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Poly(ethylene terephthalate) recycling in Central European Countries — latest initiatives

Summary — Situation on the plastics market in Western European (WE) and Central European Countries (CEC) was compared, with particular consideration of Poland as a country and polyethylene terephthalate (PET) as a plastic. Organization of plastic waste utilization in CEC was discussed. Issues of plastics recycling in Poland were presented, concluding that the PET recycling technology in Poland is sufficiently developed and capacity of existing plants is higher than the waste material supply. Launching the countrywide complex waste recovery system is necessary.

Key words: poly(ethylene terephthalate), waste, recycling, Central Europe, education, training.

Protection of the environment is one of the major challenges facing contemporary society. Quality of air, water and soil is essential to the quality of life today, but also influence welfare of future generations. Polluted areas create health problems and demands for their refinement and recovery, what generates costs and constrains further economic progress [1, 2]. The situation in the Central European Countries (CEC)*) is worse than that in Western Europe (WE) because ecology was neglected in course of implementing economical development policies over the years. Therefore, sustainable development is nowadays the only viable social and economic model. One of its elements is the approach to waste management. It involves three complementary strategies:

— eliminating waste at source by improving product design,

— encouraging the recycling and re-use of waste,

— reducing pollution caused by waste incineration.

The strategies concern billions tons of the industrial and post-consumer waste, of which plastic waste constitutes just a small portion. However, its management is not of marginal importance because of the high volume, which plastic waste occupies in landfills. It is characteristic of plastics that majority of thermoplastics produced annually turn into waste in the same year. This is caused by widely accepted application of plastics for packaging, which reached 40% on global basis. Taking into account an additional 20% of non-packaging waste, which has to be managed every year, one arrives to 120 Mt of waste plastics produced annually on global scale. Such amount of the petrochemical industry products may be either landfilled, creating an accumulating ecological problem — or recycled.

PLASTICS IN THE CENTRAL EUROPEAN COUNTRIES

Plastics production in CEC is estimated to the amount of 2.5 Mt, half of which is produced in Poland (Fig. 1). Steady progress is observed in the production and processing of plastics — this branch is doing well even during the recent recession period. One has to expect even faster progress, being accelerated by the integration with the European Community.

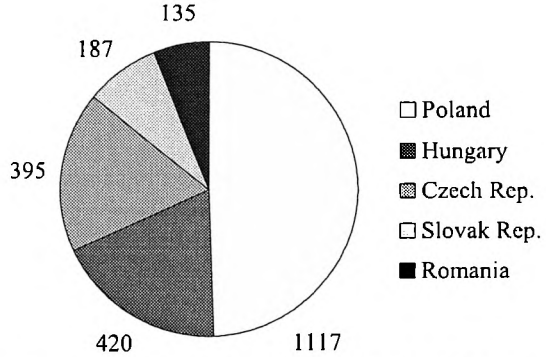

Fig. 1. Plastics production (kt) in the CEC in 2000 [3]

*) CEC means here Czech. Rep., Hungary, Poland, Romania, Slovak Rep.

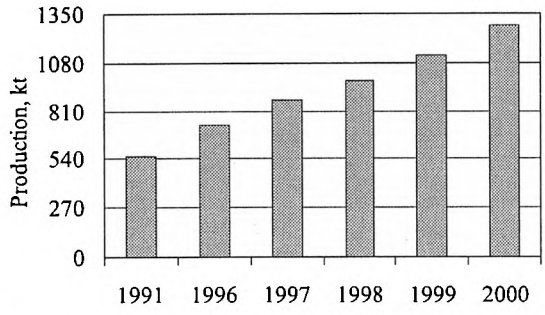

Fig. 2. Plastics production (1991—2001) in Poland [3]

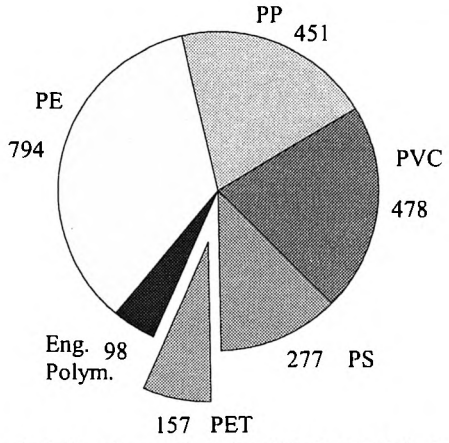

Fig. 4. Kind of plastics production (kt) in CEC in 2001 [3]

Dynamics of plastic production in Poland has been presented in Fig. 2. Increase of 170 kt has been reported within first 5 years of the recent decade, with unchanged annual levels thereafter. Significant amount of polyolefines (PE-HD, PP) and poly(ethylene terephthalate) (PET) are additionally imported. Thus, total plastics consumption *per capita* in Poland is currently 45 kg, compared with 91.5 kg in WE. Plastics consumption levels comparable with those in WE (80 kg) are expected in Poland in 2007.

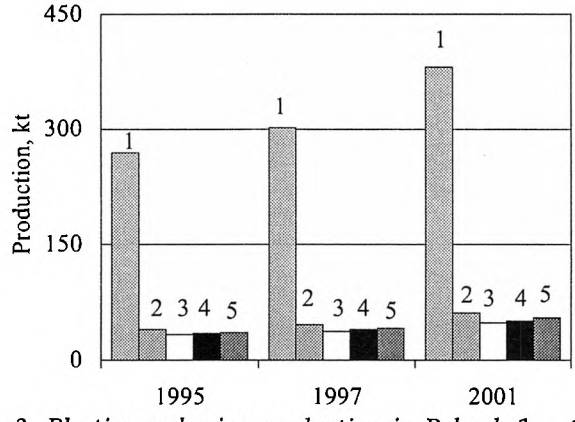

Fig. 3. Plastics packaging production in Poland; 1— total, 2 — bags, 3 — PET bottles, 4 — sacks, 5 — thermoforming

Packaging sector consumes 43% of plastics production in Poland (Fig. 3) with a 6.5% annual growth rate. Production of plastic bottles has the highest dynamics, increasing at a pace of 38% in 1991—1996 in comparison to 20% for other plastics packaging.

POLY(ETHYLENE TEREPHTHALATE) IN THE CENTRAL EUROPEAN COUNTRIES

The assortment structure of plastics production in CEC shows commodity plastics constitute majority of the production (Fig. 4). PET accounts only for 7% of the total amount, not covering even 50% of its consumption, which strongly increased recently [4]. PET bottles are the fastest developing application, commonly used for packaging mineral water, soft drinks and cooking oil. Even higher production demand should be expected in parallel with new products offered in PET bottles, jars and tubes (beer, fruit juice, honey, spices *etc.*) [5—8].

Currently, main PET producers in Central Europe are the Czech Republic and Poland (Elana SA, Toruń). PET production in Poland is 45 kt, whereas consumption amounts to 110 kt. One expects a further increase in PET consumption in Poland — particularly for bottles, which reflects a general trend observed all over Europe [5—13]. PET bottles production has increased regularly in WE over the last 6 years (from 1000 kt in 1997 to 2200 kt in 2003) and in Poland (from 39 kt in 1997 to 170 kt in 2003). It is expected that total PET production in WE will reach 2400 kt in 2004.

PLASTIC WASTE MANAGEMENT IN CENTRAL EUROPE

Central Europe follows the European Community (EC) in waste management, because solution of ecological problems is an example of a success story at the EC. Waste recovery and recycling has been well organized and verified within recent 10 years in WE. Proper legislation, recovery and recycling systems and public awareness should be listed as key factors of successful recycling.

EC legislation has been based on the European Parliament and Council Directive 94/62/EC of 20 December 1994 on Packaging and Packaging Waste. The Directive aims to reduce the overall impact of packaging on the environment by reducing packaging at source, eliminating harmful materials in packaging waste, maximizing the recovery of packaging waste for reuse, recycling, composting or energy generation and minimizing the quantity going for final disposal. The CEC legislation refers to the WE standards, but the complex systems of recovery and recycling of packaging waste are still lacking (apart from Hungary, the Czech Republic and Poland, which belong to the Green Dot system). Several Small and Middle Enterprises (SME) in Central Europe also have been active at the recycling business, but they

suffer of poor economy lacking support from the system. However, the problem does not rest with technology — several recycling plants in CEC are comparable with those working at WE. The main difficulty lies in the availability of waste plastics, which only rarely are recovered.

When looking for the plastic waste source for recycling one has to consider post-consumer waste, which represents 2/3 of the available waste stream. Its structure according to the plastic type has been presented in Fig. 5.

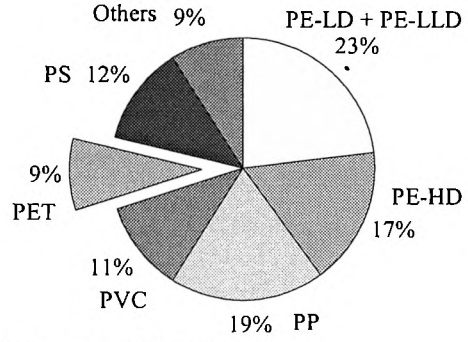

Fig. 5. Plastics in municipal waste

Mixed post-consumer waste is not advantageous for recycling — a selective collection system, which assumes separation of waste for plastics, glass, paper and metal at their source (consumer) is much more favorable. Such systems have been implemented in several CEC cities. For example in Poland a collection rate has been 40—50 t/month (Wrocław with 700 000 inhabitants) and 30 t/month (Zielona Góra — 120 000 inhabitants).

The mass fraction of particular components in the containers for selective waste collection in Wrocław is shown in Fig. 6.

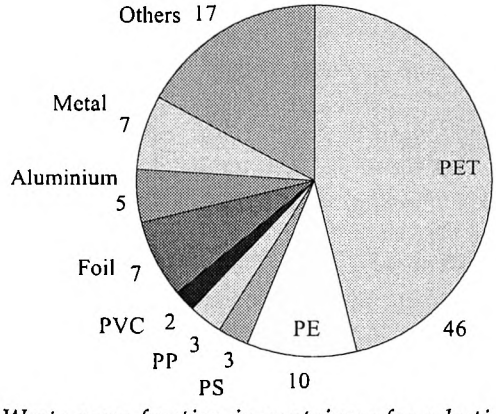

Fig. 6. Waste mass fraction in containers for selective waste collection in Wrocław (2000)

PET is dominating in the containers for selective collection, what is even more visible in the volume fractions (Fig. 7). This finding is not seasonally dependent.

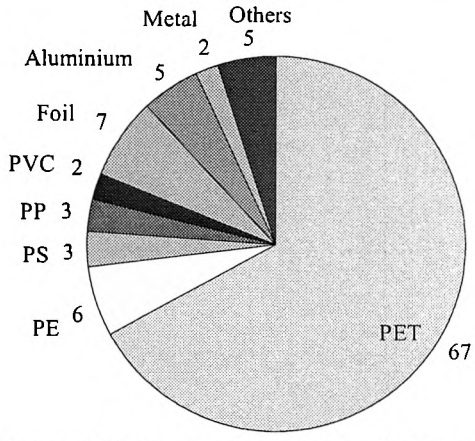

Fig. 7. Waste volume fraction in containers for selective waste collection in Wrocław (August, 2000)

PET RECYCLING

Majority of plastic waste is landfilled in CEC, but increasing quota have been reported as reprocessed and incinerated, depending on the country. Mechanical recycling is developing with high dynamics with different technologies and products offered to the market. Numerous SMEs recycle polyolefines, which are either agglomerated or offered in that form to the processors or agglomerated and pelletized, the latter form being more useful for reprocessing. Recycling PET is much more complicated, therefore only a few plants are technically prepared to this business. Both mechanical and chemical recycling is implemented in the CEC. Currently working PET recycling plants have been listed below.

Poland

Recycling plants have been launched within recent years in parallel with increasing PET consumption. The list below specifies plants (and capacities) dealing with mechanical PET recycling.

POLOWAT Ltd., Bielsko-Biała — 20 kt, product offered in a form of flakes.

ELANA PET Ltd., Toruń — 4 kt (3 kt fibers, 1 kt pellets).

HANEX Ltd., Sokółka — 2 kt (multi-layer packaging foil).

EKO-REGENERATION Ltd., Piotrków — 1.5 kt (flakes).

PLASTMAL JAKO Ltd., Toruń – capacity of 1.5 kt (flakes).

There is extensive research activity on PET recycling technology in several industry and academic institutes (Industrial Chemistry Research Institute, Warsaw, Krakow University of Technology, Szczecin University of Technology, Rzeszow University of Technology, University of Lublin, Wroclaw University of Technology). Innovative products have been offered, which represent blends and composites with enhanced interfacial adhe-

sion and advantageous end-use properties [14—20]. Possible applications include technical details, construction, road and building infrastructure, thermal insulation, *etc.*

Other CEC

Czech Republic. PET consumption in the Czech Republic is 50 kt, of which 20 kt is for bottles.

SILON Ltd., Plana and Luznici is the only plant with recycling ability — capacity of 4 kt (fibers, non-woven textiles).

Hungary. There is no PET production. Consumption accounts for 33 kt, including 25 kt for bottles.

PLASTWAY HUNGARY Ltd., Budapest performs mechanical recycling with capacity of 5.5 kt (2.5 kt pellets) and SOTEX Ltd., Nyireghaza (grinding 1 kt). General situation in utilizing plastics waste in Hungary has been discussed in [21].

Slovak Republic. Production is 11.5 kt, of which 5.5 kt is exported, whereas 4 kt is imported. There is no recycling in the country — waste PET is recycled in Silon Ltd. (Czech Republic).

Romania. Imports 36.5 kt of PET — no recycling activity is reported.

EDUCATION AND TRAINING

Sustainable development in every economy needs conscious and well-educated society. Therefore, several activities on the ecological education in Central Europe have been initiated. In 1995—1998 within the TEMPUS Phare scheme Wroclaw University of Technology (WUT), together with the University of Palermo and the University of Minho, had implemented the project "Ecological Aspects of Plastic Waste Management". Principal WUT staff has been trained on recycling at the European Community, a new course on "Plastic waste utilization" has been implemented at WUT, the Polymer Recycling Laboratory has been created and a book "Introduction into Plastics Recycling" has been published.

Starting from 1998 WUT has launched the biannual Conference on "Plastics Recycling" aimed at strengthening the national links and identification of possible recycling problems and partners.

In 1999 the Network on Polymer Engineering and Recycling has been created under Central European Education Program on University Studies (CEEPUS, Vienna) at which Poland, Hungary, Bulgaria, Romania, the Slovak Republic and Croatia have been gathered till now. The Network has been devoted to the staff and student exchange and training on plastics recycling between Central European countries.

In 2002 the Materials Recycling Center of Excellence has been created at Wrocław University of Technology under 5th Framework Programe.

Purposed, tasks and operating plans of the Materials Recycling Center of Excellence have been discussed in [22].

CONCLUSIONS

— Central Europe is importer of substantial amount of bottle grade PET.

— There is no effective recovery system developed in the Central European Countries.

— Poland is a leader among CEC in PET consumption and recycling.

— Education and training has been developed in CEC, being promoted by Wrocław University of Technology, Poland.

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