UPOTREBA ALTERNATIVNIH GORIVA U CEMENTNOJ INDUSTRIJI KAO NAČIN UŠTEDE NEOBNOVLJIVIH ENERGENATA

USE OF ALTERNATIVE FUELS IN CEMENT INDUSTRY AS MEANS OF SAVING OF NON-RENEWABLE ENERGY SOURCES

Stručni rad

Bajtarević Almir,
Bajtarević Amna

Tvornica cementa Kakanj d.d. Kakanj
HEIDELBERGCEMENT GROUP,
Selima ef. Merdanovića 146, Kakanj

REZIME

Upotreba alternativnih goriva kao energenata u cementnoj industriji je praksa koja se pokazala izuzetno efikasnom i kao takva je sve više zastupljena u cementarama u Europi, a i svijetu. Jedna od najvećih prednosti ovog koncepta je reduciranje potrošnje neobnovljivih, fosilnih goriva. S druge strane, ostvaruje se poboljšanje zaštite životne sredine smanjenjem ukupnih emisija štetnih plinova u zrak, kao i čišćenje okoliša od smeća. U ovom radu su predstavljene osnovne vrste alternativnih goriva koje se mogu koristiti u proizvodnji cementnog klinkera, dati su efekti njihove upotrebe , kao i osvrt na već postojeću praksu u Tvornici cementa u Kaknju.

Ključne riječi:
alternativna goriva, neobnovljivi energenti, RDF, stare gume

Keywords:
alternative fuels, nonrenewable energy sources, RDF, old tires

Paper received:
08.09.2016.
Paper accepted:
01.12.2016.

Professional paper

SUMMARY

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 this paper, primary types of alternative fuels which can be used for production of cement clinker are presented, consequences of use of them are shown and review of current apply in Cement factory in Kakanj is given.

1. UVOD

U današnje vrijeme, savremena civilizacija ostvaruje komforan način života, te teži ka daljem razvoju (istog?). Međutim, to naravno ima i svoje (negativnosti?) u šta između ostalog spada i proizvodnja ogromne količine otpada. Kada se govori o otpadu u ovom radu misli se i na komunalni i na industrijski otpad čija je pojava neizostavni dio svakodnevnice danas. Istraživanja su pokazala da se u zemljama EU u prosjeku godišnje proizvede 0,5 t otpada po osobi [1]. U skladu s navedenim, u savremenom svijetu se odavno primjenjuju različite metode zbrinjavanja otpada. Najefikasnija metoda je prevencija nastanka otpada. Naravno, ovu metodu je moguće koristiti samo u malim procentima. Iz tog razloga se pribjegava drugom načinu eliminacije otpada, tj. reciklaži.
Navedeno dovodi do toga da prilikom

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.

proizvodnje treba voditi računa da otpad koji će nastati od tih proizvoda bude pogodan za reciklažu. Konačno, ukoliko su prve dvije metode zbrinjavanja otpada neodgovarajuće, pristupa se procesu pretvaranja otpada u energiju.

S druge strane, funkcionisanje i dalji razvoj savremene civilizacije je uslovljen nesmetanom komunikacijom koja se ne može ni zamisliti bez razvijenog saobraćaja. S tim u vezi, smatra se da cestovni saobraćaj u mnogim aspektima ima vodeću ulogu. To dovodi do činjenice da na planeti postoji više od 700 miliona automobila(?? provjeriti podatak, samo u Njemačkoj ima ca. 50 miliona automobila!) od kojih je 550 miliona u svakodnevnoj upotrebi [2]. Prema tome, masovna upotreba drumskih vozila za posljedicu, pored emisije nepoželjnih materija sadržanih u ispušnim gasovima ima i veliku količinu otpadnih guma. Procjenjuje se da se u svijetu godišnje (stvara?) oko 1,4 milijarde korištenih guma, od čega SAD, zemlje EU i Japan zauzimaju 44%[2]. Praksa je pokazala da se problem otpadnih guma može riješiti analogno rješavanju problema komunalnog otpada, tj. korištenjem guma kao energenta.

2. UPOTREBA NEOBNOVLJIVIH ENERGENATA U CEMENTNOJ INDUSTRIJI

Uzimajući u obzir ukupne energetske potrebe u svijetu, neobnovljivi izvori energije su još uvijek vodeći u toj opskrbi. . Znatan procent energije se dobiva iz fosilnih goriva u koje spadaju nafta, ugalj i zemni plin. Zalihe neobnovljivih izvora energije su ograničene. S druge strane, koncentracija ovih energetskih resursa, osim uglja, je u svega nekoliko oblasti u svijetu, tako da se države koje zavise od uvoza fosilnih goriva nalaze u podređenom položaju.

2.1. Upotreba uglja pri proizvodnji cementa

Ugalj je gorivi sediment koji se sastoji od produkata raspada biljaka. Proces nastanka uglja se zasniva na povećanju relativnog sadržaja ugljika (C), uz istovremeno smanjenje sadržaja kisika (O_2), azota (N_2) i vodika (H_2).

Ovaj energent predstavlja najviše korišten energetski izvor u proizvodnji cementa. Obično sadrži povećane udjele sumpora i mineralne mase pepela. Međutim, ugalj iskorišten u cementnoj industriji najmanje šteti okolišu, jer se sumpor u procesu proizvodnje cementa najprije pretvara u sumpor (IV)-oksid, a zatim se spaja s kalcij oksidom u kalcij sulfat (gips)

Finally, if first and second methods are not applicable, it is necessary to use concept of transformation waste into energy.

On the other side, functioning and further development of modern civilisation are conditioned by unobstructed communication which cannot 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 million of cars on the planet and 550 million 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 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_2), of nitrogen (N_2) and hydrogen (H_2). 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

koji se i tako mora dodati u klinker, a i sam pepeo se ugrađuje u klinker. U Tvornici cementa u Kaknju, ugalj se koristi kao pogonski energent u tehnološkom procesu proizvodnje klinkera u rotacionoj peći. Elementarni sastav ovog uglja je prikazan u tabeli 1 [3].

Tabela 1. *?sastav uglja iz TC Kakanj*

Maseni udjeli		Maseni udjeli	
c	0,43	n	0,008
h	0,037	a	0,271
s	0,017	w	0,160
o	0,077		

Nus produkt procesa sagorijevanja uglja u rotacionoj peći jeste emisija oksidnih plinova u zrak. To je pojava koja je nezaobilazna za svaku cementnu industriju. Cilj svake društveno odgovorne kompanije, kao što je i Tvornica cementa u Kaknju jeste maksimalno smanjenje negativnog uticaja ovih emisija na ljude i okoliš uvođenjem modernih filterskih tehnologija, inovativnih procesa i procesa u koje je integrisana zaštita okoliša. Pri upotrebi uglja za proizvodnju klinkera, ugljik iz uglja reaguje sa kisikom gdje kao produkt potpunog sagorijevanja nastaje ugljen dioksid (CO_2). koji je staklenički plin. S druge strane, vezivanje sumpora sa kisikom rezultira emisijom sumpornih oksida (SO_x, dominsntno SO_2). Ovaj proces uzrokuje i emisije drugih plinova, kao što su ugljenmonoksid (CO). i azotni oksidi (NO_x). Proces proizvodnje klinkera iz sirovinskog brašna koji se odvija u rotacionog peći zahtijeva značajan angažman energije. To rezultira upotrebom znatnih količina uglja. Analizama koje su provedene u Tvornici cementa Kakanj za period od 2004. do 2009. utvrđeno je da je prosječna potrošnja uglja u iznosu klinkera [3] (svesti na neimenovan broj, t/t !).

2.2. Mazut kao pomoćno gorivo

Ranije se u tvornicama cementa, uključujući i Tvornicu cementa u Kaknju, koristio mazut kao osnovno pogonsko gorivo. Mazut je teško loživo ulje koje se dobiva frakcijskom destilacijom nafte. Neophodne karakteristike koje treba da ima da bi se moglo upotrebljavati u cementnoj industriji su predstavljene u tabeli 2 [3]. Treba naglasiti da je manipulacija ovim gorivom vrlo složena jer je mazut potrebno zagrijati na temperaturu 55-60°C da bi njegov viskozitet bio odgovarajući za transport.

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 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_2) 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_2). This process causes emissions of other gases such as CO, NO_x and SO_x.

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].

2.2. Heavy oil as auxiliary fuel

Early, heavy oil is used as primary operating fuel in cement factories including cement factory in Kakanj. Heavy oil is produced by fractional distillation of petroleum. Necessary properties of heavy oil to be used in cement industry are presented in table 2 [3]. It is important to know that manipulation of this fuel is difficult because heavy oil would be heated on temperature 55-60°C, if its viscosity was adequate for transportation.

Tabela 2. *Potrebne karakteristike mazuta*

Karakteristika	Vrijednost
Donja toplotna moć	40,193 MJ/kg
Sadržaj sumpora	max 1%
Max. tačka paljenja	150°C
Viskozitet na 100°C	10 do 30 mm^2/s
Sadržaj pepela	max 1%
Max. sadržaj vode	2 %

S druge strane, emisije CO_2 su znatno veće pri upotrebi ove vrste goriva u odnosu na upotrebu uglja. Iz navedenih razloga, mazut se u tvornici cementa u Kaknju danas koristi kao pomoćno gorivo.

3. UPOTREBA ALTERNATIVNIH GORIVA U CEMENTNOJ INDUSTRIJI

Posljednjih godina, prvenstveno iz razloga očuvanja Planete od klimatskih promjena i zaštite okoline , razvijene zemlje EU i ostatka svijeta pribjegavaju korištenju obnovljivih resursa kao izvora energije. To potvrđuje podatak EUROSTAT-a u kojem se navodi da je procenat upotrebe obnovljivih izvora energije u zemljama EU u 2014. godini porastao na 16%, što je gotovo duplo u odnosu na 8,5% koji je bio zabilježen 2004. godine. Iz istog izvora se navodi da je čak devet država članica EU već postiglo svoj cilj (koji cilj?) koji je planiran za 2020. godinu.

Ovakva praksa se primjenjuje i kod upotrebe energenata za cementnu industriju. Trend upotrebe različitih vrsta otpada kao zamjene za gorivo je u stalnom porastu u cementnim industrijama Europske Unije. Naime, postotak zamjene fosilnih goriva različitim vrstama zamjenskih goriva u nekim primjerima iz Europe doseže čak i preko 80%.

Brojne su koristi koje se ostvaruju korištenjem goriva iz otpada. Pored smanjenja količine otpada koja se odlaže na odlagalištima, vrši se smanjenje troškova energije kao i emisija stakleničkih plinova. Međutim, najvažnija korist jeste smanjenje udjela korištenja fosilnih goriva, tj. neobnovljivih prirodnih resursa. U tabeli 3 su dati primjeri vrsta otpada koje se mogu koristiti kao gorivo.

Table 2. *Necessary properties of heavy oil*

Property	Value
Lower heating value	40,193 MJ/kg
Content of sulfur	max 1%
Max. burning temp.	150°C
Viscosity at 100°C	10 do 30 mm^2/s
Content of ash	max 1%
Max. content of water	2 %

On the other hand, emissions of CO_2 are higher when this fuel is used, than emissions which appear when coal is used. For those reasons, heavy oil is used as auxiliary fuel in Cement factory in Kakanj, nowadays.

3. USE OF ALTERNATIVE FUELS IN 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.

Tabela 3. *Vrste otpada kao alternativno gorivo*

Čvrsto (80%)	Tečno (20%)
Komunalni otpad (RDF)	Katran
Stari papir	Otpadne kiseline
Tekstilni otpad	Staro ulje (maziva)
Tepisi	Petrokemijski otpad
Plastični otpad	Otpadni rastvarači
Guma	Kemijski otpad
Stare automobilske gume	Otpadne boje (lakovi)
Otpadno drvo	Otpadni destilati
Kanalizacijski mulj	Voštane suspenzije
Koštano brašno	Asfaltni mulj

Table 3. *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. Alternativno gorivo iz otpada – RDF

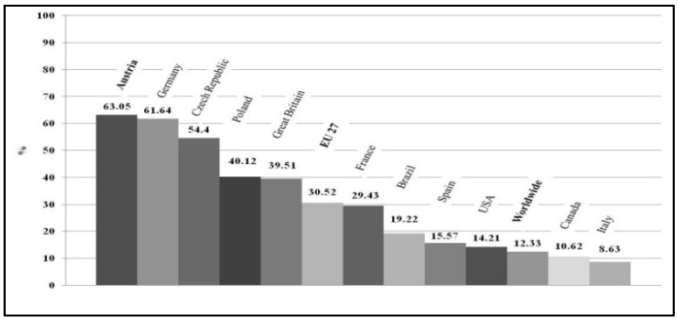
Različite vrste otpada kao što su: miješani komunalni otpad, glomazni otpad, te ostali neopasni otpad se mogu obraditi u postrojenjima za mehaničko biološku obradu otpada te proizvoditi RDF (Refuse Derived Fuel). Gorivo iz otpada ili RDF je vrsta goriva koje se dobiva obradom otpada, tj. usitnjavanjem, odvajanjem metala, kamenja, PVC plastike itd. (NEEE! To je obnovljivo gorivo!!!, Hd je druga stvar. Ako ste na to mislili?!)). Koristi se kao alternativni energent za proizvodnju energije i kao takav zadovoljava kriterije propisane europskim normama CEN TC Solid Recovered Fuels (SRF). Najvažniji parametri koji određuju kvalitet goriva iz otpada su energetska vrijednost i sadržaj hlora i teških metala.

Korištenje RDF-a u cementnoj industriji se smatra sastavnicom „Best Available Technique“ („Najboljom raspoloživom tehnikom“) prema podacima EUROSTAT-a. Naime, u europskoj cementnoj industriji, prosječna stopa zamjene fosilnih goriva primjenom RDF-a iznosila je 30% u 2010. godini. U pojedinim zemljama, procenat prelazi i 60% kao što je prikazano na slici 1

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.



Slika 1. *Upotreba RDF-a u zemljama svijeta*
Figure 1. *Use of RDF in countries of the world*

Postupak korištenja otpada kao alternativnog goriva je siguran način valoriziranja otpada koji može donijeti dobit i društvenoj zajednici i cementnoj industriji. Naime, visoka temperatura koja se ostvaruje u procesu u rotacionoj peći (1450°C) i dug proces sagorijevanja osigurava kompletnu destrukciju svih organskih komponenti. S druge strane, neorganske komponente se vežu za sirovinu, te izlaze iz procesa kao dio klinkera.

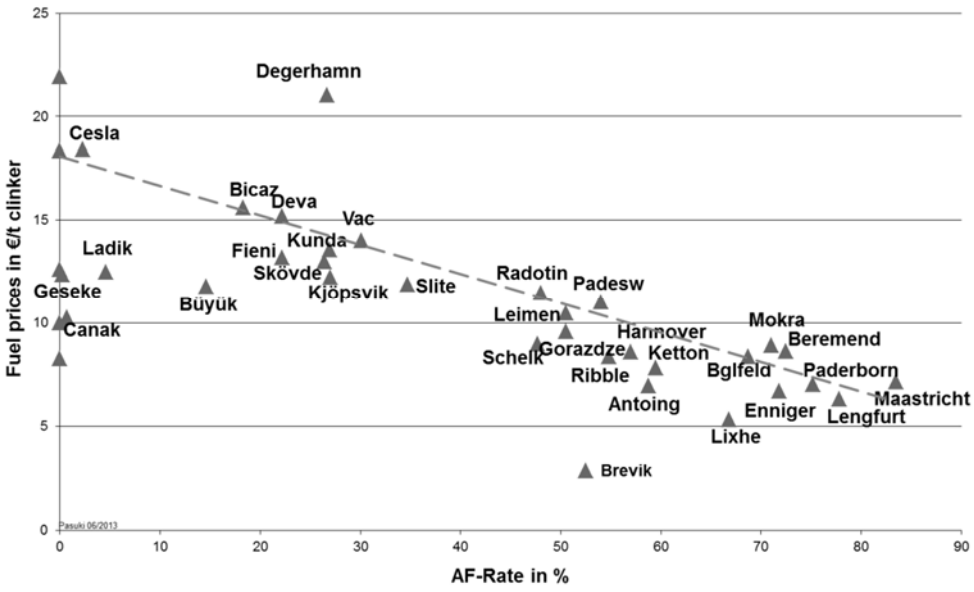
Količine i sastav emisija koje se javljaju prilikom procesa sagorijevanja pri proizvodnji klinkera zavise od sirovina, goriva kao i tehnologije procesa. Istraživanja su pokazala da neće doći do porasta emisija u zrak ako se ova alternativna goriva koriste u kontroliranom procesu, koji je u skladu sa EU direktivama i na visokim temperaturama sagorijevanja.

Pored toga što se ostvaruje ušteda neobnovljivih energetskih resursa, korištenjem RDF-a kao zamjene za gorivo, ostvaruje se značajno smanjenje troškova u cementnim industrijama. Na sljedećem dijagramu prikazani su troškovi energije iz 2012. godine u € po toni proizvedenog klinkera u zavisnosti od stepena primjene alternativnih goriva, u nekim tvornicama Heidelbergcement grupacije.

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.

Saving of non-renewable energy sources and reducing of costs are achieved by using RDF as alternative for fuels in cement industry. On next diagram 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.



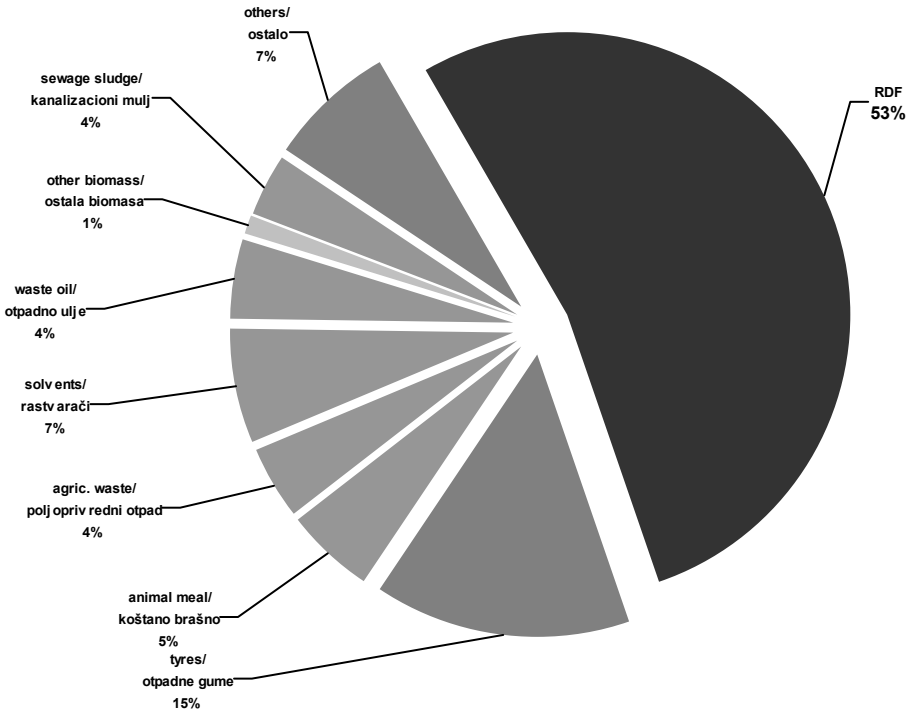
Slika 2. *Troškovi energije (€/t klinkera) u zavisnosti od stepena primjene alternativnih goriva (AF-Rate) u nekim tvornicama HC u 2012. godini*

Figure 2. *Troškovi energije (€/t klinkera) u zavisnosti od stepena primjene alternativnih goriva u nekim tvornicama HC u 2012. godini*

Kao što se može vidjeti iz dijagrama Tvornica cementa u Leimen-u (Njemačka) je imala udio alternativnih goriva oko 50%, te ukupne troškove energije oko 10 €/t. S druge strane, prema podacima iz HC grupacije, fabrike cementa u Rustavi-u (Gruzija) i Kaspi-u (Gruzija), koje te godine nisu upotrebljavale alternativna goriva, imale su troškove od 32,61€/t i 28,93€/t, respektivno.
Prednosti upotrebe RDF-a kao alternativnog goriva dokazuje i činjenica da ovaj energent u fabrikama Heidelbergcement grupacije 2014. godine zauzimao više od polovine ukupnog učešća u odnosu na ostale vrste alternativnih goriva.

As it is shown in diagram, 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



Slika 3. *Udio pojedinih vrsta alternativnih goriva na nivou HeidelbergCement Grupacije u 2014. godini*
Figure 3. *Share of individual alternative fuels in HeidelbergCement Group in 2014.*

Gorivo bolje kvalitete, koje se dobiva iz sitnijeg otpada i kao takvo ima manju krupnoću zrna - komadića se naziva Solid Recovered Fuel ili kraće SRF. Promjer zrna ovog goriva je do 25 mm. U većini slučajeva, sastav RDF-a i SRF-a je isti, s tim što RDF ima znatno veći promjer (do 50 mm). Mogući sastav RDF- a/SRF-a koje bi se moglo koristiti u cementnoj industriji je:

- drvo 5 – 10 %
- papir 5 – 10 %

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:

- wood 5 – 10 %
- paper 5 – 10 %

- plastika bez Cl 60 – 70%
- guma 5 – 8 %
- tekstil 5 – 10%
- ostalo ispod 5%.

U sljedećoj tabeli je dat prikaz potrebnih mehaničko – hemijskih karakteristika SFR/RDF goriva.

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

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

Tabela 4. *Klase goriva iz otpada*
Table 4. *Classes of fuels from waste*

Svojstva RDF-a/SRF-a Properties of RDF/SRF	Vrijednost/Value
Kalorijska vrijednost/ Caloric value	20MJ/kg
Gustina u rasutom stanju/ Density of bulk	ispod/under 240 kg/m^3
Sadržaj pepela/Content of ash	ispod/under 15%
Sadržaj vlage/Content of humidity	ispod/under 15%
Sadržaj hlora/Content of chlorine	ispod/under 1%
Sadržaj kadmija/Content of cadmium	ispod/under 6 mg/kg u suhom stanju/at dry state
Sadržaj žive/Content of mercury	ispod/under 1 mg/kg u suhom stanju/at dry state
Sadržaj sumpora/Content of sulphur	ispod/under 0,5 mg/kg u suhom stanju/at dry state

Na kvalitet goriva iz otpada značajno utiče sadržaj vlage, tj. što je sadržaj manji, gorivo ima bolji kvalitet.

Proizvodnja RDF/SRF goriva iz neopasnog otpada je rastuća industrija u Evropi. Ovo gorivo se pored upotrebe u cementnim pećima može koristiti i kao gorivo za energane, za industrijske kotlove, zajedno sa ugljenom u elektranama itd. MBO?? tehnologija proizvodnje ovakvih vrsta goriva se iz Njemačke proširila i u ostale europske zemlje. Poznato je da je u Europi instalirano više od 70 MBO (akronim – pojasniti!) postrojenja [4]. To dovodi do zaključka da se primjenom ove vrste goriva javlja potreba za njegovom proizvodnjom iste i otvara mogućnost dodatnog razvoja lokalne privrede, što je još jedna od prednosti upotrebe RDF-a.

3.2. Otpadne gume kao alternativno gorivo u cementnoj industriji

Gume se klasifikuju kao visoko-energetski materijali. Naime, prosječna toplotna moć gume je 24-26 MJ/kg, što je značajno imajući u vidu da su prosječne toplotne moći komunalnog smeća 8,1 MJ/kg, lignita 16,2MJ/kg, novinskog

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-coke,

papira 17,2MJ/kg, drvene piljevine 18,4MJ/kg, kamenog uglja 28MJ/kg, petrol-koksa 32MJ/kg, benzina 35,4MJ/kg i lož-ulja do 41,8MJ/kg.
Prema tome, visoka toplotna moć gume, kao i činjenica da pneumatik sadrži 20-30% prirodne gume (biomasa) pa svojim sagorijevanjem ne zagađuje životnu sredinu emisijom CO_2, dovode do primjene starih guma kao alternativnog ili osnovnog energenta u industrijskim energanama, pećima za kreč ili cement. Ispitivanja su pokazala da se uz pravilnu upotrebu odgovarajućih gorionika i podešeno sagorijevanje, bez ikakvih štetnih uticaja na sam tehnološki proces i bez ugrožavanja životne sredine produktima sagorijevanja, otpadne gume (usitnjene ili cijele) mogu biti korištene kao dodatni energent [2]. Navedeno je posebno važno za cementnu industriju. Guma u pećima za proizvodnju klinkera sagorijeva na temperaturi od 1450°C, pri čemu se ostvaruje dovoljno zadržavanje gasova da bi organski polutanti u potpunosti sagorjeli.

gasoline and light destillate 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_2, 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.

Slika 4. *Pripremljene stare gume za upotrebu u rotacionoj peći*
Figure 4*. Prepared old tires for use in rotary kiln*

Gasoviti produkti sagorijevanja ostaju u granicama propisanih standarda, dok čvrsti

Gaseous products of combustion are in boundaries which are assigned by standards.

ostaju ugrađeni u cementnom klinkeru, (analogno upotrebi RDF-a), u vidu silikata ili oksida. Upotreba otpadnih guma kao alternativnog goriva u ovom procesu rezultira smanjenjem ukupnih emisija u atmosferu i to iz dva razloga. Prvo, raspadanjem guma na deponijama nastaje metan koji ima 20 puta nepovoljniji učinak na efekat staklenika od CO_2, koji nastaje izgaranjem. Drugi razlog je to što se spaljivanjem guma radi dobivanja korisne energije stvaraju emisije koje su dio emisija koje bi svakako nastale. Jedna od najvažnijih prednosti upotrebe starih guma kao alternativnog goriva jeste očuvanje okoliša, tj. eliminacija starih guma koje se više ne mogu upotrijebiti ni u jednu drugu svrhu. Tu se fokus može postaviti na stanje u Bosni i Hercegovini i spaljivanje guma u Tvornici cementa u Kaknju. Prema dostupnim podacima, u ovoj fabrici je za proizvodnju jedne tone cementnog klinkera potrebno oko 3,2GJ toplotne energije. To znači da bi se zamjenom 15% uglja otpadnim gumama, potrošilo 33 tone starih guma dnevno, odnosno 10 hiljada t godišnje. Naime, u Planu upravljanja otpadom ZDK naveden je podatak da je na osnovu CARDS Pilot projekta reciklaže u BiH 2004-2006, te istraživanja JP „Rad“ Sarajevo procijenjeno da u BiH nastane od 10 do 12 hiljada tona starih guma godišnje [5]. U ciljevima upravljanja otpadom, istog dokumenta navedeno je da se do 2011. trebalo iskoristiti 30% starih guma, do 2014. 60%, a do 2018. 90% starih guma bi trebalo da bude odgovarajuće zbrinuto . Tvornica cementa Kakanj ima ispunjene sve zakonske i tehničke uvjete kako bi se kao energent mogle iskoristiti sve stare gume koje se nalaze po divljim deponijama, deponijama vulkanizerskih radionica, te raznih privrednih subjekata. Ova fabrika je u sastavu multinacionalne Heidelbergcement Grupacije koja ima ogromna iskustva u upotrebi alternativnih goriva širom svijeta. Ozbiljnost ove kompanije dokazuje činjenica da je Heidelbergcement članica WBCSD (World Business Council for Sustainable Development). U Tvornici cementa u Kaknju je od 2015. godine zastupljena upotreba guma kao alternativnog goriva procentualno 1,2% u odnosu na ukupnu upotrebu goriva. Ova praksa je već u prvih šest mjeseci pokazala odlične rezultate. Naime, od januara do septembra 2016. godine u Tvornici cementa u Kaknju je spaljeno ukupno 761 tona starih guma.

Ova manja količina guma koje su upotrijebljene zajedno sa primarnim gorivom – ugljem je

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 $C0_2$ 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 Herzegovina 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 Herzegovina. That data is confirmed by CARDS pilot project of recycling in Bosnia and Herzegovina 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.

donijela značajne novčane uštede. S druge strane, smanjile su se količine starih guma na odlagalištima. Gume se u Tvornicu cementa u Kaknju dostavljaju preko vanjskih dobavljača koji iste skupljaju, transportuju, te za to ostvaruju određenu naknadu. To s jedne strane ima koristi u tome što se ostvaruje čišćenje okoliša od zagađenja izazvanog starim gumama i svim popratnim efektima, a s druge strane, stvara se mogućnost razvoja lokalnog biznisa po pitanju skupljanja i transportovanja guma do fabrike.

Analize su pokazale da kada bi se u Tvornici cementa u Kaknju primijenila upotreba od 10% guma ili 20% RDF/SRF goriva kao alternativnog goriva, ostvarilo bi se smanjenje potrošnje uglja u iznosu od 12000t/godišnje. Emisije bi također bile reducirane. Tako bi se emisija CO_2 smanjila za oko 45000t na godišnjem nivou proizvodnje od 500000t cementa. Ostvarilo bi se i smanjenje emisija NO_x. Pored navedenog, rezultati analize su pokazali da bi se ostvarilo smanjenje smeća na odlagalištima za oko 16000t godišnje.

4. ZAKLJUČAK

Nakon svih izloženih činjenica u ovom radu, zaključuje se da je koncept upotrebe alternativnih goriva u cementnoj industriji višestruko koristan . Naime, po pitanju zaštite životne sredine, analize su pokazale da se upotrebom RDF/ SRF goriva deriviranog iz komunalnog otpada ili upotrebom starih guma kao goriva smanjuju emisije štetnih plinova u odnosu na upotrebu fosilnih goriva, a s druge strane životna sredina se na ovaj način čisti od otpada . Posmatrajući sa aspekta razvoja društvene zajednice, potreba za RDF/SRF gorivom kao i starim gumama daje šansu za razvoj lokalne privrede. Stvara se mogućnost osnivanja fabrika koje bi proizvodile RDF/SRF gorivo za potrebe cementne industrije, kao i motivacija svake kompanije koja u svom poslovanju manipuliše većom količinom guma da neupotrebljive gume ne odlaže na deponije nego dostavlja cementarama. Prema tome, količine otpada na deponijama bi se znatno smanjile. Konačno, ovaj koncept ostvaruje uštede neobnovljivih izvora energije,tj. fosilnih goriva, koja su ranije bila primarno gorivo u cementnoj industriji. Rezultati istraživanja pokazuju da je društvo razvijenih zemalja svijeta svjesno koristi upotrebe alternativnih goriva, te da je trend njihove upotrebe u cementnoj industriji rastući.

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_2 would be reduced in amount of 45000 t annually for production of 500000t of cement. Emissions of NO_x would also decrease. Additionally, results of analysis showed that it would be reduction of waste on dumps in amount of 16000t per year.

4. CONSLUSION

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.

5.LITERATURA - REFERENCES

[1] Bajtarević A.: *Otpadne gume kao alternativno gorivo u cementnoj industriji*, Međunarodna konferencija o upravljanju opasnim i neopasnim otpadnom u regiji, Zenica, 2010.

[2] Stanojević D., Rajković M., Tošković D.: *Upravljanje korišćenim gumama, dometi u svetu i stanje u Srbiji,* Savez hemijskih inženjera Srbije, Beograd, 2011.

[3] Elaborat o opravdanosti zamjene mazuta sa ekstra lakim uljem kao rezervnim gorivom na rotacionoj peći u TC Kakanj, Zenica, 2009.

[4] Skoko D.: *Osvrt na koncepte MBO i biološkog reaktora za odlagalište otpada,* HAAS INŽINJERING, Đurđevac, 2005.

[5] Plan upravljanja otpadom na području ZDK, 2008.

[6] Bajtarević A.: *Cement factory and sustainable development*, 5th International Scientific Conference Environmental and Material Flow Management, Zenica, 2015.

Coresponding author:
Almir Bajtarević
Tvornica cementa Kakanj d.d. Kakanj
HEIDELBERGCEMENT GROUP,
Selima ef. Merdanovića 146, Kakanj
Email:
almir.bajtarevic@heidelbergcement.com
Phone: +387 61 180 391