Life cycle assessment to support the design of a new road manufacturing process with recycled materials

Gianluca Melis

Life cycle assessment to support the design of a new road manufacturing process with recycled materials

Abstract

Plastics are a key asset used in many manufacturing sectors, but in addition to convenience factors such as affordability and easy processability, negative impacts due to their production are increasingly being considered. One solution to production from fossil fuels can be recycling, which allows these materials to be given new life. Such practices are becoming increasingly popular, in numerous fields of application; one example for different polymers concerns the use of recycled polymeric materials within asphalt mixes in order to increase specific mechanical or thermal properties. The world of asphalt and road construction also allows the recycling of both individual asphalt layers and stone aggregates. This type of operation usually requires a lot of energy consumption and is limited in terms of polymer reuse and the environmental impact of extracting bitumen from petroleum.

There are several methods for assessing the environmental impact of a product/process. One of the most internationally recognized and regulated by both standards and European protocols is Life Cycle Assessment (LCA). This methodology makes it possible to obtain estimates, on different environmental indicators, of a product, to obtain a wide-ranging assessment, not limited to a single category or subsystem.

The main focus of this Ph.D. research, conducted at the Materials and Micro Systems Laboratory of the Polytechnic University of Turin (Chilab), concerns a life-cycle assessment of a new process for road production. This process in order to construct the road layer uses recycled materials, such as polymers and milled asphalt.

The research involved conducting two case studies. The first concerns a case of classic asphalt production from virgin materials (stone aggregates, bitumen, bitumen emulsion and filler). While the second case concerns production according to the newly developed technology involving the recycling of polymers and milled and reprocessed asphalt. The analysis was comparative in nature, and consequently the same functional unit, the same main information database, and the same methodology for calculating impacts were used. The conduct of the classic case is motivated by the need to obtain benchmark data with which to compare the indicators of the innovative case.

The thesis is organized by a theoretical research section on the various recycling technologies for polymers and asphalt and a second section in which the analyses conducted are described and the results obtained are compared. For each analysis, the research focused on creating a Life Cycle Inventory by production process, collecting data from both primary sources through experimental measurements and secondary sources from literature. Following the analyses, an inventory of results was produced for each of the two processes.

The end result was the obtaining of a profile of environmental indicators related to the process as a whole and the identification of the individual processes with the greatest impact, so that the innovative process could be developed according to a greater environmental consciousness.