



## Use of the alternative fuels in the cement industry

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### Abstract

*Use of alternative fuels as energy sources in cement industry is practice which is proven as very effective and which is used in cement factories in Europe and world, more and more. One of the biggest advantages of this concept is reducing of consumption of non-renewable, fossil fuels. On the other hand, improvement of environmental protection is achieved by reducing of pollutants emissions and environmental is cleaned from the waste in that way. In this paper, primary types of alternative fuels which can be used for production of cement clinker are presented. Consequences of use of them and review of current apply in Cement factory in Kakanj are also shown.*

**Key words:** *alternative fuels, nonrenewable energy sources, refuse derived fuels, old tires*

### 1. INTRODUCTION

Today, a modern civilization achieves comfortable lifestyle and strives to its development. However, it results with some disadvantages such as production of big amount of waste. In this paper, term “waste” alludes municipal and industrial waste whose appearance is constant part of everyday life. Research showed that 0,5 t/person waste is produced annually in countries of EU [1]. So that, modern world apply various methods of elimination of waste from a long time. The most effective method is prevention of occurrence of waste. This method can be used very rarely. For that reason, other way of elimination of waste, i.e. recycling is used. In this case, material of waste which appears from some product should be suitable for recycling. On the other side, functioning and further development of modern civilisation are conditioned by unobstructed communication which can not exist without developed traffic. Related to this, it is considered that road traffic has the most important role. This leads to the fact that there are more than 700 millions of cars on the planet and 550 millions are everyday used [2]. Thus, huge use of road vehicles has consequences such as emissions of carbon dioxide, nitrogen oxides and other types of air pollution, and also big amount of old tires.

It is estimated that 1,4 billion old tires are appeared annually in the world. USA, countries of EU and Japan cover 44% of this amount [2].

It is proven by experience that problem of old tires can be solved such as solving of problem of municipal waste, i.e. by using old tires as energy sources.

### 2. USE OF NON-RENEWABLE ENERGY SOURCES IN THE CEMENT INDUSTRY

Considering total consumption of energy in the world, non-renewable energy sources are still primary energy sources. Considerable part of energy is got from fossil fuels which include petroleum, coal and natural gas. Stocks of non-renewable energy sources are limited. On the other hand, concentration of fossil energy sources is in some fields in the world, so countries which depend of import of fossil fuels are subordinate.

#### 2.1 Use of coal during production of cement

Coal is fuel sediment which consists of products of disintegration of plants. Process of creation of coal is based on increase of relative content of carbon (C) and decrease of content of oxygen (O<sub>2</sub>), of nitrogen (N<sub>2</sub>) and hydrogen (H<sub>2</sub>). This energy source is the most widely used energy source for production of cement. It usually contains increased content of sulphur and results with large amount of ash. However, coal which is used in cement industry is least harmful for environment because sulfur during process of production turns into sulfur (IV)-oxide and then merges with calcium oxide

making calcium sulfate (gypsum). Gypsum has to be embedded into clinker and ash also embeds into clinker. In the cement factory in Kakanj, coal is used as operating energy source at technological process of production of clinker in the rotary kiln. Chemical composition of this coal is presented in table 1 [3].

**Table 1.** Chemical composition of coal from CF Kakanj

Mass fractions		Mass fractions	
C	0,43	N	0,008
H	0,037	A	0,271
S	0,017	W	0,160
O	0,077		

Nus product of process of combustion of coal in rotary kiln is emission of oxide gases in the air. This is occurrence which is ordinary for every cement industry. Target for every responsible company, such as Cement factory in Kakanj is to reduce negative influence of those emissions on people and environment by implementation modern filter technology and processes for protection of environment. During use of coal for production of clinker, carbon from coal reacts with oxygen. In that case, carbon dioxide (CO<sub>2</sub>) which is greenhouse gas, appears as product of total combustion. On the other hand, binding between sulfur and oxygen creates emission of sulfur dioxide (SO<sub>2</sub>). This process causes emissions of other gases such as CO, NO<sub>x</sub> and SO<sub>x</sub>.

Process of production of clinker from raw meal which is conducted in rotary kiln requires huge amount of energy. It results with use of big amount of coal. Analyzes which are conducted in Cement factory in Kakanj for period from 2004. until 2009. showed that average consumption of coal is 46949 t for production of 462265 t of clinker [3].

### 3. USE OF ALTERNATIVE FUELS IN THE CEMENT INDUSTRY

Last years, developed countries of EU and world, prefer to use renewable energy sources considering scantiness of amounts of non-renewable energy sources. That is confirmed by data of EUROSTAT (European Commission)

where is noted that percentage of use of non-renewable energy sources increased to 16% in 2014. That is almost doubly in regard to 2004. when this percentage was 8,5%. In the same data is mentioned that nine countries which are members of EU are already achieved its target which is planned for 2020.

This practice is also applied for use of energy sources for cement industry. Trend of use of different types of waste as replacement for fuel increases in cement industries of European Union. Therefore, percentage of replacement fossil fuels with different types of alternative fuels reaches over 80% in some countries in Europe.

There are a lot of advantages which are realized by using fuel from waste. Thus, reduction of amount of waste on dumps, reduction of costs of energy and reduction of emissions of greenhouse gases are achieved by this principle. However, the most important benefit is reduction of usage of fossil fuels, ie. non-

renewable natural resources. Examples od types of waste which can be used as fuels are presented in table 3.

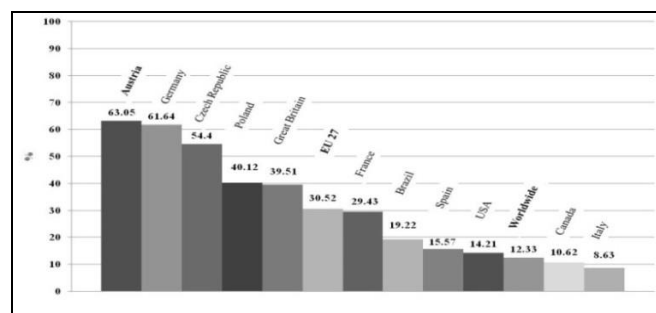
**Table 2.** Types of waste as alternative fuel

Hard (80%)	Liquid (20%)
Municipal waste (RDF)	Tar
Old paper	Waste acid
Textile waste	Waste oil
Carpets	Petrochemical waste
Plastic waste	Waste solvents
Rubber	Chemical waste
Old automotive tires	Waste lacquers
Waste wood	Waste distillate
Sewage sludge	Vax suspension
Animal meal	Asphalt sludge

#### 3.1 Alternative fuel from waste – RDF

Various types of waste such as: mixed municipal waste, bulky waste and other types of harmless waste can be processed in plants for mechanical biological processing of waste and can produce RDF (Refuse Derived Fuel). Fuel from waste or RDF is type of waste which is made by processing of waste, i. e. by shredding, separation of metal, stone, PVC plastic etc. This type of fuel is very similar with fossil fuel – stone coal. It is used as alternative energy source for production of energy and satisfies criteria which are specified by European standards CEN TC Solid Recovered Fuels. The most important parameters which determine quality of fuel from waste are energy value and content of chlorine and heavy metals.

Use of RDF in cement factory is considered as “Best Available Technique” according to data of EUROSTAT. Namely, in European cement industry, average rate of replacement of fossil fuels with RDF was 30% in 2010. In some countries, this percentage was over 60% which is shown in figure 1.

**Figure 1.** Use of RDF in countries of the world

Procedure of using of waste as alternative fuel is certain way of valorization of waste which can be useful for both the community and cement industry. Namely, high

temperature which is actualized at process of rotary kiln (1450°C) and long process of combustion in hot air achieve complete destruction all organic components. On the other hand, inorganic components are tied with raw materials and come out from process as part of clinker.

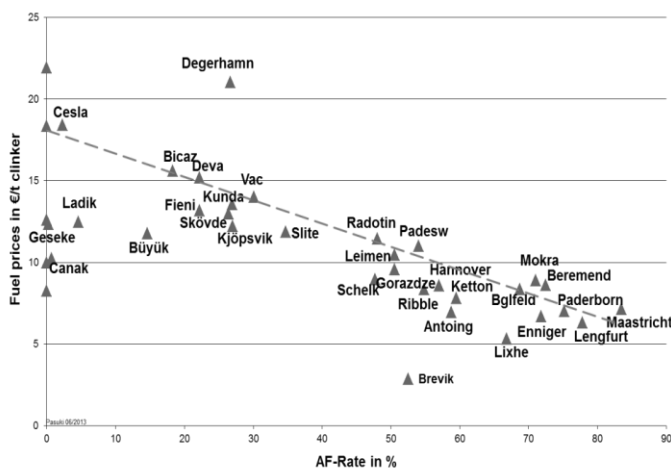
Amounts and content of emissions which are made during process of combustion for production of clinker depend of raw materials, fuel and technology of process. Research showed that emissions will not decrease if alternative fuels are used at controlled process which is in accordance with EU regulations and which is on high temperatures of combustion.

- wood 5 – 10 %
- paper 5 – 10 %
- plastic without Cl 60 – 70%
- gum 5 – 8%
- textile 5 – 10%
- other - under 5%

In the next table, required mechanical and chemical properties of SRF/RDF fuel are shown.

**Table 3.** Classes of fuels from waste

Properties of RDF/SRF	Value
Caloric value	20MJ/kg
Density of bulk	under 240 kg/m <sup>3</sup>
Content of ash	under 15%
Content of humidity	under 15%
Content of chlorine	under 1%
Content of cadmium	under 6 mg/kg at dry state
Content of mercury	under 1 mg/kg at dry state
Content of sulphur	under 0,5 mg/kg at dry state



**Figure 2.** Costs of energy (€/t of clinker) in correlation with percentage of application of alternative fuels in some factories of HC in 2012

Saving of non-renewable energy sources and reducing of costs are achieved by using RDF as alternative for fuels in cement industry. In diagram on the figure 2 are showed costs of produced clinker from 2012. in € per ton depending on percentage of application of alternative fuels in some factories of Heidelbergcement Group.

As it is shown in diagram (figure 2), Cement factory in Leimen (Germany) had percentage of alternative fuels about 50% and total costs of energy about 10 €/t. On the other hand, cement factories from Rustavi (Georgia) and Kaspi (Georgia) which did not use alternative fuels this year, had costs in value of 32,61€/t and 28,93€/t, respectively.

Advantages of use of RDF as alternative fuel are proved by fact that this fuel was used in Heidelbergcement Group factories, more than half than other alternative fuels.

Fuel which has better quality, which was made from smaller waste and which has smaller size of grain is called Solid Recovered Fuel or SRF.

Size of grain of this fuel is max 25 mm. In most cases, content of RDF and SRF is the same therewith RDF has significantly bigger size (max 50 mm). Possible content of RDF/SRF which can be used in cement industry is:

Content of humidity has consider influence on quality of fuel from waste, i.e. if content is lower, fuel has better quality.

Production of RDF/SRF fuel from harmless waste is increasing industry in Europe. This fuel can be used as fuel for power plants, industrial steam boilers, for electric power plants, besides the use in cement kilns.

MBO technology of production of these types of fuels was expanded from Germany to other European countries. It is known that it is installed more than 70 MBO plants in Europe [4]. It can be concluded that application of this type of fuel leads to need for production of it.

So, one more advantage of use of RDF is possibility of development of the local economy.

### 3.2 Waste tires as alternative fuel in cement industry

Tires are classified as high-energetic materials. Namely, average caloric value of tire is 24-26 MJ/kg which is high considering that average caloric value of municipal waste, lignite, newspaper, sawdust, stone coal, petrol-cokegasoline and light distillate oil are: 8,1 MJ/kg, 16,2MJ/kg, 17,2MJ/kg, 18,4MJ/kg, 28MJ/kg, 32MJ/kg, 35,4MJ/kg and 41,8MJ/kg, respectively. Thus, high caloric value of tire and fact that pneumatic contains 20-30% of natural tire (biomass) so its combustion does not pollute environment with emission of CO<sub>2</sub>, lead to application of old tires as alternative or primary energy source in industrial power plants, kilns for lime or kilns for cement.

Research showed that proper use of burners and adapted combustion lead to use of waste tires

(crunched or whole) as additional energy source without harmful influence on technological process and without endangering of environmental [2]. This is very important for cement industry. In kilns for production of clinker, tire burns at 1450°C, where gases are retained sufficiently so organic pollutants can be completely burned. Gaseous products of combustion are in boundaries which are assigned by standards.

On the other hand, hard products are embedded in clinker (as well as use of RDF) as silicates or oxides. Use of waste tires as alternative fuels results with reduction of total emissions in atmosphere because of two reasons. First, decomposition of tires at depots produces methane which has 20 times more negative influence on greenhouse effect than CO<sub>2</sub> which is made by combustion.

Emissions which are made by burning of tires for reaching energy are part of emissions that would be appear anyway.

One of the most important advantages of use of old tires as alternative fuel is environmental protection, i.e. elimination of old tires that can not be used for other purpose.

In this paper, focus can be put on situation in Bosna and Hercegovina and burning of tires in cement factory in Kakanj. According to available data, 3,2 GJ of thermal energy is necessary for production of one ton of cement clinker. Thus, replacement 15% coal with old tires would be result with consumption of 33 tons of tires daily or 10 thousands of tons annually. According to the Plan of waste management of Zenica-doboj canton, from 10 to 12 thousands of old tires are made annually in Bosnia and Hercegovina. That data is confirmed by CARDS pilot project of recycling in Bosnia and Hercegovina and by research of public enterprise "Rad" Sarajevo[5].

In the part of this document which is called „Objectives of waste management“, it is specified that it should be used 30% of old tires until 2011, 60% until 2014 and 90% until 2018.

Cement factory in Kakanj has completed all legal and technical conditions for using of old tires from illegal depots, depots of tire shops and various companies.

This factory belongs to the multinational Heidelbergcement Group which has big experience in the use of alternative fuels. Confidentiality of this company is proven by fact that Heidelbergcement is member of WBCSD (World Business Council for Sustainable Development). Cement factory in Kakanj uses tires as alternative fuels in amount of 1,2% from 2015. This practice showed excellent results in the first six months. Namely, from January to September 2016., 761 tons of old tires are burned at Cement factory in Kakanj. This small amount of tires which are used in combination with primary fuel - coal reached considerable financial savings.

On the other hand, amounts of old tires at depots are reduced. Tires are delivered in cement factory in Kakanj

by external providers. They are payed for collecting and transport of tires. This process has two useful effects. First, environmental is cleaned from pollution which is caused by old tires. Second, possibility of local business is created by need for collection and transport of old tires to the cement factory.

Analyses showed that if 10% old tires or 20% RDF/SRF fuel applied in cement factory as alternative fuel, consumption of coal would be reduced in amount of 12000 tons per year. Values of emissions would be also reduced.

Thus, emissions of CO<sub>2</sub> would be reduced in amount of 45000 t annually for production of 500000t of cement. Emissions of NO<sub>x</sub> would also decrease. Additionally, results of analysis showed that it would be reduction of waste on dumps in amount of 16000t per year

#### 4. CONCLUSION

According to all mentioned facts in this paper, it can be concluded that concept of use of alternative fuels in cement industry is multiple useful from more different aspects. In fact, when subject is environmental protection, analyses indicated that emissions of harmful gases are reduced by using waste or old tires as fuel concerning fossil fuels. On the other hand, environmental is cleaned from waste which appearance is imminent. From aspect of development of local community, need for RDF/SRF fuel and old tires creates chance for development of local business. Possibility of flotation of factories which would produce RDF/SRF fuel for cement industry is created. Besides, every company which manipulates with big amount of old tires would prefer to deliver useless tires to the cement factories instead to the depots.

So, amounts of waste at the depots would be reduced considerably. Finally, this concept achieves saving of nonrenewable fuels, i.e. fossil fuels which were primary fuels in world cement industry, early.

Results of research show that society of development countries has cognition about advantages of use of alternative fuels. Thus, trend of use above-mentioned fuels in cement industry is ascending.

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