INTRODUCTION

The composite materials is growing rapidly in the automotive and constructive industries, especially those composites which consist of unsaturated polyester resin matrices. It has low viscosity and hardness at room temperature when a catalyst is added. Polyester resins have rigid and slightly brittle properties, more thermal resistance to heat, flexible insulation properties, and adhesion chemical resistance, which are easy to process, molding and affordability [1].

To improve the mechanical properties of polyester resin, fillers are added. Fillers of polyester resin composites are usually fibers glass, because of compatibility between the matrix properties and fillers [2]. Natural fillers and compounds of fiber glass with natural fillers [3] are tends for polyester composites produced to have good mechanical properties.

Research on unsaturated polyester resin filled with natural ingredients has been carried out, using clam shells [4], lontar fruit fibers [5], eggshell powder [6], snail skin powder [7] and CaCO₃ [8]. In this study the fillers used are clam shells. Utilization of clam shells research in Indonesia is not optimal because it is used as a craft or decorative art. Clam shells contains calcium carbonate compounds of 94.99 % (total overall weight of shell) [9-13] carbonate groups (CO₃²⁻), 0.51 % magnesium and 0.078 % silicates (Si-O). Clam shells as mineral fillers are hydrophilic and provide good interaction with the polyester matrix.

The use of clam shells as mineral fillers are expected to produce composite products to be a strongest mechanical properties, so that in the future this composite product can be used as an alternative to automotive and construction basic materials. The purpose of this study is to determine the effect of clam shell filler composition on tensile strength, elongation at break and water absorption of polyester composite.
**Preparation of composite:** This polyester composite is made by mixing matrix dough and fillers: 100:0; 99:1; 98:2; 97:3; 94:4; 95:5 (% wt.) into 200 mm × 200 mm × 3 mm iron plate mold which is especially smeared with lubricant such as glycerin so that the resin is not attached to the mold. The mold was pressed at a pressure of 125 psi for 40 min [3]. The dried composite is removed from the mold and smoothing at the speed of 50 mm/min.

**RESULTS AND DISCUSSION**

**Tensile strength:** The greater the value of tensile strength of a material means that a larger force is needed to break the material. The effect of variations in clam shell filler composition on the tensile strength properties of unsaturated polyester composites is presented in Fig. 1.

Tensile strength increased along with the addition of clam shells. The highest tensile strength at the composition of 3% clam shells filler is 17.785 MPa. The increase in tensile strength is caused by the clam shell being good distributed into the polyester matrix. The addition of mineral fillers to polymeric materials increase the composite tensile strength and calcium carbonate is a hydrophilic filler which can provide good interaction with polyester matrix. Hydrophilic groups from the surface of calcium carbonate interacted with OH group of polyester polymer chains. This increased tensile strength is also supported by Yilmaz et al. [13].

Fig. 1 showed the tensile strength decreased when filler composition is increased to 4-5 %. As the filler particles formed a larger agglomerated and uneven particle distribution, so the tensile strength decreased. The same observations are also reported by Yusof and Amalina [14] that increased filler content (wt. %) decreased the tensile strength.

**Elongation at break:** The effect of variations using clam shells filler composition on elongation at break properties is presented in Fig. 2. The elongation at break properties decreases along with the addition of clam shell mass. The greatest at the composition of 0% filler which is 9.766 %. This decrease is caused by more clam shell being distributed into the polyester matrix, so the composite material becomes more rigid, but in other side the elasticity decreases [13]. The higher of filler content, the lowering elongation properties. High tensile strength has an impact on decreasing the elongation at break. The properties of tensile strength are inversely proportional to elongation at break.

![Fig. 2. Effect of clam shell filler composition variations on elongation at break properties polyester composites](image)

**Water absorption:** The purpose of analyzing water absorption properties to find out whether a composite can be damaged if submerged in water. When the composite is soaked in water, the water will be diffused into the composite, and can damage the composite structure from the inside so as to reduce the composite mechanical of properties. The effect of absorption time variation on water absorption of clam shell composites is shown in Fig. 3.

Fig. 3 showed that the highest water absorption in first 24 h (0.811 %) reached the saturation point, where the polyester composite:clam shell (97:3) does not absorb water any more and the water content in the composite remains constant. This water absorption is influenced by clam shells (Anadara granosa). This mineral component is finely distributed into the matrix.

**Water absorption equation:** The greater the value of water absorption means that a larger amount of water will be absorbed by the composite. The water absorption properties can be calculated using the following equation:

\[
\text{water absorption} = \frac{w_f - w_o}{w_o} \times 100 \%
\]

where: \(w_i\) = percentage of composite weight gain; \(w_c\) = composite weight after immersion; \(w_o\) = weight of composite before immersion.

**FTIR analysis:** FTIR spectra was analyzed from Prestige-21 Fourier Transform Infrared Spectrophotometer with A21-004602022 LP Series Number, Power 220-240 V 50/60 Hz produced by Shimadzu Corporation.
and the resulting composite has a tight porosity, so the water absorption is small.

**FTIR analysis:** The results of FTIR of polyester composite filled with clam shells, unsaturated polyester and particle clam shell are shown in Fig. 4. Fig. 4 showed the absorption bands at 1701.22 cm\(^{-1}\) which is attributed to carbonyl stretch group (C=O), band at 1600.91 cm\(^{-1}\) is stretched due to aromatic ring group, unsaturated bonding (C=C) at 1070 cm\(^{-1}\) as deformation peak. Meanwhile the FTIR of composites shows additional peak at 1268-1132 cm\(^{-1}\) assigned as vibration of asymmetric stretching of Si-O-Si bonds and the band at 996 cm\(^{-1}\) is Si-OH because clam shell particles contained silicate groups, which is supported by Sudirman et al. [16].

**Conclusion**

Addition of clam shells (*Anadara granosa*) as filler in unsaturated polyester composite increased the tensile strength, elongation break and also its water absorption capacity. The highest tensile strength is achieved at the composition of 97.3 wt. %, 17,785 MPa, while the elongation break is greatest at composition (100: 0), 9,766% and water absorption is found to be 0.811%.

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**CONFLICT OF INTEREST**

The authors declare that there is no conflict of interests regarding the publication of this article.

**REFERENCES**