LIFE SPAN AND RECYCLING OF MOTOR VEHICLES

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Abstract: *The car is prevalently considered as a technical system that produces costs and pollution, also as a source of exhausted parts and recycled raw material. In the course of entire life cycle it seriously deteriorates natural balance to the extent to appear as a threat to overall ecological biodiversity on the Earth. Due to mass production and use what includes building-in vast number of materials and component that yield adverse effects on human health, engine cars has become one of major problems of today.*

The management of secondary waste requires an established flow of integrated information as well as an complementary system of knowledge and methods regarding landfill remnants reduction and adequate treatment of useful materials. Global automotive industry incites development of national economies and integrates contemporary achievements in the areas of techniques, technology and other scientific disciplines. Thus, the aspects of energy efficiency, waste recycling and environment protection sustainable development environmental shall be taken into account in car designing and production.

KEY WORDS: *CAR, RECYCLING, LIFE CYCLE, SUSTAINABLE DEVELOPMENT, ECOLOGY, EXPLOITATION*

INTRODUCTION

There have been so many initiatives aimed to establish an integrated system of recycling of motorcars at their life cycle end which actually yielded some effects in renewing car fleet as well as in raising traffic safety and improving environment protection. Although new Law on waste management has been endorsed many ambiguities how to meet requirements still persist particularly related to car registration cancelling, certain car recycling phases, cost reimbursement issues, establishing the market of detached parts etc. Therefore, it appears necessary to define an adequate model of cooperation among manufacturer /importer, corresponding state authorities, recycling entities and other relevant parties.

The development of car recycling industries along with state supporting policies has produced significant effects in this area, like: car fleet renewing and improved traffic safety, increased engagement of human resource in car industry, opening new jobs in car recycling industry, environment conservation, natural resources conservation, energy resources conservation.

A system to monitor cars in life cycle and after their exploitation period termination is to be reliable thus to provide sufficiency of relevant data to interested parties in recycling system. It may be assumed that there is a huge number of unregistered car left by the owners (in garage, public parking places, houses for rest) looking for adequate solution how to get rid of them. However, the problem appears to be harder when parts are detached from the car with the intention to be solved on black market while remaining parts unable to find a buyer (chassis, seats, wheels, parts of motor and transmission) remain partly lying on car waste fields (counting more than thousand in Serbia), partly in recycling entities and unfortunately some are left by local and forest roads, by river and lake banks, on fields and other locations.

To avoid such behavior or to reduce it to a reasonable level, an option might be provide the car be dispatched to auto scrap collection and treatment facility. At first sight this option should be a good solution but it requires auto scrap (end-of life vehicles) companies establish more transparent operation, particularly maintaining control on routes of used parts, primarily for roads safety reasons and for sustainable environment sake. [8]

EU DIRECTIVE ON END-OF LIFE VEHICLES

In order to enhance end-of life recycling process European Union adopted Directive 2000/53/EC in September 2000, imposing EU national governments to implement it by 21 April 2001. Some general clauses of Directive 2000/53/EC regard following principles: The Directive harmonizes national measures for end-of life vehicles recycling, predominantly to reduce their adverse effect on natural environment thus contributing protection, conservation and improvement of environment quality, energy conservation, and unimpeded operation of EU market and prevention of distortion between member states. Such a framework appears necessary to secure coherence between national approaches in accomplishing phase objectives, i.e.: design, exploitation, recycling (collecting, treatment, reuse and recovery) taking into account the principle of subsidiarity and polluter-pays principle.

According to EU strategy, the basic principle lies in decline waste deposition to extent possible and rather turns to reuse and recovery, including energy production, consequently creating the system aimed to economically justify collection, treatment and reuse of car parts at the end-of life cycle and its integration into new vehicles production.

Every year there is 8 – 9 million tones of waste generated by vehicles requiring to be managed in a proper way.

Directive provides that Member States shall take the necessary measures to ensure that the delivery of the vehicle to an authorized treatment facility occurs without any cost for the last holder and/or owner as a result of the vehicle's having no or a negative market value. This policy relates to components, spare parts and materials regardless applied safety standards (climate change, exhaust gases emission, noise).

Directive 2000/53/EC is preceded by some other directives which treated the issue of waste produced by end-of life vehicles, namely: Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labeling of dangerous substances from 1967, Directive 70/156/EEC relating to the type-approval of motor vehicles and their trailers from 1970 and Directive 75/442/EEC on waste from 1975

Directive 75/442/EEC treats the issue of vintage vehicles meaning historic vehicles or vehicles of value to collectors or intended for museums or other modes of preservation which are to be kept in a proper and environmentally sound manner.

Directive 2000/53/EC include preventive actions starting from conceptualization stage, implementation phase, up to end-of life stage. More specifically it regards reduction and monitoring of hazardous materials located in the vehicle in order to prevent their ingress in the environment and simultaneously to facilitate recycling and avoid hazard waste deposition. It particularly relates to: lead, mercury, cadmium, hexavalent chromium, sulfuric acid and other items. These heavy metals may be used in certain applications only, however under permanent supervision and according to regulations thus to prevent entering to recycle line.

Commissions in charge for improving Directive in the area of plastic material usage and recycling are permanently active trying to reduce PVC adverse effects on sustainable environment upon recycling process.

Recycling systems and the market of recycling materials are to be permanently promoted and supported, particularly in regard of new car design and manufacturing with the aim to prevent environment hazards and to remain economically profitable.

Directive arranges the issues of certificate of vehicle deregistration and notification of authorities about the fact that the vehicle has been directed to the recycling system.

EU member states are obliged to provide Directive implementation and to maintain access to SMEs having license for collecting, decommissioning, storage and other treatment in vehicle recycling process.

Vehicle manufacturers shall be aware of quantified objectives regarding reuse of recycled products yet in design stage thus to meet requirements on safety and environment protection. In that regard, EU shall promote European standards preparing and other measures that would not affect design concept of vehicles, but would meet relevant regulations [10]

By the beginning of 2006 Member States were obliged to attain 85% average weight (per vehicle, per year) through reuse of recycled material and energy return by waste incineration. For vehicles produced before 1.January 1980., Member States may lay down lower targets, but not lower than 75% for reuse and recovery and not lower than 70% for reuse and recycling. Up to January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 95%, but for the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year. Such EU position resulted in production of vehicles containing materials and parts that can be reused and recycled to the minimum level of 85 % to reach minimum level of 95% in 2015. Fig.1 below shows the application of Directive transitional clauses in time framework.

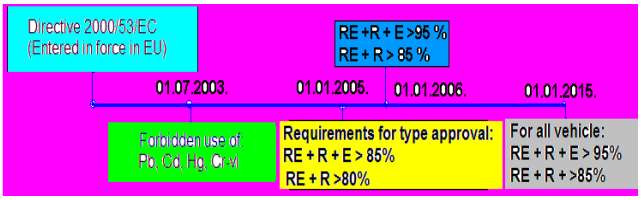

Fig. 1. *Directive 2000/53/EC application (RE-reuse, R-recycling, E-energy)* [2]

One of major problems in recycling process is parts separation which makes standards for parts and material coding indispensable. European Parliament Commission established the decision 2003/138/EC
on component and material coding standards. Plastic parts which mass exceeds 100gr. shall be appropriately labeled according to ISO 1043-1:2001, 1043-2:2000 and 11469:2000. Parts made of rubber exceeding 200gr. shall have labels following ISO1629:1995.

The essence of end-of life automobile treatment lies in efficient and profitable recycling system capable to yield reduction in unrecycled waste deposition and environment improvement. Highly unified vehicles for all markets thus meet regulation requirements including the laws relating to recycling of end-of life vehicles.

END-OF LIFE RECYCLING OF MOTOR VEHICLES

Expanding number of motor vehicles in the world imposes first to developed countries but also to the others to tackle the development of procedures and equipment for recycling. According to some credible sources, it is considered that there exist about 800 million vehicles in exploitation, 160 there of in European Union. The fact that only in EU that about 17million vehicles are withdrawn from exploitation means that 20million tones of such waste results thus rise the recycling of such waste to become a major issue.

Some sources indicate that the number of vehicles that were not reregistered in 2009 attains 170,000 units, what makes about 11% of car fleet

There is no reliable answer where all of these vehicles might be, if they are not in traffic, since there is no system to monitor paths of worn-out vehicles. On the other hand, significant variations are observed from year to year. For example, average age of unregistered vehicles is constantly increasing in last 15 years with falling trend in last five years, having noticeable variations. It may be explained with fluctuations in life standard and possibilities to bear costs for vehicle re-registration, exploitation and maintenance.

In order to obtain data on unregistered vehicles it is necessary to identify how many vehicles just omit one or two re-registrations and what makes the rest of destroyed vehicles or by any other reason permanently out of exploitation. The latter group appears to be important for interested parties in vehicles recycling process. Potential quantities of different material that might be obtained from unregistered car recycling are shown in Table 1, below.

Table 1*. Recycled car material potential in Serbia* [6]

No.	Sort of material	Potential quantity (t)
1.	Plastic	13.500
2.	Fluids	3.500
3.	Rubber	8.300
4.	Glass	5.700
5.	Non-ferrite materials	12.000
6.	Ferrite materials	115.000
7.	Other	6.000

Motor car is highly sophisticated product, composed by several thousand parts of different materials requiring series of different technologies and operations.

A motor car include use of different sorts of materials which participate in the car with percentage as shown in Fig.2.

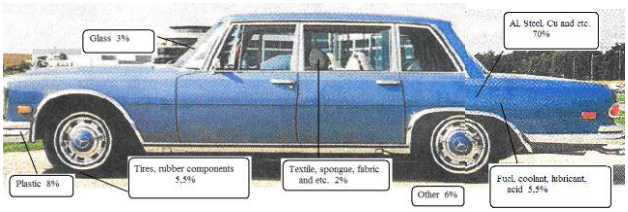

Fig. 2. *Percentage of materials in overall car mass*

There is not a single plant in the world where the entire vehicle may be recycled since this activity is performed in facilities differing both in sort of material and capacity. Holland and Austria, being the leaders in this area, recycle 50-60% of car waste, while in Serbia, mostly due to capacity shortage and weak legislation, this percentage is rather low not exceeding 10-14% in recent years.

At preparing stage for recycling, the parts that are first to be dismantled from the vehicles are: engine, tires, battery, all liquids (lubricants, fuel, antifreeze and other liquids), seats, wheels and other parts. Battery along with its acid belongs to hazardous substances requiring special treatment and storage in special vessels. Such a car is recycled in special facility with prior separation of: plastics, glass, fabric, etc. the remaining part of car is further compressed in a cuboids with basic dimensions 100x40x60 cm. In this way, starting with 1000kg car several cuboids of 700kg total weight is obtained, meaning that 70% of vehicle parts is ready for further recycling process. This process may be even more effective provided that vehicles for recycling are in better condition, i.e. life cycle is shortened.

It is the vehicle composition requiring recycling process to remain complex. For instance, Glass makes about 3% of car mass. Due to chemical complexity and production technology it is not recycled in glass sector but is frequently used as an additive in construction sector for concrete production. The same applies to plastics which taking part in car weight with 8% which is ultimately destroyed or by special treatment prepared used as semi-product in production of: plastic packaging, containers, box and other product that do not jeopardize human health. Under certain circumstances, plastic may be used for energy generation in special plants provided that it does not violate the requirements of sustainable development of occupational and living environment.

Particular care is given to the car fluids which appear to be rather toxic thus requiring careful collection and storage. Some fluids, like lubricating oil may be recycled with high effectiveness rates.

Tires and other rubber parts making 4% of car weight are directed to further processing in production of some coverings. The remaining part of car counting 70% of car weight is tin, different steel sorts, non-ferrous metals are treated to yield the same material sorts except alloyed steel that is submitted to particular treatment to have construction iron as most frequent ultimate output.

MANAGEMENT OF VEHICLE LIFE CYCLE

European Union has established a set of technical requirements participants in recycling process have to meet in order to prevent any damage car owners or authorized dealer might experience by using certificates, reports or monitoring activities.

The manufacturers of cars, subsystems or components shall apply marking according to valid standards as well as obey principles regarding reuse, recycling and recovery of energy by incinerating futile waste. The same applies to companies involved in collecting and recycling activities which are to obey regulations, instructions and data issued to facilitate further operation.

The management of car life cycle may be presented by a pyramid (Fig.3) having six layers: prevention, reduction, reuse, recycling, energy and waste.

Prevention is grounded on design input data, proper material selection, adequate solutions of technological processes thus creating preconditions for longer car life cycle and for diminishing permanent waste rate when life cycle is up.

Reduction is secured at the stage of design and technology development, through material selection and consumption reduction in first place.

Reuse (RE) means any operation by which components of end-of life vehicles are used for the same purpose for which they were conceived, in current status or upon certain treatment

Recycling (R) relates to the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery

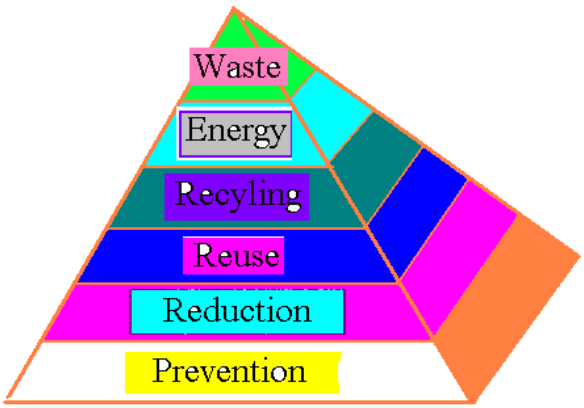

***Fig. 3**. Management objectives of car life cycle* [2]

Energy (E) is the last level of management that relates to use energy generated through direct incineration of materials which cannot be reused or recycled in the new production but still may be converted in thermal energy in an economic way.

Waste denotes the remainder that can not be used for any of above mentioned objectives thus representing an unfavorable product. Consequently, it is necessary to make efforts at design stage to reduce this amount to the smallest possible extent and to provide its storage following regulation.

The analysis of motorcar life cycle includes beside product life cycle phases, all stages that relate to sustainable development and recycling of materials, assemblies and parts.

On the other hand, motorcar life cycle may be defined by keeping track of the sequence of events/activities. These events include issues like: registration, deregistration and ownership at the end-of life cycle.

CAR RECYCLING IN SERBIA – POSSIBLE APPROACH

To conceive activities of an integrated and sustainable end-of life vehicles recycling in Serbia the following issues are to be highlighted:

- Vehicle stream definition (production, import, registration, exploitation, maintenance, average life cycle, withdrawal from use, disposal, storage, etc.),
- Identification of material resources and overall waste from end-of life vehicles (quantities, dynamics, recycling possibilities),
- Recycling system data (recycling level, modes of recycling, possibilities for recycling),
- The market of end-of life vehicles (current, potential, business activity rate),
- Establishing the information system on general flows of vehicles with special reference to vehicle recycling activity (IS architecture and needed software).

It is necessary to define legal aspects of end-of life cycle vehicle recycling including determination of current legislation state in Serbia and comparison with the corresponding state in EU. Further steps will include:

- Establishment of an integral and sustainable model of vehicle recycling from production to end-of life,
- Development of technological pilot project for Center for vehicle dismantling and backing documentation,
- Analyzing the techno-economical effects of end-of life vehicles recycling,
- Analyzing direct and indirect effects of vehicles recycling in ecological sense,
- Establishing the Serbian association for vehicles recycling.

At the first stage, major part of activities would be oriented towards current state definition and its influence on the environment (disposal/landfills of worn vehicles, worn vehicles handling, liquids leakage, heavy metals, plastics, rubber, etc.)

At the second stage, the effects on environment improvement through the implementation of the recycling system would be in focus (landfills decommissioning, proper handling with liquids, material recycling, reduction of energy consumption for production of steel, aluminum, non-ferrite metals, etc.). Also the effects on employment by the implementation of the model for vehicle recycling would be monitored.

Fig. 4 shows, an option of positioning the Association within the motor vehicles recycling
system for end-of life vehicles.

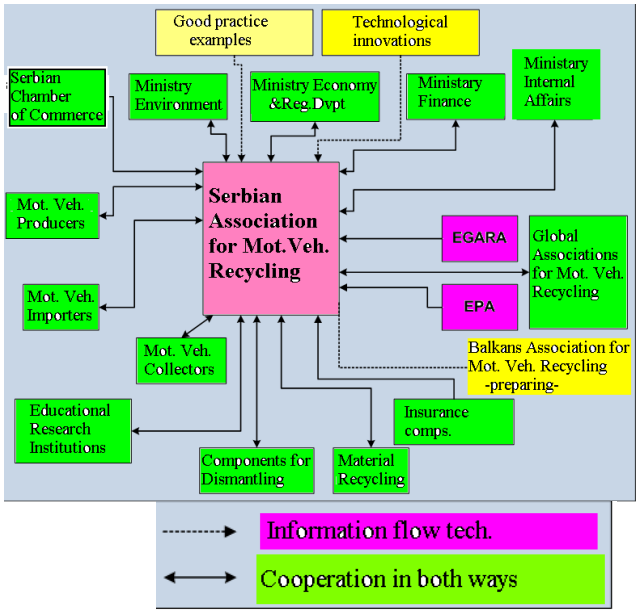

Fig. 4. *The position of potential association in the recycling system* [9]

The Serbian association for MV recycling would be grounded on: Transfer of technology and good practice to Serbia, Education which is to provide the development of knowledge, technology and skills and getting acquainted with meeting legal requirements, Integration of companies and research units to meet sustainable development, Providing expertise for preparing legal documents, Integration of national and international entities on commercial basis, Development of projects in this area and on resources protection,

Establishment of international cooperation with allied institutions,It is quite realistic that such an approach along with further development of the recycling system would have significant positive impact on sustainable environment protection in Serbia. [10]

CONCLUSION

Taking into the account numerous analyses done on this issue worldwide, it may be inferred that in case of omission to make serious steps in this regard, adverse impact of passenger and other vehicles will appear as a major global ecological problem. Developed countries and their governments, mostly turned to profit and power increase, have neglected the influence of mass production of motor vehicles on global environment.

Establishing the law covering issues of adverse effects reduction on global eco-system (exhaust gases emission, oil/lubricants quality, noise and vibrations, ergonomics and comfort, recycling etc.) is only one but inevitable step in right direction. Vehicle recycling issue is becoming more apparent in the world thus compelling every producer and every country to tackle the problem in order to prevent quite realistic ecological catastrophe.

The response to end-of life vehicles recycling problem is not sufficiently prepared in Serbia. Therefore, urgent legal solutions and the implementation of an integral model for sustainable recycling according to EU legislation are indispensable.

The issue of motor vehicles recycling in Serbia is not coordinated enough with environment sustainable development program thus requiring enhanced mobility of all relevant state authorities which would, along with the Association for vehicle recycling, be capable to face and solve the problem and make Serbia compliant with EU in that regard.

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