Problems of production, use and recycling of motor vehicles

Radomir Janjić, Milan Bukvić*, Blaža Stojanović*

Tehnical Test Center of Belgrade, Serbia
**Faculty of Engineering University of Kragujevac, Serbia*

Abstract
The paper outlines considerations recycling motor vehicles in terms of ecology and sustainable development. Presenting a global model impacts and environmental management in the automotive industry are analyzed parameters which affect the motor vehicle living and working environment. The subject of analysis in this paper is related to the participation of certain types of materials in the total weight of an average passenger car, which directly affects the design of the recycling process. Through a tabular overview of the process set forth trend dismantling and recycling of motor vehicles by 2050 for different concepts of motor vehicles, as conventional, hybrid and electric vehicles, as well as their transitional concepts.

Keywords: *motor vehicle, recycling, ecology, materials, waste.*

1. Introduction

Motor vehicle industry is characterized by leading the process of reeling over motor vehicles and components for vehicles, including the use of materials, energy and equipment, and hiring processes. It generates through its activities and pollutants which requires finding solutions to protect against contamination and the inclusion of the legislation of the country. The automotive industry uses the general production processes that are associated with raw materials, by-products or waste and materials that should be recycled or disposed of. The team and identify the sequence of the process in order to provide accurate information in the processes by which waste is generated. On the other hand, it should have accurate information on the hazards (water, air, soil), which represents the waste produced [1].
Motor vehicle consists of parts and assemblies, in which approximately takes to be installed in a vehicle of 8,000 to 10,000 different parts, for approximately 100 leading vehicle components. They are made of different materials, where the material selection and construction of a motor vehicle after an extremely important aspect of ecology. Requirements for zero waste at all stages of the life cycle of a motor vehicle is a complex task for researchers and developers, especially in the development of new materials and completely safe (benign) technology. Among other things, the requirements for ease of disassembly of the vehicle at the end of the life cycle and safe sorting of material faces the problem of vehicle safety and effectiveness of its recycling.

2. Ecology and sustainable development

Construction of a motor vehicle, in front of a number of brandishing, it should meet the demand recycling of vehicles at the end of the life cycle and without residue (the ultimate goal in coming decades). In order for this approach to be implemented by the development of new materials that are installed in a vehicle, the development of new fuels and propulsion, as well as the development of new production technologies and recycling.
Almost all of today's research and analysis is carried out from the moment of component production, according to the recycling of spent motor vehicle or, more usually, only the cycle of recycling vehicles at the end of the life cycle. This approach provides a much more favorable view of negative impact of motor vehicles on the environment. Even going so far as to announce a "clean" vehicles which solves all the environmental problems that are now present (for example, electric vehicle). In doing so, do not mention the problems ahead, and those who precede the use of

vehicles (ores, energy, raw materials - that is all that is built into a vehicle), a partially problems behind (after a period of exploitation) related to waste batteries and electronic materials [2].
Figure 1 gives an overview of the basic principles for the development of new environmentally friendly products. However, it is still not satisfied with the present-day motor vehicles in which the environmental aspect only after the point of reliability, comfort, safety, mass production and profitability. Thus, the production, use and disposal of end of life following large amounts of waste, pollution of soil, air and water are still underdeveloped recycling, reduction and elimination of pollutants and recycling of motor vehicles at the end of the life cycle. Waste and pollutants generated along the entire life cycle of a motor vehicle and to code [2]:

- energy production that is "embedded" in a vehicle,
- production of ores, raw materials and supplies that are installed in a vehicle,
- production and transportation of water to be installed in a vehicle (virtual water),
- performed transport required for production of the motor vehicle,
- exploitation and maintenance of motor vehicles,
- disposal of the vehicle at the end of the life cycle and
- recycling motor vehicle.

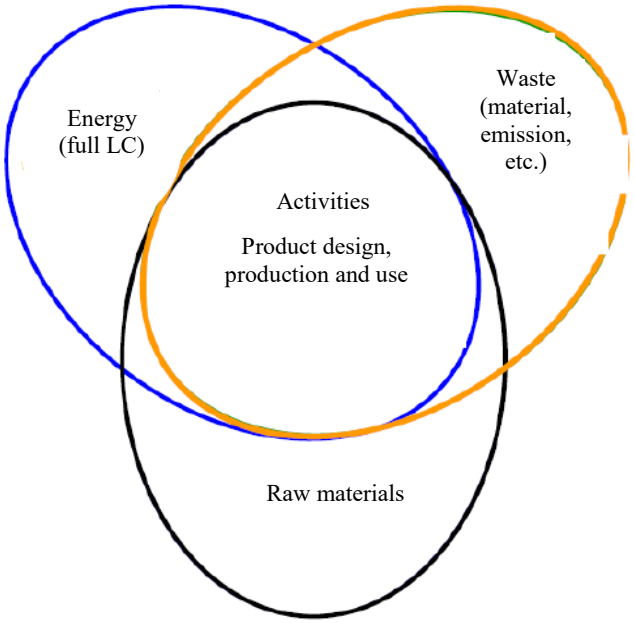

Figure 1. Aspect of ecology and sustainability [2]

3. Recycling of motor vehicles

Figure 2 shows the impact of the global model of automobile industry on the environment and the effects of pollution. Motor vehicle and automotive industry is characterized by the following parameters that indicate its negative impact on the environment and human health. Those are:

- the use of large quantities of water for drinking,
- low energy and eco-efficiency,
- high energy intensity,
- installation of non-recyclable materials,
- installation of toxic materials,
- accelerated depletion of natural resources (energy, water, ores),
- large quantities of toxic waste water,
- a large number of illegal dumps of motor vehicles at the end of the life cycle and automotive components (tires, *etc.*).

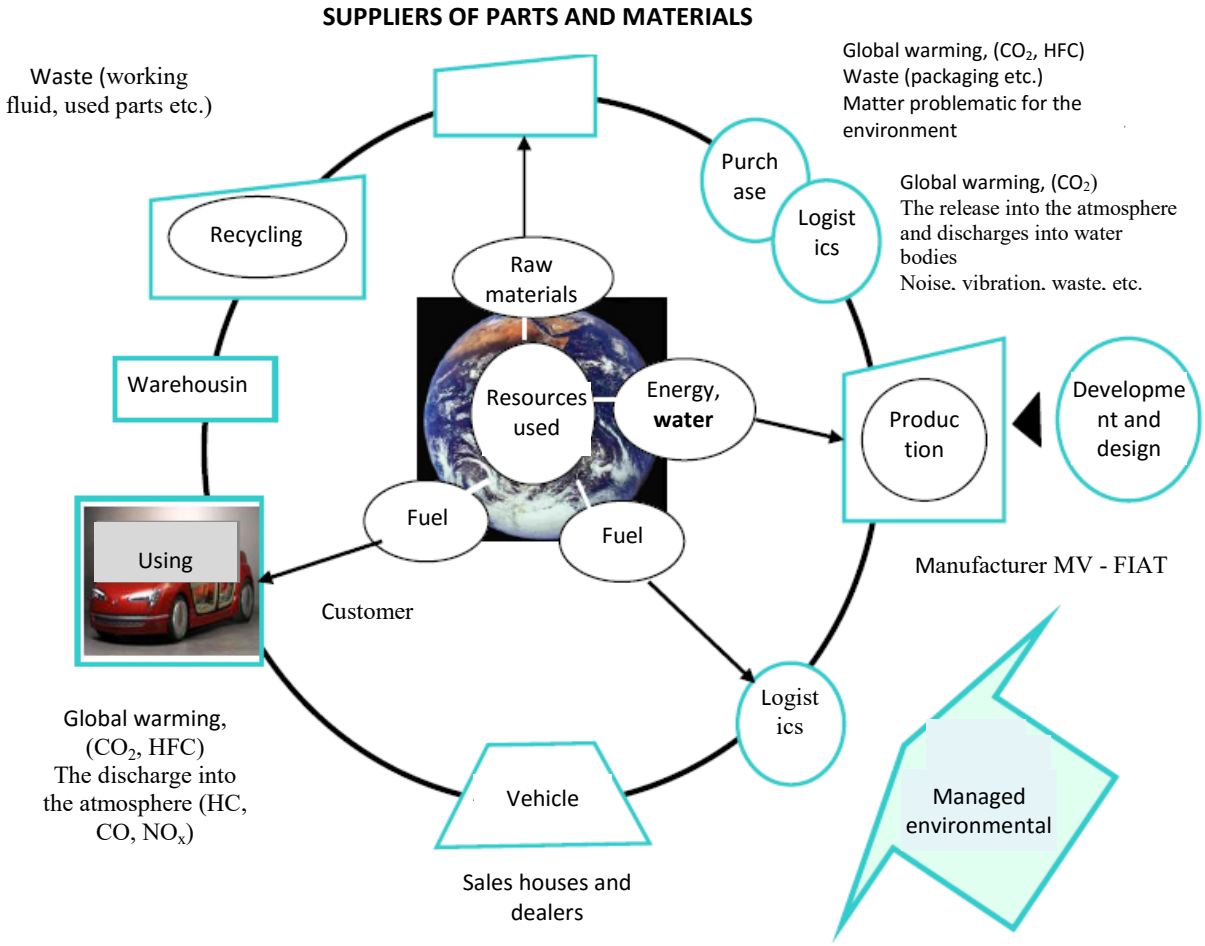

Figure 2. Global model impacts and environmental management in the automotive industry [2]

On the other hand, in most of the world has not lived for recycling of motor vehicles at the end of life cycle. Even the most developed countries have big problems in the aforementioned recycling, which are reflected in:

- illegally discarded vehicles (watercourses, forests, green areas),
- hardly dismantling,
- high installation costs,
- the high cost of recycling waste materials from vehicles (plastic, rubber, etc.),
- still large quantities of highly toxic waste, etc.

Also absent holistic (humanistic) approach to recycling and the elimination of pollutants souls during all life cycle of the vehicle, but under the integrated approach implies only recycling of motor vehicles at the end of the life cycle.

Recycling to achieve the following strategic goals [2]:

- Savings on raw material resources (all materials originate on the nature and name them in limited quantities),
- on saving energy (no waste of energy in the primary processes, as well as in transport and processes which follow, and additional energy is obtained by burning materials that are not recycled),
- the protection of the environment (waste materials degrade living environment, and recycling for environmental damage),
- on the creation of new jobs (processes in the recycling of materials include investment knowledge and work, which creates a need for jobs).

In terms of re-use, the materials may be:

- recyclable (can be used to recapture the production process),
- nonrecyclable (can not be returned to the process and are used for energy - burning or in an environmentally safe manner warehouse),
- dangerous - hazardly (materials that are harmful to man and his environment),
- harmless (materials that are not harmful to man and his environment).

According to the method of delivery of materials in the process of re-use, there are the following types of recycling:

- primary (recycling that after appropriate preparation of the same material used to produce new products or processing of used products to their reuse),
- secondary (recycled where recyclable materials are conventionally processed using new technologies to the maximum possible utilization).

4. Participation in the weight of motor vehicles

Basically, the car is a very high complexity for whose production uses hundreds of different technologies and in which is installed about 15,000 parts. Car parts are made of different materials. The total weight of the current passenger car is the dominant representation of cast iron and steel, but the participation of other materials respectable, especially when you take into account their value. Share of different types of materials in the total weight of an average passenger car is the percentage shown in the diagram in Figure 3 [2,3].

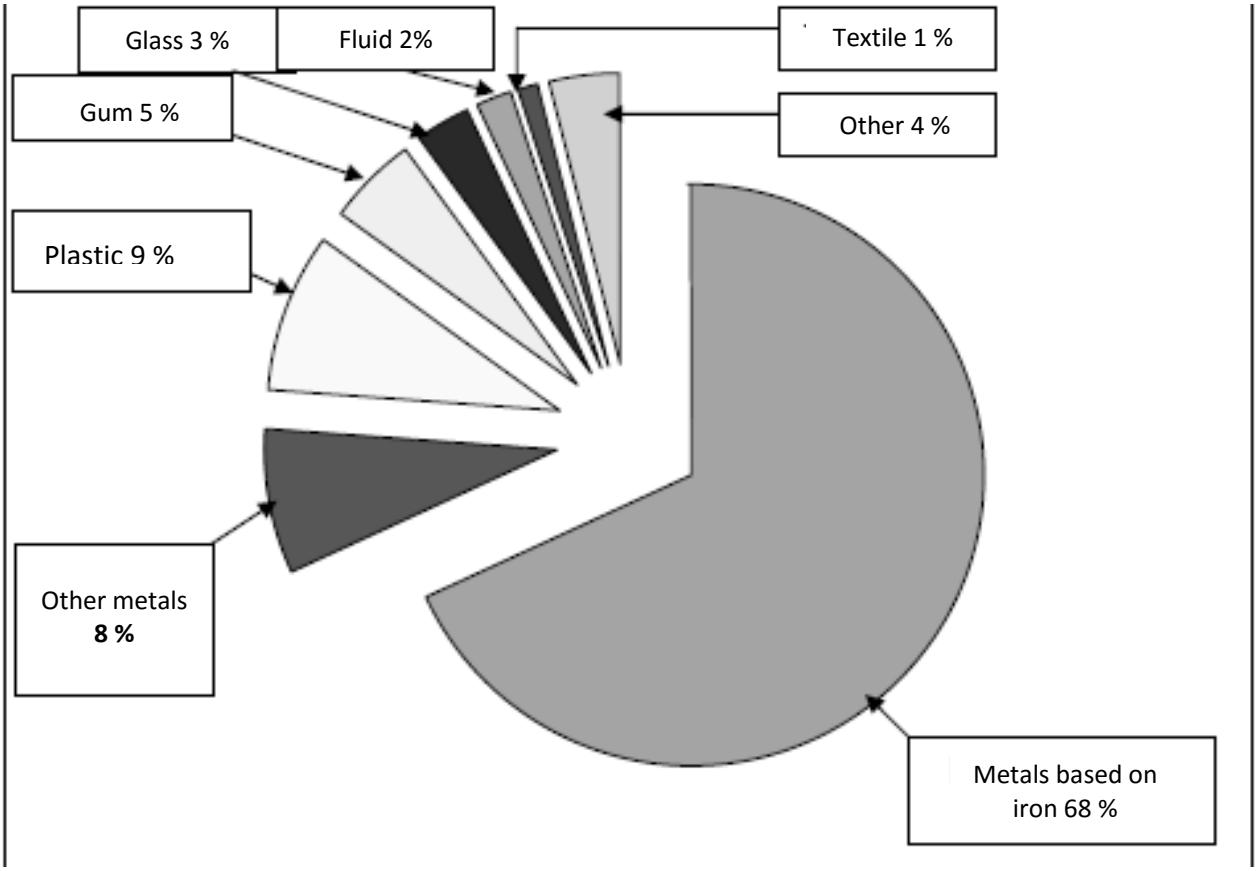

Figure 3 - Share of different types of materials in the total weight of an average passenger car [3]

According to this as the automotive industry is very propulsive, it is also a consumer of raw material resources. In the production process, and waste during operation, as well as waste after the expiration of the lifetime of the vehicle degrades the environment. These facts require that the

recycling of used vehicles (End of Life Vehicles - ELV) shall establish an appropriate system that allows high-quality and comprehensive managed.
Requirements for the future are based on the process of research, development and design of the vehicle. Those from researchers and designers set the objectives and tasks which are often in conflict with today's generally accepted attitudes and behavior (consumer society, extravagance, lack of concern for future generations, *etc*.). Some of the future are required [4]:

- 100% recyclable materials,
- the low energy and eco-efficiency,
- the long life,
- the easy removal,
- cost-effective recycling,
- the closed circuit materials and energy,
- waste: a renewable source of material,
- the sustainable exploitation of natural resources,
- the preservation and improvement of the environment, etc.

5. Sustainable integrated process recycling of motor vehicles and future trends

According to the above scheme is established and sustainable integrated process of recycling of motor vehicles along the entire life cycle, which includes all the processes and all the openings in a motor vehicle (from energy and mining to recycling of motor vehicles at the end of the life cycle and reinstallation of recycled materials and regenerated components). This approach to the recycling is shown in Figure 4 [2,5].

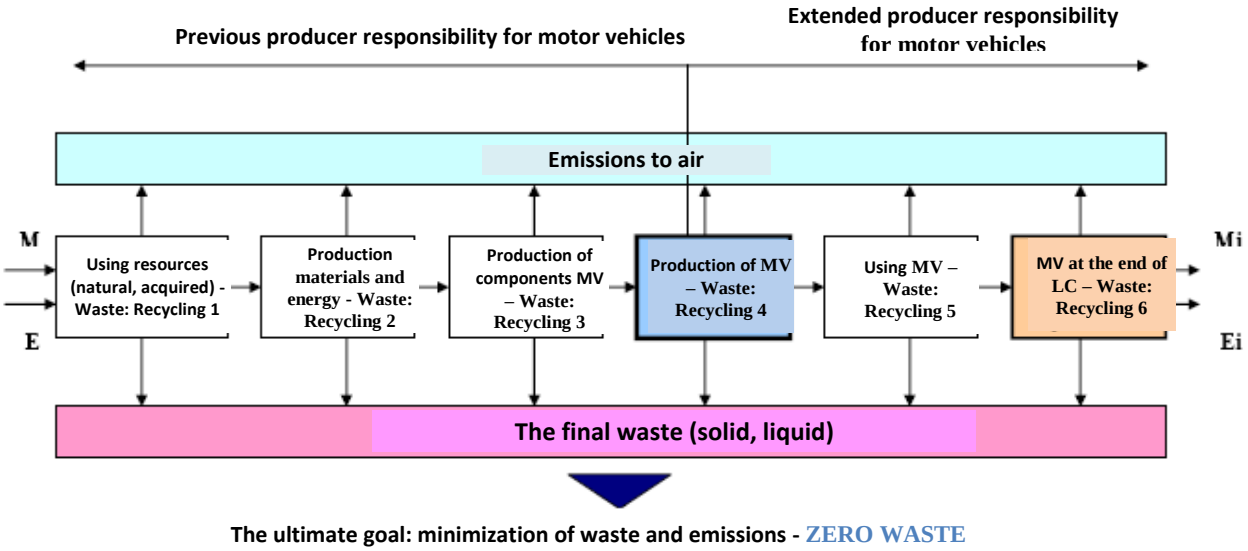

Figure 4 - Simplified display model of sustainable integrated recycling of motor vehicles along the entire life cycle [5]

As can be seen from the table below, in accordance with the development of new motor vehicles in the future will change the technology of recycling of motor vehicles at the end of the life cycle (recycling of batteries, fuel cells, electronic materials, "green" composites, biological materials) [6,7].

Table 1 - Trend assembly process and recycling of motor vehicles by 2050

Drive a motor vehicle	**vehicles with internal combustion engines using fossil fuels**	**Advanced motor vehicles with internal combustion engines (natural gas, hydrogen)**	**Hybrid vehicles (internal combustion engine + electric drive)**	**Electric vehicles (battery operated)**	**Motor vehicles powered by fuel cell (hydrogen)**
The structure of materials on motor vehicle	Standard materials are incorporated in the current vehicle	Standard materials have a greater presence alloys. Increasing electronic materials	The significant presence of light alloys (Al, Mg) electric and electronic materials and composites	Alloy (Al, Mg) electric and electronic materials and composites	Alloy (Al, Mg) electric and electronic materials, composites and biological materials
Requirements for new technologies assembly	Disassembly of the air bag	Dismantling equipment for hydrogen	Dismantling the batteries (Cd, Ni).	Dismantling the batteries (Cd, Ni and others)	Dismantling of fuel cells and biological components
Requirements for new recycling technologies	Recycling of plastics	Recycling of electronic and plastic materials.	Recycling batteries, composites and electronic and plastic materials	Recycling batteries, composites and electronic and plastic materials	Recycling of fuel cells, composites and electronic and plastic materials of biological materials
	2010.	**2020.**	**2030.**	**2035.**	**2050.**

6. Conclusion

In the decades to make plans to manufacture of motor vehicles "friendship" (cleaner) Environment (EFV - Environment Friendly Vehicle). The reason for developing such a concept is rapid climate change, improving energy efficiency and the depletion of natural resources (energy, water, ores). Also, in accordance with the concept being developed and introduced a renewable fuel, in order to reduce the impact on climate change and human health.

In addition to the ongoing development drive (moto) groups for these stages in parallel, the development of alternative fuels, the development of recyclable materials and the development of intelligent vehicles. In accordance with these stages of development of the motor vehicle will be developed methods and technologies of recycling of motor vehicles that will exit a sustainable and cost-effective recycling, and in the third phase and recycling residue-free (zero waste). Of course we are still upholding the concept of sustainable and integrated recycling of motor vehicles along the entire life cycle. The characteristics of modern vehicles will be following [6]:

- friendly to the environment,
- constructed of recyclable materials,
- for the production will be use renewable energy,
- prime waste along the entire life cycle,
- in use will have zero emissions (air, water, soil),

- work without noise,
- absolutely safe (active and passive safety),
- will have the "intelligence" / intelligent vehicles,
- inexpensive to use.

References

1. Jovan Milivojevic, Sanja Grubor, Kokic Aleksandra Arsic, Influence of recycling of motor vehicles at
2. the end of the life cycle of the development of new motor vehicles, Faculty of Mechanical Engineering Kragujevac, 2009.
3. Dejan Krstic, life cycle management of vehicles, 32. National Conference on Quality, Kragujevac, May 2005.
4. Ken Heitner, Advanced Battery Readiness ad hoc working group meeting, Feb. 8–Mar 1, 2001, Hyatt Arlington Hotel, Washington, D.C.
5. Stojanovic B., and Glisovic J., Automotive Engine Materials. In: Saleem Hashmi (editor-in-chief), Reference Module in Materials Science and Materials Engineering. Oxford: Elsevier; 2016. pp. 1-9.
6. B.J. Jody, E.J. Daniels, C.M. Duranceau, J.A. Pomykala, Jr., and J.S. Spangenberger, End-of-Life Vehicle Recycling: State of the Art of Resource Recovery from Shredder Residue, Center for Transportation Research Energy Systems Division, Argonne National Laboratory, September 2010.
7. Milan G. ET, Maja S. Trumic, role preparation recycling of waste and the sustainable development of Serbia, Faculty Bor, 2006.
8. Vid Vukasovic, Managing Batteries and accumulators and their waste, Original research grad, September 2007.