Hybrid Method Analysis of Variance (ANOVA) and Loss Function to Analyzed Optimizing Composition of Fiber Baggase and Fly Ash

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Abstract. Research on the utilization of bagasse fiber as a composite material has been done, but still has shortcomings in the composite material brilliance. Therefore, the use of bagasse fiber combined with coal ash can be an alternative to make a composite material. The purpose of this research is to know the effect of bagasse fiber composition and fly ash composition to tensile stress and bending stress. This paper discusses the application of Analysis of Variance (ANOVA) on composite material data. There are two variables measured are variable of tensile stress and variable of bending stress. The result obtained that there is influence composition of bagasse fiber and composition of fly ash at tensile stress and bending stress. Furthermore, further tests using Tukey method showed that the different composition pairs significantly were 10% -30%, 10% -40% and 20% -40% in both compositions of the two variables studied. In the determination of loss function with Signal-to-Noise (SN) Ratio with larger-is-the-better criteria, the composition of 40% bagasse fiber, 10% fly ash composition and 50% matrix can produce optimal tensile and bending strength.

1. Introduction
Research on the utilization of bagasse fiber as a composite material has been done, but still has shortcomings in the composite material brilliance. Therefore, the use of bagasse fiber combined with coal ash can be an alternative to make a composite material. This material can later be used as material on making desks, wardrobe, and others. One reason for choosing such materials is because the bagasse and fly ash are relatively cheap and easy to obtain [1].

Seeing the problem, [1] made a new breakthrough in exploiting bagasse fiber and fly ash as combined with polyester matrix to make better composite material. [1] has conducted tensile and bending tests on the resulting composite material. To see the optimization of the material will be analyzed by analysis of variance (ANOVA) with the aim to see there is no difference treatment of bagasse fiber

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composition and the composition of fly ash against tensile strength and bending strength in each observation.

ANOVA is a statistical technique used to decide whether samples from a population have the same averages [2]. In this study, expansion of ANOVA is used by calculating the loss function with knowing the value of Signal-to-Noise (SN) ratio at each treatment level. It is expected to provide more information in choosing the optimum composition on the composition material.

2. Review of Literature

2.1. Analysis of Variance (ANOVA)

Suppose there is a treatment or one factor with different levels will be compared. Observation response of each treatment is random variable $y_{ij}$. Characteristics of analysis of variance with one factor are [2]:

- Level factor of at least 3 groups / levels
- Intergroup assumptions are homogeneous
- The residual distribution is normal

2.2. Linear Model

\[
y_{ij} = \mu + \tau_i + \epsilon_{ij}, \quad i = 1, 2, ..., k \\
j = 1, 2, ..., n
\]

where:

- $y_{ij}$ = observation to $i$-th, treatment to $j$-th
- $\mu$ = general average effects
- $\tau_i$ = treatment effects to $i$-th
- $\epsilon_{ij}$ = residual of observation to $i$-th, treatment to $j$-th

\[N = \sum_{i=1}^{k} n_i = nk \quad [3].\]

2.3. Fixed Effect Model

In this model, the treatment effect $\tau_i$, for $i = 1, 2, ..., k$ is defined as a deviation from the general mean so

\[\sum_{i=1}^{k} \tau_i = 0 \quad (2)\]

Statistical Hypothesis:

- $H_0 : \tau_i = 0$, $\forall i = 1, 2, ..., k$
- $H_i : \tau_i \neq 0$, at least for one $i$

Testing Criteria: Rejected $H_0$ if $F_{hit} > F_{table}$

2.4. Tukey Test

Tukey has introduced a double-comparison procedure that is also based on statistic of student range. The procedure requires the use of $q_{a(k,f)}$ to determine the critical value of all comparison pairs. So the Tukey test specifies that mean is significantly different if the absolute value of the sample mean difference is greater than $T_a = q_{a(k,f)}S_{\bar{y}}$

Statistical Hypothesis:
\[ H_0 : \mu_i = \mu_j , \text{ untuk } i \neq j \]
\[ H_1 : \mu_i \neq \mu_j \]

**Test Statistic:**
\[ T_\alpha = q_{\alpha(k,f)} \sqrt{\frac{KTE}{n_i}} \]

where:
\[ S_{\bar{Y}_i} = \sqrt{\frac{KTE}{n_i}} \]

KTE = Mean Square Error

**Testing Criteria:** Reject H₀ if \[ |\bar{Y}_i - \bar{Y}_j| > T_\alpha \] [5].

### 2.5. Loss Function

The loss function is a new approach to assessing process capability a product [4]. The quality characteristics are divided into the following three characteristics:

a. **nominal-is-best**
   - the process under study has a finite target value.

b. **smaller-the-better**
   - the process becomes worse if the value of the measure increases.

c. **larger-the-better**
   - the process that the quality is judged to be increasing.

In the field of communication engineering, a quantity called the signal-to-noise (SN) ratio has been used as the quality characteristic of choice. Two of the applications in which the concept of SN ratio is useful are the improvement of quality via variability reduction and the improvement of measurement. There are several SN ratios available depending on the type of characteristic: continuous or discrete; nominal-is-best, smaller-the-better or larger-the-better. Here is the loss function and the SN ratio formula for n observations in Table 1 [4].

| Type of Characteristic     | SN-Ratio               |
|----------------------------|------------------------|
| Nominal-is-best            | -10 \( \log \left[ \frac{1}{n} \sum_{i=1}^{n} (y_i - m)^2 \right] \) |
| Smaller-the-better         | -10 \( \log \left[ \frac{1}{n} \sum_{i=1}^{n} y_i^2 \right] \) |
| Larger-the-better          | -10 \( \log \left[ \frac{1}{n} \sum_{i=1}^{n} \frac{1}{y_i^2} \right] \) |

### 2.6. Composite Materials

The fiber of bagasse in the test as a composite material is usually mixed with hard materials such as epoxy resin, polyester resin, cement, asbestos and concrete which result in press test, bagasse fiber as composite material not yet fulfill requirement as reinforcement material. On the other hand, in the elasticity test using lamination plating technique as an asbestos reinforcement material, bagasse fiber proved to have better elasticity than using plastic fiber [1].
Fly ash is a solid waste resulting from the combustion process in the furnace on the steam power plant which is then carried out by the burning remains. Fly ash is a mineral residue in a fine grain produced from burning coal that is smoothed on a power plant. Fly ash consists of inorganic materials contained in coal that have undergone fusion during combustion. This material solidifies while inside the exhaust gases and is collected using an electrostatic precipitator. Because these particles solidify during suspension in the waste gas, the fly ash particles are generally spherical [1].

3. Data and Methodology

The data used are tensile stress and bending stress data on a composite material with matrix material, bagasse fiber and fly ash [1]. The composition of each material is 50% matrix and 50% bagasse fiber and fly ash. Because the composition of the matrix is fixed, the material observed is only in the composition of the bagasse fiber and fly ash. Tests with ANOVA were performed separately on each composition of bagasse fiber and fly ash that divided by 10%, 20%, 30% and 40% levels.

4. Estimation Result

The first variable observed is the variable tensile stress of a composite material. In this paper we will see the effect of bagasse fiber and fly ash on four levels are given: 10%, 20%, 30% and 40%. Based on the data obtained [1], there is a relationship between the composition of bagasse fiber and tensile stress and relationship between the fly ash composition and the tensile stress in Figure 1.

According to Figure 1, the composition of 40% of bagasse fiber provides the highest tensile stress. This is inversely proportional to the provision of fly ash composition. In the composition of fly ash decreases the tensile stress if the fly ash composition increases at 40% level.

The second variable is the bending stress variable of a composite material. In the same way in the variable tensile stress, the level of bagasse fiber composition and fly ash composition are also given at the same level. Next, Figure 1 about plots the relationship between the composition of the bagasse fiber and the bending stress and the relationship between the fly ash composition and the bending stress. Figure 1 shows the relationship between the bagasse fiber composition and the fly ash composition against the bending stress equal to the tensile variable. The higher of the bagasse fiber
composition the higher value of the bending stress. Conversely on the fly ash composition, the higher of the fly ash composition the lower the bending value.

To perform the ANOVA, one of the assumptions that must be met is the assumption of homogeneity. This means that each group should be homogeneous, so it must be tested homogeneity between levels of bagasse fiber composition at tensile stress, homogeneity test between level of fly ash composition at tensile stress, homogeneity test between level of bagasse fiber composition at bending stress and homogeneity test of fly ash composition at the bending stress. Based on levene test for all four test performed, shows that p-value obtained more than 0.05. So it can be continued ANOVA test in Figure 2

Based on Figure 2 shows that the ANOVA test results on the influence of the composition of bagasse fiber and fly ash is significant. This is seen from the p-value generated less than 0.05. This means that there is an effect of giving the composition of the bagasse fiber and giving the composition of fly ash to the magnitude of tensile stress and bending stress.

Therefore the resulting ANOVA test is significant, it can proceed to further test with Tukey method to see which pairs of compositions differ significantly. Given a summary of Tukey test results in Table 2.

| Variable        | Treatment       | Pair of Treatment Significantly |
|-----------------|-----------------|--------------------------------|
| Tensile Stress  | Bagasse fiber   | 10% dan 40%                    |
|                 | Fly ash         | 10% dan 30%; 10% dan 40%       |
| Bending Stress  | Bagasse fiber   | 10% dan 30%; 10% dan 40%       |
|                 | Fly ash         | 10% dan 40%; 20% dan 40%       |
To see the loss function used SN-ratio criteria with larger-the-better type. The value of each SN Ratio is presented in Table 3.

| Variable     | Baggase fiber composition | Fly ash composition |
|--------------|----------------------------|---------------------|
|              | Level | SN Ratio | Level | SN Ratio |
| Tensile Stress | 10%   | 18,64675 | 40%   | 18,64675 |
|              | 20%   | 19,8736  | 30%   | 19,8736  |
|              | 30%   | 20,69669 | 20%   | 20,69669 |
|              | 40%   | 22,40224 | 10%   | 22,40224 |
| Bending Stress | 10%   | 16,51256 | 40%   | 16,51256 |
|              | 20%   | 22,56626 | 30%   | 22,56626 |
|              | 30%   | 23,85788 | 20%   | 23,85788 |
|              | 40%   | 26,67851 | 10%   | 26,67851 |

Based on Table 3, the strength of tensile strength and bending stress is influenced by the large bagasse fiber composition of 40% and the small fly ash composition of about 10%.

5. Conclusion

Based on ANOVA test, it was found that the composition of bagasse fiber and fly ash composition had significant effect on tensile stress and bending stress variables. At variable tensile stress there is one pair of composition of bagasse fiber which is significant is 10% and 40% composition of bagasse fiber while the composition of fly ash contains two significant couples that is 10% and 30%; 10% and 40% fly ash. The bending stress variables are two pairs of sugarcane fiber composition ie 10% and 30%; 10% and 40% while the composition of coal ash contained four significant couples ie 10% and 20%; 10% and 30%; 10% and 40%; 20% and 40%. Furthermore, based on SN-ratio shows 40% bagasse fiber composition, 10% fly ash composition and 50% matrix can produce optimal tensile and bending strength.

REFERENCES

[1]. Akbar, H. 2018. Studi Eksperimen Kekuatan Tarik dan Tekan (Bending) pada Material Komposit Serat Ampas Tebu Dipadukan Abu Batu Bara (Fly Ash) yang Diperkuat Resin Polyester. Skripsi. Jurusan S1 Teknik Mesin FT UHO.
[2]. Yamin, S. dan Kurniawan, H. 2009. SPSS Complete. Teknik Analisis Statistika Terlengkap dengan Software SPSS. Jakarta: Salemba Infotek.
[3]. Montgomery, D.C. 2001. Design Analysis of Experiment. New York: John Wiley & Sons.
[4]. Park, S.H. 1996. Robust Design and Analysis for Quality Engineering. New York: Chapman & Hall.
[5]. Suwanda. 2011. Desain Eksperimen untuk Penelitian Ilmiah. Bandung: Alfabeta.