AN INNOVATIVE METHOD OF POLIMERIC SAWDUST BOARDS PRODUCTION

Białasz Sebastian, Klepka Tomasz,
Department of Technology and Polymer Processing , Faculty of Mechanical Engineering – Lublin University of Technology, Poland
Sebastian.bialasz@gmail.com; t.klepka@pollub.pl

Abstract: *The paper summarizes studies pertaining to an innovative method of polymeric chips and sawdust boards production. RD boards are manufactured from post-production waste in the form of chips. The chips are heated and pressed under small pressure in metal forms. The product is characterized with good sound and thermal insulation, small mass, and low manufacturing cost. As a consequence, it can be applied in several types of products as a filler.*

Keywords: POLYMERIC BOARDS, PRESSING, INNOVATION, INSULATION, RECYCLING, WINDOWS, DOORS

1. Introduction

At present, the inner space of window and door frames is filled with PVC, mineral wool, wood, cardboard, cellulose, polystyrenes, etc.

Insulation is a critical feature of products constituting a moving partition between the interior and exterior. Figure 1 presents several zones with negative heat transfer. In order to minimize heat loss and improve sound insulation, the development of insulating material improving insulating properties and the material's application in the production of doors, windows and stairs, has been undertaken.

The material constitutes a filler of inner spaces of such products in order to decrease the need for high-quality material in production of frame profiles, and to boost the attractivity of end products by improving specific properties.

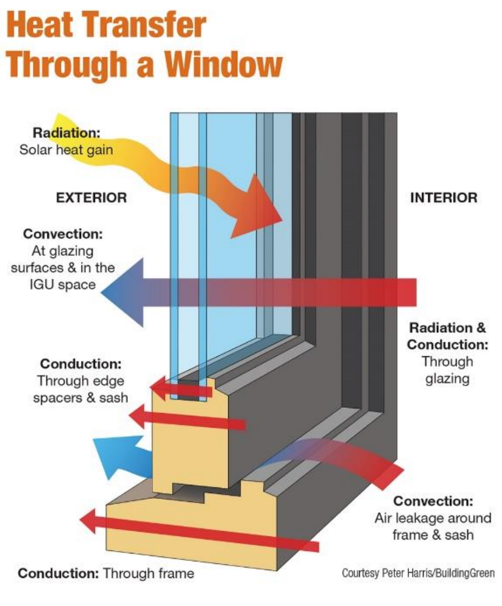


Fig.1. Heat transfer zones in a window frame

In case of doors, solid wood, chipwood, or cardboard can play the role of the filler. Stairs are made of solid or glued wood. No fillers are known to be applied in this case.

The new material must be characterized with: low mass, high sound and thermal insulation, low manufacturing cost, high availability of manufacturing components, ecology (recycling), ability to form any size of product. The material is to be applied as: a filler of inner spaces in cantilevered stairs in order to provide sound insulation and reduce mass, sound insulation for internal doors made of wood encased by plywood, sound insulation or back/side panel of wardrobes or cases which divide rooms into sleeping and living rooms, and in classic stairs.

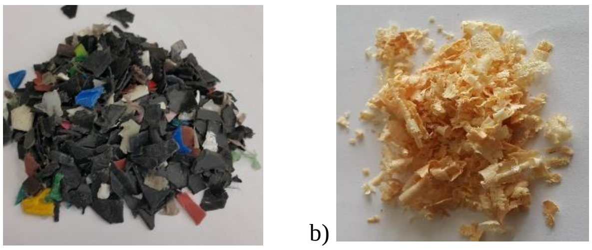
Under patent description no. PL191 427, current state of the art contains a lamination method by pressing composite board made of slag wool, and a method for manufacturing objects by low-temperature sintering in which components are mixed to obtain a homogenous mass whereof objects are made, dried and kilned in low-temperature (PL 162 322). The two technologies may be considered similar to the one described in the present paper.

Based on the current state of the art, a product innovation was developed in the form of a polymeric structural board named "RD Board" (RD for Reduced Density). The manufacturing process was patent claimed in PL218877. The board is characterized with a layered structure, low mass, good sound and thermal insulation. Therefore, it may be applied as a thermal or sound insulation.

Owing to the fact that the new product is manufactured with post-production waste, it results in the waste's quantity being reduced. On the one hand, it leads to the reduction of economic costs for manufacturers (less waste to be utilized) and public administration, and those associated with environment protection (e.g. necessity of maintaining and creating new waste disposal sites). On the other hand, such mode of production will contribute to environment protection. Another aspect significant from the point of view of the general public can be seen in the product's unique sound and thermal insulation properties.

2. Materials and methods

The material used for manufacturing RD boards may be sawdust, polymeric, or polymeric-wood chips (figure 2) constituting post-production waste e.g. originating from machining of pipes or composite boards.



a) b)

Fig.2. Materials used for the production of RD boards: a) polypropylene chips, b) sawdust

In the manufacturing process, chips are introduced into a metal form comprised of a socket and a stamp and placed in a vertical press. Subsequently, external walls of the socket are heated to a temperature lower than the softening temperature of the polymer. The top part of chips introduced into the forming socket is pressed with the pressure between 0,2 to 25kN. The pressure is introduced by the stamp moving vertically. After between 20 and 240 seconds has elapsed, the bottom of the forming socket is heated to between 70% and 100% of the softening temperature of the polymer for between 5-45 seconds. Subsequently, the stamp is removed from the board and the socket. Having been formed in the above manner, the board cools in ambient temperature or is cooled with water. Figure 3 presents individual steps of the process: introduction of chips- pressing- form opened-board removed from the form.

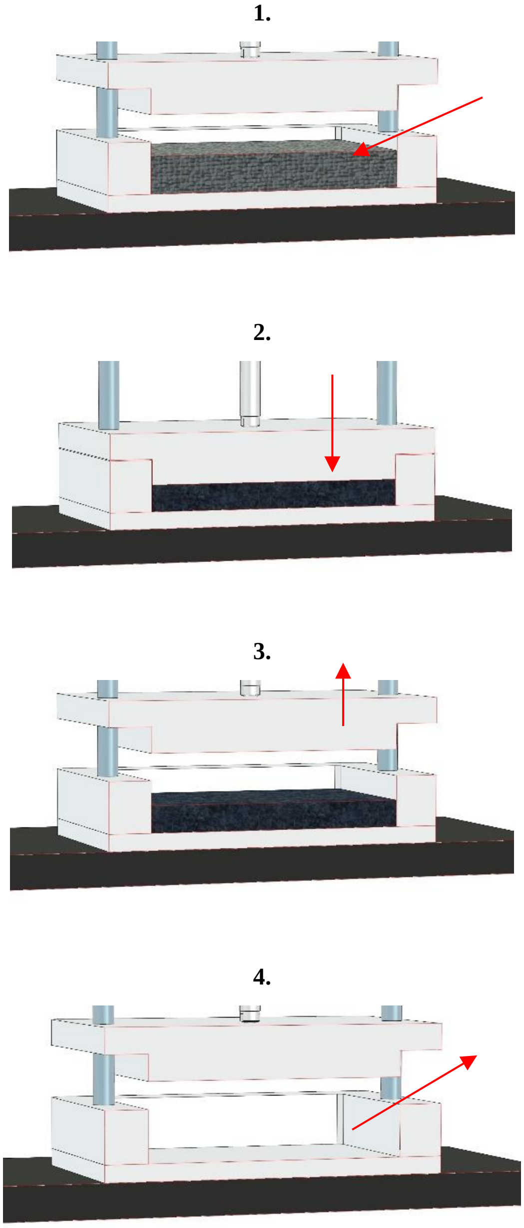


Fig.3. Description of RD boards' manufacturing process

As indicated in Figure 4, the board's structure is layered. The external layer (1) is of solid structure with improved hardness, and the internal layer (2) is composed of heated chips with air chambers between them.

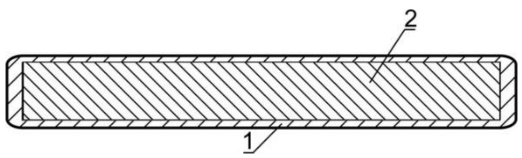


Fig. 4. Structure of RD boards: 1 – solid external layer, 2 – internal layer composed of heated chips and air chambers between them.

The manufacturing process of RD boards may be realized in three manners:
- Pressing with heating in order to soften polymeric chips (e.g. PP or PVC).
- Pressing with heating in order to soften and bind polymeric chips and sawdust together (e.g. PP/PVC and wood).
- Pressing with heating in order to bind sawdust (wood and thermosetting adhesive).

The board is characterized with layered structure, low mass, good thermal and sound insulation. Therefore, it may be applied in constructions as a thermal and sound insulation.

Manufacturing of the board from chips does not require any additional technological operations. Apart from temperature and pressure, no additional adhesives are required in order for chips in the socket to be bound together. Pressing with heating is not expensive, which offers cost reduction when manufacturing products of original structure and composition.

3. Methodology and results

In order to conduct the study, RD boards were required. Boards were manufactured in three compositions:
- Polypropylene-chip board (PP)
- Polyvinyl chloride-chip board (PVC)
- Polypropylene-chip board (PP) combined with sawdust

Studies were made in order to establish the manner and parameters of RD boards' manufacturing, determine mass and density, sound and thermal insulation properties, so as to evaluate the effectiveness of the new product.

In order to manufacture boards, a form was used. The form's socket measured 120x200x15 mm. The form was made of aluminum. Heating was independent (both the form and stamp). Manufacturing parameters for individual components were determined.

PVC-chip board was manufactured as the first. It was characterized with low mass (density) and short production time. One of the boards was defective due to improper manufacturing parameters being applied (heating time too long). The board was presented in Figure 5. Having modified these parameters, a quality PVC board was manufactured- featured in Figure 6.

Fig. 5. Defective PVC board

Fig. 6. PVD RD board

Next, a PP board was manufactured. Mixed chips were used- polypropylene chips containing some impurities (e.g. paper).

The end product was characterized with greater rigidity and strength than the PVC board. Manufacturing conditions were friendlier as well- lower impact of manufacturing temperature and time upon the product. An example PP board was presented in Figure 7.

Next, a composite board made of polymer-wood (polymeric chips and sawdust in 3:2 ratio) was manufactured. The product was presented in Figure 8.

Fig. 7. PP RD board

Fig. 8. PP-wood RD board

The board was characterized with larger mass than in case of the one made of polypropylene exclusively, and was more porous (see photo).

The board made of sawdust bound with thermosetting adhesive was manufactured last. Manufacturing process was considerably shorter due to the fact that no cooling was required. As a result of the application of the adhesive, sawdust was bound to make a solid external layer and porous internal core of the board.

The assessment of sound insulation was conducted in order to determine insulating properties of RD boards, cardboard (paper), and chipboards, i.e. materials applied as a door fillers.

The assessment measured noise level by means of a digital sound meter positioned in a fixed distance from a PMMA box whose one side was made of the evaluated material. A wireless Bluetooth speaker emitting sound with a constant, known volume was located inside the box.

In order to examine sound insulation, a testing station was developed (Fig. 9.). The station was composed of a table (1), sound level meter (2), PMMA aquarium (3), Bluetooth speaker (4), tested material (5) constituting the front wall of the aquarium.

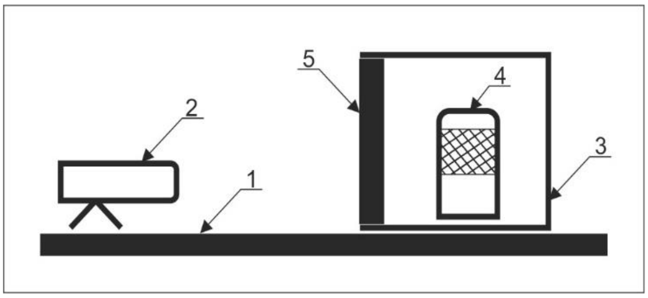


Fig. 9. Sound insulation testing station: 1- wooden table, 2- digital sound level meter), 3- PMMA aquarium, 4-Bluetooth speaker, 5-tested material

The following materials were examined: RD board made of PP, RD board made of PP and wood, RD board made of PVC, cardboard board (obtained from a door), chipboard.

The measurement enabled sound insulation properties of these materials to be determined. Results were presented in a table and in chart 1. Sound reduction index [dB] denotes the result of subtracting sound volume with the examined board from the volume without the board (directly from the speaker). The formula for the calculation is presented in formula 1.

Formula 1.:

Sound Reduction Index = Volume A [dB] – Volume B [dB],

where A- without board, B- with board.

The greater the index, the more insulation the material offers.

Table 1: *Sound Reduction Index [dB].*

	Śr. pomiar I	Śr. pomiar II	Śr. pomiar III
PP RD board	27	28	26
PP+wood RD board	32	29	29
PVC RD board	25	25	26
Chipboard	24	25	26
Cardboard	4	5	5

Chart 1 compares average sound reduction index values for examined boards.

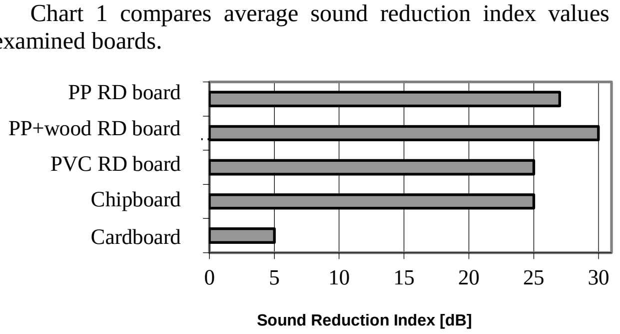


Chart 1.Comparison of sound reduction index for examined boards.

Measurements of sound insulation were conducted in order to determine insulating properties of RD boards, cardboard (paper), chipboards, and solid wood, i.e. materials applied as door and stairs fillers.

The test measured temperature by means of a pyrometer positioned in a fixed distance from PMMA box whose one side was made of the evaluated material. A heater with a thermostat, which heated the interior of the box and maintained a fixed temperature was located inside the box.

In order to examine thermal insulation a testing station was developed (Fig. 10.). The station was composed analogically as in case of the previous test: a table (1), pyrometer (2), PMMA aquarium (3), heater with a thermostat (4), tested material (5) constituting the front wall of the aquarium.

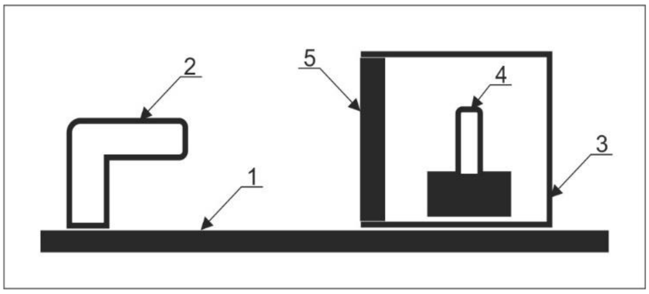


Fig. 10. Thermal insulation testing station: 1- wooden table, 2- pyrometer, 3- PMMA aquarium, 4- heater with a thermostat, 5- tested material

The following materials were examined: RD board made of PP, RD board made of PP and wood, RD board made of PVC, cardboard board (obtained from a door), chipboard, solid oak wood.

The measurement enabled thermal insulation properties of these materials to be determined. Thermal insulation index denotes the result of subtracting temperature of the board's surface from the temperature of the heater (no board in the box). Heating time equaled 10 minutes (600s). The formula for the calculation is presented in formula 2.

Formula 2.:

Thermal Insulation Index = Temperature A [^{o}C] – Temperature B [^{o}C],

where A- without board, B- with board.

The greater the index, the more insulation the material offers.

Table 2: *Thermal Insulation Index [^{o}C].*

	Śr. pomiar I	Śr. pomiar II	Śr. pomiar III
PP RD board	10	10	10
PP+wood RD board	12	11	13
PVC RD board	16	19	17
Chipboard	8	7	8
Cardboard	1	3	2
Wood board	9	9	8

Chart 2 compares average thermal insulation index values for examined boards.

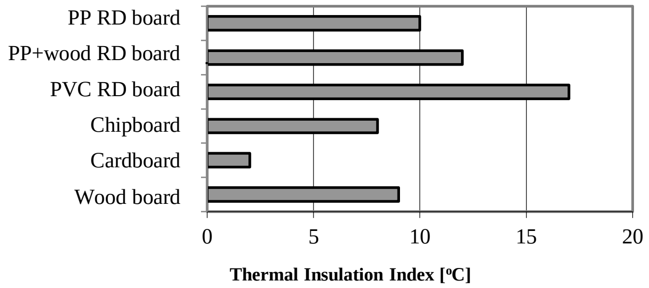


Chart 2. Comparison of Thermal Insulation Index for examined boards.

Measurements of mass and size of boards were conducted in order to examine these properties for RD boards, cardboard (paper), chipboards, and solid wood, i.e. materials applied as fillers in doors and stairs.

Boards of the same dimensions were weighed, which enabled density to be calculated. Measurements of mass and density were conducted by means of a laboratory weight, slide caliper, and a calculator.

The following materials were examined: RD board made of PP, RD board made of PP and wood, RD board made of PVC, cardboard board (obtained from a door), chipboard, solid oak wood.

Table 3 presents density and mass of these boards.

Table 3: *Mass and density of examined boards.*

	Mass [g]	Density [kg/m^3]
PP RD board	195	540
PP+wood RD board	250	695
PVC RD board	173	480
Chipboard	234	650
Cardboard	249	690
Woodboard	545	1515

4. Conclusions

Tests and measurements indicated that the application of innovative fillers in the form of RD boards in manufacturing window frames, boards and door frames, and stairs is valid. Example applications of RD boards are presented in Figure 11.

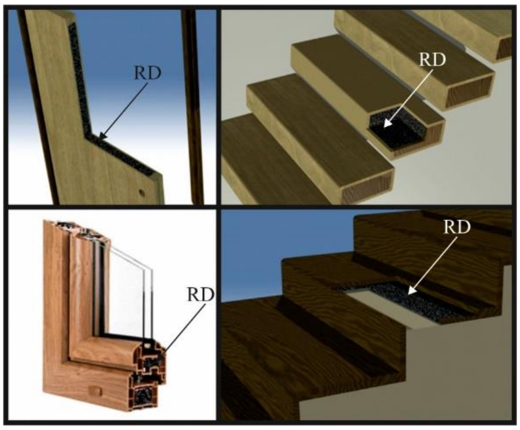


Fig. 11. Example applications of RD boards.

Moreover, the said product innovation offers numerous benefits. What is more, it constitutes a stimulus for the development of social responsibility of the company and product as well. At the same time, it feeds back into CSR (Corporate Social Responsibility), which also motivates the development of innovation. It has been acknowledged by an European Commission report published in 2008 which discussed competitiveness of European economy. The report indicates that CSR may contribute to the development of innovation, and at the same time, boost competitiveness of enterprises.

References

1) Klepka T., Sikora J.: Badania naturalnego kąta usypu granulatu z PVC (Assessment of the angle of repose for PVC granulate). Transfer inovácií 22/2012, pp. 83-85

2) Osiecka E.: Materiały budowlane wykłady (Lectures on construction materials). Politechnika Warszawska. Wydział inżynierii lądowej. (Warsaw University of Technology. Faculty of Civil Engineering).

3) Sikora R.: Przetwórstwo tworzyw polimerowych (Polymer processing). Podstawy logiczne, formalne i technologiczne (Logical, formal, and technological basis). Wydawnictwo Politechniki Lubelskiej, Lublin 2006. ISBN 83-7497-006-5

4) Sobczak P., Zawiślak K.: Zmiany wybranych właściwości fizycznych granulatu uzyskanego z dodatkiem różnych substancji wiążących. (Changes in the selected physical properties of granulate obtained by adding various binding substances) Inżynieria Rolnicza 5(93)/2007. pp. 437-444

5) Patent application no. JP63049289

6) Patent application no. JP2001047008

7) Patent application no. JP10113926

8) Patent application no. JP7133663

9) Patent application no. PL191427

10) Patent application no. PL218877

11) Patent application no. PL210698

12) Advertising materials and catalogs