# Eco-Innovation in Manufacturing Process in Automotive Industry

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**Abstract.** One of the current problems of the global nature is environmental pollution caused by industrial production. Nowadays, we know many advanced hi-tech materials and production methods in the car industry, but when it comes to such innovations, the environment is often forgotten. Therefore it is necessary to find a solution that technological innovations in automobiles will go hand in hand with innovations of emission reductions in manufacturing process. One of ways to achieve a reduction of emissions and prevent leakage of harmful substances is to change the structure of the different principles in the production process (substitute auxiliary compounds, change amount of the compounds, the expansion of the recycling process). The aim of this paper is to highlight the innovation of the manufacturing processes in the automotive industry in order to reduce emissions and save the environment and partially point out also the innovated products of the manufacturing process.

**Keywords:** Environment · Sustainability · Manufacturing process · Automotive industry

## 1 Introduction

Decrease of fossil fuel reserves, environmental and human health damage as well as the ethical dimension of the problem related to that whether we have the moral right to extract and burn all the oil need to think about changing the status quo. Efforts to change requires new technologies which require a new way of thinking.

European cities are home of 70 % of the EU population which forms more than 80 % of EU GDP. Mobility within cities is still more complicated and inefficient. Road transport has become the largest polluter of the environment in urban areas, while emissions from transport grow every year [1].


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Automotive companies are beginning to recognize the new situation that calls for faster implementation of eco-innovation in manufacturing processes, which will be related to the production of new fuels and lower consumption of vehicles. There are still more and more examples. Toyota is already selling models in Japan with consumption of 4 l/100 km. In Brazil, several million cars runs on ethanol. Shell has built its own division specialized in the renewable energy sources. BP became one of the world's most successful manufacturers of solar panels and General Motors are trying to introduce higher tax on gasoline. All this can be included in innovative approaches in manufacturing processes.

## 2 Problem Identification

Eco-innovations are normally defined as innovations whose primary purpose is to reduce damage to the environment and the nature by various scientific disciplines, such as institutional and evolutionary economics, industrial economics, system analysis and operation research, knowledge management, organizational change management and so on [2].

The term "eco-innovation" refers to innovative products, processes or organizational innovations that reduce environmental costs, increase the acceptance of society and contribute to sustainable development. The concept is often used in conjunction with "eco-efficiency" and "eco-design" and also covers ideas related to environmentally friendly technological advances and socially acceptable, innovative ways towards sustainability [3]. Eco-innovations reduce material requirements, use closed material flows, or create respectively use new materials. They also focus on reducing energy demand, or create respectively use alternative energy sources, reduce overall emissions released into environment or existing environmental burdens and health risks in order to support the idea of healthy lifestyles and sustainable consumption [4].

The automotive and transport industry has taken steps to reduce $CO_2$ emissions and other environmental impacts, notably those associated with fossil fuel combustion. Combined with the growing demand for mobility, particularly in developing economies, many eco-innovation initiatives have focused on increasing the overall energy efficiency of automobiles and transport, while heightening automobile safety. Eco-innovations have, for the most part, been realized through technological advances, typically in the form of product or process modification and re-design, such as more efficient fuel injection technologies, better power management systems, energy-saving tires and optimization of painting processes. Yet, there are indications that the understanding of eco-innovation in this sector is broadening.

For example, the introduction of new legislative requirements for motor vehicle emissions in the United States in 1993 intensified pressures on the automotive industry to reduce the environmental impact from the use of automobiles. In response, a number of steelmakers from around the world joined together to create the Ultra-Light Steel Auto Body (ULSAB) initiative to develop stronger and lighter auto bodies. From this venture, the ULSAB Advanced Vehicles Concept (ULSAB-AVC) emerged. The first proof-of-concept project for applying advanced high-strength steel (AHSS) to automobiles was conducted in 1999. By optimizing the car body with AHSS at little

additional cost compared to conventional steel, the overall weight saving could reach nearly 9 % of the total weight of a typical five-passenger family car. It is estimated that for every 10 % reduction in vehicle weight, the fuel economy is improved by 1.9–8.2 % [5]. At the same time, the reduced weight makes it possible to downsize the vehicle's power train without any loss in performance, thus leading to additional fuel savings. Owing to their high- and ultra-high-strength steel components, such vehicles rank high in terms of crash safety and require less steel for construction.

The iron and steel industry's continuing R&D efforts in this area also stem from its attempt to strengthen steel's competitive advantage over alternatives such as aluminum. The Future Steel Vehicle (FSV) is the latest in the series of auto steel research initiatives. It combines global steelmakers with a major automotive engineering partner in order to realize safe, lightweight steel bodies for vehicles and reduce GHG emissions over the lifecycle of the vehicle [6].

Innovation plays a key role in moving manufacturing industries towards sustainable production. Evolving sustainable manufacturing initiatives – from traditional pollution control through cleaner production initiatives, to a lifecycle view, to the establishment of closed-loop production – can be viewed as facilitated by eco-innovation. Figure 1 provides a simple illustration of the general conceptual relations between sustainable manufacturing and eco-innovation. The steps in sustainable manufacturing are depicted in terms of their primary association with respect to eco-innovation, i.e. with innovation targets on the left and mechanisms at the bottom. The waves spreading towards the upper right corner indicate the path dependencies of different sustainable manufacturing concepts.

While more integrated sustainable manufacturing initiatives such as closed-loop production can potentially yield higher environmental improvements in the medium to long term, they can only be realized through a combination of a wider range of innovation targets and mechanisms and therefore cover a larger area of Fig. 1.

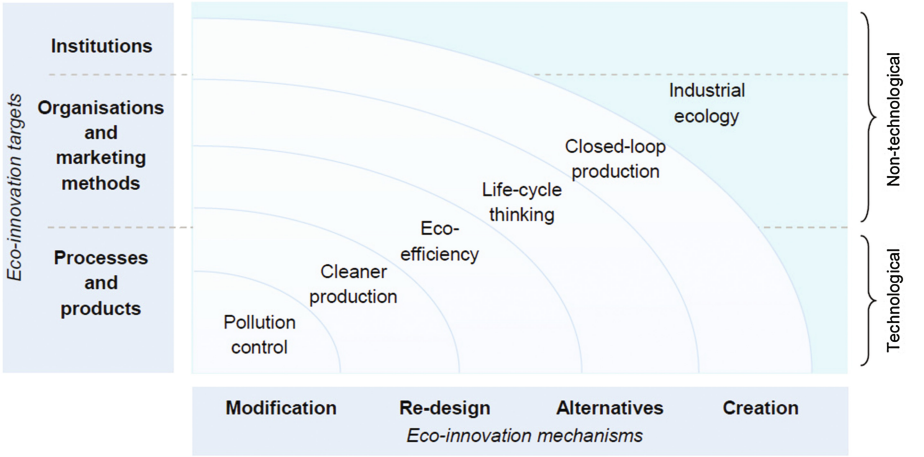


**Fig. 1.** Conceptual relationships between sustainable manufacturing and eco-innovation [6]

These complex, advanced eco-innovation processes are often referred to as system innovation – an innovation characterized by fundamental shifts in how society functions and how its needs are met [7]. Although system innovation may have its source in technological advances, technology alone will not make a great difference. It has to be associated with organizational and social structures and with human nature and cultural values. While this may indicate the difficulty of achieving large-scale environmental improvements, it also hints at the need for manufacturing industries to adopt an approach that aims to integrate the various elements of the eco-innovation process so as to leverage the maximum environmental benefits. The feasibility of their eco-innovative approach would then depend on the organization's ability to engage in such complex processes [6].

## 3 Results and Discussion

"Ecological modernization" – understood as systematic eco-innovation and its diffusion – has by far the largest potential to achieve environmental improvements. In general, the market logic of modernization and competition for innovation combined with the market potential of global environmental needs serve as important driving forces behind "ecological modernization" [8]. In recent times, however, additional factors like rising energy prices or fears from climate change have favored the rise of this innovation-based approach to environmental policy.

Environmental strategic visions and plans of automotive companies are generally based on the following key objectives:

- non-waste production technologies,
- reduction of emissions throughout the life cycle,
- reduction in fuel consumption and alternative sources of propulsion,
- replacement of non-recyclable materials,
- reducing the consumption of energy and water in the production process.

As a model case, we chose the Volkswagen Group, which is one of the world's largest automotive concerns. Within the protection of environment it deals with environmentally relevant issue where belong all the production and manufacturing processes with the aim to reduce the proportion of key environmental indicators at the end of the year 2018 by 25 % in comparison to year 2010.

In 2013, Volkswagen Slovakia joined to the strategy called Think Blue to achieve with production even greater environmental benefits. The seriousness Volkswagen approaches how this strategy has real results that are for example annual savings of 1 million kWh of electricity, 77.000 $m^3$ of natural gas and 595.8 tons of $CO_2$ (in 2013). In this context, we focused mainly on eco-innovations in the production process of the body shop, paint shop and SUVs assembly line at Volkswagen Slovakia in Bratislava.

**Bodyshop.** In the manufacturing process are used techniques such as welding, soldering, gluing, riveting and bolting. An important technique of bonding is energy efficient resistance spot welding. There are used also environmentally friendly manufacturing processes such as gluing using solvent-free adhesives and laser welding - energy efficiency of laser aggregates is very high. Several machines in the manufacturing process are

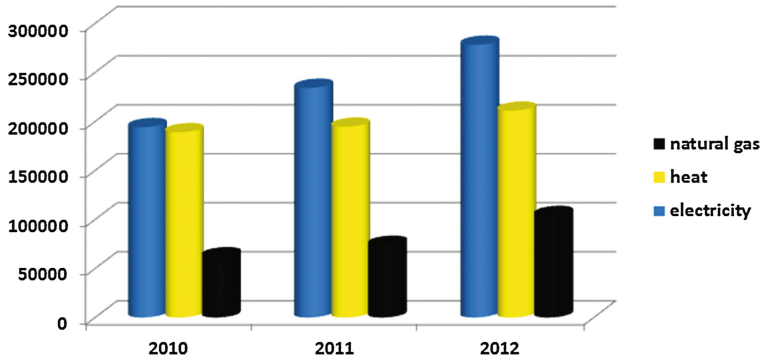


**Fig. 2.** Lowering values of energy indicators in Volkswagen Slovakia [9]

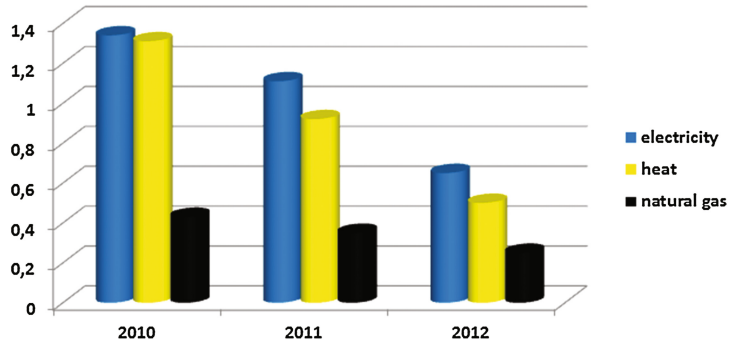


**Fig. 3.** Energy indicators in MWh/vehicle [9]

powered hydraulically. The relevant units are equipped with sump, which protect the subsoil in the event of malfunction against leaking hydraulic fluid. Welding smoke is suctioned and before being discharged into the environment is filtered through appropriate filtering equipment that removes polluting particles. Metals residues that remain from the production of car body are transported for recycling (Figs. 2 and 3).

Laser soldering. Impact on energy savings has also soldering of roof welds with side body parts, which is performed by a laser beam with more options of metal soldering. It can bond work pieces on the surface or create deep welds. The surface of the soldered joint is smooth and clean. Using the proper soldering wire will reduce the need for subsequent treatment of products. The source of this laser beam is so-called diode laser, which in comparison to the previous generation of arc lamp is 8-times more effective and has 33 % lower power consumption.

Degreasing and cleaning aluminum parts. Aluminum is still more frequently used in order to reduce the weight of SUVs. This lightweight material brings along also some technologies, such as degreasing and washing. After welding, the parts must be precisely degreased and washed. For this process is used special equipment for cleaning and degreasing. Its daily shutdown for 12 h can save up to 20 % of electricity.

Gelling devices. In the manufacturing of bodyworks are used two methods of curing of adhesives - infrared and induction. With infrared curing, burned infrared lamps have to be changed more often. On the other hand, the deployment of induction gelling devices for rear hood will save an average of 360 lamps per year.

**Paint shop.** The paint shop handles large amounts of material, water and energy. In the manufacturing process, the generation of emissions is limited by using separators and filters. Furthermore, the emerging waste water is treated and purified before discharge into the recipient. This area has therefore, in the whole manufacturing process of vehicles, the greatest relevance to environmental protection.

*Material savings.* By using the new technology EcoBell 3 is achieved saving of 70 % of varnish while achieving perfect adhesion of varnish to the body and less waste from the captured varnish. Eco LCC technology enables savings of up to 10 ml when changing paint colors in robot's spray nozzle.

*Water savings.* Saving of 30–60 $m^3$ of demineralized water/day was achieved by omitting the process of washing the bodywork after the grinding process. This technology uses a closed compartment where robotic brush after grinding process dedusts and cleans the whole bodywork. This cleaning /1} process also saves energy, which is required for the transport and treatment of water as well as energy required for the drying the bodywork after cleaning process.

*Emission savings.* Electrostatic separation, or E-Scrub, is a new technology for separating waste varnish resulting from the bodywork varnishing. Varnish which is not applied in the process of spraying the bodywork, remains in the form of aerosols in the air. These aerosols are by the circulation of air discharged into the separating system that disposes the varnish particles. 90 % of thus cleaned air becomes the circulation air again.

*Waste savings.* The main advantage of innovative varnishing process while maintaining the quality, one color layer - filling layer has been left out. The function of the filler is integrated into the base paint. Reduction of the whole process of applying the filler is significant both in terms of reducing the incidence of hazardous waste as well as reducing vehicle weight by 0.5 kg [9].

**Assembly** of a vehicle refers to the connection of the bodywork with a drive unit (motor), attachment parts and mounting modules, which is all carried out on partially automated assembly lines. During vehicle assembly arises waste from packaging in which parts were packed. This waste is as a priority used again, respectively it is recovered as secondary material. By separation, adhesive residues and cleaning cloths containing solvents are separated from recyclables.

*Reduction of $CO_2$ emissions.* For the control of quality and noise of vehicles are used vibrating rollers that simulate driving on the road. 90 % of finished of New Small Family vehicles drive on vibrating rollers, which means annual savings of 96 tons of $CO_2$ emissions.

*Saving water in water tests.* Water tightness tests for vehicles are carried out in monsoon conditions. Vehicles are in the water test tunnel exposed to a strong pressure of water from different spots. This process uses only technical water, not drinking water.

Innovations in the manufacturing process have a positive impact on the environment and saves energy that can be used somewhere else. For example, this energy can be used to power products from this innovated manufacturing process. It should be noted that innovation of the manufacturing process must be reflected in its final products - automobiles. When you take it from a different perspective that environmentally friendly manufacturing process would makes automobiles that produce high emissions, what all the eco-innovations of manufacturing would be for?

The final product of these innovations is an environmentally friendly automobile what is also positive to the final consumer - very low emissions which means low fuel consumption. When mentioning very low fuel consumption, most people will think of an automobile that in one side has a very low fuel consumption but on the other side the performance probably will not be much impressive, because a lot of people still have the one old rule in their minds - the higher the performance, the higher the fuel consumption. This is not currently true. Volkswagen AG came up with a solution that is not only highly environmentally friendly, but has a performance the end user will be pleasantly surprised with. As an example of one of those solutions, We would like to mention particular automobile model - Volkswagen Golf GTE. Golf GTE is powered by a turbocharged petrol engine in a combination with an electric motor. These two power units together give the automobile power of 204HP/150 kW. Acceleration from 0 to 100 km/h in 7.6 s, fuel consumption of 1.5 l/100 km and produces only 35 g/km of $CO_2$ emissions, which is a very favorable combination.

## 4 Conclusion

In the article we have dealt with eco-innovations in automotive industry on the example of the Volkswagen Group. For eco-innovation is considered every innovation, which can reduce the exploitation of natural resources and release of harmful substances in the whole life cycle. We can find eco-innovation in presented company either in the all manufacturing sectors (body shop, paint shop, assembly line etc.) as well as in new manufactured vehicles. The introduction of 'Think Blue. Factory' (strategy of sustainable production of vehicles), had a significant impact on the increase of eco-innovations in the vehicle manufacturing while the production adapted to it in all its stages. Volkswagen Slovakia produces environmentally friendly vehicles through green technologies. This confirms that technical progress is indeed inextricably linked to increasing of competitiveness, but it can also represent significant environmental protection.

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