BIO-FUELS AS A SOLUTION OF REDUCTION OF EMISSION LOAD FROM TRANSPORT

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Summary: Acid rain, disturbed ozone layer, danger of global warning and also risk of respiratory and cardiovascular diseases and other aspects of air pollution are results of emissions from power engineering, industry and transport. The article is focused on air pollution by air pollutants from transport and influence of these emissions on environment and also possibilities of reduction of their production. Possible solution of increasing concentration of polluting matters in the air is to substitute the fossil engine fuels for bio-fuels.

Key words: emissions, polluting matters, bio-fuels, bio-oil, bio-ethanol

1. INTRODUCTION

More often we can hear or read about global warming of the Earth, greenhouse effect, and necessity to cut greenhouse gasses, which would adversely affect atmosphere of our planet and by that also climatic changes mainly carbon dioxide. Even if there is much information from media and technical literature, it is not possible to get unique answer to obscurity about climatic changes. But one thing is certain and that is increasing power consumption in the world and because the most of energy is gained by direct combustion of fossil fuels, more dangerous and deleterious matters than carbon dioxide are emitting into air.

2. POLLUTING MATTERS RISING WHILE TRANSPORT AND THEIR INFLUENCE ON ENVIRONMENT

Air transport and mainly increasing automobile conveyance have big part in worse air quality besides of emissions from power engineering and industry. Particles rising in transport contain gross and fine fractions.

2.1. Particles of gross fraction

Gross fractions of particles rise mainly as a result of mechanic abrasive of surfaces, as abrasion of roadways surfaces, tires, brake disks or continuous swirling of particles on deposit onto road surface as a result of sinuous flow caused by previous vehicles and air flow behavior. Gross fractions of particles can rise also in oil

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combustion when soot is emitted into the air. Creation of these particles is connected with insufficient fuel combustion with its surplus and oxygen absence.

2.2. Particles of fine fraction

Fine fraction of particles rise mainly directly in combustion space and they contain organic, inorganic particles and soot. Organic particles are mainly the result of faulty fuel combustion and perhaps even lubricants. Inorganic matters (metal) have connection with processes of mechanical wear inside of engine and also by impurities presence in fuel. Emissions from petrol engines are characterized by high concentrations of very small particles. Soot rising is connected with operation of diesel engines mainly of heavy trucks.

Besides of emissions of particles of fine and gross fraction are in exhaust gases also gaseous antecedents for secondary particles arise in the atmosphere. There belong NO_x which present one of the most significant pollutants of the air emitted by transport and they relate to ammonia nitrate which can present nearly one third of particles of fine fraction.

Size and structure of small parts as well as their emissions from combustion processes depend on fuel composition, combustion conditions (temperature, ratio of fuel and oxygen, persistence time, size of combustion space, speed of cooling) and from efficiency of emissions clearing. A part of particles of fine fraction rises by transformations of particles in the atmosphere. The most known example is exchange of gaseous sulfur dioxide (SO_2) and nitrogen oxide (NO_x) to sulphates and nitrates presenting sufficient share of ultra-fine suspended particles.

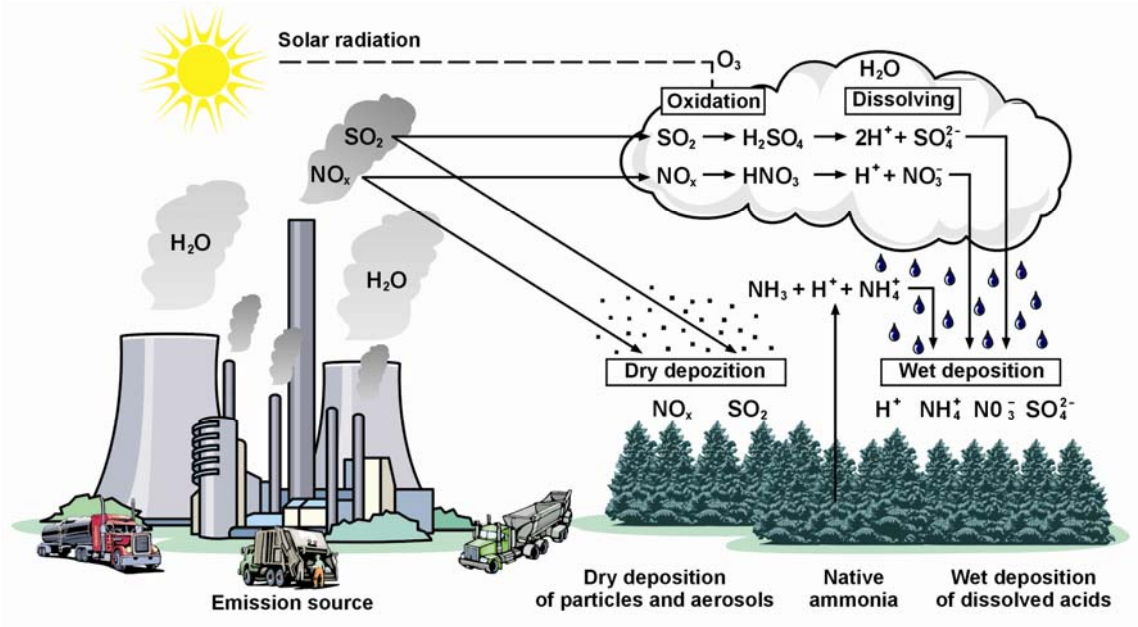
2.3. Falls of exhaust air pollutants on environment

Ill-effects in the atmosphere are subject to physical changes, they are spread in space by air flow and there is their dilution and they are washed out. There are chemical changes (fig. 1) caused by air particles, sun radiation and mutual reaction (synergy effect). For example salt can rise by reaction of alkalic dust with acid gas. Some matters oxidizes when origin others – more reactive substances and there is also disintegration of organic compounds.

The basic chemical activity in the air is oxidation where sulfur dioxide oxidizes to sulphur trioxide and ozone rises from oxygen. Aldehydes oxidize to organic acids, sulphan, methane, carbon monoxide and nitrogen dioxide are subject to oxidation, it is more important for ozone rise than sulfur dioxide. Also in low concentration of NO_2 in the air there can arise considerable amount of ozone. To NO_2 coming from burnt gas of automobile engines is given decisive part in so called oxidizing smog, which takes effect mainly at midday.

Smog is characterized as state of the air with lower visibility at high air pollution by industry air pollutants, burnt gases of motor vehicles and burnt gases of their

interact, which are featured by irritable effects to human organisms. In the morning hours at low temperatures and high humidity of air there can so called reductive smog appear, it is mixture of smoke, soot and sulfur dioxide and it acts on human health irritating breathing organs.



Source: [4]

Fig.1 – Creation of acid deposition

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Ozone is created as other product of oxidizing smog at ground layer by activity of sunlight to gaseous harmful substances as hydrocarbons, oxide of nitrogen and carbon monoxide emitted by exhaust gases of automobiles. Naturally ozone occurs in upper stratum of the atmosphere where it protects Earth's surface against harmful ultraviolet sun radiation. But by reason of higher production of exhaust gases it occurs in lower layers of the atmosphere in higher concentrations where it reacts toxically to vegetation, animals and also people.

3. POSSIBILITY OF REDUCING NOXIOUS AGENTS IN AIR USING BIO-FUELS

Particles of gross fraction emitting to air as a result of mechanic abrasion are maybe possible to reduce only by reduction of transport. Still particles of gross and

fine fraction as well as gaseous antecedents coming from combustion process in engine is possible to reduce by using gaseous but mainly liquid bio-fuels.

3.1. Gaseous and liquid bio-fuels

Gaseous and liquid bio-fuels are products of organic matters which are possible to gain by thermo-chemical (gasification, pyrolysis), bio-chemical (alcohol fermentation, methane fermentation) respectively chemical (esterification of raw vegetable oils) changes of biomass.

Wood gas and bio-gas

By gasification and pyrolysis of wood it is possible to gain wood gas with current rise of wood coal. Whole process proceeds in gaseous respectively pyrolysis reactor in the presence of small amount of air. The result of this process is a mixture of inflammable gases compounded from carbon monoxide (20 to 30 %), hydrogen (10 to 25 %), methane (0 to 4 %), carbon dioxide (2 to 15 %) and nitrogen (45 to 60 %).

Bio-gas rise in fermentation reactors as a result of anaerobic decomposition of organic mass. It is a mixture of gases where prevailing component is methane together with carbon dioxide.

Both gaseous fuels (wood gas and bio-gas) are possible to use in petrol and Diesel motors. However this requires alternations of engines. Even if these gases have, in comparison with diesel oil and petrol higher octane and they better mix with air, from the view of energetic content they do not reach level of earth gas (35 $MJ \cdot m^{-3}$). Energetic content of wood gas (5,6 $MJ \cdot m^{-3}$) is considerably lower than energetic content of bio-gas (21,6 $MJ \cdot m^{-3}$). From this reason mainly wood gas is not the most suitable fuel for engines of automobiles.

Bio-ethanol and bio-oil

Nowadays two types of bio-fuels are the most used as diesel oils and these are methyl-ester of fat acids marked as bio-oil and bio-ethanol (absolute alcohol).

Bio-oil is made from raw vegetable oil by process called preesterification. Absolute methanol reacts with oil in the presence of alkaline catalyser (NaOH, KOH). So called ester phase is gained by reaction, which unloads methanol and water by this methyl ester is gained. Raw glycerol and fat acids are gained after correction from the second so called glycerol phase. Even if it is possible to produce methyl esters from different vegetable oils, the most significant are methyl esters of colza-oil (FAME) which have properties comparable with oil.

In contrast to oil, production of bio-oil does not product any harmful waste and it is ecologically unexceptionable. It does not contain almost any sulfur and it does not cause emission SO_2 and it has lower content of CO (10 to 12 %), essential hydrocarbons (10 to 35 %) and solid particles (24 to 36 %) in exhaust gases. Purity of

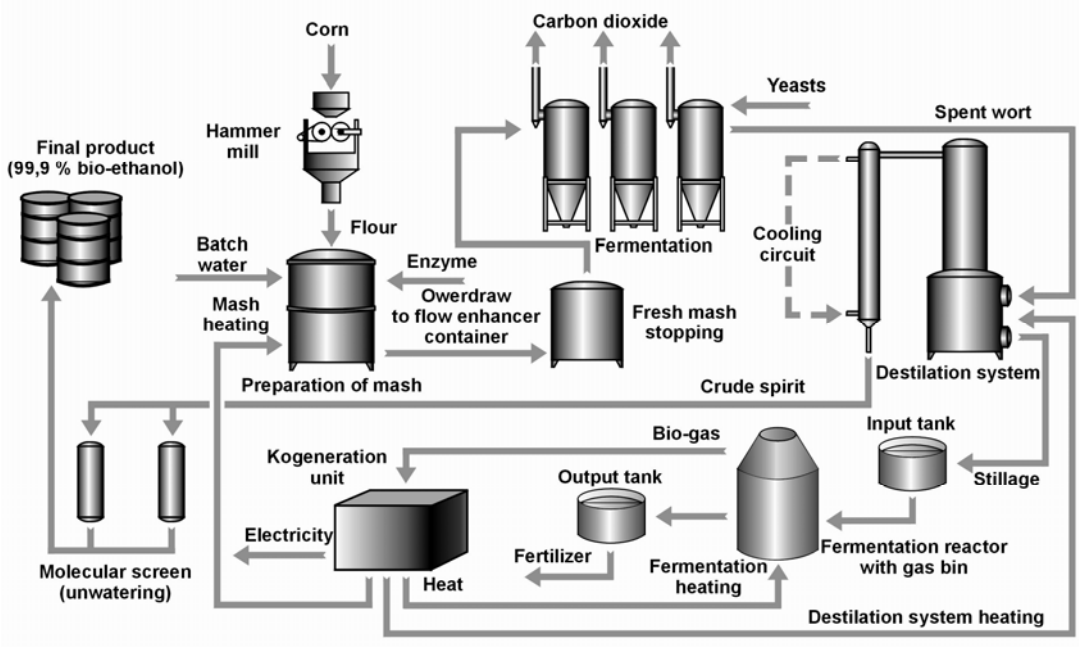
combustion as well as low heat properties depend on FAME purity. It is not flammable and transport and storing of bio-oil is so safer than at oil.

Bio-ethanol is volatile liquid which it is possible to use directly like fuel or it is mixed into petrol. In this case purity 99,5 to 99,9 is required. Raw bio-ethanol after distillation contains purity 95 to 96 % so called azeotropic mixture of ethanol and water. Adding to classic fuels it improves their octane number and combustion what leads to reduction of some harmful matters in exhaust gas as well as CO_2 emissions.

It is gained by fermentation and following distillation over-fermented mash which is mostly prepared from corn. Bio-ethanol is produced also from maize, sugar cane, molasses and other vegetable products. Energetic balances (efficiency) in production of bio-ethanol are nearly half in comparison with bio-oil (FAME), but from 1 ha it is possible to gain more litters of fuel (c. 4750 litters) than in case of FAME (c. 1400 litters). To raise source material often needs fertilizers and gas sprays which carry risk of environment pollution.

3.2. Cooperation of distilleries and bio-gaseous stations

Production of bio-ethanol also brings waste in form of stillages. Dried slops are suitable pasture for livestock but raise of livestock is constantly lower in some countries. Possibility how to use weak stillages is production of bio-gas.



Source: Author

Fig.2 - Scheme of possible cooperation of distillery and bio-gas station

Deject of livestock is mostly treated in bio-gas stations. Limitation of livestock raising has, of course, influence on accessibility of material suitable for fermentation. From this view weak still ages seem to be the suitable product. If we take into

consideration the fact, that production of bio-ethanol is connected with high energy intensity (mainly process of multi-stage distillation requires high consumption of thermal energy), it is possible to cover this energetic intensity by cogeneration unit burning gained bio-gas. It would require building of bio-gas stations near bio-ethanol stations. The scheme of possible cooperation of bio-ethanol and bio-gas stations is shown in the fig. 2.

4. CONCLUSION

Polluted air, contaminated by energetic, industry and transport emissions can present more and more the risk of respiratory and cardio-vascular diseases. Important is also impact on other factors of environment. Even small concentrations of harmful substances can damage health. Investments to reduction of air pollution are higher and higher regarding to this and regarding to production of new emissions. That is why it is needed in the next years to try to find a solution to constantly rising transport (mainly trucks) by its restriction and by increasing the rate of bio-fuels in the market with fuels. Nevertheless this requires considerably more attention in research and legislative.

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LITERATURE

[1] ADAMEC, V.: *Vliv emisí pevných částic z dopravy na zdraví obyvatel*. Doprava. Ekonomicko – technická revue, 5/2005, s. 11-13, ISSN 0012-5520

[2] JANDAČKA, J. – MALCHO, M. – MIKULÍK, M.: Technológie pre prípravu a energetické využitie biomasy. Jozef Bulejčík, 010 01 Mojš 94, 2007, s. 222, ISBN 978-80-969595-3-2

[3] OCHODEK, T. – KOLONIČNÝ, J. – BRANC, M.: *Ekologické aspekty záměny fosilních paliv za biomasu*. VŠB-TU Ostrava, 2007, s. 144, ISBN 978-80-248-1595-4

[4] www.fpv.umb.sk/~vzdchem/KEGA/TUR/ZP03.htm

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