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The Effects of Post Curing Process on the Mechanical Properties of Glass Fiber/Phenol –Formaldehyde Molded Composites

R. M. Rudd[1*], S.R. Ghafarian[2], A. Taherkhani[3]

[1]Lecturer, Department of chemical engineering, Takestan Branch , Islamic Azad University, Takestan, Iran
[2]Professor, Faculty of Polymer engineering, Amir Kabir University of Technology, Tehran, Iran
[3]Department of physics, Takestan Branch, Islamic Azad University, Takestan, Iran

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ABSTRACT

The effect of post curing on Tensile and flexural strength as well as its effect on the impact energy of a Glass/Phenol-Formaldehyde (Novolac) composite is studied. The results clearly show that the post curing has a detrimental effect on Tensile and flexural strength of the composite. On the contrary, it improves the impact resistance of the it.

KEYWORDS: Post Curing, Glass / phenol –formaldehyde composite, Tensile Strength, Flexural strength, Impact resistance

1. INTRODUCTION

The heat resistance of Phenol-formaldehyde resin and its behavior after degradation as well as its reasonable price, give it a prominent position among the resins which are used for heat resistant composites in many applications such as heat shields against ablation.

For some ablation applications, another important requirement for the part is high mechanical resistance, while the part is exposed both to high temperatures and to severe mechanical stresses and shear. These two important requirements should be considered duly in designing the part, its structure and in the production process.

In composite industry, one of the supplemental processes after shaping and curing process of a part ,is post curing process which is done, in order to increase the density of cross links in the cured resin network. The effect of this process on Tg and other physical properties of cured resin is investigated and reported by authors in another article .In the present work, the effect of post curing on mechanical properties.

The effect of post curing process on mechanical properties of composites with Novolac matrix are studied by a few teams of researchers (1) (2) (3) (4) but there is not a clear correspondence between their in some properties, consequently , it is not possible to achieve a comprehensive understanding regarding the matter. In the works of researchers in rogers corporation(1), which is a leading manufacturer of phenolic resins and parts, The effect of post curing on the Flexural Modulus, flexural strength and fatigue strength is examined . Results show that the flexural Modulus of post cure samples stays constant as the temperature raises, then, in the temperatures more than 150 C°, decreases considerably. The pattern for not post cure sample is different: the flexural Modulus declines steadily when the temperature raises. The flexural strength of both sample types decreases similarly with increase in temperature. But the fatigue strength of post cured samples decreases less sharply than not post cured samples, when the temperature goes up. All these effects are deemed to be connected to the increase of Tg by post curing. In another research work, Chandra and Rao from Indian science institute, the effect of post curing on interlaminar shear strength (ILSS), compressive strength and impact energy is studied. The outcomes show that the ILSS and compressive strength of samples decreased after post curing but the impact energy of the samples raised.

The effect of post curing of phenolic resin on the properties of the Resulted Carbon-Carbon composite is studied by TSE-HAO and Wen-Shyong in Feng-Chia university of Taiwan .Their achievement show that post curing of Carbon fiber reinforced Novolac which was used for making Carbon-Carbon composite contributed to a considerable improvement on the properties of resulted composite. Furthermore, it decreases the shrinkage of the Carbon-Carbon composite during the concentration process.

MATERIALS AND METHODS

Composite samples The Novolac resin of IP-500, purchased from Resitan Company of Iran was used as the matrix for the composites. E-glassgrade Glass mat was used as the reinforcement.

Corresponding Author: R. M. Rudd, Department of chemical engineering, Takestan Branch , Islamic Azad University, Takestan, Iran email: r_rad@nikoogroup.com

The reinforcement fabric was dipped in the resin solved in Ethanol and dried in oven in 60 C for one hour the sheets were molded in a compression molding press and cured in the mold for one hour in 160 C.
The samples was prepared in standard dimensions for tensile strength, Flexural strength and Impact Strength,

Post curing of samples

For the post curing of samples, three patternswere used. A set of samples was post cured in step increasing temperatures for equal time,they were post cured in 75 C (2 hours), 95 C (2 hours), 130 C (2 hours), 160 C (2 hours), 200 C (2 hours) for the total time of 10 hours.
The other two set of samples were post cured in two temperatures of 160 and 200 C in different times.

RESULTS AND DISCUSSION

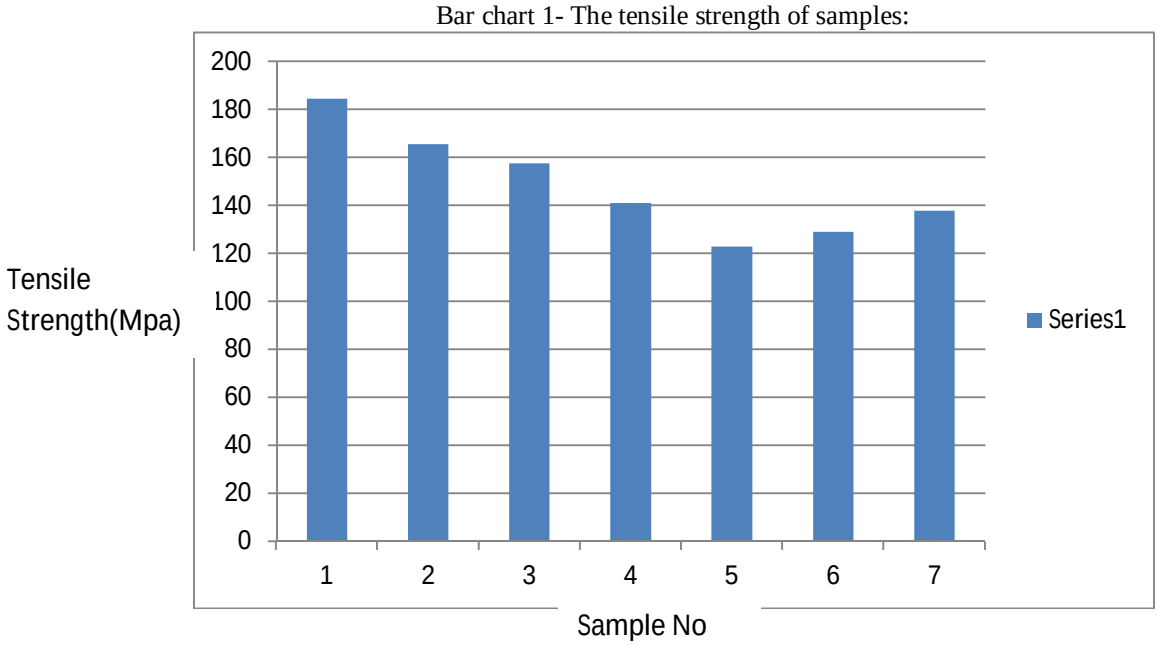
1- The effect of post curing process on the tensile Strength of composites with Novolac cured matrix

The samples with different post curing history were tested in a standard tension test device based on ASTM D638 standard.
The results are given in the table 1:

Table 1. The Tensile strength of various samples with different post curing history:

Sample no	Composite structure	The reinforcement mass percentage in the sample	The post curing procedure	Tensile strength (MPa)
1	Novolac/E-Glass matt	48.119	Not post cured	184.7
2	Novolac/E-Glass matt	48.966	2 hours,160 C°	165.7
3	Novolac/E-Glass matt	50.566	2 hours,200 C°	157.6
4	Novolac/E-Glass matt	52.021	5 hours,200 C°	141.1
5	Novolac/E-Glass matt	51.369	10 hours,200 C°	123
6	Novolac/E-Glass matt	52.555	75,95,130,160,200C,2 hours each,10 hours totally	129
7	Novolac/E-Glass matt	50.459	2 hours,230 C°	137.9

Bar chart 1- The tensile strength of samples:



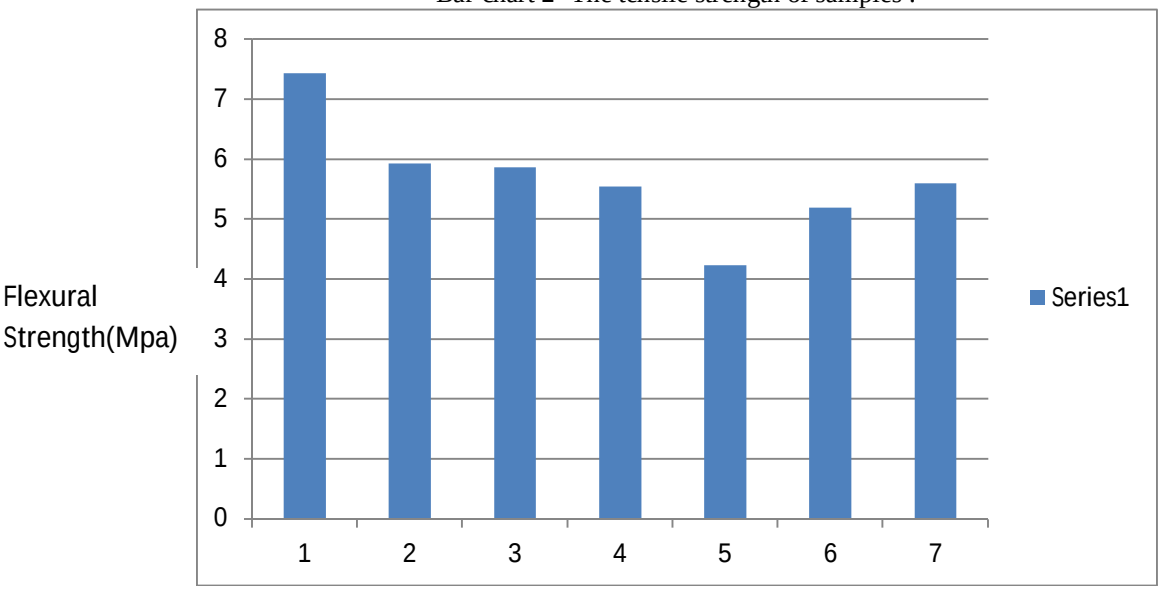
2- The effect of post curing process on the Flexural Strength of composites with Novolac cured matrix

In these series of tests, samples were tested in an standard Flexural test device based on ASTM D790Standard. the results are indicated in table2:

Table 2. Flexural Strength of composites with Novolac cured matrix with different post curing history

Sample no	Composite structure	The reinforcement mass percentage in the sample	The post curing procedure	Flexural Strength (Mpa)
1	Novolac/E-Glass matt	50.258	Not post cured	7.44
2	Novolac/E-Glass matt	52.699	2 hours,160 C°	5.93
3	Novolac/E-Glass matt	51.333	2 hours,200 C°	5.87
4	Novolac/E-Glass matt	47.899	5 hours,200 C°	5.55
5	Novolac/E-Glass matt	49.236	10 hours,200 C°	4.23
6	Novolac/E-Glass matt	48.256	75,95,130,160,200C,2 hours each,10 hours totally	5.19
7	Novolac/E-Glass matt	48.624	2 hours,230 C°	5.60

Bar chart 2- The tensile strength of samples :



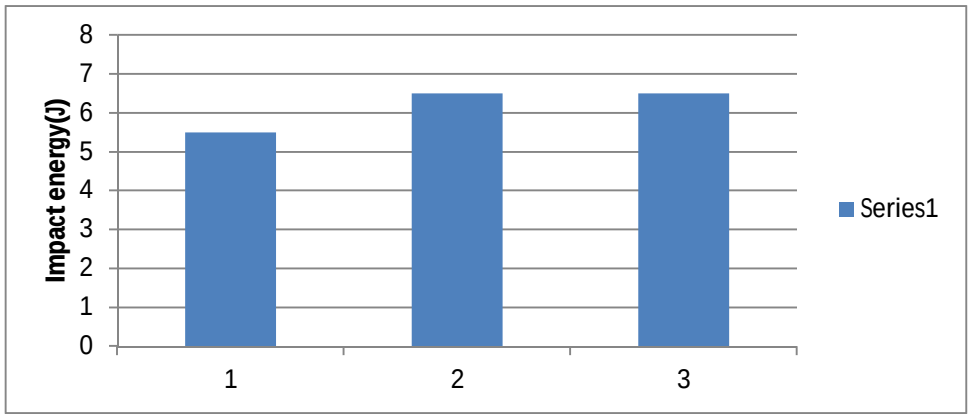
3- The effect of post curing process on the Impact energy of composites with Novolac cured matrix

The samples were prepared in standard shape for impact test and were tested in a standard device based on ASTM D256standard,the results are shown in table and bar chart 3:

Table 3. The absorbed energy in impact test of composites with Novolac cured matrix with different post curing history

Sample no	Composite structure	The reinforcement mass percentage in the sample	The post curing procedure	Tg temperature besed on DMA curve(C)
1	Novolac/E-Glass matt	50.258	Not post cured	5.5
2	Novolac/E-Glass matt	51.333	2 hours,200 C°	6.5
3	Novolac/E-Glass matt	49.256	75,95,130,160,200C,2 hours each,10 hours totally	6.5

Bar chart 3- The Impact energy of samples:



CONCLUSION

The results clearly show that the post curing process deteriorates the tensile and flexural strength of Novolaccomposites. This can be related to some interruption on the interfaces of resin and fibers due to the different thermal expansion coefficient of glass and resin and the thermal cycles which happen in post curing. However this interruption increases the impact resistance because it can divert the energy of the impact into millions of microscopic cracks and prevent macro cracks to pass the bulk and break the part.

The present results plus the effects of post curing on thermal resistance of the composite, suggests that post curing has not a implicit effect on the properties of the composite. In other words, the application of the part and the importance or the sequence of thermal and mechanical stresses that the part should bear determines that whether post curing is necessary or not and if required, what procedure should be taken.

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