INTERNATIONAL SEMINAR AND NATIONAL SYMPOSIUM

Global Competitiveness through Research Supporting Commercial Industry

June 23, 2012
University Technology Yogyakarta

PROCEEDINGS

International Seminar & National Symposium
Global Competitiveness through Research Supporting Commercial Industry

ISBN 978-979-1334-32-7

Edited by Endah Tisnawati and Endy Marlina

Cover designed by Bayu Wirabongko

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THEME III : ARCHITECTURE AND CIVIL ENGINEERING

THEME IV : ECONOMIC

The Quality Design of Chicken Feather Based Composite Roof by Taguchi Method

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Abstract

There are a lot of chicken feather wastes produced by chicken based industries. However, just few of them are used so that they can harm environment. A proposed alternative is to use the waste as component of roof (“Genteng”). The composite of chicken feather and soil can give color and beauty of the roof. This research tries to get best combination of components and processes for getting the best quality of the product. The quality characteristic analyzed is flexural strength of the product. Taguchi method is applied to get best composition factor level of polyester matrix (A), chicken feather (B), Mekpo catalyst (C), strength of pressing process (D), duration of pressing process (E), duration of the mixing process (F), and first layer molding standing time (G). A case study is performed.

Keywords: Taghuci method, factor, level factor

1. Introduction

A lot of waste are produced by chicken based industries. Chicken feathers are the waste most produced and very difficult to be disposed. They can potentially harm environent. One way to overcome this problem is by using it to be something useful and valuable (Sutrisno, 2005).

The use of chicken feather fibers as composite reinforcement is a good step to save the environment, because it can replace the use of synthetic fibers which can cause environmental pollution. Another benefit of chicken feather composite tile is to reduce the environmental damage caused by large areas of land used for the manufacture of clay tiles. This chicken feathers can reduce the use of land in tile industries.

There are some anvantages of the use of chicken feathers composite. Besides having light weight, the chicken feather composite has a unique color, resembling the look of “batik” patterns. This can improve the beauty of the building.

The quality of chicken feather composite tile can be measured from some indicators such as flexural strength, leaking rate, and water absorbed level. There are many factors that influences the quality namely levels of polyester matrix, feather fiber content, MEKPO catalyst content, pressure molding, suppression duration, mixing matrix duration and the catalyst, and the first layer of standing time mold.

Some experiments related to chicken feather composite tile have been performed, especially on the influence of chicken feather fiber content to the quality performance. Janari (2010) developed some chicken feather composite tile prototypes. Nur (2011) examined visibility of chicken feather composite tile. He underlined that chicken feather fiber volume faction has important impact on flexural strength, leaking rate, and water absorbed level. Priyono (2011) indicated that 20 % chicken feather fiber volume faction give best performance on the three indicators. Based on the the findings, this research is run to answer the question related to the influence of others factors; such as level polyester matrix, MEKPO catalyst content, molding pressure, long suppression, long mixing matrix and the catalyst, and the first layer of standing time mold; to the composite tile performance. To do so, this work is going to explore the best composition of all parameters in order to get best quality, namely flexural strength. In order to obtain a high flexural strength, Taguchi based experiments design will be performed

2. Literature Review

2.1 Chicken Feather Based Composite Roof

Roofing tiles or “Genteng” basically serve as a protection from rain or extreme hot weather. In hot conditions, it can reduce heat and in the rain, it can hold water. A good tile is a tile that can withstand high loads and can not easily be broken or fractured when exposed to the load. To do so, some composites are developed to improve quality of tile.

Composite is a material that is formed when two or more different materials are combined into a single entity and does not eliminate the nature of its constituent elements so as to form a new material. The incorporation of this material is intended to discover or obtain a new material that has properties between the constituent materials. Materials properties of the merger are expected to improve each weakness and lack of constituent materials. Fiber is one material that can be used to improve composite.

There are two kinds of fiber, namely natural fibers and synthetic fibers. Natural fibers are derived from natural fibers, usually in the form of organic fibers from plants and animals. Natural fibers that have been used are: cotton, wool, silk, banana, coconut fiber, palm fiber, pineapple fiber and jute.

One of important natural fibers is chicken feathers. It contains about 91% protein (keratin), 1% lipids, and 8% water. Amino acid sequence of the feathers are very similar to the other, and have in common with reptiles than claw keratin (Fraser, 1996). Contour feathers (vaned) gives color to the bird and the first layer in contact with physical objects, sunlight, wind, and rain (Bartels, 2003). A large contour feathers usually divided his time half and half hair fibers feather bones (Winandy et al., 2003). Wool and Hong, (2005) reported that the density of feather rachis of Tyson Foods, Inc., is 0.8 gr/cm3. This value is interpreted as a severe type. Five main types of feathers is shown in Figure 1.

Smaller feathers have more number of fibers, which have aspect ratios greater than bone (Winandy, 2003). Keratin fibers have a maximum diameter of 50 μm (Ananda *at al*, 2001). Tensile strength of the chicken feather fibers have been tested directly. Fibers are bonded with adhesive tape and tested the voltage on the crosshead speed of 1.3 mm / min, power ranged from 41-130 MPa. Strength fibers of the fracture energy data for the composite fibers are mixed with. The result is 94-187 MPa corresponding to the strength of fibers is measured directly (Hong and Wool, 2005).

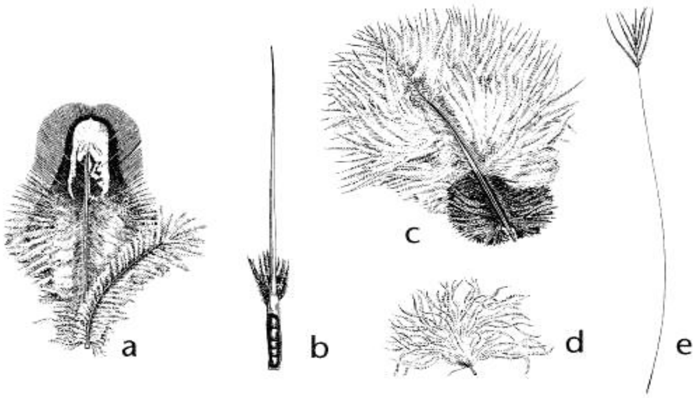

Figure 1. Five Main Types of Fur: (a) Contour,
(b) Bristle, (c) Semiplume, (d) Bottom or Powder, (e) Filoplume (Bartels, 2003).

2.2 Taguchi method Quality

Conventional definition of quality is usually described the characteristics of such products directly from a performance, reliability, easy to use, aesthetics and so on. The strategic definition of quality is anything that is capable to meeting customer needs or desires (Vincent,2001).

Quality control can be defined as the measurement processes made during the design of products / processes. Quality control activities are done in every phase of the research, product development and production process. Quality control can be divided into two types namely on-line and off line quality control. On-line quality control is an activity to observe and control the quality in every production process.

Off line quality control is applied before product manufacture (design phase). This method was first introduced by Dr. Genichi Taguchi. Taguchi method used matrices called orthogonal arrays to determine the minimal number of experiments that can provide as much information as possible to all the factors that affect the parameters. The most important part of the orthogonal array lies in the selection of level combinations of input variables for each experiment (Peace, 1993).

Taguchi's philosophy of quality consists of three concepts, namely (Montgomery, 1998):

1. Quality must be designed into the product and not just check it out. The best quality is achieved by minimizing the deviation from the target.
2. Products must be designed so that the robustness against environmental factors that can not be controlled.
3. The cost of quality should be measured as a function of a certain standard deviation and the loss must be measured on the entire system.

Off-line quality control involves 3 (three) phases (Peace, 1993; Belavendram, 1995; Ross,1998), they are (1) *Design Concept*, associated with generating ideas in design and product development activities (2)

Design Parameters, serves to optimize the level of the controlling factors for the effects of other factors that caused the product can be tough against noise, (3) *Tolerance Design*, the last stage which is made orthogonal matrix, loss function, and ANOVA to balance cost and quality of a product.

S / N ratio is the logarithm of a quadratic loss function and is used to evaluate the quality of a product. There are several types of S / N ratio, ie (Belavendram, 1995):

1. Smaller-the-Better (STB)

$$S/N\_STB = -10Log\left[\frac{1}{n}\sum_{i=1}^{n} yi^2 \right]$$

where: n = number of tests in the trial (trial)
yi = the value of the response to the footage - i for certain types of experiments

2. Larger-the-Better (LTB)

$$S/N\_LTB = -Log\left[\frac{1}{n}\sum_{i=1}^{n} \frac{1}{yi^2} \right]$$

3. Nominal-the-Better (NTB)

Value of S / N for this type of NTB characteristics are:

$$S/N\_NTB = 10\log\left[\frac{\mu^2}{\sigma^2}\right], \text{ Where : } \qquad \sigma^2 = \frac{\sum\left(y_i - \overline{y}\right)^2}{n-1}$$

One element of Taguchi method is experimental design. Experimental design is a design of experiments (with each step / action well - very well-defined) so that the information relates to or is required to issue under consideration can be collected (Peace, 1993). There are two types of experimental design, namely, the conventional experimental design and Taguchi experimental design. In taguchi experimental design, experiment does not use all combination of level factors available, but it uses some of them based ortogonal array. There are 5 steps to carry out the Taguchi design of experiments, they are as follows:

1. Selection of quality characteristics of products studied.
2. Identification and selection of the factors that influence the quality characteristics.
3. Determination of the factors determining the level of control and factors.
4. Selection of Orthogonal matrix
5. Implementation of Experiments

Taguchi method recognises two type of factors, namely controllable and unconrollable factors. Controllable factors are the factors that set (or controlled) by the manufacturer during the design stage of products / processes and can not be changed by the consumer. Unconrollable or noise factors are factors that can not be controlled directly by the manufacturer.

3. Research Methodology

The object of the study was chicken feathers based composite tile. The study was conducted in the laboratory of Mechanical and Industrial Engineering Islamic University of Indonesia. Data required for this study are obtained from experiments and secondary data from previous similar research data. The raw materials used were chicken feathers resin, cobalt, catalyst, calcium carbonate (talk) and pigment (coloring). The tools used are the mold and hydraulic press.

Dependent variable of the model is a variable response in terms of quality tile composite flexural strength. There are 7 independent variables that are identified influence the quality of tile composites. They are polyester matrix, feather fibers, MEKPO catalyst levels, pressure molding, the old emphasis, the matrix and the stirring time and standing time of the catalyst layer of the first mold. All factors (independent variables) consist of two level factor by some consideration below:

a. Polyester matrix

In the composite fiber, the matrix has a very important function, namely as the binder fiber and continue the load among the fibers (Schwardz, 1984). Matrices are often used to produce composite FRP (Fiber Reinforced Plastic) is a tangible resin. Level factor used is 1.75 kg and 2 kg, which is intended to meet the desired pressure flexural strength.

b. Chicken feather fibers

Fiber is supported material of the composite that is functioning as load-bearing. Factor levels of fiber used was 0.75 kg to 1 kg, which is intended to look for mechanical strength approaching optimum flexural strength, the fiber composition of the control factors must also be adjusted to the weight of the chicken feather composite tile.

c. Catalysts MEKPO

MEKPO type catalyst (Methyl Ethyl Ketone Peroxide) on unsaturated polyester resin serves to accelerate the hardening process of the liquid resin (curing) at higher temperatures. The addition of catalysts in large quantities will cause excessive heat during the curing process. This will damage the product and make brittle or ductile composites. Therefore, the use of catalysts is limited to 1% of the volume of resin (Anonim, 2001). Levels of 0.0175 kg of catalyst used MEKPO until 0,02 kg

d. mold pressure

Long process in the master mold pressure will affect the unity between the fiber and the matrix, curing processes that occur when using a pressure of 20 bar pressure - 22 bar in order to see the variation in flexural strength of composite tile feather.

e. Suppression time old

Long suppression by using the hydraulic jack is very influential to determine the composite curing process, the choice of time is 12 hours and 24 hours

f. Stirring the old matrix and Catalysts

It is a 10-15 minutes minute long agitation to see the resistance to flexural strength testing.

g. Layers First Time Standing Matter

Standing time when the first layer of mold is 2.5 minutes to 4 minutes

Level settings of the above factors can be summarised in Table 1.

Table 1. Factor level setting

No	Factor	Level 1	Level 2
A	Matrix Of Polyester	1.75 kg	2 kg
B	Chicken Feather Fiber	0.75 kg	1 kg
C	MEKPO Catalyst Level	0.0175 kg	0.02 kg
D	Mold Pressure	20 Bar	22 Bar
E	Suppression Time	12 hours	24 hours
F	Mixing Duration Of Matrix And The Catalyst	10 Menutes	15 Menutes
G	First Layer Of Molding Standing Time	2.5 Menutes	4 Menutes

Implementation of the experiments carried out through three stages. They are (1) Preparation (2) Tile-making process of the composite of chicken feathers (3) Quality Control.

4. Result and Discussion

To identify the flexural strength of experiments performed using the L8 27. Data of experimental results shown in Table 2.

Table 2:Flexural strength of experiments

	Controllable factor							flexural strength (kgf)			
Trial	A	B	C	D	E	F	G				
1	1	1	1	1	1	1	1	20.00	20.88	21.00	20.22
2	1	1	1	2	2	2	2	23.00	25.00	23.00	21.00
3	1	2	2	1	1	2	2	21.00	22.67	22.10	20.00
4	1	2	2	2	2	1	1	25.00	26.00	25.00	21.00
5	2	1	2	1	2	1	2	19.45	19.23	19.00	19.23
6	2	1	2	2	1	2	1	20.00	20.00	22.00	25.00
7	2	2	1	1	2	2	1	19.67	19.89	20.12	20.14
8	2	2	1	2	1	1	2	21.00	20.00	25.00	21.00

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To identify main factors that influence the reselience strength, ANOVA is performed. To do so, Normality test is performed to satisfy the ANOVA assumption. Based on Kolmogorof Smirnov (K-S) test on $\alpha = 0.01$, data are normally distributed. This is shown by the value $p = 0.038$ that is larger than 0.01.

The ANOVA result shows that three are two factors that significantly influence the flexural strength, namely polyester matrix and mold pressure (Table 3). The other factors are not significanly influenced. This test also indicates that 7 factors can influence flexural strength to up to 0.995 (R^2).

Table 3. Analysis of Variance Result

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	14889,871(a)	8	1861,234	749,815	,000
A	23,018	1	23,018	9,273	,006
B	3,498	1	3,498	1,409	,247
C	,708	1	,708	,285	,598
D	43,711	1	43,711	17,609	,000
E	,256	1	,256	,103	,751
F	,011	1	,011	,004	,949
G	,858	1	,858	,346	,562
Error	59,574	24	2,482		
Total	14949,445	32			

To identify the best combination of the factors examined, Signal to Noise Ratio (S/N Ratio) analysis is performed (Table 4). The result shows that the best combination is A1 B2 C2 D2 E2 F1 G1. This combination has been done in the experiment so that confirmatory experiment is not needed. Based on the experiment the average of flexural strength is 24.25 and deviation standard is 2.28.

The both findings can be combined by reducing quality of factors that are not significantly influence the flexural strength. Some factors, namely B, C, E, that are proposed to set in the second level can be changed to level 1 to decrease cost and process time. This change will not significanly decrease the performance of flexural strength.

Table 4. Signal to Noise Ratio (S/N Ratio) analysis

	Controllable factors						
	A	B	C	D	E	F	G
Level 1	**27.54**	26.43	26.27	25.88	26.54	**27.18**	**27.00**
Level 2	25.99	**27.10**	**27.26**	**27.65**	**26.99**	26.38	26.53
Difference	1.55	0.67	0.99	1.77	0.45	0.80	0.47
Rank	2	5	3	1	7	4	6

5. Conclusion

Based on the results of research on the design of quality for feather chicken fiber composites tile using Taguchi experimental method can be summarized as follows:

1. Based on the analysis of variance, the factors that influence the flexural strength of chicken feathers composite tile are polyester matrix and mold pressure.
2. The best combination of factor levels is A1 B2 C2 D2 E2 F1 G1. It means that the best composition is 1.75 kg of polyester matrix, 1 kg of chicken feather fibers, 0.02 kg MEKPO catalyst, mold pressure 22 bar, 24-hour long suppression, 10 minutes long mixing matrix and the catalyst, 2.5 minutes standing first layer of molding time

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