PACKING OPTIMIZATION WITH EMPHASIS ON SUSTAINABLE PROGRESS IN SPHERE OF WASTE PRODUCTION

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Abstract. The paper deals with packing problems from the waste production, the packing efficiency and the sustainable progress point of view. The research aim was to evaluate methods of compacting the drinking PET packing and to suggest a press eliminating a necessity to release a cap of a pressed drinking packing. The second part of the research focused on an experimental study dealing with a chemist packing, its weight, a used and an unused content regarding the price point of view at the same time. A low efficiency of the packing materials is one of essential problems from the sustainable progress of human society point of view. The efficient compacting of the drinking packing leads to solving a problem with often filled up containers, financial means savings in the sphere of the waste economy and not last to the general aesthetic appearance and hygienic standards around a salvage place. The experiment results showed that a high compacting rate was reached by a manual press. When evaluating packing some packing was found out to be solved constructionally very differently, although the products do not differ from each other with their composition or consistency.

Keywords: compacting, effectiveness, optimalization, packing.

Introduction

Waste disposing represents a huge number of processes beginning from collecting, sorting and ending with recyclation. Plastics are often used in packing applications which are very required for their qualities. The packing waste processing can wind off in different directions, so the collection and proper separation of the waste are very important.

Increased standards of a consumer society call for a wider product palette which is connected with a larger amount of the produced packing materials. A contemporary trend of our consumer society is an accrual of the packing material and connected production and storing of the waste.

The significance of the packing increases when the place and time of a packing move away from the place and time of consumption. The techniques change in the sphere of goods circulation (during manipulation, storing, transport and selling) provokes secondarily the need for a corresponding way of the packing [1]. Often redundant.

The packing ecological problems can be characterized as the whole influence of the packing techniques on the environment. The packing waste position is influenced negatively by the characteristic features of the packing: large volume with low mass, ability to attract, design [1; 2].

An average family in a developed country is supposed to produce about 1 t of a solid waste per one year. About 30 mass % of this amount is the packing waste; the volume portion is much higher. A portion of people taking part in the waste separation reaches about 70 % [3]. So, packing waste liquidation is a significant problem of all developed countries. It is a general aim to reduce maximum the packing waste [1].

The plastic drinking packing waste is distinguished for its dominant representation. Owing to its construction it takes up a front place in low efficiency of a storing and transporting space comparing with a material yield. The waste problem is not only its huge production and the connected necessity to collect separately, but also completely unsuitable geometry in many cases which disables to use 100 % of the content.

When buying a product a price comprises not only the final product (the packing content), but also an essential commission of sellers, packing, logistics, marketing and other costs which are integrally connected with the final price creation.

Many types of the packing are designed entirely unsuitably, so the huge amount of the final product remains in the packing. This negativism tells on several limiting elements, namely on the decreased yield of the bought final product, the increased waste production, a loss of primary raw materials.

The research found out that the household waste composition has changed in the last 20 years significantly. These findings were carried out by means of the result comparisons of the household

waste analyses. The representation of single parts corresponds above all to the consumption of relevant consumer packing, to the purchase power of citizens and to the whole state economic situation [3]. Loula [4] dealt with production optimization and processing of PET bottle packing. He evaluated the geometric aspect of the shape and sizes of the PET packing in consideration of the transport space yield during the transport and manipulation. A variant of PET bottle with a square section seems to be the optimum according to his study. On the contrary, he evaluated a commonly used circle PET bottle as the most unsuitable. The square PET bottles of the volume 1.5 l take till 86 % of the transport space opposite the circle bottles reaching only 56 % of the space. He used the standard euro-palette for computations [4]. The square PET bottles can be seen in the market at present. However, the circle bottles still have the dominant positions.

The sphere of the material recyclation is worked out at present and efficient technologies are used. A poor place of the whole system is the absence of enough amount of secondary raw materials in the required quality which enter the whole recyclation process [2]. Their transient storing in the place of the waste creation (the households) has an essential disadvantage – an empty packing needs a large space. This situation leads to the necessity to shorten the period of carrying off the packing to the collection places or to compact it. The decreasing number of users engaged in the sorting of salvage is the consequences of this. Plastic drinking packing puts high requirements to storing up after the content consumption owing to their voluminosity. When comparing the volume and the weight of own plastic packing material the minimum yield is reached during unsuitable or even no pressing. Filled up containers for sorted salvage are connected logically with it.

This fact leads to the necessity to reduce significantly the whole volume of the packing waste by means of the compacting process. Essential savings of the space determined for storing up and following manipulation and transport can be reached by means of consistent deformation of the packing volume. Consequently, the costs and environment impacts connected with the transport and distribution (fuel consumption, exhaust gas emission, repair costs) are decreased. Effective compacting of drinking packing leads to solving out the problem with often filled up containers, to financial savings in the sphere of waste economy and not last to the general aesthetic appearance and hygienic standards around the salvage place.

A huge amount of entirely “not – compacted” drinking packing can be often found in the containers for the sorted salvage. The reason for this is the fact that the manual deformation of the drinking packing seems to be exacting for users, unhygienic and inefficient. Considerable differences are reached when manually compacting by a man and a woman or a child. The volume decreasing by means of the compacting the packing waste can be done in a few ways. A basic sortion is manual pressing without the press, the second way is using mechanical presses. Decreasing of drinking packing waste volume is solved by many utility patterns and inventions. The available mechanical presses are distinguished for various constructions and they differ often in the partial performance.

The aim of the research was to evaluate the methods of compacting PET drinking packing. The second part of the research deals with an experimental study of chemist packing, its weight, used and unused content regarding the price point of view at the same time.

Materials and methods

The experiment is focused on plastic packing, namely PET bottles, because the consumption of drinks from this packing becomes very popular these days. Measurements and calculations should show visually how the salvage of the sorted waste would improve economically so long as people would compact the packing in the optimum way. The paper analyses the methods of compacting PET drinking packing materials. This reason leads to thinking about fast and easy “compacting” of PET drinking packing. A certain degree of the compacting is very important for a comparison of a volume and weight.

The PET drinking bottle compacting was evaluated from a common user point of view – both developing only a human force (pressing manually or by foot), and using a press. The most often used PET drinking packing (the volume 0.5 l, 1.5 l and 2.0 l) was evaluated. The weight of PET drinking packing was measured without a cap and a label. The scales weighing for 0.1 g was used for setting

the weight. The volume of the bottle before compacting and after it was set on the base of a level uplift in a calibrated laboratory tub coming from the Archimedes law.

The second part of the research was focused on the evaluation of the packing from its function and perfect content use point of view. The chosen method of the evaluation was measurements of single products before use and after it. The aim was to find out what part from the whole content becomes waste after the product consumption. Plastic packing of chemist products coming from households was chosen for measurements which consumers have used and which should be thrown away. Three pieces of each of the products were bought and three different consumers consumed them. An unused content was found out during weighing of each packing on a base of different masses and the price balance was calculated. The mass was found on laboratory scales which weigh for 0.1 g.

The following masses were set on these scales.

- Product mass – the mass was set at the bought product. It is the mass of the product and of the packing. The packing was weighed with a cap. The packing was not transparent.
- Mass of consumed product - already used products (their packing) were weighed after the content consumption.
- Mass of packing – it was set at packing deprived of the content. Some packing had to be mechanically dislocated (lengthwise cut by a knife) in order to remove entirely the unused content. Consequently the packing was washed properly by water and then dried up.
- Mass of unused content – it was calculated as the difference between the mass of the consumed product and the mass of the packing.
- Mass of used content – it was found as the difference between the product mass and the mass of the consumed product.

Based on these found out partial masses the efficiency of the packing was evaluated and the price per unit of the product was calculated at the same time. Table 1 shows the characterization of the evaluated packing.

Table 1

Characterization of packing used in study

Product	Volume, ml	Packing characterization	Price, EUR*
Cleaning sand	500	cylinder	2.8
Shampoo	400	cylinder	2.7
Cream no. 1	250	pot	3.4
Washing gel	1000	cylinder	7.1
Hand cream	50	tube	2,3
Liquid soap	300	cylinder	1.8
Shower gel	350	cylinder	2.2
Hair gel	300	truncated cone	4.4
Cream no. 2	75	pot	1.9
Sunbath cream	200	cylinder	6.8

* the price is approximate, it can differ in different shops

Results and discussion

The efficient compacting of the drinking bottles leads to solving the problem with often filled up containers, to financial means savings in the sphere of the waste economy and not last to the general aesthetic appearance and the hygienic standards around the salvage place.

In Fig. 1 the influence of the mass and the volume of PET bottles before compacting and after it can be seen. A linear increase of PET material mass and the bottle volume depending on its specified volume are logic. The experimental results showed that the manual press reached high compacting rate. This conclusion can be anticipated. A surprising conclusion is relatively low percentage of the difference between the mechanical pressing and the compacting by means of treading by foot or squeezing manually. The compacting by treading is about 7 % higher then at the mechanical press. The compacting by manual squeezing is about 14 % higher on average. The compacting methods

stated in Fig. 1 reach various degree of compacting ranging in the interval 47 – 80 %. Higher percentage of compacting is reached at the bottles with larger volume.

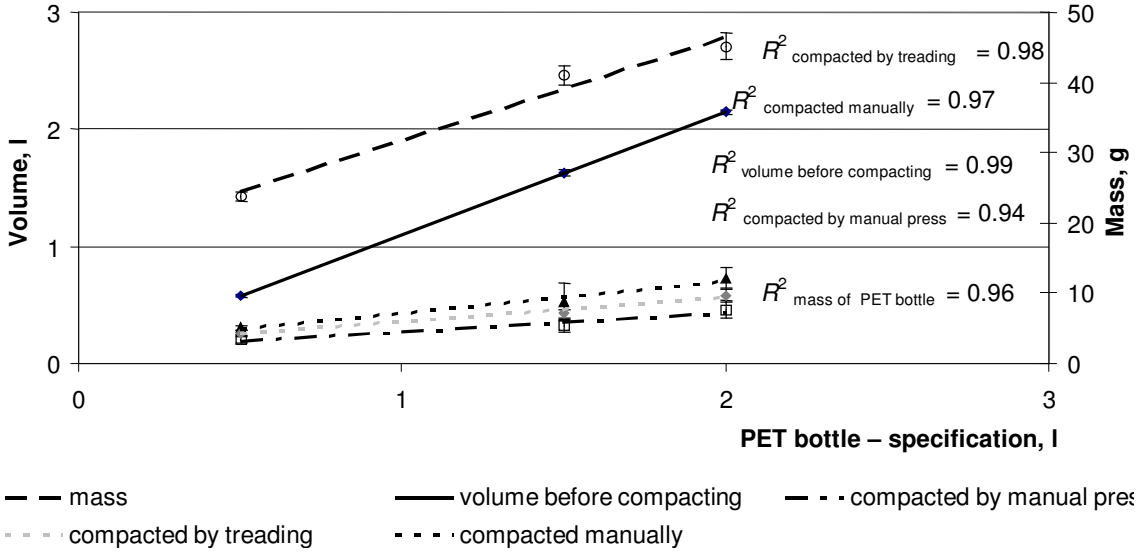

Fig. 1. **Influence of mass and volume of PET bottles on compacting process**

Looking at the effectiveness of packing based on PET bottles the whole spectrum of negatives occurs comparing with the water bags (Fig. 2) commonly distributed, e.g., in Africa which take 0.5 l of water and they are only 1.84 g. Their volume is only 0.007 l after they are free of content.

The study results focused on the effectiveness of using the content are visible in Fig. 3. The items "the mass of the unused content" and "the mass of the packing" represent the waste. The waste amounts 6 – 36 % at the ten chosen reference chemist products and the average value is 15 %. This number is huge considering the amount of the chemist products production. The portion of the packing mass to the whole mass of the product was about 6 – 12 %. The portion of the unused content mass to the whole mass of the product amounts 0 – 26 %. The portion of the used content mass ranges among 64 – 93 % of the whole product mass.

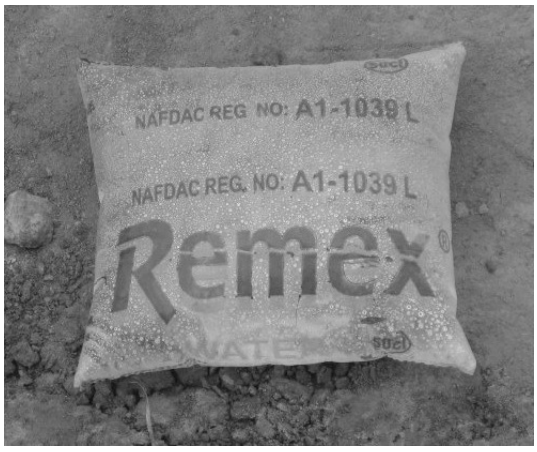

Fig. 2. **Water in bag – Nigeria [5]**

The packing of the hand cream in the form of a tube seems to be the entirely unsuitable constructional design from the content usage point of view. This type is also distinguished for higher portion of the packing mass at the same time. The producers should take into regard the physical essence of the content put into the packing and they should choose suitably the constructional and geometrical packing design on the base of the physical parameters.

The least unused content stayed at creams no. 1 and no 2. filled in pots. It is given by the suitability of the constructional and geometrical design of the packing due to which the consumer could use the product content effectively and the packing mass is comparing to the packing in the form of the tube.

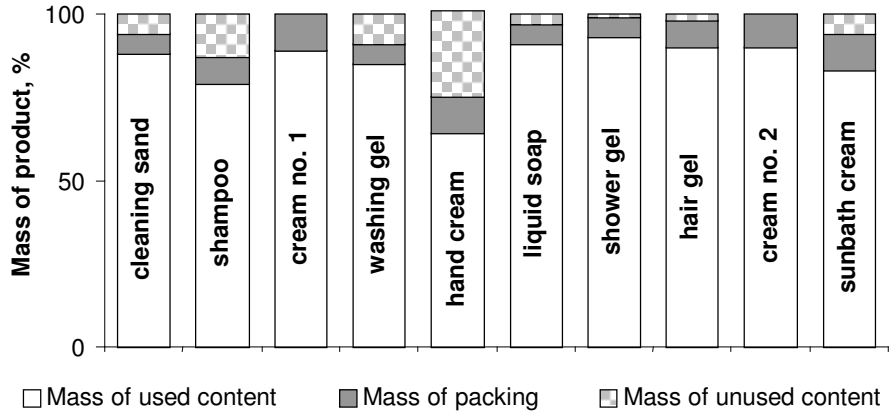

Fig. 3. **Itemization of products from mass point of view**

When evaluating the packing, it was found out that constructions of some packing were solved very differently although the products differed from each other neither in their composition nor in their consistence. It is necessary to mention that the effort of the producers to design the packing so that it is attractive and different from others is very visible, so it is placed the emphasis on in marketing.

Fig. 4 shows what part of the purchase value the consumer has used. The unused content of the packing decreases the profit from the bought goods, increases the price per unit related to the used content at the same time and secondarily it rises up the waste volume. The packing price was not encompassed intentionally in the product price expressing in numbers because these costs are fixed.

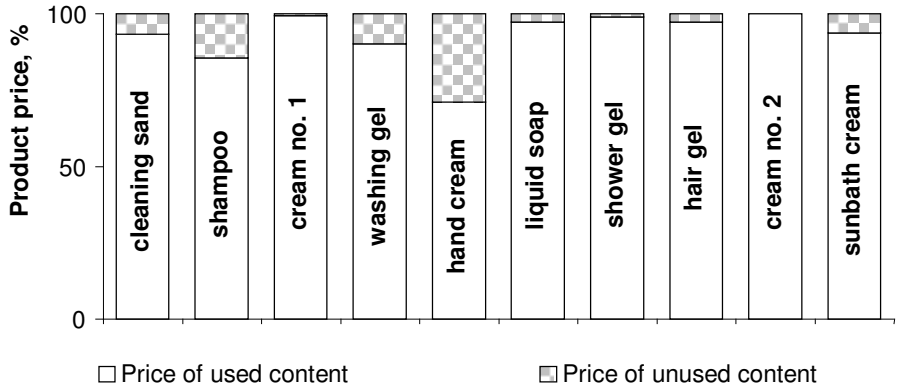

Fig. 4. **Itemization of products from price point of view**

The value of the unused content ranges in a very extensive interval 0.01 – 0.70 EUR. It depends on the price per unit of the product which differs at each product regarding the producers and the packing efficiency from the yield point of view. At the tube packing almost 29 % of the product price was not used.

The process of packing and waste treating is very expensive. The product price encompasses packing costs, transport costs, costs for following processing of the packing. On the one hand, it enters the product with interesting packing (various shapes, masses and colors) and on the other hand, this product gets out as the waste. This waste is created from the packing and from the unused content. It is important from the ecological as well as economical point of view to transfer this packing to first quality secondary raw material. The process of the packing and waste treating is connected with the transport in all stages which is also expensive.

Conclusions

The studies and researches show the filled up containers for sorted salvage. The common attribute of this state is the minimum packing distinguished for a certain rate of the compacting. The reason is the fact that manual deformation of the packing seems to be exacting and ineffective from the user point of view. The results showed that mere “foot treading“or “manual pressing” reached high rate of compressing suitable for common users.

Compacting of the drinking packing bottles shows up in positive way in the whole waste economy. The compacting influences the essential input factor – the increase of the packing mass in the containers at the constant container volume. Consequently, it has increased the yield at unit costs of manipulation and transportation.

The experimental study focused on the chemist products found out that the packing shape and the size of the opening for emptying are very significant. The most unused content was left in the tube, the least in the pots. It means that not only the packing waste is put into the salvage containers but also many remains of the content. This state is not ideal from the consumer point of view for whom the product bought becomes waste involuntarily. The optimization of the packing geometrical shape can decrease the waste production and increase the yield of the sold product at the same time. The producers of the packing material should focus not only on the marketing and protective function of the packing but also on the possibility of the content effective usage.

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