testing for this research, a 3-point bending test is used. 3-point bending testing is one of the common methods used to measure the mechanical properties of materials, including polycarbonate. This method requires a polycarbonate sample to be placed on two supports at the ends and weighted at the midpoint.

III. RESULTS AND DISCUSSION

A. *Vickers Hardness Test*

Results carried out with 5 specimens. The data obtained is the hardness value of each specimen in Vickers Hardness (HV) units.

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Table 1. Vickers Hardness Test Results

Speciment	D1	D2	Average (μm)	Hardness Vickess (HV)
Non Coating	189,75	187,95	188,85	52.01
Self-coating Rub	183,06	183,00	183,03	54,18
Self-coating Spray	186,44	186,00	186,22	53,49
After Market Coating rub	186,00	185,94	185,97	53,28
After Market Coating Spray	187,00	187,75	187.375	52,82

Load used: 4.9 N = 500 gf
Loading Time: 15 seconds

From the results above, this was done using two methods, namely by smearing and spraying. It can be seen that specimens that have a high HV value are specimens that have a high level of hardness.

B. Microstructure Testing

The following test results are microstructure tests which are carried out using a microscope to see the microscopic structure of a material to reveal the internal details of the material, such as grains, phases and the arrangement of atoms in the crystal. The following is an image of the microstructure of this specimen.

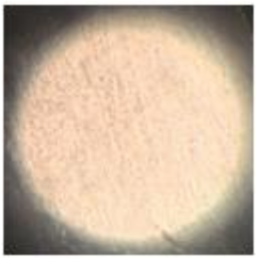

Fig 1. Non-coating Result

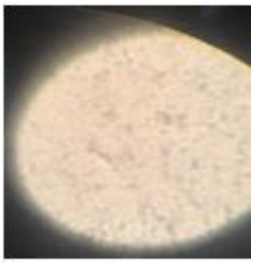

Fig 2. Self-coating Rub Result

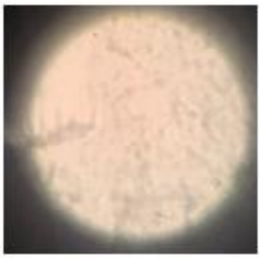

Fig 3. Self-coating Spray Result

Fig 4. After Market Coating Rub Result

Fig 5. After Market Coating Spray Result

The bending test was carried out using 5 specimens at a speed of 110 rpm and the formula used:

$$\sigma b = \frac{3\,FL}{2\,bd^2}$$

Information :

σb = Bending Strength (MPa)
F = Load (N)
L = Span Length (mm)
b = Width of Test Object (mm)
d = Test Object Thickness (mm)

Table 2. Bending Test Result

Speciment	Length (mm)	Width (mm)	Thick (mm)	Two Focus Point Distance (mm)	Force (N)	Bending Strength (N/mm^2)
Non Coating	100	30	2	48	32,63	19,578
Self-coating Rub	100	30	2	48	47,77	28,662
Self-coating Spray	100	30	2	48	41,75	25,05
After Market Coating rub	100	30	2	48	30,56	18,336
After Market Coating Spray	100	30	2	48	28,56	17,136

From Table 2, the test results can be seen that the bending strength values produced from independent coatings have higher bending strength values compared to using aftermarket coatings. However, this does not mean that aftermarket coatings automatically have lower quality. Sometimes, there are also aftermarket coatings that have equivalent or even better performance than OEM coatings depending on specific needs and the quality of the product itself. Testing and selection of coatings must be carried out taking into account these factors, as well as the needs and desired quality standards.

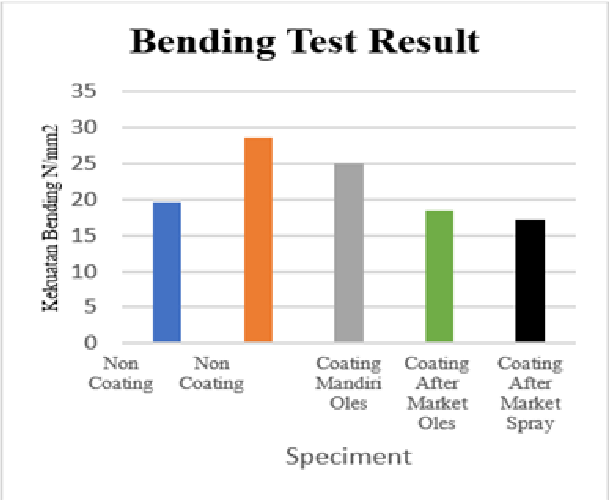

Fig 6. Result Graph

From this data, it can be seen that both types of self-coating (rub and spray) have higher bending strengths than non-coatings, while after-market coatings, both in topical and spray applications, show lower bending strengths. However, it is important to note that these results only represent one set of test data, and a more in-depth evaluation would require retesting or further testing to ensure consistency of results as well as other factors that may influence coating quality.

IV. CONCLUSION

- To carry out this test, the coating liquid uses 2 application methods, the first is applied using an applicator pad and the second is sprayed onto the surface of the specimen.
- From all the tests that have been carried out, it can be seen that several data have been produced, namely data from Vickers hardness testing for specimens that have been coated and not coated.
- The data that has been obtained shows that if the glass is not used with coating liquid, the resulting HV value is 52.01, while glass that has been smeared and sprayed with coating liquid shows HV results of 54.18 and 53.49, where if the HV value is produced is low then the hardness value of the material is also low.
- Self-coating has higher bending strength in both topical and spray form, Mandiri coating shows higher bending strength compared to non-coating and after market coating.

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