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Effect of Degassing Pressure Casting on the Hardness, Density and Tear Strength of Silicone Rubber RTV 497 and RTV 00A with 30% Talc Reinforcement

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Abstract **- Shoes are one of the human needs that are useful for protecting the feet. In addition, the use of shoes is currently adapted to the activities carried out such as formal events, sports to lifestyle enhancement. When humans stand upright, the two hind feet bear the burden of 60% of the body weight. When walking, the weight of one foot in the heel area can reach 70% of the body weight. So we need a shoe insole to overcome these problems. This study aims to improve the mechanical properties and reduce the value of porosity that arises due to air bubbles resulting from the reaction of hardener with silicone rubber, so it is necessary to have a method to reduce the value of porosity in the insole material which is made from silicone rubber and 30% talc using the degassing pressure casting method. The pressure variations applied during the molding process are 200 KPa (2.07 bar), 275 KPa (2.76 bar), and 345 KPa (3.45bar). Composite specimens were tested for tear strength, density, and hardness to determine hardness, density, tear strength. The highest tear strength value was at a pressure of 200 KPa (2.07 bar) and the lowest was at 345. KPa (3.45 bar). The highest strain is at a pressure of 200 KPa (2.07 bar) and the smallest is at 345 KPa (3.45.bar), while the highest stress is at a pressure of 345. KPa (3.45.Bar) and the smallest at 200 KPa (2.07 bar) for RTV.497.**

Keywords: Composite, silicone rubber, talc, hardener, degassing pressure casting.

I. INTRODUCTION

Shoes are one of the human needs that are useful for protecting the feet. In addition, the use of shoes is currently adapted to the activities carried out such as formal events, sports to lifestyle enhancement. Shoes have variations from good materials to bad materials. When we choose shoes, most of us choose the model and the comfort. Therefore, shoe-making materials are focused on the properties for the upper sole, insole and outsole related to comfort in use [1]. The sole of the human foot contains very important information, including knowing the type of foot (flatfoot, normal, or high arch) [2], pressure distribution on the sole of the foot after surgery, determining shoe size and others. The distribution of the load on the soles of the feet is influenced by many factors, namely body mass index [3], gender, type of sole or area of foot contact, and daily activities [4]. When humans stand upright, the two hind feet (rear foot/heel region) bear 60% of the body weight [5]. When walking and the heel strikes the runway, the weight of one foot in the heel area can reach 70% of the body weight [6].

In a previous study [7], research was carried out to increase the hardness of silicone rubber by adding talc powder to the silicone rubber mixture. This research is used in pewter craft. Research on silicone rubber used in health products is still very rarely done. However, in this study, the result of molding shoe insoles with talc mixture had a high porosity value, resulting in bubble cavities in the insole which reduced the aesthetic value for sales. The air cavities that arise are caused by the reaction between the hardener and silicone rubber, where the hardener acts as a material that allows the curing process to occur. Hardener consists of a catalyst and accelerator which will generate heat, the effect of heat will accelerate the drying process so that the material is strong. Catalyst is a material that accelerates the opening of the double bonds of polymer molecules and then the bonds between the molecules will occur. Meanwhile, accelerators, materials that accelerate the occurrence of bonds between molecules that already have single bonds and to accelerate the curing process (hardening) also act as blowing agents [8]. Therefore we need a method to suppress the large porosity value due to the hardener reaction by carrying out a vacuum degassing process or removing air bubbles from the mixture of RTV silicon rubber with hardener during the mixing process. However, during the process of pouring into the mold, the result of the degassing vacuum mixes with air which causes bubbles to appear on the surface.

Degassing can also be done by applying pressure to the mixture during molding, so that air bubbles can be suppressed

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and removed. This is done to provide comfort and satisfaction to the printed product because it has a smooth surface texture. The degassing pressure casting method is to apply pressure to the material. Applying pressure to the material does not release air bubbles but allows the material to reach the tolerance point without a problem or until the air bubbles can be ignored so that the result of molding does not appear bubbles on the surface or holes due to bubbles that usually arise when molding. This method is rarely used compared to vacuum casting degassing because it requires special equipment to apply pressure, because this method needs to be studied in order to determine the characteristics of the resulting product to provide comfort to shoe insole users [9].

Based on the description above, it is necessary to conduct research on ways to increase the aesthetic value of silicone rubber insoles and ways to improve the mechanical properties of silicone rubber to obtain new innovations in the development of material technology. Therefore, this study was conducted to provide information about the effect of degassing pressure casting on the value of the hardness test, density test and tear strength test of silicone rubber RTV 497 and RTV 00A with 30% talc reinforcement as filler. This study aims to increase the aesthetic value of the insole and improve the mechanical properties with mechanical properties data in the form of tear strength, hardness and density tests. So as to get new material characteristics and also increase the aesthetic value of making shoe insole products.

II. MATERIALS AND METHODS

2.1 Silicone rubber RTV 497 and RTV 00A

Silicone rubber is an elastomer based on high-molecular-weight linear polymers, polydimethylsiloxane (PDMS) with a Si-O main chain and two methyl groups on each silicone. The bonds in the silicon oxide (Si-O) main chain are more stable than the silicon-silicon (Si-Si) bonds. The arrangement in the main chain Si-O provides a high level of resistance to ozone, oxygen, heat (up to 315^{o} C), UV rays, humidity, and general weather effects, and is often used as a protective layer [7]. Type silicone rubber there are two kinds of silicone rubber with a vulcanization system heating and vulcanization at room temperature or room temperature vulcanized (RTV) silicone rubber.

2.2 Talc

Talc is a hydro magnesium silicate having the chemical composition $Mg_3Si_4O_{10}(OH)_2$atau $H_2Mg_3(SiO_3)_4$. A small amount of Al or Ti can replace Si and Fe, while Mg can replace Mn and Al, also a small Ca amount of Ca can replace Mg. When Mg is substituted for Fe in greater quantities, the mineral is known as minnesotaite and when Al replaces Mg, the mineral is known as pyrophyllite. Talc is usually green, white, gray, brown or colorless, insoluble in water & slightly soluble in dilute mineral acids [10].

Table 1: Specification of Talc

Density (g/cm^3)	2.7 – 2.85
Oil Absorption	30-55
Solubility in H_2O	Not dissolved
Appearance	White Powder, Gray
Smell	No smell
Mohs scale hardness	1.0-1.5
pH	8.4-9.4
Crystallography	Flat
Hegman grind	3-6

2.3 Degassing Pressure

A way to reduce the size of the air cavity of the material by applying pressure to the material. Applying pressure to the material does not release air bubbles but allows the material to reach a tolerance point without a problem or until the air bubbles are negligible [11]. This method provides uniform pressure on the surface of the material so that the air produced due to compressed air in the compressor does not enter the material [12].

2.4 Experimental procedure

The tests carried out in this study were tear strength , density, porosity calculations, and hardness of the silicone rubber composite RTV 497/RTV 00A + 30% talc. The study was conducted by weighing the RTV's silicone rubber according to the needs, then weighing 30% of the mass of silicone rubber talc. Stirring was carried out using a stirrer at a speed of 600 rpm for 2 minutes. The hardener was weighed as much as 4% of the mass of the silicone rubber + 30% talc mixture and stirred again using a stirrer for 2 minutes. Furthermore, the composite which is still in liquid form is poured into the specimen mould, then placed in a pressure chamber and degassing is carried out with pressure variations of 200 KPa (2.07 bar), 275 KPa (2.76 bar) and 345 KPa (3.45 bar) for 30 minutes. Minutes to compress the air trapped in the material during stirring and minimize porosity. After degassing is complete, then testing is carried out.

2.5 Tear strength test

The tear strength test is the force per unit thickness required to cause a tear in the rubber when pulled in a direction perpendicular to the plane of cut. The tear strength test can be carried out using a tensile testing machine. There are various types of test pieces used to perform tear strength tests. Because tear strength is prone to cutting, testing using a

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test piece at an appropriate angle will provide better reproducibility of test results. For materials made from silicone rubber, using a method that refers to the ASTM D624 standard regarding Conventional Vulcanized Rubber and Thermoplastic Elastomers.

2.6 Hardness test

The hardness test was carried out with the ASTM D2240 standard using a shore A durometer, each vacuum pressure parameter was tested three times, namely on the left, middle, and right sides and then looked for the average.

2.7 Density dan porosity

Density is searched using a densitymeter, the value that comes out on the densitymeter is the actual density value that can be used to find the porosity value with the equation:

$$P = \left(1 - \frac{p_p}{p_{wz}}\right).100\%$$

Description:

P = Percentage of porosity
p_p = Density of specimen
p_{wz} = Actual Density

With the actual density, find using the equation:

$$m_c = m_1 + m_2$$

$$\rho_c V_c = (\rho_1.\%V_1) + (\rho_2.\%V_2)$$

$$\rho_c = \frac{(\rho_1.\%V_1) + (\rho_2.\%V_2)}{V_c}$$

Description:

m_c : composite mass (gr)
m_1 : mass of material 1 (gr)
m_2 : mass of material 2 (gr)
ρ_c : density of composite (gr/cm^3)
ρ_1 :density of the material 1 (gr/cm^3)
ρ_2 :density of the material 2 (gr/cm^3)
V_c : composite volume (cm^3)
$\%V_1$: percentage of material volume 1 (cm^3)
$\%V_2$: percentage of material volume 2 (cm^3)

III. RESULTS AND DISCUSSION

3.1 Tear strength test results

The data from the tear strength test are force, strain, stress and tear strength where the stress value is obtained from the calculation of the force divided by the cross-sectional area, while the strain is derived from the addition of length divided by the initial length. The following results of the tear strength test of silicone rubber + 30% talc composite can be seen in Figure 1 stress vs. strain where (a) RTV.497 and (b) at RTV00A.

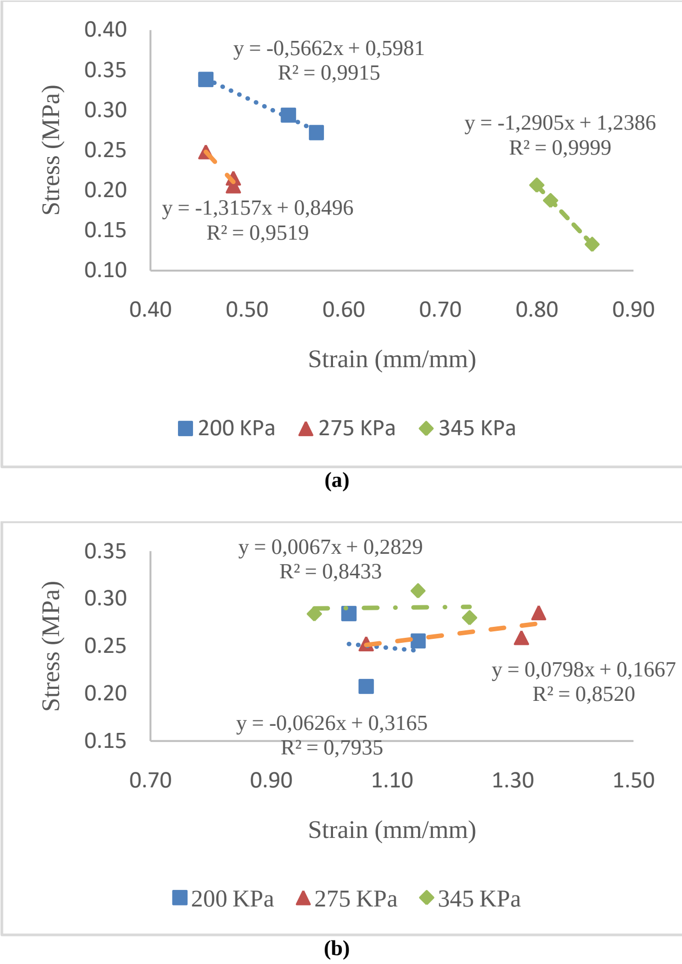

Figure 1: Tear strength test results

The stress-strain graph above shows the stress value of silicone rubber RTV 497 and RTV 00A with various molding pressure of 200.KPa (2,7 bar), 275 KPa (2,76 bar) dan 345.KPa (3,45 bar). Based on the graph, it can be seen that at RTV 497 the higher pressure applied during molding, the higher strain value but the lower stress value. Meanwhile, RTV 00A the higher the pressure applied during molding, the higher the value of strain and stress.

3.2 Densities test results

The first test was carried out on composite specimens, namely the density test, where the test was carried out 3 times for each specimen. After getting the results from the test, the next step is to compare it with the theoretical calculation of the density of the specimen, the aim is to prove whether the composite specimen is porous or not. The printed specimen is the whole specimen from the casting, while the cut specimen

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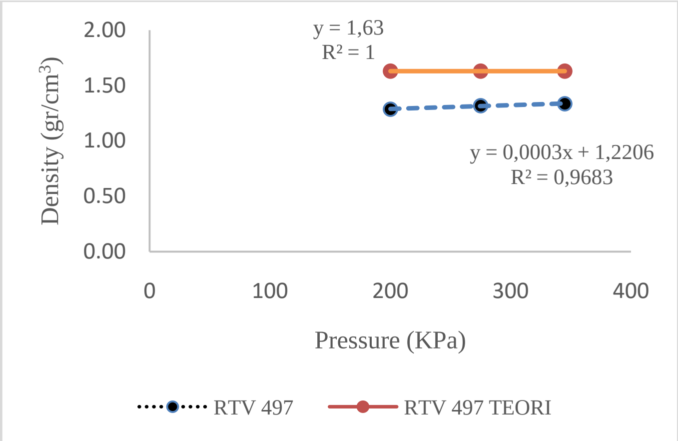
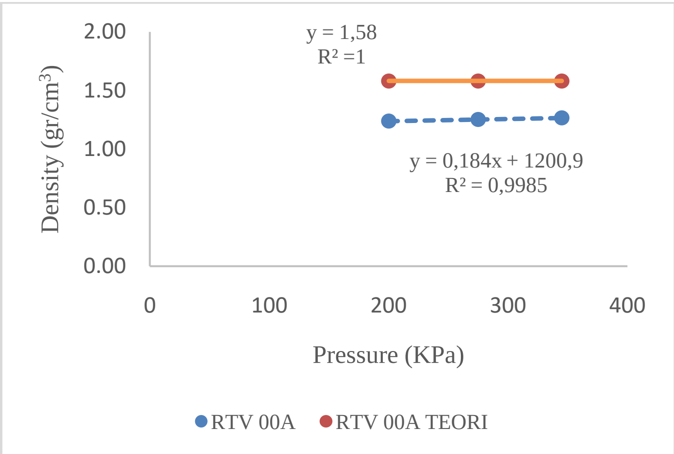
is part of the specimen which is completely filled with composite.

Using a densitymeter, the comparison of the specimen test results with the theoretical density is obtained as follows:



(a)



(b)

Figure 2: Comparison of specimen test results with theoretical density (a) RTV 497 (b) RTV 00A

Figure 2 shows that the results of the density test with the results of manual calculations have parallel graphs, where the density values from the test results and theoretical calculations have relatively the same value. In addition, from the graph it can be seen that the higher the molding pressure, the higher the density value.

3.3 Porosity value

The density value from specimen testing using a density meter is used to find the porosity of the specimen by comparing the theoretical density of silicone rubber + 30% talc with the density of the test results according to the calculation in point 2.7 and the following results are obtained.

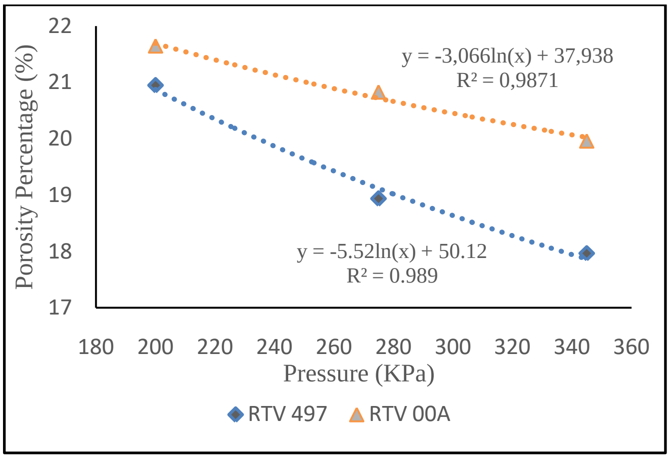
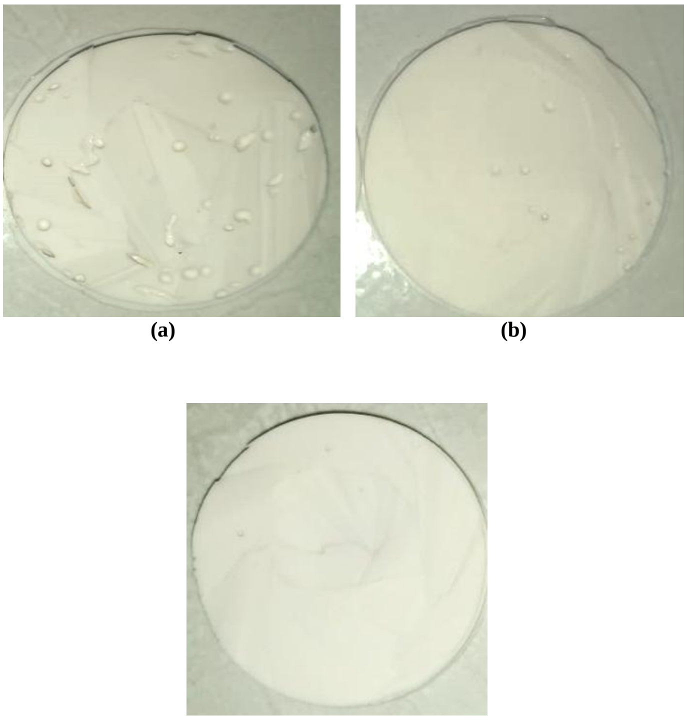


Figure 3: Porosity calculation results

In Figure 3 it can be seen that the value of the porosity will be smaller if the pressure during the molding process is greater. Judging from the logarithmic trend of the regression graph from the ratio of the percentage of porosity to the molding pressure where the trend will be asymptotic and constant along with the addition of pressure during the molding process. However, in this study, the pressure was limited to 345 KPa (3.45 bar) only.

The porosity that occurs in silicone rubber with the addition of 30% talc reinforcement can be seen in Figure 4 below.



(a) (b)

(c)

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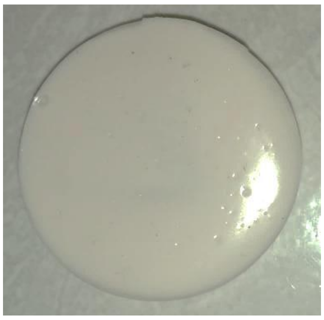
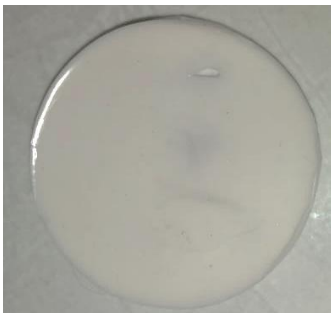


(d)



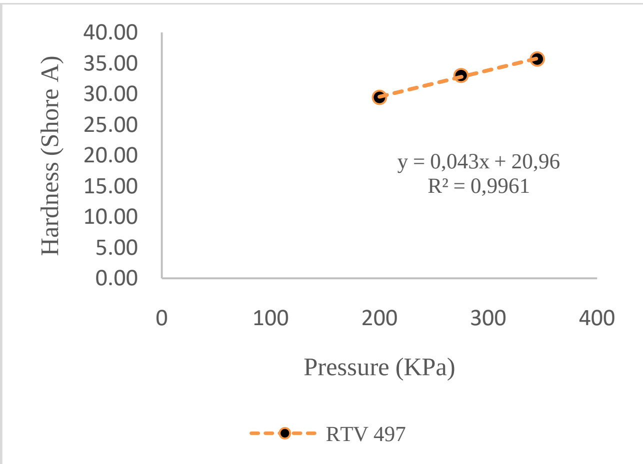
(e)

(f)

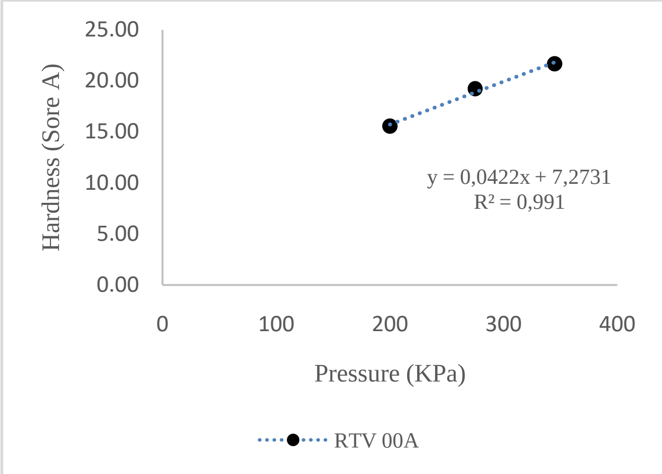
Figure 4: Specimen porosity (a), (b), (c) RTV 497 at each pressure variation and (d), (e), (f) RTV 00A at each pressure variation

3.4 Hardness test results

Hardness testing was carried out using a shore A durometer and the test results can be seen in Figure 5 as follows,



(a)



(b)

Figure 5: Hardness test (a) on RTV 497 and (b) on RTV 00A

The graph that is formed explains that the results of the 30% talc composite RTV 497 and RTV 00A composites can be seen that the higher the molding pressure, the higher the hardness value and the linear graph tends to increase with the greatest hardness value at 345 KPa (3.45 bar).

IV. CONCLUSIONS

From the results of research on the effect of pressure variations on degassing pressure casting on RTV 497 / RTV 00A + 30% Talc silicone rubber composites that have been carried out, the following results are obtained:

The greater the pressure applied during the molding process, the greater the aesthetic value given. This is because the greater the pressure applied, the less air bubbles are produced and the insole of the shoe is comfortable to wear.

The greater the pressure applied during the molding process, the smaller the tear strength, and the greater the pressure applied, the higher the hardness of the composite material. The hardness with RTV 497 increased form 29,44 to 35,64 at a pressure 200 KPa (2,07 bar) to 345 KPa (3,45 bar). RTV 00A increased form 15,56 to 21,67 at a pressure 200. KPa (2,07 bar) to 345 KPa (3,45 bar). The greater the pressure applied during the molding process, the highter the density of the composite material. Density in RTV 497 increased form 1,28 gr/cm^3 at a pressure 200 KPa (2,07 bar) to 1,33 gr/cm^3 at a pressure 345 KPa (3,45 bar). RTV 00A increased form 1,24.gr/cm^3 at a pressure 200 KPa (2,07.bar) to 1,26 gr/cm^3 at a pressure 345.KPa (3,45 bar).

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