Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 4; January-March, 2015, pp. 230-234

http://www.krishisanskriti.org/jbaer.html

Design of Pulverizer for Discarded E-waste

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Abstract— *Accumulation of Electronic waste is one of the greatest threats in the present scenario. The innovation of the products in the market results in the accumulation of outdated electronic goods. Electronic waste is not only limited to discarded computers and television, but also includes CDs, PCBs and other light equipments. The dumping of these electronic goods and its effluents on the environment is threatening. This threat can overwhelm by the introduction of recycling technique. The flaming of Electronic waste leads to the production of flue gas which cause environmental pollution, hence recycling can be carried out by powdering it and making new components using Fiber Reinforcement Polymer technique. The conventional grinding machines are of high cost. Hence it is necessary to design a pulverizer to powder the Electronic waste considering the cost factor. The new design includes the main part as the grinding wheel, which rotates in a controlled speed. Due to the grinding action the electronic waste material will grind and obtain in powder form.*

1. INTRODUCTION

Electronic waste or E-waste is one of the fastest growing wastes in the world. The emerging of new technology and neglecting existing models cause the increase in E-waste. E-waste often misinterpreted as related to old computers or IT equipments. Technically it is collection of waste Electrical and Electronic Equipment (WEEE). The waste electrical and electronic equipment includes all components and subassemblies, which are either part or whole of such product during the time of discarding.

Current studies conforms E-waste management in India is different from worldwide. The informal recycling practices create more adverse effect to environment as well as to human health. More than 500,000 tonnes of E-waste is generated in India each year while some developed countries also ship there wastes here. Major E-waste in India is generated in Maharashtra, Tamilnadu, Andhra Pradesh, Uttar Pradesh [1].

The advantage of E-waste pulverizer is that the running cost and the manufacturing cost will be low because of its simple mechanism. For a pulverizer machine, many studies have been conducted [2-4]; how-ever few reports are available using grinding wheel and dealing with electronic waste.

This study investigated the effect of pulverizer operating condition on the shape and size distribution of grinded products. Various E-waste materials such as PCB's, CD's are grinded using the pulverizer. The size of particles obtained from the pulverizer is sieve analyzed and testing is carried out using SEM and EDAX for further studies.

2. EXPERIMENTAL

2.1. Materials

The samples which used in the pulverizer were discarded compact disc and discarded printed circuit board.

2.1.1. Printed Circuit Board (PCB)

PCB is one of the most important components in Electrical and Electronics Equipment (EEE), [5-6]. A typical PCB is made of epoxy resin, fiberglass and copper. Also bromine fire retardant is added to resin to increase the fire resistance [7]. The metal scrap presented in PCB consists of copper, iron, tin, nickel, lead, zinc, silver, gold and palladium [8-9]. The powder produced during the PCB grinding consists of metals and non metallic materials.

Table 1: Comparison of main processes in PCB's

Types	Thermal Processes	Non-Thermal Process
Characteristics	• Non-metallic materials cannot be recovered • High investment for installation and equipment	• Large investment in waste-water treatment • Health for milling operation
Environmental impacts	Generation of gaseous pollutants	• Waste-water generation, with acidic residues • Generation of solid waste

Table 1 illustrates the main environmental impacts and their related issues. from PCB's three main types of materials can be retrieved such as recyclable metals like copper, aluminium

etc also recyclable polymeric materials from combustion and incineration and ceramic materials which can be reused or disposed if they are free of metals, polymers or other contaminants[10]

2.1.2 Compact Disc (CD)

A compact disc is fairly simple piece of plastic, which use to store data. CD's are mostly disposed with other waste electrical and electronic equipment. Mostly CD's end up in landfills, which is an environmental nightmare. CD's weighs about 20 grams and is about 1.2mm thick, with a diameter of 120 mm and centre diameter of 15 mm. It consists of four layers of materials, a polycarbonate disc layer, a reflective metal layer made of aluminium, silver or golden alloy, a lacquer layer to prevent oxidation. According to CD recycling centre of America, every month approximately 10000 pounds of CD's became useless [11]. Approximately 10% of all CD's manufactured are rejected due to the complex in manufacturing process [12].

Table 2: Comparison of CD Recycling Methods

	Chemical Stripping	Mechanical Abrasion	Thermal Processing
Use of acids/solvents	Uses solvents and aggressive chemicals, acetic acid	No	No
Water Use	Stripped discs are washed	Discs may be misted for cooling	Unknown
Electrical Use	Process requires elevated temperatures and hot air dryer	Required elevated temperatures for drying	Not excessive
Health Issues	Use harmful solvents	Relatively safe	Health issues are high
Emissions	Chemical gases produced during reaction	Unknown	Very high

Chemical stripping, Mechanical abrasion, Thermal processing are the various techniques which is existing in processing compact disc. Table 2 compares the various recycling processes.

2.1.3 Grinding Wheel

The grinding wheel is the main component in the E-waste pulverizer which helps in powdering the E-waste materials. The grinding wheel material used is aluminium oxide. The aluminium oxide abrasive is a synthetic material which consists of crystalline oxide (α-Al_2O_3). They have adjustable parameters and good abrasive properties make them useful in grinding material.

2.2. Pulverizing

The samples were pulverized in room temperature (20 ± 5 ^oC) and at ambient humidity. The design model of E-waste pulverizer is given in Fig. 1.

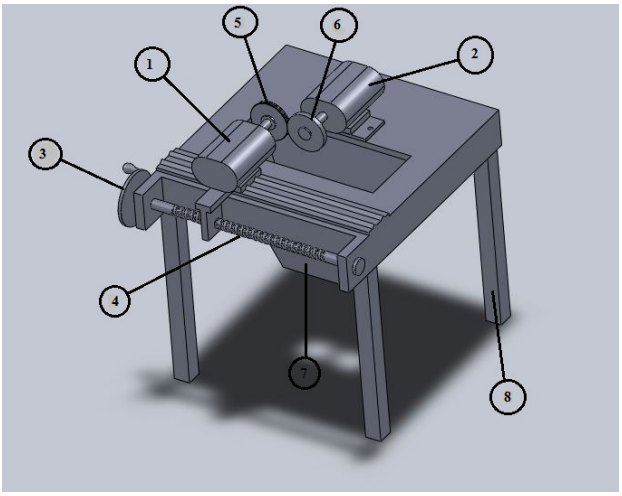

Fig. 1: Design model of E-waste pulverizer

From the Fig. 1 the main parts of the pulverizer is listed below

1. Movable motor
2. Fixed motor
3. Hand wheel
4. Lead screw
5. E-waste Holder
6. Grinding wheel
7. Powder collector
8. Table

3. DESCRIPTION OF E-WASTE PULVERIZER

The fabricated model of E-waste pulverizer is given in Fig. 2.

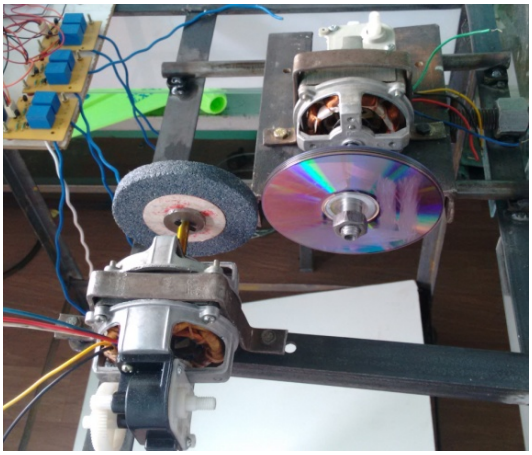

Fig. 2: E-waste Pulverizer

The main parts of the pulverizer are fixed motor, movable motor, grinding wheel, lead screw. The major mode of operation is with the grinding wheel. The grinding wheel rotates with the variable speed such as 500, 550, 600 rpm respectively. The movable motor is fixed in the lead screw which is connected with the hand wheel. The feed can be given with the help of hand wheel. The grinding wheel is connected with the fixed motor. The electronic waste material is attached with the movable motor. The movable motor will rotate in the anti-clockwise direction. The rotation of both motor will help in grinding process and also help in reducing the temperature in grinding wheel due to the change in contact area surface.

4. RESULT AND DISCUSSION

4.1 Powder Analysis

Particle size and shape analysis were performed on a representative 10 g sample of pulverized product. Sieve mesh of size 355,360,254 µm is used to separate the powder obtained. The Fig. 2 shows the powder obtain from the pulverizer.

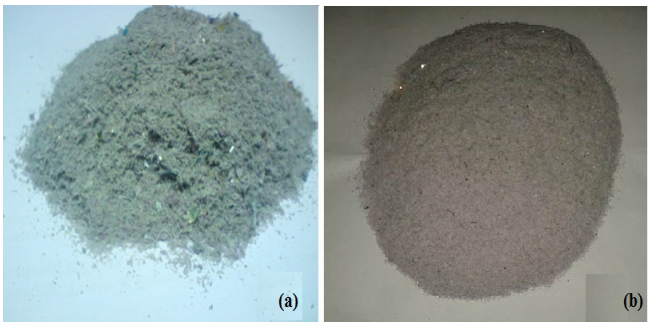

Fig. 2: a) Powder sample of PCB, b) Powder sample of Compact Disc

4.1.1 SEM Analysis

The powder then carried out for SEM analysis to find out the porous free surface, absence of voids The SEM analysis were carried out for varies magnification factor and for various micron meter. The various magnification factor of the powder sample will help in identifying the various morphology of the sample obtained. The Fig. 3 illustrates the SEM image of CD powder and Fig. 4 illustrates the SEM image of PCB samples.

The results disclose that the PCB material posses spherical morphology and posses very good surface property and the CD material posses globular morphology. The flat plates that are formed shows that the surface of the material has very smooth curvature. .

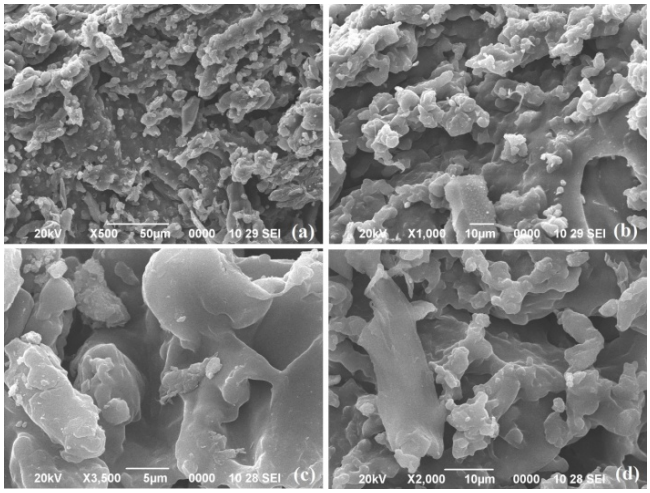

Fig. 3: a) SEM image of the CD material at 10 micron meter, b) SEM image of CD material at 5 micron meter at 5000 magnification factor, c) SEM image of CD material at 2 micron meter, d) SEM image of CD material at 5 micron meter at 3500 magnification factor

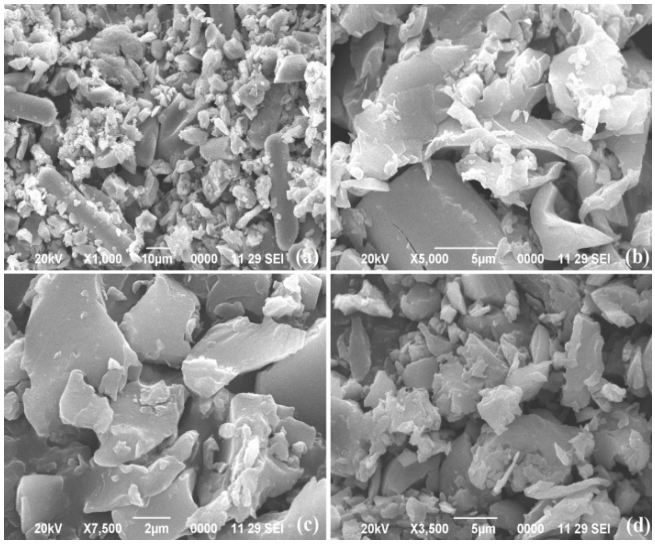

Fig. 4: a) SEM image of the PCB material at 10 micron meter, b) SEM image of PCB material at 5 micron meter at 5000 magnification factor, c) SEM image of PCB material at 2 micron meter, d) SEM image of PCB material at 5 micron meter at 3500 magnification factor

4.1.2 EDAX Analysis

EDAX test is to carry out to identify the materials which are presented in the both powder samples. Since it is recycled material it is necessary to find out the materials and its toxic nature.

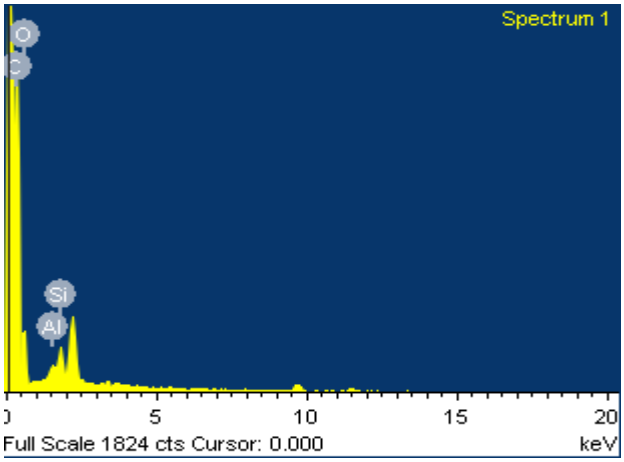

Fig. 5 EDAX analysis of CD sample

Fig. 5 illustrate the EDAX result of the CD powder. It consist of carbon, aluminium, silicon and oxide.

Table 2: Material composition and their concentration of CD sample

Element	C K	O K	Al K	Si K
App concentration	128.05	15.67	0.68	2.26
Intensity correction	1.2579	0.3956	0.8863	0.9397
Weight%	70.42	27.38	0.53	1.66
Weight% sigma	1.28	1.30	0.13	0.15
Atomic%	76.61	22.36	0.26	0.77

The material composition and the concentration of the CD sample is given in table 2.

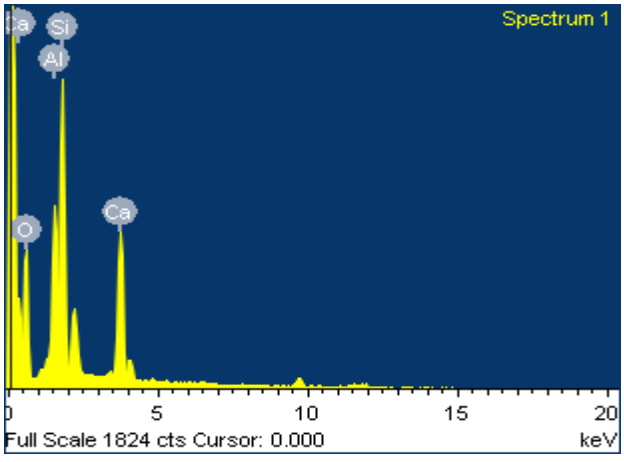

Fig. 6: EDAX analysis of PCB sample

The EDAX analysis of the PCB samples is given in Fig. 6. The results shows that the sample contains elements such as oxides, calcium, aluminium and silicon in various amount. The material composition and their concentraion of PCB powder is given in table 3.

Table 3: Material composition and their concentration of PCB sample

Element	O K	Al K	Si K	Ca K
App concentration	43.16	10.02	21.59	16.67
Intensity correction	0.6662	0.8596	0.8253	0.9663
Weight%	54.05	9.73	21.83	14.40
Weight% sigma	0.82	0.35	0.50	0.40
Atomic%	69.29	7.39	15.94	7.37

From the EDAX graph the main element present in the CD powder sample is carbon and oxide and in the PCB sample it is calcium, aluminium and silicon. So the result shows the absence of toxic materials such as lead. So the powder can be used in FRP process for making new materials.

5. CONCLUSION

The need of new recycling techniques is essential due to the enormous growth of E-waste in our society. This paper deals with a safe and cost effective method of powdering E-waste materials such as PCB and CD. The powder obtained from the pulverizer can be used for making new components using FRP process.

6. ACKNOWLEDGEMENTS

We wish to extend our gratitude to all the faculties in Mechanical Department, Adhiyamaan College of Engineering Hosur, helped us giving suggestions and motivations for this work.

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