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A METHOD FOR MANUFACTURING OF CONSUMER PRODUCTS FROM RECYCLED RAW MATERIALS

Key words

Materials recycling, textile wastes, secondary raw materials, fabrics.

Abstract

Waste management is one of the most important branches of environmental protection. In the European Union, one of the most important legal acts regards the document on community strategy in the field of waste management, with its emphasis on waste prevention, recycling and re-use of waste in the form of useful products. The article presents models of non-woven utility products derived from raw materials from recycling. The study aimed to obtain useful products made from non-woven textile waste. Indicated are methods for grinding and fiberisation of worn textile to form secondary fibres and possible techniques to be applied in their processing. The end result is to present examples of raw products in the three groups of assortment: "A" with a predominance of natural fibre up to 85%, "B" – a mixture of fibres of PE and PP, and "C" – a mixture of synthetic fibres. In each of these groups, using the proper technique, the examples of commercial, technical, and living products

were manufactured, which may be the subject of trade. Developed solutions will be put into production by a company interested in the results of this work after market research.

Introduction

Growth in the EU is still accompanied by increasing amounts of waste, causing unnecessary losses of materials and energy, environmental damage, and adverse effects on the health and quality of life. One of the strategic objectives of the EU is to reduce these negative impacts by turning the EU community into a society using recycling and being resource efficient. Waste management is already governed by a comprehensive set of rules, but there are still opportunities for further improving the management of some major waste streams [1].

Textile waste represent, on average, approx. 3% of household waste, which is approx. 250 thousand tons of textile waste annually produced in Poland. Only approx. 10% of that is subjected to material recycling and at least 50% is suitable for processing. For comparison, in the UK, households annually produce approx. 1 million tonnes of textile waste, and 25% of the mass of waste is recycled. Textile waste is generated mostly in households, and this is approx. 8–9%. With the undertaken projects in waste management and the target consumption of textiles per capita per year, it is assumed that the recycling of the textile weight placed on the market should be at the level of 55%. This will be similar to the present state of textiles placed on the market, i.e., approx. 250 thousand tons per year [2].

In the last few years in Poland, there was a large import of used clothing from Western Europe, which is sold in an extensive network of retail outlets throughout the country, and we also now have a huge influx of cheap textiles from the Far East, mainly from China. Because of the shorter lifespan of these goods, the textile waste problem will be more serious than it is today [3].

Considering the overall balance of post-consumer textile waste, it is necessary to take into account the textiles from exploited vehicles. It is assumed that, on average, one car is approx. 15 kg of textiles for various purposes, and in accordance with the requirements of the European Commission Directive it is required, since the 1st of January 2006, to recycle 80% of recyclable materials from the liquidated cars.

Because waste management is one of the branches of the textile industry in the field of environmental protection, it is necessary to prevent waste through the use of low-waste technology for textile production, the introduction of cleaner production, and the development of recycling methods aimed to obtain raw materials for re-use in different processing technologies [3].

In the European Union, among the most important acts is the document titled “Communication from the Commission to the Council and the European Parliament on a Community Strategy in the field of waste management”. These are guidelines for the Union's policies with an emphasis on waste prevention, recycling and reuse of waste, and the safe disposal of residues not recyclable.

The next few years will be a period of further demand for textile products, with a reduction of the lifetime of the products by at least 20%, and a further increase in the share of synthetic fibres. These are the next challenges for effective relief of the environment and obtaining valuable raw textile material for re-use.

These research problems, including recycling field and particularly textile recycling, were included in the research priorities of the Strategic Project *Innovative technical support for sustainable economic development* implemented by the Institute for Sustainable Technologies, National Research Institute in Radom. This is a proof that the subject of textile recycling is an object of technology and implementation research aimed at increasing textile recyclables for reuse.

1. Segregation of post-consumer textile products for material recycling

The most important issue, which, when properly solved, determines the ability to recycle all waste material is their segregation by appropriate groups, specific criteria, and procedure. Postconsumer products supplied as complete, used household objects (Fig. 1) have been categorised in three groups in terms of the percentage of the highest quantity of certain raw materials.

Fig. 1. Provided postconsumer products

The “A” group includes postconsumer products with a high share in its composition of natural materials, i.e. wool, cotton, and artificial materials with natural origin, such as viscose. The average share of these commodities in the group was 88%.

The “B” group includes postconsumer products with a high proportion of synthetic polyester (PES) and polypropylene (PP) fibres. The average share of these commodities in the group was 82%.

The “C” group included all other postconsumer products where their fibre composition was dominated by synthetic fibres (approx. 60%).

2. Technological recycling attempts for particular groups of waste and equipment for the production of finished usable products

In order to obtain the raw material for further processing of textile waste, it is necessary to grind it into the appropriate fraction. Each group of waste has undergone a process of shredding and defiberisation on industrial devices, such as cutters, choppers, and defibrators. The pregrinding process by cutting was performed using a guillotine cutter and rotary cutter (Figs. 2, 3).

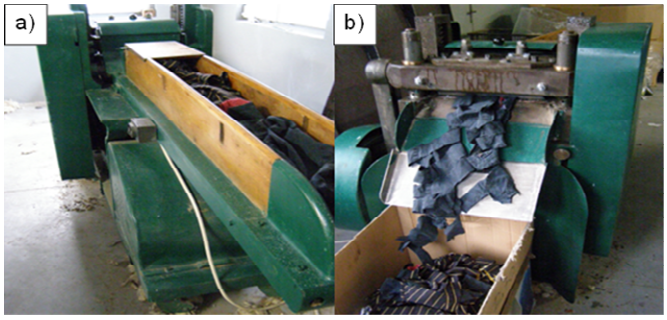

Fig. 2. Guillotine cutter: a) input, b) output

Fig. 3. Rotary cutter: a) input, b) output

After the grinding process, the next stage of textile material recycling of post-consumer products is defibrating, which was performed on two types of

devices on which different degrees of defibrate materials can be achieved. The first device that was used for this purpose was defibrator (Fig. 4).

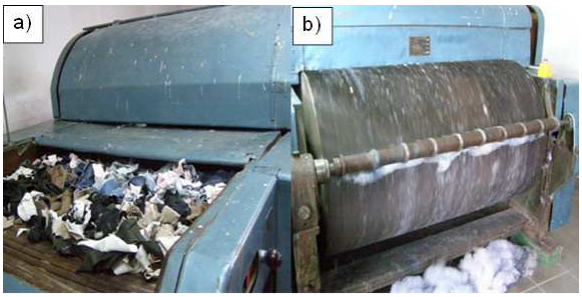

Fig. 4. Defibrator: a) input, b) output

The second device is a six-drum chopper shown in Figure 5.

Fig. 5. Six-drum chopper

As a result of technological trials, secondary fibres were obtained in the three groups of products, all of which were prepared sample products that could be marketed.

With post-consumer products in the "A" group, secondary fibres were obtained with its composition containing natural fibres, i.e. wool, cotton, and natural fibres such as viscose. Figure 6 shows the form of raw material obtained after the defibration process called "selected plunk", which may be a commercial product.

Useful products obtained from recycled fibre in the "A" group were prepared by two mechanical manufacturing techniques – sewing and needling. The sewing technique allows obtaining household products, e.g., woven material, cloth, packaging, etc. (Fig. 7). It is based on stitching of a moulded layer of raw material with yarn using special needles on a piercing machine.

Fig. 6. Six-drum chopper

Fig. 7. Clothes from stitched weave

Needling consists in mutual interlinking of the moulded layer of raw material in a uniform, stable product with the use of needles with special notches, fixed in the board of needling machine. This technique was used to produce, from waste products, the raw materials of agronomic types, such as shielding mats, anti-weed mats, veneers enriched with fertilizer made from fabaceae. The obtained consumer products are shown in Figures 8, 9, and 10.

Fig. 8. Non-woven reinforced fabric with grass seed for strengthening slopes and embankments

Fig. 9. Non-woven agronomic fabric to control the growth of weeds

Fig. 10. Agronomic fabric for cultivation with fertilizer made from *fabaceae*

In the post-consumer waste products from group “B”, secondary fibres were obtained by grinding and defibrating with a high proportion of synthetic

polyester fibres (PES) and polypropylene (PP). With this type of fibre, one can produce both household products for thermal insulation materials (warmers, duvet insert) and technical fabrics, such as drainage and road components.

Nonwoven materials are obtained with simplified fleece moulding, as used for blanket inserts, where a loose and airy texture is obtained to a predetermined thickness to achieve a stable structure of the given parameters. The resulting samples of insulating nonwovens of different thicknesses are shown in Figures 11 and 12.

Fig. 11. Thick warmer

Fig. 12. Thin warmer

Another consumer product obtained from recycled fibres derived from post-consumer products in the “B” group is the “technical nonwoven”, which was prepared with mechanical consolidation of a fleece layer by needling on a needling machine to obtain a product with stable parameters for the surface weight and thickness. This non-woven material is generally intended for drainage, as a lining for ditches, and mostly as a reinforcing material, stabilizing land for the construction of roads, both access roads and highways. Examples of manufactured consumer products in the form of technical nonwovens are shown in Figures 13 and 14.

Fig. 13. Drainage fabric

Fig. 14. Road-construction fabric

Post-consumer products, qualified for the final “C” group, were secondary fibres obtained mostly as a mix of different types of fibres. Such a mixture of fibres has commonly been called “synthetic plunk”.

From the plunk, two consumer products were obtained. The first is a felt that is often used in furniture manufacturing, which is manufactured with the mechanical needling technique (Fig. 15).

Fig. 15. Furniture fabric – felt type

The second product obtained is “synthetic plunk”, which is also used in furniture manufacturing, which is produced by needling and thermally stabilising established technical parameters.

The thermal stabilization technique is conducted on a needled fabric by subjecting it to a temperature and pressure in a calender machine. The figure below presents the device producing the finished product in the form of a furniture fabric with given parameters (Fig. 16).

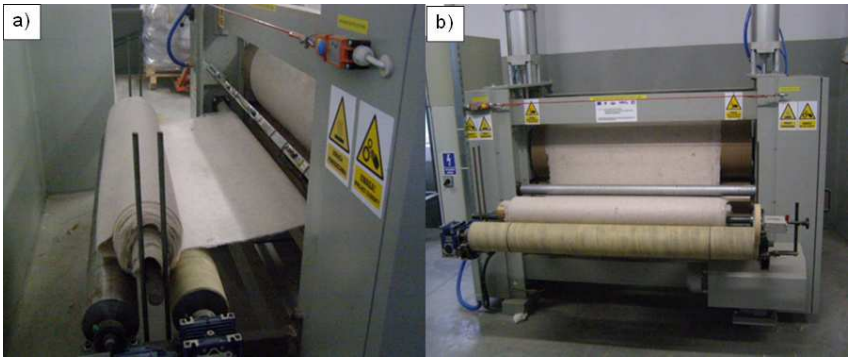

Fig. 16. Thermal stabilization process of furniture fabric: a) infeed of a fabric, b) the output of the finished product

The thermal stabilization process allows one to obtain the finished product with a predetermined thickness, density, and rigidity characteristics, which is of particular importance in the application of these products. Presented below is furniture fabric derived from the processing of reclaimed synthetic plunk of varying density, stiffness, and thickness (Figs. 17–20).

Fig. 17. Thick furniture fabric

Fig. 18. Thin furniture fabric

Fig. 19. Stiff furniture fabric

Fig. 20. Comparison of thickness of fabrics

Conclusions

From post-consumer products received from the client, as part of the material recycling, one can produce finished consumer products for both household and technical appliances. A higher economic effect can be achieved by the selection of used materials in terms of raw materials. Waste selection is essential in processing materials for recycling into the form of finished products of a certain application and purpose. The article presents examples of a selection for the three groups of raw material products for recycling. With the

obtained secondary fibre a total of 15 examples of products (several in each group) were produced to be used in the economy.

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Metodyka wytwarzania wyrobów użytkowych z surowców wtórnych z recyklingu materiałowego

Słowa kluczowe

Odpady tekstylne, recykling materiałowy, wyroby użytkowe z surowców wtórnych.

Streszczenie

Gospodarka odpadami jest jedną z najważniejszych gałęzi ochrony środowiska. W Unii Europejskiej jednym z najważniejszych aktów prawnych jest dokument dot. strategii Wspólnoty w dziedzinie gospodarki odpadami, kładący nacisk na zapobieganie powstawaniu odpadów poprzez recykling i powtórne wykorzystanie odpadów w postaci wyrobów użytecznych. W artykule zostały przedstawione wzory włókninowych wyrobów użytkowych otrzymanych z surowców pochodzących z recyklingu materiałowego. Badania miały na celu uzyskanie pełnowartościowych włókninowych wyrobów wytworzonych z odpadów tekstylnych. Wskazano metody rozdrabniania i rozwłókniania zużytków tekstylnych do postaci włókien wtórnych oraz techniki możliwe do zastosowania w ich przerobie. Wynikiem końcowym jest zaprezentowanie wzorów wyrobów w trzech surowcowych grupach asortymentowych: "A" z przewagą włókien naturalnych do 85%, "B" z mieszanki włókien PE i PP oraz "C" z mieszanki włókien syntetycznych.

W każdej z tych grup, przy zastosowaniu odpowiedniej techniki, wytworzono wzory wyrobów komercyjnych, technicznych i bytowych, które mogą być przedmiotem obrotu handlowego. Opracowane rozwiązania zostaną wdrożone do produkcji przez zainteresowane wynikami tych prac przedsiębiorstwo po wcześniejszym dokonaniu marketingowego rozpoznania rynku zbytu dla opracowanych wzorów wyrobów.