REDUCTION OF COAL DUST CONCENTRATION IN THE AIR BY USING RENEWABLE RESOURCES AS DUST SUPPRESSANTS

OGĻU PUTEKĻU KONCENTRĀCIJAS GAISĀ SAMAZINĀŠANA, IZMANTOJOT ATJAUNOJAMOS DABAS RESURSUS KĀ PUTEKĻU APSLĀPĒTĀJUS

E. Dāce, S. Valtere

Keywords: biopolymers, by-products, coal dust, dust suppression, renewable natural resources

Introduction

Latvia is a transit country – there are three major ports, which are mainly involved in processing transit freight – around 80 % of the transit freight transported through Latvia is handled through these ports, including coal. Since 1996 the total amount of coal handled in the ports of Latvia has gradually increased reaching 18 321.5 thsnd.t in 2008 [1]. Moreover, Latvia has a number of boiler houses, which are powered by coal, not to mention a coal-fired power plant planned in Liepaja [2]. Therefore there are reasonable grounds to believe that the amount of coal shipped through Latvia will only increase in the coming years.

Depending on the coal's mechanical properties, dust is often created during handling operations. When the coal dust is carried away by the wind, this is not only an economical loss, but can cause serious damage to the surrounding environment and its inhabitants. That kind of dust is a nuisance that can cause health and safety problems to coal terminal workers and to residents living in nearby houses. Moreover, dust can cause damage to coal handling equipment. All of these problems are the reason why air quality legislation concerning solid particles gets more and more stringent in the European Union and in Latvia [3].

There have been several methods developed in order to prevent coal dusting. In coal dust suppression by employing spray-on method different chemicals are used world-wide that are mostly composed of nonrenewable natural resources, besides their impact on the surrounding environment is often unknown. Whereas water sprays that are used in Latvia are effective only in short-time period, therefore regular re-application is required, which lowers the coal value [4,5].

Considering the above statements, the basic purpose of the study – the development of an innovative coal dust suppressant that would be suitable for Latvian conditions – is resolved by providing utilization of renewable resource stocks, which occurred as an existing production process byproduct and require no additional resources, in coal dust suppression by sprinkling techniques.

Due to non-renewable resource depletion, as well as the related pollution during their extraction and processing, an increasing interest has occurred in world practice associated with alternatives utilized as resources in various sectors, particularly in production of energy, and various polymers and plastics. Moreover nowadays there is an increasing pressure for wider use of renewables promptly in production of speciality goods [6,7].

Biopolymers are renewable resource produced by living organisms. Before depositing, composting or burning biopolymers which are a by-product of some kind of existing production process, they may be used for production of new materials or different kinds of products'. For these reasons, there is a need to look for more and more new and economically sound uses of biopolymers and their derivatives, in order to effectively utilize existing, and save future, natural resources.

There are great stocks of renewable resources around the world and in Latvia, which have occurred as a by-product of an existing production process and which, without

additional supply of resources, can be used for coal dust suppression by sprinkling techniques. By using an agent, made of biopolymers, secondary natural resources would be used instead of burning or depositing them in landfills. Moreover, depleting primary nonrenewable resources and energy needed for their extraction would be saved and related emissions into the environment would be prevented. Thus, the problems related to coal dust emissions would be reduced.

Materials and methods

Within the study process, three different innovative coal dust suppressants that would be suitable for Latvian conditions were developed. Besides that, the developed dust suppressants fulfill the factor of being renewable natural resources that have occurred as a byproduct from an existing production process (biopolymer mix).

Several experiments were carried out in a laboratory in order to evaluate the proposed biopolymers in coal dust suppression. For this purpose a test rig was built, where the simulation of blowing wind affecting coal pile occurred (Fig. 1).

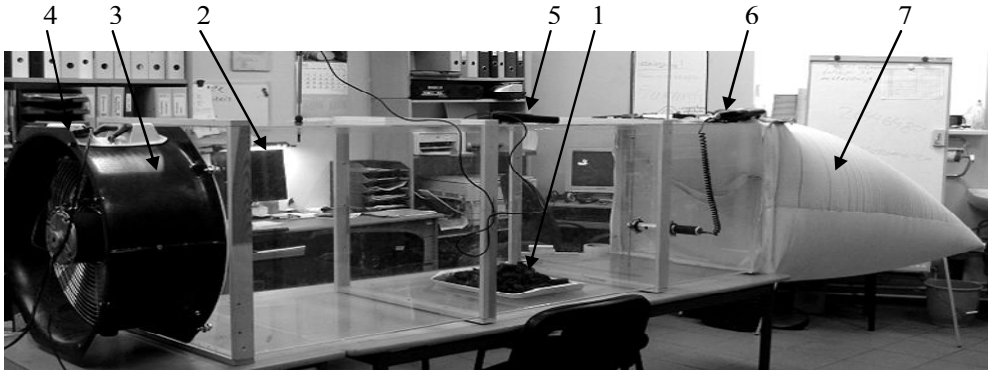

Fig.1. The test rig with coal pile inside its channel affected by a simulated blast of wind
1 – coal sample, 2 – channel, 3 – fan, 4 – tachometer, 5 – thermal anemometer, 6 – aerosol photometer, 7 – filter

For experimental purposes, a Class D air-dry bituminous hard coal was taken. The coal was broken in mills and then fractioned through sieves, resulting in five different sizes of particulate matter:

- >2 mm,
- >1.4 mm,
- >0.5 mm,
- >0.25 mm, and
- ≤0.25 mm.

The fractioned solid particles were apportioned in Petri dishes and sprayed with water or developed dust suppression agents. There were different concentrations of provided agents taken:

- 45 % biopolymer mix A,
- 22.5 % biopolymer mix A,
- 50 % biopolymer mix B,
- 17 % biopolymer mix B,
- 50 % biopolymer mix C,
- 17 % biopolymer mix C.

After spraying all of the prepared samples, they were left to desiccate at room temperature for 24 hours (water, biopolymer mixes A and B) and 5 hours (biopolymer mix C). After desiccation, a mass loss of the samples was observed in the amount of 4 to 7 % as compared with the original mass after spraying. Samples sprayed with water were left to desiccate for 48 hours and during this period of time, water had evaporated in the range of 90 – 100 %.

The prepared samples (1) were inserted in a channel of the test rig (2) and exposed to a wind stream at three different average velocities:

- 1.16 m/s,
- 3.84 m/s, and
- 4.40 m/s.

The wind was created by a fan (3) the rotation speed of which was set and measured with a tachometer (4). The average wind speed was estimated by taking measurements with a thermal anemometer (5). The amount of particulate matter, which was carried away from the coal sample during the experiment, was estimated by using an aerosol photometer (6), which measures particulate concentrations. There was a filter (7) placed at the far end of the channel of the test bench to collect the carried away dust.
Each experiment lasted 1 minute.
Before and after the experiment, each of the samples was weighed to determine the mass loss. All of the acquired data were processed in MS Excel program creating the diagrams where the results are presented.

Results and discussion

Dust is often created during coal handling operations. When dust is carried away by the wind, it is not only an economical loss, but can cause serious damage to the surrounding environment and its inhabitants. To prevent these problems, a number of different dust control systems have been developed, including wind control, wet suppression systems, chemical binders, sealants, enclosures etc. [8]. Most of the existing systems are economically ineffective and mostly use non-renewable resources that can cause even more damage to the environment.
Therefore three different mixes of biopolymers which are able to perform the function of coal dust suppression have been developed. All of the developed dust suppression agents meet the following demands:

- Based on renewable natural resources, that have occurred as a waste product of existing industrial process,
- Meet requirements regarded to health, safety and the environment,
- Economically effective,
- Suited to Latvia meeting both weather conditions (high air humidity and low temperatures in winter) and accessibility.

In the experiment different fractions of treated coal were exposed to wind effects, obtaining interesting results, which are reflected in the diagrams below (Fig 2).

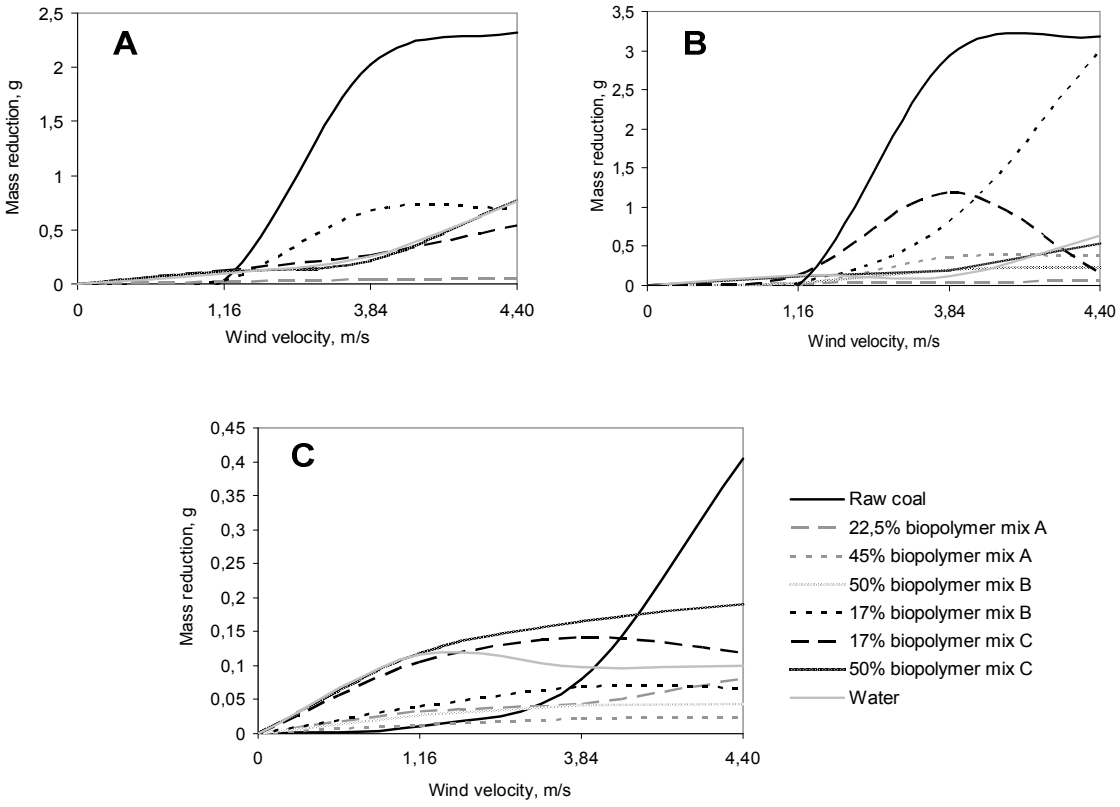

Fig. 2. Mass reduction of the treated samples, depending on wind velocity:
A – coal fraction <0.25 mm; B – coal fraction >0.25 mm; C – coal fraction >0.5 mm

Figure 2 shows significant variations in mass reduction. As expected, the greatest mass reduction is observed in the samples of raw coal, whereas the lowest – in the samples treated with biopolymer mix A. This indicates that the biopolymer mix A has been effective in dust suppressing preventing coal dust escape from the samples. However the diagrams shown in Figure 2 do not show a total view of the effectiveness in coal dust suppression of each individual agent used in the experiment (for example, in the first case (Fig.2.A) at wind velocity 1.16 m/s 17 % biopolymer mix B is just as effective as 22.5 % biopolymer mix A, whereas at 3.84 m/s it presents the worst results). For this reason, an assessment of each experimentally-tested agent was conducted. All of the presented results by the tested agents were evaluated using a point system from 1 to 7 – where the agent showing the highest efficiency at a given wind velocity received 1 point, while the agent with the lowest efficiency – 7 points. Consequently, the lesser the number of points – the more effective the dust suppressant. Aggregating the resulting number of points for each of the agents and dividing it by the regulated wind velocity numbers during experiment, i.e. 3, the average efficiency score of each agent was obtained (Fig. 3).

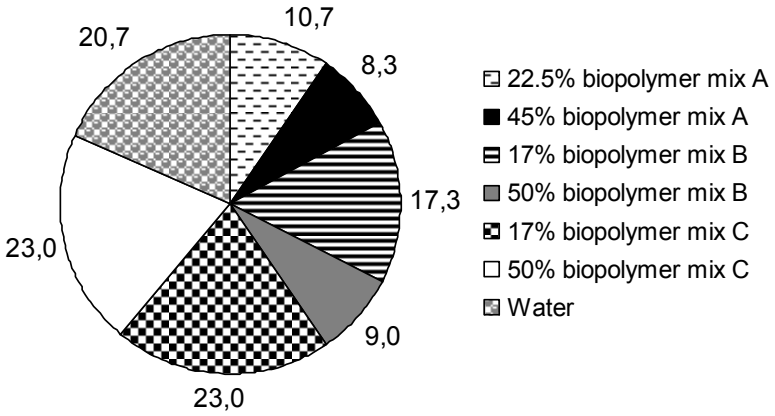

Fig. 3. Assessment of the effectiveness of experimentally-tested biopolymers in coal dust suppression

Figure 3 shows that in coal dust suppression the most effective agent of those experimentally tested is the 45% biopolymer mix A, however high efficiency is also shown by the 22.5% biopolymer mix A and the 50% biopolymer mix B.

Since the biopolymer mix A showed comparatively high results in coal dust suppression experiments in one day after samples were sprayed, it was decided to perform additional measurements of mass reduction of the same samples after 12 days since samples were sprayed. There were measurements of mass reduction induced by wind made for samples sprayed with water after 48 hours. During this period of time, water had evaporated in the amount of 90 – 100%. On the contrary samples sprayed with 22.5% biopolymer mix A in the period of 12 days had lost around 4.5 – 6.5% of initial agent mass, but 45% biopolymer mix A – only around 1.8 – 4.4%.

Performing these experiments results shown in Figure 4 were obtained.

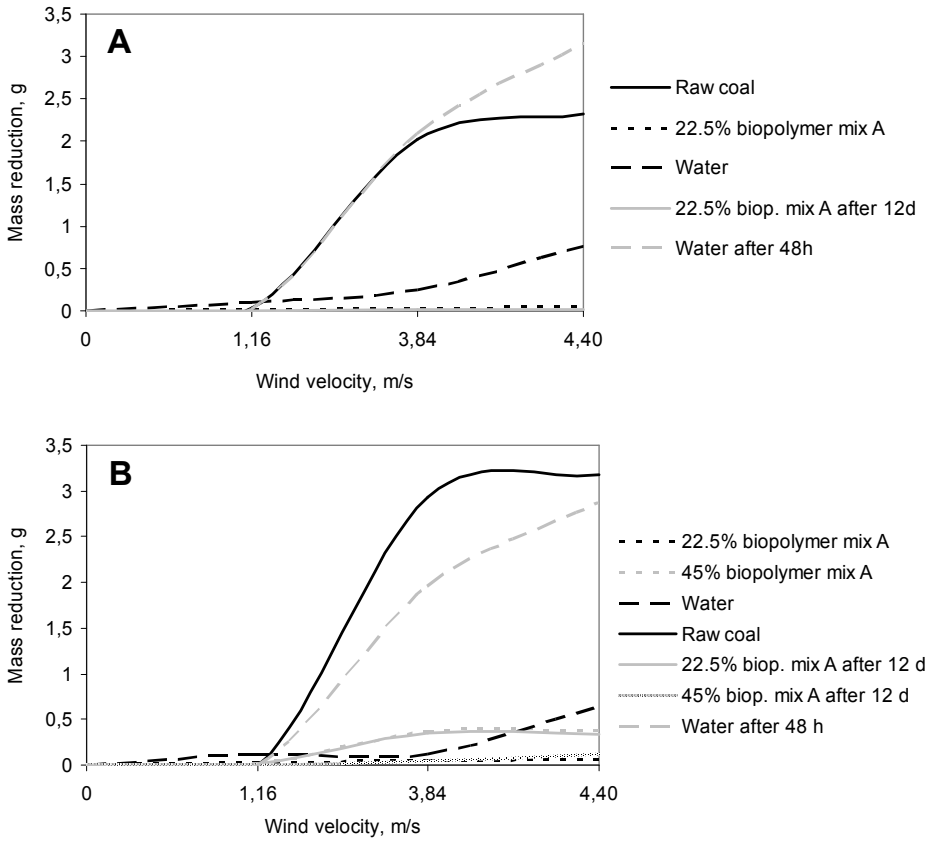

Fig. 4. Wind-induced mass reduction of the treated samples after a period of time:
A – coal fraction <0.25 mm; B – coal fraction >0.25 mm

As shown in Figure 4, water has lost its dust suppression abilities after 2 days already, whereas the biopolymer mix A has retained its effectiveness also after 12 days.

Conclusions

In this study, experimental tests of three innovative coal dust suppressing agents were performed obtaining interesting results. Despite that these results can not be absolute confirmation of one or another agent's effectiveness, since it is largely determined by environmental and meteorological conditions, and mechanical properties of coal, and other factors. However, initial findings have been made in respect to dust suppression of air-dry Class D bituminous hard coal at room temperature. In these particular circumstances the best dust suppression performance was shown by biopolymer mix A, however it is necessary to carry out further studies and experimental tests to determine what concentrations, and in what quantities, should be applied to achieve the maximum effect. A study should also be made on this agent's persistence in rainy weather. At the same time, the developed agents should be tested in suppressing dust of other bulk materials, like sawdust and gravel. There should also be tests on other such production by-products, which can be used in dust suppression.

In any case, in Latvia the first step in solving problems caused by coal dusting using the spray-on techniques, has been taken. It is obvious that this study has to be continued, as in Latvia this is a prospective field of research in which to work.

References

1. Cargo turnover in ports of Latvia 1996 – 2008 / http://www.transport.lv/doc_upl/latvia_12eng.pdf - 10.06.2009.

2. Lēvalde V. Gerhards sliecas ogļu stacijas projektu realizēt Liepājā // Dienas Bizness – (2008., 9.aprīlis) / http://www.db.lv/Default2.aspx?ArticleID=b8f655e0-35bc-4487-925c-650a5b4e3084&ref=rss – [12.06.2009.]

3. Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe // Official Journal of the European Union – L 152/1 (June 11, 2008)

4. Nicol S.K., Smitham J.B. Coal Stockpile Dust Control // 1990 International Coal Engineering Conference: Preprints of Papers – Barton, Australia, 1990. – 154 – 158 p.

5. Drbal L.F., Boston P.G., Westra K.L. Power Plant Engineering, Black&Veatch – Kansas, Missouri, USA: Springer, 1995. – 858 p.

6. Scott G. Degradable Polymers: Principles and Applications. – New York City, USA: Springer, 2002. – 493 p.

7. Smith R. Biodegradable polymers for industrial applications – Cambridge, England: Woodhead Publishing Limited, 2005. – 531 p.

8. Carpenter A.M., Porter D., Scott D.H., Walker S., Transport, storage and handling of coal – International Energy Agency: Clean Coal Centre, 2003. – 139 p.

E. Dāce, M. sc. ing.,
Institute of Environment and Energy Systems, Faculty of Energy and Electrical Engineering, Riga Technical University
Address: Kronvalda blvd. 1, Riga, LV 1010, Latvia
Phone: 371 67089923, 371 67089908,
Fax: 371 67089908
e-mail: elina.dace@rtu.lv

S. Valtere, Dr. sc. chem.
Institute of Environment and Energy Systems, Faculty of Energy and Electrical Engineering, Riga Technical University
Address: Kronvalda blvd. 1, Riga, LV 1010, Latvia
Phone: 371 67089908,
Fax: 371 67089908
e-mail: svaltere@latnet.lv

Elīna Dāce, Sarma Valtere, Ogļu putekļu koncentrācijas gaisā samazināšana, izmantojot atjaunojamos dabas resursus kā putekļu apslāpētājus

Pētījumam tiek izvirzīts sekojošs mērķis – rast inovatīvu ogļu putekļus aizturošu līdzekli, kas atbilst sekojošiem nosacījumiem:

- *tā pamatā ir atjaunojamie dabas resursi, kas radušies kā kāda esoša ražošanas procesa blakus produkts;*
- *tas ir nekaitīgs veselībai un draudzīgs videi;*
- *tas ir ekonomiski izdevīgs;*
- *to izmantojot, netiek pazemināta apstrādāto ogļu siltumietilpība un netiek radīti iekārtu un aprīkojuma bojājumi;*
- *tas ir piemērots Latvijai gan laika apstākļu, gan pieejamības ziņā.*

Pētījuma gaitā izvirzītais mērķis tiek sasniegts, kā arī tiek veikti piedāvāto ogļu putekļu apslāpēšanas līdzekļu eksperimentālie izmēģinājumi, kuru gaitā tiek iegūti rezultāti, kas parāda, ka analizētos līdzekļus ar labiem panākumiem iespējams izmantot ogļu putekļu apslāpēšanā. Iegūtie rezultāti arī parāda, ka nepieciešami papildu izmēģinājumi, nosakot koncentrācijas un daudzumus maksimālā ogļu putekļu apslāpēšanas efekta sasniegšanai.

Elina Dace, Sarma Valtere, Reduction of coal dust concentration in the air by using renewable resources as dust suppressants

The aim of the study is to develop an innovative coal dust suppression agent which meets the following demands:

- *Based on renewable natural resources, that have occurred as a waste product of existing industrial process,*
- *Meets requirements regarded to health, safety and environment,*
- *Is economically effective,*
- *Has no adverse effects on coal quality or plant and machinery,*
- *Suited to Latvia meeting both weather conditions and accessibility.*

The aim of the study has been reached. During the study the developed suppression agents have been experimentally tested, gaining results which show that the agents analyzed may be used successfully as coal dust suppressants. The results show as well

necessity of additional experiments where concentrations and quantities of agents would be determined to reach the maximum effect.

Елина Даце, Сарма Валтере, Уменьшение коцентрации угольной пыли в воздухе использоя возобновляемые ресурсы

Цель работы – предложить иновационное вещество, сдерживающее угольную пыль и соответствующее следующим условиям:

- *основой вещества должны быть возобновляемые природные ресурсы, полученные как побочные продукты другого производственного процесса;*
- *вещество не должно наносить вреда здоровью человека и должно быть безвредно к окружающей среде;*
- *вещество должно быть экономически* выгодное*;*
- *используемое вещество не должно уменьшать теплоёмкость угля, а также портить оборудование;*
- *вещество должно быть адаптировано климатическим условиям Латвии и должно быть доступным.*

В ходе исследования поставленная цель была достигнута, а также были проведены экспериментальные испытания со средством подавления угольной пыли. Полученные результаты в ходе экспериментов свидетельствуют о том, что анализированные средства с хорошими результатами могут быть использованы для подавления угольной пыли. Полученные результаты также свидетельствуют о том, что необходимы дополнительные испытания для определения концентрации и количества изучаемого средства с целью достижения максимального эффекта подавления угольной пыли.