INVESTIGATION AND ANALYSIS OF RECYCLING POTENTIAL OF FILTERING COMPOSITES BASED ON CELLULOSIC FIBRES RESULTED FROM THE INDUSTRIAL FILTRATION PROCESS OF ALIMENTARY LIQUIDS

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Abstract: In this paper are presented some aspects related to recycling of material recovered from the waste fibrous filter composites, when obtaining some board grades with technical applications. Based on obtained results can be appreciated that the fibrous material from the waste filtering composites can be recovered in certain proportions to obtain of gypsum board grade used in building industry. It is emphasized that the quantity of fibrous material from waste filtering composites can be increased above 25%, maintaining of the same level of strength characteristics, both by utilization of dry strength agent and some quantity of virgin fibers (unbleached Kraft softwood pulp, TMP, pulp, etc.).

Key words: waste, filtering composites, recovery, gypsum board

1. INTRODUCTION

Waste recovery and reuse of waste has a key place in the environmental policy of the EU, and the waste management strategy provides the following priorities:

- Prevention and reduction of waste at source (main priority);
- Recycling and reuse of materials and /or energy, and finally storage;
- Harmonization of standards concerning waste storage and incineration, to be based on a high environmental protection;
- Elaboration of some strict waste transport rules;
- Decontamination of land where waste has been stored.

In case of products based on cellulosic fibers, recycling is the first management option, when prevention is not possible. The main motivations for recycling are related to the rise of volume and complexity of waste flow that resulted in: exponential increase of costs related to landfill, depletion of resources, and negative public perception of companies generating this waste [1]. Moreover, in many EU Member States, high organic waste storage is discouraged and will probably be forbidden in the near future. For example, in Germany, the storage of waste containing over 5% organic substances is already forbidden. The New EU Waste Directive has the same trend to restrict the amount of biodegradable waste (municipal) sent to landfill [2].

Consequently, the alternative recovery operations, as material recycling and incineration with energy recovery will play a major role in the future [1, 2].

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1.1 General aspects concerning reduction of volume of fibrous material waste

The fibrous material waste is generally characterized by means of a relatively high quantity of organic matter. The recovery operations – where rejects are subject to further use, and some or all components (including energy) are reused and recovered, are considered options preferred for this waste treatment, and their land filling should be avoided. Figure 1 shows the various options of recycling/reuse of fibrous material waste and the main factors that result in selecting an option or another one. The main influence factors are local infrastructure, costs, including freight costs, competition with residues from other industries and continuity of waste takeover. As regards transport, the proximity principle reduces environmental impact and costs. The use of fibrous and mineral material waste (fillers) as a raw material in the fields mentioned in Figure 1 is, among other things, dependent on the local availability of suitable processes.

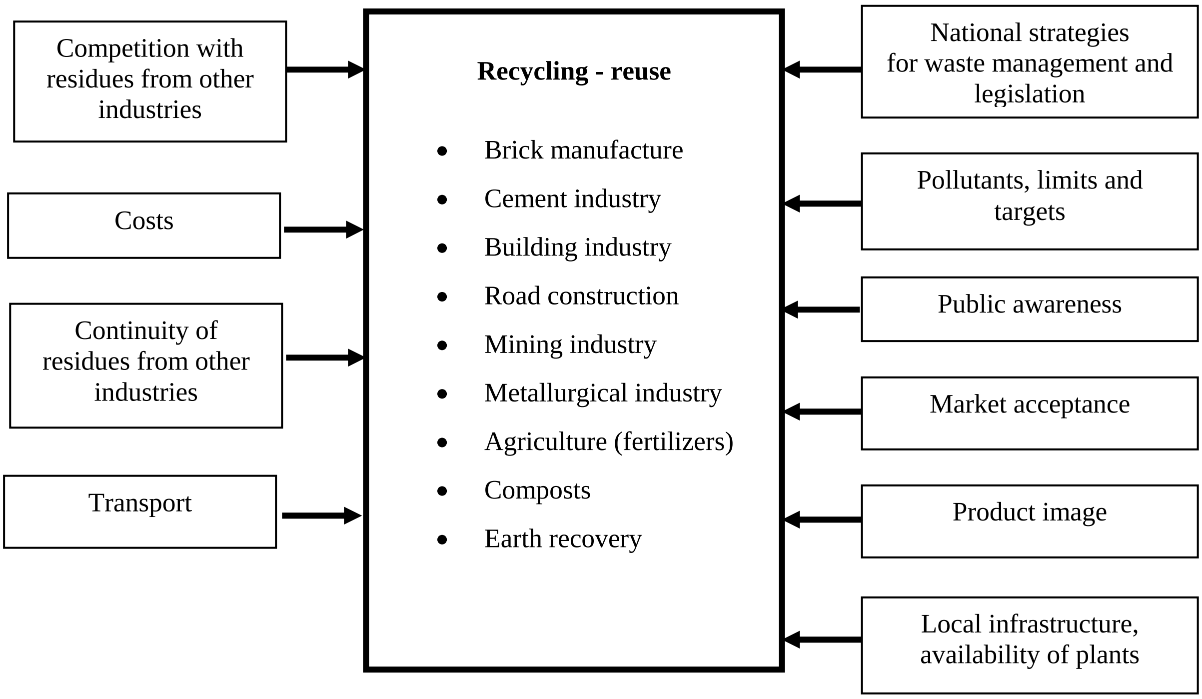

Fig. 1. Solutions and influence factors for recycling / reuse of solid waste in the paper industry.

1.2 Volume of waste based on fibrous filter composites and environmental impact potential

Filter composites resulted in the filtration process of alimentary liquids is a particular case of fibrous waste, which cannot be framed either in category of solid waste from the pulp and paper making and the category of waste paper.

Data from the literature sustain a global consumption for such materials of around 20,000,000 - 25,000,000 m^2/year. Considering a basis weight ranged between 1300 g/m^2 and 1600 g/m^2, it results an annual consumption of 28 - 34 thousand tonnes worldwide. Nationally, the total annual consumption of filter composites for the entire filtration range (primary, clarifying, fine, sterilizing) is around 1335 tonnes, of which composites for the sterilizing segment about 500 tonnes. To these consumptions, significant volumes of filter material based on cellulosic fibers and Kisselgur can be added. They are used for the primary filtration of wine and other alimentary liquids [3].

At present, the waste filter composites are sent to landfilling in municipal waste dumps. Although the amount of 1335 tonnes per year could appear as insignificant compared to the high volume of municipal waste generated per capita, the following environmental impact aspects should be taken into account:

- About 50% of a.d. material in the mass of filter composites is cellulosic fibrous material, organic matter, respectively;

- The used filter composites are saturated with aqueous liquids and plugged with contaminated material retained from the filtered liquid, material that mainly consists of organic, chemical and microbiological components.

The field of application as regards filter composites does not allow the application of prevention solution of solid waste generation. Also, recycling or internal reuse of these waste products are not solutions applicable in the filtration of alimentary liquids [4]. The current solution of landfilling has a negative environmental impact from the following reasons: consumption of energy for transport to the landfill; occupation of a land that is taken out from agricultural circuit; the content of moisture and dissolved organic can result in fermentation and gas generation processes [5].

Under these circumstances **the analysis of external recycling/reuse of these waste fibrous materials** comes out as desirable. Based on these reasons, the paper shows some aspects related to recycling of material recovered from the waste fibrous filter composites, when obtaining some board grades with technical applications.

2. EXPERIMENTAL PART

2.1 Full recycling of waste filter composites for producing technical boards

The samples of waste filter composites from the white wine and red wine filtration have been used in various fibrous compositions for producing the board for the gypsum-board complex [2, 4]. This board grade should present, apart strength and dimensional stability characteristics, values preset for air permeability, expressed by Gurley porosity. It should also present a certain degree of water repellence, certain water absorbability, respectively. Generally speaking, in order to get these characteristics, the fibrous networks used in producing these board grades contain recovered fiber (waste paper) and virgin fiber (unbleached pulps, mechanical pulps, thermo-mechanical pulps) in definite proportions. A high porosity is required for these board grades so as the drying rate of the complex depends on this characteristic, and implicitly, the plant production capacity. If the drying rate is low, difficulties in manufacturing the plates may occur, for instance the board sheets that cover the sheet can be separated from the gypsum core. Some technical characteristics of a board grade are shown in Table 1 used in producing the gypsum-board complex [6].

Table 1. Quality characteristics for gypsum base board.

Characteristic	Value
Basis weight, g/m^2	below 270
Thickness, 10^{-3}m	below 0.45
Apparent density, Kg/m^3	below 6.5
Wetting deformation, %:	
- MD	below 0.5
- CD	below 1.0
Residual strain, %:	
- MD	-
- CD	below 0.5
Smoothness, Bekk, s	below 3
Water absorption (Cobb 60), g/m^2	12/12
Gurley porosity, s, F/S	67/70
Burst strength, Kgf/cm^2	below 5.7
Wet breaking tensile strain, Kgf, L/T	min. 5/8
Dry breaking tensile strain, Kgf, L/T	min. 110/40
Sizing degree, mm	2

The waste filter composites have been pulped within a laboratory device with a rotation speed of 2000 rpm, for 15 min. In order to remove the content of contaminants, as well as the part removal of the mineral matter content (the ash content in composites being very high of around 50%), the pulp has been washed by gradual passing on the Büchner funnel. The filtrate from every washing cycle has been analysed for sugar and polyphenol content. Material remained on the washing screen has been analysed to determine the ash content as a part of it is carried over in the washing waters.

In Figure 2, the amounts of sugars, polyphenols and ash remained in pulp after each washing cycle have been related to the absolutely dry material. It is noticed that while colloidal and dissolved materials are removed almost totally after four washing cycles, the filler content (ash) remains almost steady at 10% after cycle 3. The filler that cannot be removed by washing may comprise two categories of particles: very small particles that remain absorbed on the fiber surface, being fastened also by means of aids used in producing sheets, of which a part is represented by colloidal silica that also contributes to the ash content; large sized particles, especially pearlite, that do not pass the washing screen holes.

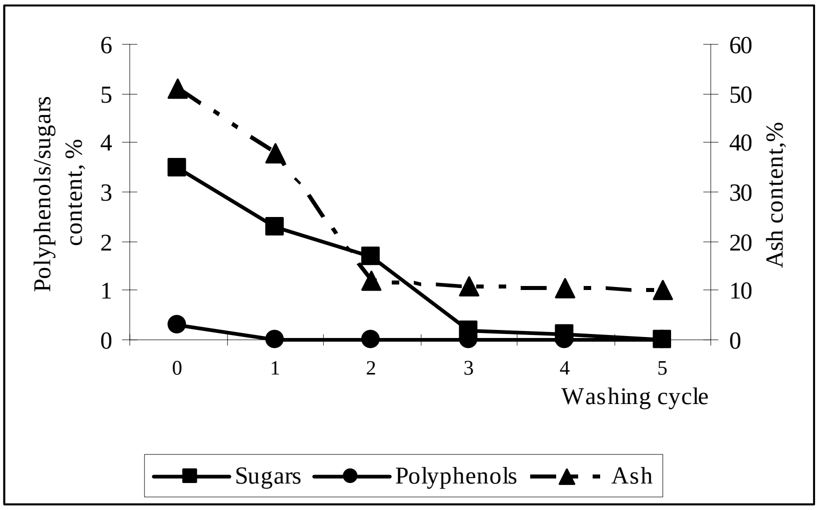

Fig. 2. Development of sugar, polyphenol and ash content in a.d. material according to the washing cycle.

Microbial activity tests have showed that both composites used in the white wine filtration, as well as the red wine filtration contain yeasts/moulds and mesophilic aerobic microorganisms, but are not contaminated with bacteria and E. coli (Table 2). By repeated washing (3 cycles) over 97% of yeasts and moulds was removed in case of A sample, resulted from the white wine filtration, and only 57 % in case of B sample from the red wine filtration. Situation is somehow reverse in case of mesophilic aerobic microorganisms, that are removed in a proportion of 92% in case of A sample and 100% in case of B sample. It is also noticed that none of the samples is contaminated with coliforms and E.coli.

Table 2. Microbial contamination of used microfiltration composites before, and after washing.

Sample	Yeasts and moulds UFC/ml	Mesophilic aerobic microorganisms (NTG), UFC/ml	Coliforms, UFC/ml	E. coli, UFC/ml
Primary filtrate, from pulping of composites used in white wine filtration ***(A sample)***	1.5×10^6	2×10^6	absent	absent
Filtrate after 3 washings of material contained in the ***A sample***	4×10^4	1.5×10^5	absent	absent
Primary filtrate from pulping of composites used in red wine filtration ***(B sample)***	7×10^5	5×10^5	absent	absent
Filtrate after 3 washings of material contained in the ***B sample***	3×10^5	0	absent	absent

The slight contamination of resulted fibrous material with yeasts and microorganisms does not restrict its use for producing a board grade dedicated to the manufacture of gypsum-board sheets as the manufacture technology of this board grade comprises a drying stage at a temperature of over 100^0C, (110 – 125°C) when practically all microorganisms are destroyed.

With a material therefore prepared, versions of fibrous compositions have been done with which 250 g/m^2 board sheets have been made on the Rapid Kothen laboratory former. In order to get the strength characteristics to a level suitable to those presets for these board grades, the fibrous material obtained from waste composites has been mixed with corrugated board waste in various proportions. Sizing has been carried out in a neutral-alkaline medium with an Alkyl Ketene Dimmer dispersion, and an aqueous solution of polyamide-amine - Cartaretine F has been used as a retention aid. Sodium carbonate has been used in order to bring the pH of the working environment to the value of 7 – 7.5.

3. RESULTS AND DISCUSSIONS

The compositional versions of gypsum board containing different proportion of fibers and chemical aids and their technical characteristics are presented in the Table 3.

Table 3. Experimental versions of gypsum board and technical characteristics.

Material	Receipt, %		
	VR1	VR2	VR3
Used filtering composite	25	50	75
Secondary fibers from OCC(Old Corrugated Containers)	75	50	25
Sizing additive, Aquapel 210D	2	2	2
Retention additive, Cartaretine F (liquid)	0.8	0.8	0.8
Technical characteristics			
Basis weight, g/m^2	274	278	282
Thickness, 10^{-3} m	0.521	0.565	0.607
Apparent density, Kg/m^3	5.3	4.9	4.6
Dry breaking tensile strain, N	269	215	183
Wet breaking tensile strain, N	22.5	17.1	14.5
Water absorption, Cobb 60, g/m^2	18.9	17.3	18.4
Gurley porosity, s	23/21	15/15	16/15
Bursting strength, kPa	257	184	166
Smoothness, Bekk, s	4/2	3/2	4/2
Strain at wetting, %	+1.00	+0.69	+0.88
Ash content, %	18.17	26.51	33.48
Sizing degree, mm	2	2	2

The effects of waste filtering composite on the mechanical strength of gypsum board samples are shown in Figure 3, where can be observed a decreasing of dry breaking tensile strain and bursting strength with increasing of waste filtering composite proportion. The higher decreasing is registered by bursting strength. Can be appreciate that in case of 25% charge of waste filtering composite, the technical characteristics of obtained samples are very closed by the preset values [4].

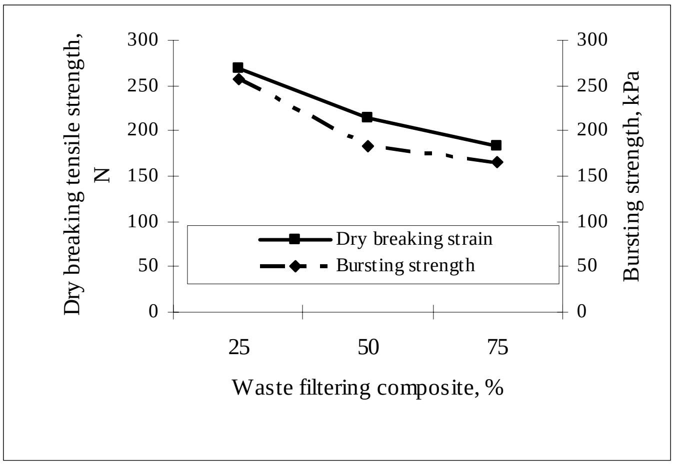

Fig. 3. The evolution of strength characteristics of gypsum board versus waste filtering composite charge.

Regarding the structural properties that are presented in Figure 4, can be observed that the apparent density has a linear decreasing with the recycled material charge, from 5.3 Kg/m^3 for sample with 25% recycled material to 4.6 Kg/m^3 for sample with 75% recycled material. Apparent density is a characteristic that offers some information about the structure of obtained material, because their increase is higher until 50% recycled material charge. The increasing of porosity can be attributed the fact that, with washing of recycled material, mostly of filler with small particles is removed. In this case, in processes remaining filler with larger sized particles that are remained on washing screen. This fact is confirmed by graphic from Figure 4.

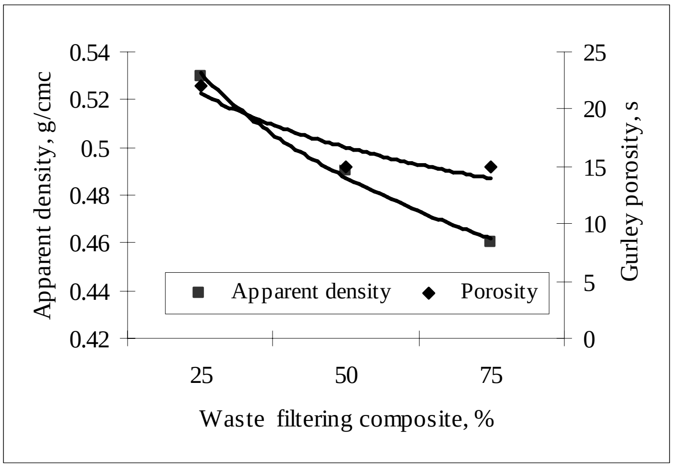

Fig. 4 . The evolution of gypsum board structural characteristics versus waste filtering composite charge.

It is emphasized that, a value porosity about 23/21 s (was registered for sample with 25% recycled material) is proper for gypsum board. Water absorption (Cobb index) for the experimental samples (that is an important characteristics for this grade of board) it is closed by the default values.

4. CONCLUSIONS

The recycling of waste filtering composites resulted from wine filtering process involved some operations for to remove of contaminants. Experiments have shown that decontamination can be accomplished by repeated washing of the material obtained after dissolution of waste filtering composites in water. The process requires 3-4 washes, considering a 0.5% consistency of pulp before drying. Along with the contaminants removal, in washing process is lost about 90% of filler and about 10% of fine material.

Based on obtained results can be appreciated that the fibrous material from the waste filtering composites can be recovered in certain proportions to obtain of paperboard grades for technical applications. This direction of recovery has a contribution to reduce of environmental pollution by solid waste from fibrous material resulting from industrial processes.

In the case of the gypsum board grade, the proportion of fibrous material from waste filtering composites can be increased above the 25%, while maintaining the same level of strength characteristics, both by using of a dry strength additive and using a certain proportion of virgin cellulose fibers (unbleached softwood Kraft pulp, thermo mechanical pulp).

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REFFERENCES

[1] ***, IPPC Directive (96/61/EEC), Package and Package Waste Directive (94/62/EEC), Waste Framework Directive (75/442/EEC).
[2] Nechita, P., Bobu, E., Ciolacu, F., Compozite microfiltrante performante – solutie eficienta pentru siguranta alimentara – Raport tehnico-stiintific la contract de cercetare 63/2006, program CEEX, etapa 4, 2008, p. 98 – 103.
[3] ***, ICDVV Valea Calugareasca – Date statistice, 2006.
[4] Nechita, P., Epure, V., Aspecte privind potentialul de reciclare/reutilizare a compozitelor filtrante fibroase uzate – Celuloza si Hartie, vol. 57, no. 3, 2008, p. 16-19.
[5] Nechita, P., Bobu, E., Ciolacu, F., Kontek, A., Study of fibrous composites behavior in hydrodynamic process of wine filtration – BioResources, vol. 4, no. 4, 2009, p. 1330-1340.
[6] Buteica, D., Cercetari privind posibilitatile de asimilare – fabricare in tara a cartoanelor pentru elemente de constructie ipsos-carton – contract 662/C/1993, SC CEPROHART SA Braila, p. 7.