

DEVELOPMENT OF A COMPOSITE MATERIAL FOR LEARNING AND TEACHING PURPOSES

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Abstract

This paper reports on the developed magnetic board composite from waste materials for use in education sector as teaching aid. The composite material was prepared using iron filings from metal machining (cutting) processes and sawdust obtained from wood waste. The determination of the sieve analysis of the two materials was carried out to obtain particle sizes of 0.4 μ m and 1.0 μ m for the iron filings and sawdust respectively. The two materials were mixed in various percentages to obtain optimum composition from the aggregates formed. An appropriate binder was used for binding the various compositions together. The resulting aggregates were cast into the required shapes and sizes, compacted and allowed to dry at ambient temperature for 5 days. Durability test was carried out for tensile stress, compressive stress and the material density. The performance evaluation of the composite was carried out by embedding the composite material into the prepared board used for charts, graphical image and data as well as information display to students for teaching and learning purposes. The magnetic board achieved 22.75% improvement in time utilization during a-60 minute lecture period.

Keyword: Composite; durability test; learning; sieve analysis; teaching; waste

1.0 INTRODUCTION

Practically in every progressive school settings, reform efforts are dramatically targeted at raising expectations of students, and consequently, of their tutors and teachers. In response to these reform initiatives, educators are being tasked to develop and adopt new methods, skills and responsibilities in order to enhance the teaching profession for better students. To meet these expectations, teachers need to deepen their content styles and learn new methods of teaching thereby collaborating with their colleagues to examine and adopt the new ways or methods being developed [1].

Nearly every state in the country is involved in the campaign for higher academic standards. This campaign calls for a shift from a behaviourist approach to teaching, in which students are often passive recipients of teacher-generated knowledge and drill, since practice is the primary pedagogy to approach which actively engage students in the edifice of knowledge.

To make this shift, teachers must not only enhance their knowledge of the subject-matter but should also

learn to use new teaching strategies through the use of teaching aids [2].

This work is aimed at developing a composite material for learning and teaching purposes.

In teaching profession, it is possible to make the teaching-learning process easier and meaningful through the use of teaching aids. It provides a great deal of convenience in teacher's ability to convey message to students in an accurate and clear manner; (i.e. making abstract knowledge concrete and enabling students to comprehend complex ideas through simplification). When properly used, printed materials, audiovisual materials and experience-giving methods, help make the teaching-learning process easier and enduring [3].

The process of teaching-learning depends on the different type of equipment available in the classrooms. Among the available teaching aids are: traditional aids (such as blackboard/chalkboard, books, periodicals); visual aids (such as objects, picture, map, figure, chart, posters, model, bulletin board, flannel board, globe, graph); Audio (such as

radio, tape recorder, teaching machine); Audio-visual (such as projector, film strips, motion picture, films, television, video cassettes) [1-3].

Isman et, al [4] (2004) indicated that with the developments in information and communication technologies, all applications of instruction start to have tendency toward technology based instruction instead of directed, teacher-centred instruction. It is important to mention that computers are the main instructional support to the learning and teaching process. Technological tools provide the equal standards, opportunities and easy path for the successful understanding and also meaningful learning for students.

Akpinar and Simsek [5] (2007) investigated usage of variety of media by teachers to support students' learning. They examined the effect of pre-service teachers' experience regarding information and communication technology use on their learning object development. They found meaningful correlation between the use of some of the learning object components.

Karchmer-Klein [6] found that having student teachers watch and analyze experienced teachers' high-quality technology supported instructions motivated to use technology in their own future teachings. Similarly, Keeler [7] found that incorporating technology-rich instructional approaches helped pre-service teachers become familiar with how to utilize technology in educational contexts and made them to be aware of the usefulness and transferability of instructional technology techniques. Can [8] investigate the attitudes of pre-service teachers towards the use of teaching materials; overhead projector and projector in their classes. According to the study, students indicated that the use of overhead projector and projector brings some kind of change and variety to the teaching, saves teaching from being monotonous, and contribute to establishing lively and smooth setting for teaching and learning.

In view of the aforementioned importance of teaching aids, this work is aim at developing a magnetic board for teaching-learning purposes. The noble thing about this work is that the composite material was prepared using iron filings (waste) from metal machining (cutting) processes and sawdust obtained from wood waste.

2.0 MATERIALS AND METHODS

2.1 Materials

The materials used for making the composite include sawdust, iron filings, binder, water, gasoline, kerosene. Other materials include: hand gloves,

vibrating sieving machine, base and compacting plates, cellophane, cylindrical steel mould for briquette and wooden rectangular mould for particleboard casting.

2.2 Iron Filings

The iron filling are small pieces of iron obtained from ferrous alloys excluding austenitic type that is not magnetic [8-9]. These filings are rarely use, except in science demonstrations to show the directions of magnetic field, and usually swept away which invariably contaminate the surrounding soil. The iron filings (Fig. 1) used in this work is obtained from machining processes, such as milling, cutting, filing and grinding at various metal workshops in Tanke area Ilorin, Kwara state.

2.3 Sawdust

The sawdust (wood dust) is a fine particle of wood which is a by-product of cutting, grinding, drilling, or otherwise pulverizing wood with saw or other tools. It could also be a by-product of certain birds and insects which live in wood, such as woodpecker and carpenter ant [10]. It is the main component of particleboard. The sawdust used in this work (Fig. 2) was obtained from wood processed from mahogany tree.

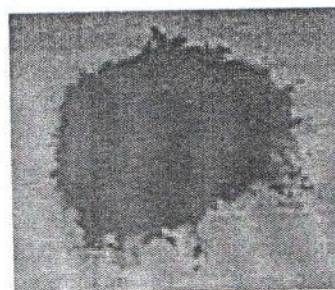


Fig. 1 Iron filings used for the work



Fig. 2 Sawdust particle used for this work

2.4 Binder

Binder is a substance added to form dry ingredients into a solid mass or to maintain an even consistency throughout a liquid or semi-liquid substance [11]. This could be a synthetic resin or natural adhesive materials. Formaldehyde based resin, such as urea-

formaldehyde or phenol-formaldehyde are examples of synthetic binders. Starch, a natural binder which can be obtained from cassava, corn, rice, yam, potato, etc. can be used in this research. Cassava starch is used in this research because of its availability and lower price.

2.5 Moulds

Cylindrical steel moulds of 12 mm were cut from galvanized pipe of 50 mm internal diameter, while rectangular wooden moulds of 12 mm x 175 mm x 90 mm were fabricated. Sandwich plywood of 10 mm was used for mould base and compacting plates.

2.6 Sample Preparation

Sieve analysis was done for the sawdust and iron filings to obtain particle sizes of 1.0 μm and 0.4 μm respectively. The iron filings was washed with kerosene, then with gasoline and dried to remove any spent oil used as lubricant during machining process. The sawdust was air-dried to constant weight. Base and compacting plates were taped with cellophane tapes for easy removal of the particleboard after casting.

2.6.1 Preparation of the sawdust-iron filings briquette

Powdery starch was dissolved in water and stirred slowly to ensure complete dissolution of the starch after which water at temperature of 100°C was added to form a gelatinous starch solution. Measured sawdust and iron filings were homogeneously mixed before adding the starch solution which is then mixed thoroughly using hand marching method. Protective hand gloves were worn during this process to avoid sticking of the mixture to the hand. The mixture was then poured and pressed into the cylindrical moulds ($\varnothing 50\text{ mm} \times 12\text{ mm}$). This procedure was repeated for the other two compositions. The casts were left to air-dried and sun-dried for 7 days. The percentage compositions of the three different briquettes prepared with constant mass of starch are shown in Table 1. Cubic specimen briquettes for each composition were prepared for compressive test based on British Standard BS EN12390-2 [10].

Table 1 Percentage composition of sawdust-iron filling briquette produced

Samples	Iron filings (wt. %)	Sawdust (wt. %)
A	50	50
B	70	30
C	30	70

2.6.2 Preparation of the particleboard

The particleboard was produced using the sawdust and starch solution. The dried, sorted sawdust was measured and mixed thoroughly with the binder to form homogeneous mixture. The briquettes were rubbed with the prepared starch solution (for good binding) and arranged in arrayed as shown in Fig.3, using a paper size of 210 mm x 297 mm (A4 paper size), on the base plate within the rectangular wooden mould. The mixture was then poured and layered on the briquette. The compacting plate was placed on the casting when the mould is full and a compressive load of 30 kg was placed on it to remove any entrapped air within the cast. The compacting mould was removed and the wet particleboard was left to air-dry and sun-dried for two and three days respectively.

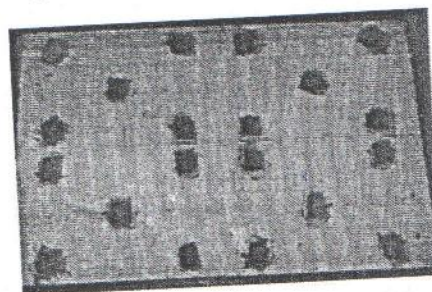


Fig. 3 Starch rubbed briquettes arrayed on the taped base plate

2.7 Materials Testing

The moisture loss, compressive test and evaluation of the particle board were carried out to evaluate the developed composite material

2.7.1 Moisture loss

The mass of the samples were determined before and after drying. Percentage moisture content was calculated using Eqn. 1.

$$\text{Moisture Loss} = \left[\frac{m_1 - m_0}{m_1} \right] \times 100\%$$

Eqn. 1

where m_1 = mass of wet sample, m_0 = mass of dry

2.7.2 Density

The mass of the particleboard was determined by weighing balance and the volume was estimated using the dimension of the final cuboid formed. The density ρ was then calculated using Eqn. 2.

$$\text{density, } \rho = \frac{\text{mass, } m}{\text{volume, } v}$$

Eqn. 2

where m is in g, v in cm^3 and ρ in g/cm^3

2.7.3 Compressive test

The cubic briquettes were loaded on the universal tensile testing machine and continuously loaded until it fails denoted by sharp drop in the maximum load as could be observed on the machine [13 and 14]. The procedure was carried out on two samples from the different compositions.

2.7.4 Evaluation of the particle board

The performance evaluation of the developed composite was carried out by embedding the composite material into the prepared board. The board was displayed in different lecture rooms for

used in charts, graphical image and data as well as information display to students during lecture. A one-hour lecture time was used as case study and the actual time lecture start with and without the use of the board was recorded for four weeks.

3.0 RESULTS AND DISCUSSIONS

3.1 Moisture Loss

The mass of wet and dry samples are presented in Table 2 from which the moisture loss in weight and percentage are estimated. It can be observed from Table 2 that there is a reduction in the mass of the samples after sun drying which is due to moisture loss. Sample C has the highest percentage moisture loss of 28.2% while sample B has the least with a value of 24.0%. This implies that the percentage moisture loss increases as sawdust increases.

Table 1 Percentage moisture loss in samples after drying

Samples	Percentage composition of sawdust (%)	Mass of wet mixture (g)	Mass of dry mixture (g)	Mass difference (g)	Percentage loss in mass (%)
A	50	420	306	114	27.1
B	30	391	297	94	24.0
C	70	440	316	124	28.2

3.2 Density

The volume of the sample is calculated to be 189 cm^3 . The density of each sample was then calculated using Eqn. 2. From Table 3, it can be observed that sample C has the least density of $1.57 \text{ g}/\text{cm}^3$ and sample B has the highest value of density which is $1.67 \text{ g}/\text{cm}^3$. This indicates that density increases as the percentage of iron filings increases. Thus these values fall between the density of mahogany and iron. According to [15], mahogany has a density of between 495 and $850 \text{ kg}/\text{m}^3$ while that of iron is about $7874 \text{ kg}/\text{m}^3$ [15]. Thus the value of the samples which falls between 1570 - $1670 \text{ kg}/\text{m}^3$ is typical of composite materials.

Table 3 Density of the briquette samples

Samples	Percentage composition of sawdust (%)	Mass of dry mixture (g)	Density (g/cm^3)
A	50	306	1.62
B	30	316	1.67
C	70	297	1.57

3.3 Compressive Stress

The compressive stress was determined by dividing the maximum load by the surface area of the cube. Table 4 shows the compressive strength of the various samples of iron filings with sample B having the highest percentage of iron filings with the highest value of the compressive stress. The least value of compressive stress is also in the sample with the least percentage of iron filings. It can be concluded that the compressive stress increases as the percentage of iron filings increases since iron has high compressive property.

Table 4 Compressive stress of the samples

Samples	Compressive load (kg)	Compressive force (N)	Compressive stress (kPa)	Average stress (kPa)
A	545.45	5345.41	835.22	835.22
	545.45	5345.41	835.22	
B	1323.00	12965.40	2025.84	2032.74
	1332.00	13053.60	2039.63	
C	318.18	3118.16	487.21	487.21
	318.18	3118.16	487.21	

3.4 Evaluation of the particle board

The results of the performance evaluation of the developed composite are shown in Tables 5a to 5d. From the analysis of the lecture time, the magnetic board achieved 22.75% improvement in time utilization during a 60 minute lecture period.

Table 5a Lecture with and without composite board (lecture period 10am-11am)

Week 1	Lecture Time		
Day	Without board	With board	Time gained
1	10:23	10:08	15
2	10:18	10:05	13
3	10:21	10:07	14
4	10:17	10:06	11
5	10:20	10:05	15

Week 1 average time gained is 13.60 minutes

Table 5b Lecture with and without composite board (lecture period 8-9am)

Week 2	Lecture Time		
Day	Without board	With board	Time gained
1	8:11	8:03	8
2	8:17	8:05	12
3	8:16	8:07	9
4	8:15	8:05	10
5	8:20	8:07	13

Week 2 average time gained is 10.40 minutes

Table 5c Lecture with and without composite board (lecture period 3-4pm)

Week 3	Lecture Time		
Day	Without board	With board	Time gained
1	3:25	3:09	16
2	3:18	3:07	11
3	3:22	3:04	18
4	3:20	3:10	10
5	3:23	3:06	17

Week 3 average time gained is 14.40 minutes

Table 5d Lecture with and without composite board (lecture period 12-1pm)

Week 4	Lecture Time		
Day	Without board	With board	Time gained

1	12:28	12:10	18
2	12:31	12:11	20
3	12:25	12:10	15
4	12:28	12:15	13
5	12:29	12:14	15

Week 4 average time gained is 16.20 minutes

Total average time gained in four weeks during the use of magnetic particle board is 13.65minutes

The percentage time gained in one-hour lecture period during the use of magnetic particle board for the four week is

$$\frac{13.65}{60} \times 100\% = 22.75\%$$

The percentage time gained of 22.75% is as a result of improved time management resulting from the use of the developed board.

4.0 CONCLUSIONS

Magnetic particleboard was produced from iron filings, sawdust and starch. From the afore mentioned results and discussion, it can be concluded that

1. The magnetic particle board enhance teaching by improving time utilization during teaching (improved time management is ascertained).
2. The high mechanical property of the composite is as a result of high percentage of iron filings present.
3. This particleboard has the advantages of being magnetic and at the same time thumb tags could be utilized which invariably increases the types of teaching aids that can be used.

References

1. Friedman, A., Bolick, C., Berson, M. & Porfeli, E. (2009). National educational technology standards and technology beliefs and practice of social studies faculty: Results from a seven year longitudinal study. *Contemporary Issues in Technology and Teacher Education*, 9(4), 476-487.
2. Heafner, T. (2004). Using technology to motivate students to learn social studies. *Contemporary Issues in Technology and Teacher Education*, 4(1), 42-53.
3. Thomas B. Corcoran. (1995). *Helping Teachers Teach Well: Transforming Professional Development in Consortium for policy research in Education*. CPRE publications. New Brunswick
4. Isman, A., Caglar, M., Dabaj, F., Altınay, Z. & Altınay, F. (2004). Attitudes of students toward computers. *The Turkish Online Journal of Educational Technology (TOJET)*, 3(1), 11-21.
5. Akpınar, Y. & Simsek, H. (2007). Pre-service teachers' learning object development: A case study in k-12 setting. *Interdisciplinary Journal of Knowledge and Learning Object*, 3, 197-217.
6. Karchmer-Klein, R. (2007). Re-examining the practicum placement: How to leverage technology to prepare pre-service teachers for the demands of the 21st century. *Journal of Computing in Teacher Education*, 23(4), 121-129.
7. Keeler, C. G. (2008). When curriculum and technology meet: Technology integration in methods courses. *Journal of Computing in Teacher Education*, 25(1), 23-30.
8. Can, S. (2010). Attitudes of pre-service teachers from the department of elementary education towards the effects of materials use on learning. *The Turkish Online Journal of Educational Technology (TOJET)*, 9(2), 46-54.
9. John D. Verhoeven, (2007), *Steel Metallurgy for the Non-Metallurgist*, DOI:10.1361/smm2007p001, pp. 147-151.
10. British Standard BS EN 12390-2:2009. Making and curing specimens for strength test. BSI (United Kingdom).
11. Milan Brozek, Alexandra Novakova, 2013, *Briquettes from Recovered Paper and Board*.
12. Novakova A. and Brozek M. briquettes from paper waste. In.: *Ecology and farming technologies: Agro-engineering approaches*. Saint-Petersburg-Pavlovsk, Russian

academy of agricultural sciences, 11, pp.
219 – 225.

13. Plistil D., Brozek M., Malatak J. and Heneman P., 2004, Heating briquettes from energy crops. *Research in Agriculture Engineering*, 50, pp. 136 – 139.
14. Milan Brozek, Alexandra Novakova, 2013, *Briquettes from Recovered Paper and Board*.
15. Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan