An Experimental Investigation to Reuse Epoxy Resin for Particle Board

Nanditha H.S[1] and Dr Sampath kumar M C[2]

Nanditha H S –research scholar B M S College of engineering, Bangalore 560 019
Dr Sampath Kumar M C-faculty civil engineering B M S College of engineering Bangalore 560 019

Abstract : The present investigation is to study the use of glass-fiber-reinforced epoxy resin waste as a filler material with the bamboo particle to make single-layer particleboard and to examine the mechanical and physical properties of panels to determine the influences of density and temperature.The reuse of comminuted glass-fiber-reinforced resin with various granularities gathered from printed circuit manufacturing residues, the molding process, and the feasibility of producing particle board were evaluated by considering the effects of mass proportion. As fillers, these residues were converted into single layered Particle board using Urea formaldehyde as a bonding agent. The mechanical properties of the reproduced particle board were examined by considering the effects of mass fraction and glass-fiber distribution. Particle board containing mass fractions of 30%, 10%, and 20% glass-fiber- reinforced resin waste respectively was executede Beyond these percentages, the materials blend became unmanageable and the mixture less amenable to impregnation with fiber.

INTRODUCTION

During the last few decades, electronic products have become an indispensable part of society and the electronic industries have experienced remarkable growth. Over million tons of electronic waste and products are generated every year and are expected to increase due to the increase usage of electronics. An increasing amount of e-glass fiber and epoxy are used to produce copper clad laminate, which is the major component material for printed circuit board industry and more than hundred thousand tons of glass-fiber-reinforced epoxy resin waste needs to be disposed every year. Disposal of plastic and glass fiber wastes becomes a serious solid waste problem. Thus there is a need to investigate the feasibility of an effective and economic application of recycled epoxy/glass wastes so as to minimize the environmental impact caused by direct land-fill disposal.

Prepreg is the FR4 laminate that is considered to be the backbone of the printed circuit industry. It consists of layers of fiberglass cloth of approximately 60 wt % impregnated with epoxy resin of 40 wt %. “FR” means flame retardant, and type “4” indicates woven glass-reinforced epoxy resin.

MATERIALS AND METHODS

The particleboard is a panel product manufactured under pressure from particles of wood or other lignocelluloses materials and an adhesive. Particleboard has been widely used throughout the world for furniture manufacture and house construction, including flooring systems, etc.The materials required are Urea Formaldehyde Resin (gm), Bamboo Particles (gm), Waste Epoxy resin (gm), Melamine (gm), Ammonium chloride (gm), Liquid ammonia (ml), Wax in emulsion. Bamboo is a versatile, strong and renewable material. It is a member of the grass family, the fastest growing woody plant on the planet. Most bamboo species produce mature fiber in 3 years. Some bamboos grow upto 1 meter a day. Bamboo can be grown quickly & easily and sustainably harvested in 3 to 5 year cycle. This process involves various phases. First phase involves selection of bamboo species of Bamboosa bamboo.This is longitudinally and in cross section cut for designated length. Before cutting debarking was done manually. The second phase involves usage of hammer mill to reduce the wooden pieces and bamboo pieces into particles. These particles were dried at 100 ± 2^{o}C temp in oven to bring down the moisture content to 4-6%.The third phase involves resin preparation 920gms of formalin was taken into resin reactor. pH of the formalin is raised to 7.5-8 by the addition of caustic soda solution ((33% concentration). 360gm by weight of urea is added and stirring is carried out to get uniform mixing. The solution is refluxed at 90 ± 2^{o}C for about one and half hour and throughout the reaction pH of 7.5-8 is maintained. In the next stage, the reaction mixture is made acidic (pH 4.5-5) by addition of diluted glacial acetic acid, refluxing is continued at a temperature of 90 ± 2^{o}C until the water tolerance of about 3-4 times in hot condition is achieved. The flow time when measured with B-4 flow cup of IS-3944 is around 17-18 seconds. At this stage, the reaction is arrested by raising the pH of resin to about 7.5-8 and residual or second urea of 40gms is added to the resin and cooled to ambient temperature by circulating cold water. The resin is then discharged and checked for its properties. The fourth phase involves mixing of adhesive in wood particle, mat formation and pre-pressing, followed by hot pressing and final phase consists of trimming and sizing. Table 1.1 indicates the adhesive formulations for 10% resin content.

Table 1.1: Adhesive Formulations for 10% resin content

Raw material	Sample A	Sample B	Sample C	Sample D
UF Resin (gm)	218	218	218	218
Particles (gm)	918	826	734	643
Epoxy waste (gm)	000	92	184	275
Melamine (gm)	4.4	4.4	4.4	4.4
NH_4CL (gm)	0.7	0.7	0.7	0.7
Liq. NH_3 (ml)	0.5	0.5	0.5	0.5
Wax in emulsion	1.75	1.75	1.75	1.75

Tests Done for Particle Board Made Using Epoxy Waste

Test samples were cut from particleboard and the following properties were determined in accordance with appropriate Indian Standard as per IS: 3087.Finished boards were kept in an open space approximately for a week to remove formaldehyde trapped inside. Test samples were cut from particleboard and the following properties were determined in accordance with appropriate Indian Standard as per IS: 3087. Specimens were used for the mechanical and physical properties. The tests that were carried out on the particle board were static bending test, internal bond strength test, thickness swelling test, density and water absorption test.

RESULTS

From the data collected and analysis made for the data collected, it was clearly identified that a large amount of Epoxy dust is being generated in the facility. Table 1.2 indicates the chemical composition of various materials in epoxy dust. Disposal of plastic and glass fiber wastes is becoming a serious solid waste problem, hence alternative was found to reuse the waste. The epoxy dust was in the powdered form and hence its mechanical and physical properties could not be identified. Hence the chemical composition of various materials in % wt is identified. The identified materials are listed below. Table1.3 indicates the characteristics for 10% resin content particle board.

Table1.2: Chemical composition of various materials in epoxy dust (wt %)

Origin of Dust	**Copper Content (%)**	**Aluminum Content (%)**	**Epoxy Content (%)**	**Gross calorific value Cal/g**	**Moisture Content (%)**	**Specific gravity**	**Melting temperature (ºC)**
Routing dust	0.15	5.36	34.65	3534	1.430	1.15	Above 150
Drilling Dust	15.96	6.18	37.09	3603	1.598	1.14	Above 150

Table1.3: Results for resin content Particle Board

PARTICULARS		**A (100%)**	**B (10%)**	**C(20%)**	**D(30%)**
Density (Kg/m^3) of Particle board		890	945.2	993	1125
Moisture Content (%)		6.4	5.15	4.03	3.42
Water absorption (%)	**2 hr**	6.41	7.56	8.0	11.1
	24 hr	38.3	28.680	31.7	36.0
Thickness swelling (%)	**2 hr**	4.1	8.51	7.498	5.3
	24 hr	6.97	9.0	9.0	9.6
Modulus of Rupture (N/mm^2)		21.02	34.3	38.39	39.7
Modulus of Elasticity (N/mm^2)		3524	3876	4021	3987
Tensile strength (N/mm^2)		1.82	1.31	1.47	1.63

CONCLUSIONS

From the experimental investigations from epoxy dust "Particle Board" has been created as per IS-3087 (Specifications for general purpose medium density Particle Board).It is found that all the panels made have passed the IS Standards: 3087. The study is limited to Laboratory Scale up to a replacement of 30% epoxy dust. Beyond these percentages, the materials blend became

unmanageable and the mixture less amenable to impregnation with fiber. Present studies indicated that communicated glass-fiber-reinforced waste- filled Urea formaldehyde resin composites are promising candidates for structural applications where high stiffness is required.The particle boards meets the requirement of IS- 3087. It has been observed that 30% replacement of epoxy dust gave highest internal bond strength. However the internal bond is more in the panel's with100% bamboo particles.Incorporation of melamine in the adhesive formulation improves the water resistance property. Incorporation of emulsified wax in the adhesive formulation improves the water resistance property and enhances the surface finish. About 8% of UF solid resin (48% basis) for the particles (epoxy dust, Bamboo) was found to be adequate to achieve desired strength properties. This study is limited to lab scale up to a replacement of 30% epoxy dust waste.

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