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QUALITATIVE ASPECTS ON THE AIR POLLUTION DUE TO THE RAILWAY TRANSPORTATION SYSTEM

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Abstract. *Watching the spectacular development of actual transportation activity, the fossil fuel consumption and the related environment abasement became a major concern on assuring a sustainable transportation. As for atmospherically pollution, the rail transportation presents some particular issues. Some qualitative aspects are underlined within this study. Since we must consider the economical and energetically related advantages of rail transportation, it becomes clear that it is necessary a new balance of transportation modes, preferring the rail based ones.*
Key words: *air pollution, rail transportation, environment protection, sustainable development.*

INTRODUCTION

Transportation is a key factor for the modern economy, having a decisive importance for economical and social development, since it guarantees and determines the individual mobility, the social integration and commercial trade. Obviously, a strong and moving economy, creating new jobs, would be impossible without an efficient transportation system, able to provide advantages both on internal and global markets. We most not forget the intrinsic economical aspect of transportation: within the EU, it covers 6% GDP, 6% employment, 40% investment and 30% energy consumption [1].

For the last two decades, this sector presented a constant growth of 2.3% for merchandise, and 3.1% for passengers, not to mention the increasing pressure on environment and society.

Two elements are decisive on the continuous transportation growth. While in the passenger transportation, the relevant factor is the growth of automobiles' market and infrastructure, on the merchandise transportation the main factor is determined by the European increased economical exchange and the entire production system evolution.

The importance of the issue has been noticed more and more. Accordingly, the main target of the European transportation policy is that of finding the suitable balance between the economic growth and the quality and safety requirements of the society, in order to develop a modern and sustainable transportation system, both social-economical and environmental-friendly.

Yet, transportation is directly and unavoidable linked with pollution, mostly that of the air that we breathe. Using about 25% of global energy consumption and about 50% of the oil based fuel, the toxic exhaust have a strong impact on local areas or even regional. More, the terrain infrastructure use should be considered. Transportation can also contribute to the loss of quality of life and economic productivity from the delays and frustration caused by congestion and stress from traffic noise.

Consequently, the EU policy on transportation would be that of preserving, protecting and improving the environment and men's health, and nevertheless the rational use of natural resources.

AIR POLLUTION DUE TO TRANSPORTATION

Almost anything-presuming motorized transportation means fossil fuel combustion to produce energy translated into motion. This combustion is the reaction of the hydrogen and carbon present in the fuels with oxygen in the air to produce – in the ideal world – water vapour (H_2O) and carbon dioxide (CO_2). Neither of these products is damaging to human health. However, CO_2 is the principal gas responsible for the greenhouse effect, an increase in the average temperature of the planet resulting from the trapping of solar energy, with which the increased presence of this gas in the atmosphere is associated. Increases in the average temperature of the planet are believed to lead to unpredictable changes in the global climate, potentially creating, exacerbating or increasing the frequency of natural disasters [2].

The combustion of hydrocarbons produces a number of other by-products more directly damaging to human health than water vapour and CO_2, these having three possible origins [2]:

- the carbon present in the fuel does not adequately react with the oxygen during combustion, for a variety of complex reasons, producing either CO or condensing to form solid carbonaceous particles, a basic component of particulate matter;
- the hydrocarbons do not combust completely or evaporate prior to combustion, being released as gaseous hydrocarbons called volatile organic compounds or adsorbing onto carbonaceous particles, thereby increasing the particulate mass;
- other elements present in fuel and air, including sulphur, lead, nitrogen, zinc and magnesium, also become involved in the combustion process, producing various oxides of sulphur (SO_x), oxides of nitrogen (NO_x), sulphite (SO_3) aerosols and ash – also important components of particulate matter – and lead aerosols.

These by-products directly damage human health, but they can also react in the atmosphere, producing "secondary" transport pollutants such as sulphuric acid, sulphates and ozone, altogether dangerous.

Beyond direct local threat on health, all these elements contribute to regional environment degradation. These environmental side effects are thought to be associated with long-range transport of air pollutants via ozone, peroxyacetyl nitrate, sulphuric acid, and other compounds. The effects include acidification, eutrophication, and forest and crop damage from exposure to ozone.

In addition, out of the six main gases responsible for increasing that effect, three of them might be considered ad transportation due : carbon dioxide, methane gas and azoth oxide.

Transportation is nevertheless responsible for about 21% global pollution, and the figure is rising [2].

MAIN CAUSES OF AIR POLLUTION DUE TO TRANSPORTATION

Though complex in details, the causes of pollutant emissions from transport are actually simple in concept: the enhanced utilization of motorized vehicles, and the fact that they are not "clean" enough when they are used. Solutions, therefore, can conceptually focus on reducing the amount of transport or ensuring that each unit of transport is cleaner.

Yet, in deciding real strategies, we need to have a better understanding of the sources of air pollution from motor vehicles that are responsible for the range of the highlighted problems.

Firstly, we must consider the vehicles transportation enhancement using, as a major factor concerning the polluting exhaust, especially when trying to find out long-term solutions, designed to minimize the problem. On macroeconomic scale, transport activity can be described as "excessive" if there are more vehicle kilometers traveled than are necessary to achieve and maintain an aspired-to quality of life for a given income or level of wealth. In micro-economic terms, it is linked to the mispricing, excessive transport activity being the difference between actual activity and that that would occur if all marginal social costs were included in the costs seen by travelers and shippers [2].

Than, older vehicles are associated with higher emissions of both global and local pollutants than newer ones, both because performance deteriorates as a function of age and because older vehicles are more likely to use obsolete, higher emitting technology. This is a problem especially in developing countries, because the average age of vehicles in operation in many of these is often greater than 10 years.

Performance deteriorates as a function of age. Vehicles lose energy efficiency through ageing, and the depreciation of vehicles increases the likelihood of neglect and poor maintenance. Older vehicles are more likely to use obsolete technology, with poor carburetion, inefficient engine design and outdated use of heavy materials. Poor design or absence of adequate regulatory requirements may also induce manufacturers or importers simply to choose not to use available emissions control technology [2]. Nevertheless, studies have documented the effect of proper maintenance on reducing emissions. The results from a 1992 pilot repair programme in British Columbia show a marked improvement in emission characteristics of cars over 11 years old after they underwent repair. The programme resulted in an emissions reduction of 46% for hydrocarbon 48% for CO and 58% for NO_x [3].

Catalyst function also deteriorates in time because of a build-up of trace contaminants, poor maintenance or misfuelling. Exhaust after treatment systems are particularly vulnerable to degradation of actual emission performance, particularly since many are precious-metal-based catalyst systems susceptible to contaminant poisoning. So, misfuelling of catalyst-equipped cars with leaded gasoline can seriously damage the ability of the catalyst to operate properly.

The fuel quality is also a criterion, since these are influencing, by composition, the level and type of various local pollutant emissions, which are greatly affected by lead and sulphur content, fuel volatility, and the proportion of oxygen, olefins and aromatics in the fuel.

Greenhouse gas emissions are indirectly influenced by octane rating of available gasoline; use of higher engine compression ratios (for example, to reduce CO_2 emissions rates) requires use of higher-octane fuels. Finally, the quality and quantity of lubricant additive to gasoline for use in two-stroke engines can affect emissions of hydrocarbons and particulates [2].

AIR POLLUTION STRATEGIES ON TRANSPORTATION

The development of a strategy involves the selection of a coherent set of measures which, taken together, will reduce the emissions of transport pollutants. These measures can be technology-oriented, targeting the vehicles and fuels used and the maintenance practices within the sector, or they can be behavioral, seeking to reduce or prevent increases for activity of the most polluting vehicles. They may also focus on systemic aspects in which the transport network influences either the aggregate amount of vehicle use or the emissions intensity of each vehicle [2].

Technical approaches seek to reduce the emissions produced by intervening to the vehicles being used and the fuels they are burning. By definition, these approaches address per unit emissions rather than the amount of activity. An exclusively technological approach may be insufficient to address the growth in emissions, for a number of reasons. The growth in activity continuously puts pressure on technology gains and technological improvements can exacerbate the growth in activity through the much-debated "rebound" effect. Also, an exclusively technological approach to addressing the problem may result in significant over-investment in technology compared with a socially optimum solution [2].

As for the vehicle technology, improvements are limited by local capacity to absorb the technology and by the availability of fuel appropriate for the technology. Consequently, vehicle technology strategies need to develop in response to particular local circumstances and in concert with fuel strategies. These strategies may involve improvements in conventional technologies to engine and fuel systems, better or more widespread use of fuel exhaust after treatments, changes and improvements to transmission systems, treatment for fuel supply and crankcase systems, or improvements to overall vehicle design to reduce friction.

Very important is also the rate of change of technology in the vehicle fleet. Over the short and medium term, the rate of change is more important than the technology itself for reducing transport emissions. Technologically speaking, the exhaust level depends on renewing the vehicles by adopting upgrades or buying new stuff. Upgrading is anyway limited, as performance and maintenance, and the costs might be bigger than acquiring new products, considering also the fuel quality. This balance between buying new vehicles and upgrading the old ones is a major issue in terms of costs.

Vehicle maintenance is also a crucial part of any technical strategy to reduce per kilometer emissions of pollutants, both because the proportion of in-use vehicles is substantial compared with new vehicles in any given year, and because of the vigilance required to ensure that exhaust after-treatment technology is well maintained and remains functional. The parallel technology of filtering the exhaust is as well a point of close concern, for both maintenance and performance.

Anyway, a proper interested maintenance could look like a miracle, environmentally speaking, besides performance cuts, otherwise determined anyway by the moral and physical "older" vehicle.

The fuel improvements are as much as important too, changing the fuel formula might sharply cut several polluting agents, such as lead elements, sulphur, volatility, along with oxygen level increase and octane.

All these strategies should also watch the infrastructure itself, so the traffic conditions would permit optimal conditions for power efficiency and reducing pollution, along with more careful policies of preventing traffic jams.

PARTICULARITIES OF THE RAIL TRANSPORTATION

Rail transportation has certain particularities compared with other transport systems.

So, a significant part of rail transportation uses electric power. This evidence comports many substantial advantages, among which many traction vehicles are not at all polluting the atmosphere. Of course, a part of the electric energy consumed is coming from polluting producing plants, as thermo centrals. Yet, the main source of electric energy is not only classically burned provided, but coming up from hydro energy sources or from nuclear plants which, despite all quarrels, do not pollute the atmosphere, though presuming other accidental risks. Anyway, the thermo centrals are precisely located in geographical terms and able to be supervised in order to reduce the air pollutants. It is not the case for the various vehicles running all over the continent, impossible to be watched and counted, either technical, or humanly. More, electrically tracked vehicles usually use motors as dynamo generators while braking, re-providing power into the electric network.

Though building an electric railway presumes substantial financial investments, working and timing deadlines, this process can perform without closing the railway traffic, meantime using the diesel-equipped vehicles.

As for non-electric locomotives, most of them are diesel fueled, which has no lead additive. Diesel engines do not need high octane ratings, historically obtained by adding tetraethyl lead to gasoline blends.

Because diesel fuel contains mostly heavier, low volatile fractions than gasoline, the pollution with volatile organic compounds, specially 1,3-butadiene stands still compared to other fuels oil-derived. More, a low presence of aldehydes in the emissions must be noticed. In addition, the CO concentration within the burning process is lower for the diesel fuel engines, usually slower than gasoline ones. Due to that aspect, it is enough time for burning upper the fuel, accordingly for turning the CO into CO_2. Concerning the sulphur oxides, despite the higher concentration in diesel fuel compared to gasoline, the longer burning process makes the diesel fuel engines more environmental friendly.

Still, the diesel fuel engines rail transportation preference upraises other major questions, such as particulate matter like soot mainly, that is not usually present at spark ignition engines. In addition, NO_x are present on diesel fuel engines' exhaust, since at high temperatures, the longer burning process can encourage chemical links disclosure determining oxidation of the nitrogen from the combustion chambre.

Concerning the rail motorized vehicles operating level, it is obvious that the energetic consume, dealing here with fuel quantity, vehicle and per/kilometer average needs are much lower than the routing transportation, even including the fossil fuel used for electrical vehicles.

Yet, it must be said that the energetic efficiency relays on the charging level in use while operating vehicles. Accordingly, there are many possibilities for improvements for integrating track design and construction characteristics and on rolling stock specifications, to ensure safe, clean, economically viable operations in order to make the railway sector more competitive.

A better suppleness and a supporting adaptability between rail transportation and market requirements, including a closer connection between sea, inland waterways, road and rail, should be watched out, in order to achieve a safe and uninterrupted trans-European network, for optimal economical results.

The railway begins to be already fit for that, e.g. for passenger transportation by using electric powered trains or auto-motors. Both these could be set together, in order to assure the necessary elastic combination adapted to the instantaneous requirements of traffic, also assuring the economic profit by completing seats as much as possible. Nevertheless, car transport wagons in passenger trains diminish the long and medium distance use of private vehicles.

We must also underline the important train charge, but also the adjusting systems, usually computer assisted, and the central monitoring display, altogether with signalization rail system, allowing a better control of the traffic that prevent an "aggressive" driving of vehicles.

In addition, the railway can sustain, by special designed carriages, complex merchandizes solutions. Small rolling wheels carriages are similarly fit to carry auto train vehicles or containers, so contributing to protect not only the environment, but also the road infrastructure.

Compared to road transportation, the railway costs are far less, always being with no doubt far safer. These factors, combined with the advantage of avoiding traffic jam problems contributes to a better solve of the environmental and economical troubles.

As for technological improvements of internal combustion engines rail vehicles and their renewal, taking into account the high level of such expenses, it is understandable a lower rhythm of this process.

Also, it must be understood that national and international active regulations, very straight ones, usually, might be much more carefully-scared to any innovations to accept in traffic, not to mention the cost of these improvements, the timing these might be applied, and above all the main criterion, which is the safety of traffic. There are no experiments risking in a traditional transportation system.

It is different for automobile industry, always disposed to throw on the market, one-step ahead the competitors, any new fast and sudden innovation or improvement. The railway market is traditionally a slower one, firstly concerned on safety. The costs of improvements reflect this attitude: it takes time and money to introduce something new, and, above all, care. Every little detail must be well verified before.

Instead, improving technologies of controlling, maintenance and fixing, presuming strictness, periodicity and planning of controls are strictly followed. The maintenance activities on the rail vehicle fleet, above assuring their functionality, contribute to pollution diminishing, at least for railway system.

These checkings are far more accurate than the auto vehicle ones, either because the fleet is sensibly smaller, either – mostly – due better care and training of the checking teams, according to their responsibility, not to mention the required technical paper work which is a much more straight and easily verifiable one compared with auto vehicle's one.

ABOUT SULPHUR REDUCTION IN FUELS

Environmental concerns have resulted also in legislation, which places limits on the sulphur content of gasoline and diesel fuels, because it is a direct contributor to SO_x emissions, and it poisons the low temperature activity of automotive catalytic converters.

In EU a maximum gasoline's sulphur level of 150 ppm year 2000 onwards has been stipulated, with a further reduction to a maximum of 50 ppm by the year 2005. Gasoline comprises a mixture of products from several process units, but the major source of sulphur in the gasoline pool is fluid catalytic cracking (FCC) naphta that usually contributes between a third and one-half of the totals. Thus, effective reduction of sulphur in this context means focusing attention on FCC naphta. If the feed is not hydrotreated, the sulphur level of the resultant FCC naphta is giving a typical concentrations ranging from 200 to 3000 ppm. When considering the effects of changes in fuel composition, lowering the level of sulphur holds the largest potential for a combined reduction in hydrocarbon, CO and NO_x emissions [4].

The current world market also imposes stiff requirements on the quality of diesel fuels, mostly used for the railway traction vehicles. Most European governments have switched to use of diesel fuels that satisfy the requirements of standard EN 590 for sulphur content: maximum of 350 ppm. EU countries must manufacture fuel with a maximum sulphur content of 50 ppm by June 1, 2005. Hidrotreating of diesel fuels is conducted with a feedstock space velocity of 2.5-3 h^{-1} at a temperature of 345-358^{0}C, hydrogen pressure of 3.5-4 MPa, and hydrogen-containing gas: feedstock ratio of 220-350 m^3/m^3 (in normal condition). In these conditions, up to 90% of the sulphur is removed from the fuel. Incomparably higher hydrogen and power consumption, development of new catalysts, etc., will be required to bring this index to 99% according to the European standards that will soon come into force. The difficulty in separating sulphur compounds from diesel cuts is due to the polarity of these compounds and the aromatic hydrocarbons with which are mixed. This is probably the reason for the heightened interest in developing more modern and less expensive methods of removing sulphur from fuels by oxidative reactions [5].

Methods for efficient oxidation of toxic and corrosive sulphur compounds from petroleum cuts to inoffensive disulfides present a growing interest. The most widely used process of sweetening is Merox developed by UOP. This process is based on the ability of a metal chelate, i.e. di- or tetra-sulfonated cobalt phthalocyanine to catalyze the oxidation of thyols to disulfides under caustic condition by molecular oxygen or by air. The overall reaction of the process is:

$$2RSH + 1/2O_2 \rightarrow RSSR + H_2O$$

Addition of base is necessary for the first step in the reaction, which is the formation of a mercaptide ion. Besides this process currently utilized in refineries, there are literature data claiming the possibility of thyols oxidation with oxygen at pH=8.5-10 and ambient temperature and pressure in the presence of transitional metal (Fe, Co, V) chelates solutions. The global process, similar to Merox, consists in aerobic oxidation of thyols to disulfides using as catalysts chelates of transitional metals in their high oxidation state. The reducing of the transitional metal ion by RS^- takes place simultaneously with the oxidation of the reduced species by the oxygen. A fundamental problem of the above mentioned procedures is associated with the use of caustic solutions which cannot be converted to a valuable product. Even worse, their discharge enhances the costs of the environmental protection. Overcoming this situation requires minimizing or eliminating the use of caustic solutions wherever possible. An ideal alternative to replace the caustic alkali solutions utilized in homogeneous processes is incorporation of solid base materials into the catalyst formulation [6].

CONCLUSIONS

Since the transportation activity is determinant for economical and social development and considering that transportation market requirements are becoming higher a higher, our concerns inevitably watch for a sustainable development on this matter. In this context, while transportation has a significant contribution to damaging the environment, mostly by polluting the atmosphere, we need to know and understand profoundly the nature of all these phenomena. Desirable, as possible, we must stop any negative effect.

From this perspective, this brief analysis, pointing only some aspects of the problems, underlines that the railway system – a strategically one, concerning the balance between modes, especially for merchandise – presents a lot of advantages compared to the other, by extension, evolvement, growth and impact, both on national and international scale.

It is a fact that for distances up to 1,000 km, railway transportation provides an understood option for passengers, both on high-speed trains and urban local crowded places, decongestion of traffic, reducing the pollution and classic fuel consumption. Besides, merchandise trains relate the industrial plants, terminals and harbors, so contributing to maritime traffic. More than that, the European railway network is sure. Therefore, the need for assuring a sustainable development of a railway transportation system is pressuring all nations inside the European Union, each one by side or altogether, focusing a common transport market.

Accordingly, far from being an extreme environmental trouble, the pollution issue raised by rail transportation is sooner a ringing bell for watching and strategically improving this sector.

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КАЧЕСТВЕНИ АСПЕКТИ НА ЗАМЪРСЯВАНЕТО НА ВЪЗДУХА ОТ ЖЕЛЕЗОПЪТНАТА ТРАНСПОРТНА СИСТЕМА

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Резюме: *Наблюдавайки грандиозното развитие на транспортната дейност, консумирането на отживели времето си горива и свързаното с това увреждане на околната среда стават основна грижа при осигуряването на устойчив транспорт. Що се отнася до атмосферното замърсяване, железопътния транспорт има някои специални проблеми. При изследването се подчертават някои качествени аспекти. След като трябва да отчетем икономическите и енергийни предимства на железопътния транспорт, става ясно, че е необходимо ново балансиране на транспортните видове с предпочитание на релсовите транспортни средства.*

Ключови думи: *замърсяване на въздуха, железопътен транспорт, защита на околната среда, устойчиво развитие.*