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Affecting Factors of the Mechanical Properties to Phenolic/Fiber Composite

Thirapat Kitinirunkul, Nattawat Winya, Komson Prapunkarn

***Abstract*—**Influences of the amount of phenolic, curing temperature and curing time on the Mechanical Properties of phenolic/fiber composite were investigated by using two-level factorial design. The latter was used to determine the affects of those factors on mechanical properties. The purpose of this study was to investigate the affects of amount of phenolic, curing temperature and curing time of the composite to determine the best condition for mechanical properties according to MIL-I-24768 by the tensile strength is more than 103 MPa.

***Keywords*—**Phenolic Resin, Composite, Fiber Composite, Affecting Factors.

I. Introduction

COMPOSITES materials are combinations of two or more materials with different physical or chemical properties and which are essentially insoluble in each other, that when combined, produce a material with different properties from the original components [1]. Properties of composites materials are such as corrosion resistance, lightweight, high strength, low moisture absorption and high temperature resistant [2]. Composite materials are generally used for robots, aerospace, sporting goods, solar cell, medical devices, electromagnetic shielding materials and nozzle of the Space Shuttle [3]. Generally, composite materials consist of a dispersed phase (reinforcement) and a matrix phase. The matrix phase generally surrounds the dispersed phase. The reinforcement is generally contained within the matrix phase. It is the strength of the material [4]. The matrix used in this research is a phenolic resin.

Phenolic resins formed from phenol and formaldehyde. This is a condensation reaction. Phenolic composites are mostly used for the production of responsible parts for various industries. Phenolic resins are known for their excellent thermal properties and chemical stability. In the field of advanced composite materials, phenolic based composites are known for their excellent flame resistance [5], [6].

Phenolic laminates are made by impregnating one or more layers of fiber with phenolic resin and laminating the resin-saturated base material under heat and pressure [7].

This study was to investigate the affects of curing time, curing temperature and the amount of phenolic to determine the best condition for mechanical properties according MIL-l-24768 standard (tensile strength is more than 103 MPa).

Thirapat Kitinirunkul, Nattawat Winya, and Komson Prapunkarn are with Chemical Engineering and Metallurgy Laboratory, Research and Development Department, Defence Technology Institute (Public Organization) Ministry of Defence, The Kingdom of Thailand ,47/433 ,4th Floor –Office of the Permanent Secretary of Defence Building, Changwattana Rd., Pakkred Nonthaburi Thailand (e-mail: Thirapat.k@dti.or.th).

II. Materials & Methods

A. Materials

The commercial available resole phenolic resin in Thailand. The density at 25°C ranges from 800 to1200 CP and the gel time of phenolic resins at 140°C ranges from 4 to 7min. The commercial fiber was locally available synthetic fiber in Thailand.

B. Measurements

The mechanical properties were measured by means of a universal testing machine (Instron 8801) according to S/H H2059)

C. Preparation of Phenolic/Fiber Composite

Preparation of phenolic composite by bringing fiber layer size at 50×50cm mixed with resole phenolic resin and hand layup process. The phenolic/fiber was forming laminate with oven at 80°C for 4h and then heated to 100°C for 30min and heated again to 120°C for 40min and vary curing temperature see Table I. After that bringing to design experimental by 2-level Factorial design to screen the factors to those factors that affect the tensile strength.

TABLE I
Shows the Experimental Design

Sample	Phenolic amount (Wt. %)	Curing Temperature (°c)	Curing Time (min)
1	50	140	15
2	50	140	35
3	50	160	15
4	50	160	35
5	75	140	15
6	75	140	35
7	75	160	15
8	75	160	35

III. Results and Discussion

The following parameters were varied: amount of phenolic resin, curing temperature and curing time (see Table I). The results of design experimental by 2-level Factorial design are used to analyze the results the tensile strength of phenolic /fiber composite. It analyzes the factors that affect the tensile strength as shown in Fig. 1 Pareto chart of the standardized effects and Fig. 2 normal probability plot of the standardized

effects, the factors that affect the response variable at significance level α = 0.05 are curing time (C), interaction between curing temperature and curing time (BC), three interaction of amount of phenolic resin, curing temperature and curing time (ABC), amount of phenolic resin (A), curing temperature (B), interaction between amount of phenolic resin and curing temperature (AB), and interaction between amount of phenolic resin and curing time (AC) affecting the response variable.

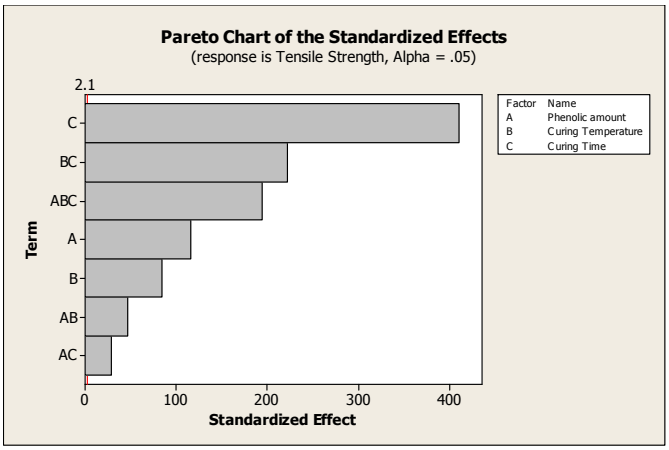

Fig. 1 Pareto chart of the standardized effects

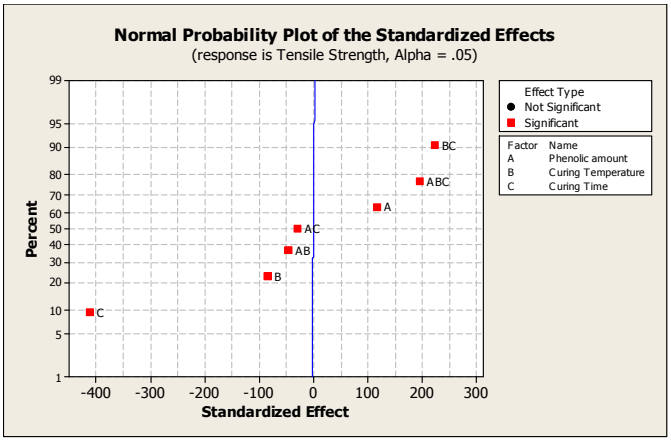

Fig. 2 Normal Probability plot of the standardized effects

See in Fig. 3 residual plots for tensile strength from graph the data has independent and has a satisfactory stability. Thus data to be used in further analysis.

See in Fig. 4 analysis of variance (ANOVA) for response the factors that will be affect the tensile strength is seven factors as follows.

- curing time
- amount of phenolic resin
- curing temperature
- interaction between curing temperature and curing time
- interaction between curing temperature and amount of phenolic resin
- interaction between curing time and amount of phenolic resin

3-way interaction of amount of phenolic resin, curing temperature and curing time

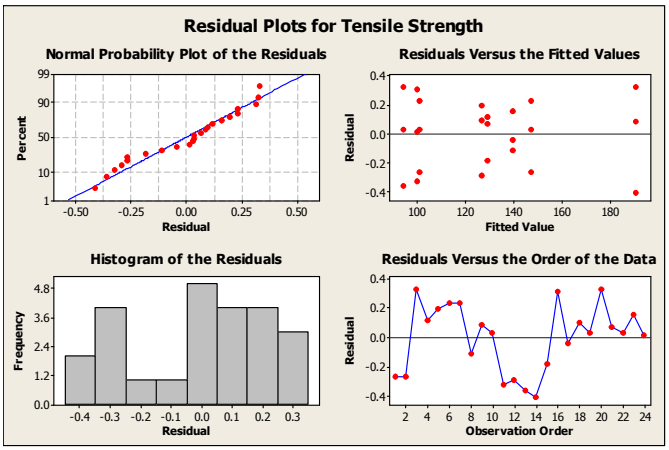

Fig. 3 Residual plots for Tensile strength

Analysis of Variance for Tensile Strength (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	3	14341.0	14341.0	4780.32	63322.46	0.000
2-Way Interactions	3	3974.1	3974.1	1324.69	17547.54	0.000
3-Way Interactions	1	2871.8	2871.8	2871.75	38040.62	0.000
Residual Error	16	1.2	1.2	0.08		
Pure Error	16	1.2	1.2	0.08		
Total	23	21188.0				

Fig. 4 Analysis of variance (ANOVA) for response

See in Fig. 5 the main effects analysis to determine 75 wt.% of phenolic resin, curing temperature 140°C and curing time 15min that were the best condition.

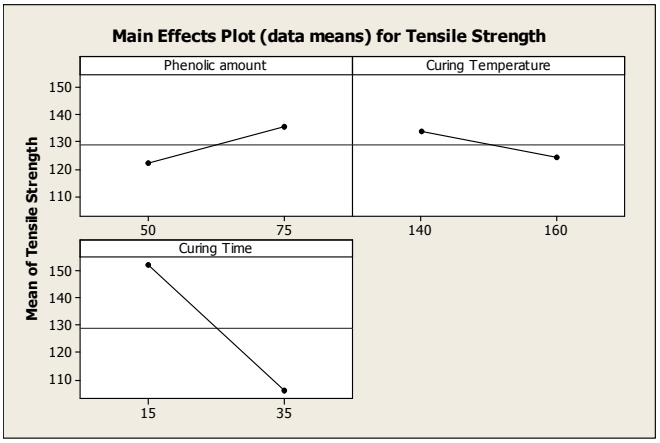

Fig. 5 Main Effects Plot for Tensile strength

From Fig. 6 Interaction plots have the interaction between the two factors that will be directly affects the tensile strength.

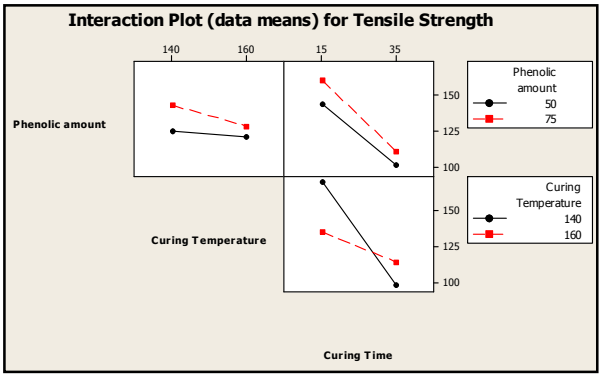

Fig. 6 Interaction plot for Tensile strength

IV. Conclusion

From design experimental by two-level Factorial design. the factors that will be affect the tensile strength is seven factors as follows curing time, amount of phenolic resin, curing temperature, interaction between curing temperature and curing time, interaction between curing temperature and amount of phenolic resin, interaction between curing time and amount of phenolic resin, 3-way interaction of amount of phenolic resin, curing temperature and curing time. Results of main effects analysis to determine 75 wt.% of phenolic resin, curing temperature 140°C and curing time 15min that were the best condition. It give the tensile strength was 191.24 MPa more than 103 MPa according MIL-l-24768.

Acknowledgment

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K. Thirapat born on Sep.8, 1990 in Bangkok, Thailand. He received the B.Eng. degree in Chemical Engineering from King Mongkut's Institute of Technology Ladkrabang, He is an researcher in Chemical Engineering and Metallurgy Laboratory, Research and Development Department, Defence Technology Institute (Public Organization) Ministry of Defence, The Kingdom of Thailand. His research interests include solid propellant and ablative materials.

W. Nattawat born on Nov.1, 1983 in Bangkok, Thailand. He received the B.Eng. degree in Chemical Engineering from Kasetsart University and M.Eng. degree in Chemical Engineering from Kasetsart University. Currently, He is an researcher in Chemical Engineering and Metallurgy Laboratory, Research and Development Department, Defence Technology Institute (Public Organization) Ministry of Defence, The Kingdom of Thailand. His research interests include solid propellant and ablative materials.

P. Komson born on May.9, 1965 in Prachupkirikarn, Thailand. He received the B.Sc. dregree in Chemistry & Physical and Materials Sciences from Royal Thai Force Academy and M.Sc. degree in in Solid Mechanic and Materials Sciences at The George Washiton University USA.. Currently, He is an researcher in Chemical Engineering and Metallurgy Laboratory, Research and Development Department, Defence Technology Institute (Public Organization) Ministry of Defence, The Kingdom of Thailand. His research interests include genretic materials, solid propellant.