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The cement industry in the context of circular economy

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Abstract. The concept of circular economy, assumed in the last years, comes to replace the concept of linear economy, characteristic for most of technologies. The circular economy implies the valorization within the fabrication process of certain wastes resulted from that or from some other technological processes, as well as their preservation for as long time as possible in the process of materials producing. This concept is now also applied to the cement and concrete industry, with favorable consequences both on natural resources (raw materials and fuel), and on the environment.

Keywords: circular economy, cement industry, concrete production, wastes.

1. Introduction

In the latest years a new concept has appeared in the technical literature: circular economy, as a counter-weight of the current concept of linear economy. If the linear economy is based on the model: "take – prepare – consume – throw", the circular economy is a model of production and consumption which involves „sharing, reusing, repairing, renovation and recycling" of the materials and existing products, as far as possible. In this manner, this life cycle of the products is extended. Practically, this involves the diminution of wastes at minimum value. When a product reaches the end of its life cycle, the materials from which it is made are kept within economy, any time it is possible. Thus, figure 1 presents a schematic model of circular economy [1].
The European Union economy currently loses a significant quantity of its potential secondary raw materials or alternative fuels which are found in wastes flows. Wastes are defined in the Directive 2008/98/CE as „any substance or object on

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Fig. 1. Schematic representation of circular economy concept.

which the owner throws away or has the intention or the obligation to dispose of". They constitute an enormous waste of resources, both concerning the materials and energy. Furthermore, wastes' administration and disposal may have a serious impact on the environment, through land occupation with landfills, and also through air, water or soil pollution.

In 2014, the total wastes generated in EU-28 by all economic activities and homesteads were raised at 2,503 million of tones (4.9 tones of wastes/per capita); this is the highest quantity registered for EU-28 in the period 2004-2014. The constructions had contributed with 34.7% in the total amount of resulting wastes, followed by the extractive industry (28.2 %), processing industry (10.2 %), water industry and (9.1 %) and population homesteads (8.3 %); the rest of 9.5 % were wastes generated by other economic activities, especially the services (3.9 %) and energetic industry (3.7 %) [2].

In 2014, in EU-28 2,300 million of tons of wastes were treated. Almost half, 47.4% respectively, of the produced wastes were subject to other operations of disposal than their incineration or storage in the landfills. Other 36.2% from wastes were subject to some operations of valorization, others than energetic valorization and filling operations (recycling). A little over one-tenth (10.2 %) from the wastes treated in EU-28 were filled, while the rest were sent to incineration, with energy recovery (4.7 %) or without it (1.5 %). The quantity of valorized wastes increased with 23.4 %, from 960 million of tones in 2004 to 1,185 million of tons in 2014; consequently, the weight of valorized wastes from the total of treated wastes increased from 45.4 % in 2004 at 51.1 % in 2014 [2].

The frame-directive reviewed from 2008, concerning the wastes, introduced a hierarchy on five levels of wastes, within which complete avoidance is the best

option, followed by reusing, by recycling and of other forms of valorization, the elimination, e. g. in waste deposits, being considered as a last resort. In accordance with this hierarchy, the 7-th Program establishes the following priority objectives concerning the policies in the domain of wastes, in EU [3]:

- decreasing of the quantity of generated wastes;
- maximization of recycling and reusing;
- limitation of incineration just at non-recyclable materials;
- limitation of wastes storage at landfills just at non-recyclable wastes and non-recovery wastes;
- insurance of competitive implementation of these objectives in wastes range, in all EU members states.

2. The cement industry in the circular economy

During the latest years, the cement industry became an active and efficient factor of circular economy, by use of a large range of wastes in cement manufacturing process. Schematic transposition of circular economy concept in cement or concrete industry, respectively is illustrated in figure 2 [4].

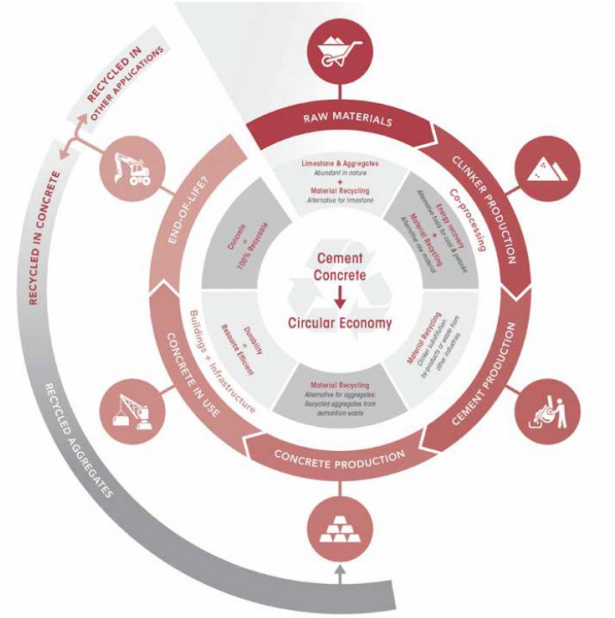

Fig. 2. Cement/concrete industry in the circular economy.

From the cement producers' points of view, the usable wastes in this industry can be divided into two large categories:

- non-combustible wastes (non-energetic), comprising utile minerals – used as raw materials, as correction additions in the mixture of raw materials or as additions at clinker grinding;
- combustible wastes (energetic) – used as partial replacer of conventional fuel at clinker burning from which cement results.

The non-combustible wastes which may be used in cement industry from our country result from chemical industry (phosphogypsum, pyrite ash, mill scale), steel industry (blast-furnace slag, foundry slag, stockpile slag, furnace slime, furnace dust), energetic industry (fly ash, slag of burning point, synthetic gypsum) and from other industrial branches (carboniferous sterile, worn plaster forms, glass wastes, metallic fibers, lignocellulose fibers, sand, lead slag).

At present, these wastes and by-products of other industries replace between 20-30 % of the natural raw materials traditionally used by the cement industry and save yearly over two million of tons of natural resources [4].

The wastes resulted from constructions sites, demolished buildings and stockpile slag may partially substitute natural aggregates [5 - 8].

The co-processing of combustible wastes in cement kilns represents the process of thermal treatment through which the entire energetic consumption of these is recovered, the resulted residue being incorporated in burning product, which is Portland clinker.

By this valorization, climate changes are reduced – alternative fuels becoming one of the main levers for the decreasing of CO_2 emissions in cement production. In accordance with International Energy Agency (IEA), alternative fuels may contribute to the decreasing with 0.75 Gt of CO_2 worldwide until 2050 [9].

At present, there are considerable differences in the rate of co-processing in EU members states, some countries reaching a rate of co-processing of only 7%, in comparison to 95% in the others. EU-28 average is presently of 41%. Significant remarks were observed among EU member states concerning the use of different treatment methods. For example, some member states had very high rates of recycling (Italy and Belgium), while others have promoted the use of landfills (Bulgaria, Romania, Greece, Sweden, Finland) [9]. The increase of processing rate of the wastes in EU-28 at 60% will have as effects:

- ➢ diminution of CO_2 emissions by 26.0 million tones;
- ➢ processing of 15.7 million tons of wastes;
- ➢ saving of 11.1 million tons equivalent of coal;
- ➢ decreasing of the public investments of 12.2 billion Euro in the power plants dedicated to wastes and energy (WTE).

The quantity of industrial and municipal wastes, co-processed in the Romanian cement industry in the period of time between 2004 and 2014 was of about 2,000,000 tones, which represents the equivalent of municipal wastes generated in

a year by 24 cities with over 250,000 inhabitants. Thus, about 1,200,000 tons of fossil fuels were saved and as many tons of CO_2 [4].

In Romania, although the developments **were significantly in the last 10 years and cement** producers made investments of over 80 million of Euro in this way, alternative energetic resources still supply only about 25-30% of the thermal energy necessary for the clinkering process [4].

The combustible wastes (alternative fuels) used in the cement industry in Romania are - as state of aggregation **- solid** (rubber, wood, paper, plastic, solidified tars, plastics, etc.), **pasty** (slimes, sludge, tars from oil and steel industry or from water purification, etc.) or **liquid** (waste oils, organic compounds from drugs, dyes, paints industry, etc.)

The specific characteristics favorable to use of the wastes within the cement clinker burning are as follows:

- the temperature at the main burner may reach the value of 2000°C, and the maintaining at clinkering temperature (1450 – 1480°C), for a period of 2-6 seconds, in an oxidant atmosphere, assures a complete decomposition of organic compounds from wastes;
- the decreasing of CO_2 emissions depends of the substitution degree of conventional fuels with alternative fuel.

These characteristics have as an effect the total burning of the above-mentioned wastes and the integral recovery of their energetic value.

It is mentioned that wastes burning does not generate, as final materials, ashes or slags and consequently, on one hand, material value is recovered integrally and, on the other hand, it does not necessitate a storage room in the end. The emissions of acid gases in the burning period are neutralized by basic raw materials (limestone).

At the moment, cement producers in Romania detain authorizations by environment authorities for using over 100 types of wastes. However, in order to be used in the process of cement production, these wastes must assure three fundamental requirements:

- the cement quality must not be affected regarding the values of technical performances and environmental protection;
- the production process must not be affected from economic, ecologic and occupational health, as well as safety point of view;
- the legal, technical, economic and ecological requirements for putting the product out on market has to be respected.

However, there are also external barriers which limit – at the moment – the use of wastes in the cement industry, out of which we may mention:

- the priority of waste generators is solving financial problems, not the issues related to environmental protection;
- the negotiations with waste generators can be very difficult, given the fact that they consider them “products”;

- there is still a tendency to resort to non-ecological solutions (storage or non-controlled incineration, mixture with other products and commercialization etc.);
- there is a lack of transparency in the reporting of waste quantity by generators;
- there is still a small number of companies for wastes' collection / transportation / pre-treatment;
- the low quantities declared and collected at present do not encourage investments in the domain of cement industry to be directed towards technologies for wastes' disposal.

3. Conclusions

The aim of this paper was to present the new concept of circular economy, in a brief and not very technical manner, with the characteristics and its peculiarities at EU-28 level and then at national level, and also the way in which the cement industry is involved in implementing of circular economy principles in real life.
The studies performed in this field showed that a better ecological designing, the avoidance of waste generation and the possibilities of reusing these wastes could bring early net savings of up to 600 billion Euro for business environment in EU, simultaneously with decreasing of the total yearly greenhouse gases emissions. Additional measures of enhancing resources productivity with 30 % until 2030 could increase GDP with almost 1 %, creating, at the same time, other two million of employment opportunities [10].

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