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Science for Environment Policy

Can 3D printing reduce environmental impacts in the automotive industry?

As 3D printing, also known as additive manufacturing (AM), begins to replace conventional manufacturing, the environmental impacts of its implementation must be assessed. This study conducted a life cycle assessment (LCA) to investigate the environmental and resource implications of using AM to manufacture the metal parts of an engine in a light distribution truck. In the LCA, the impacts of both present and possible future states of AM technology were compared with current conventional manufacturing. The results suggest that there are potential environmental and resource benefits1 to AM technologies, but that these benefits rely on the achievement of a clean energy source and further technological development.

AM is an emerging technology. Unlike conventional manufacturing technologies, AM constructs 3D objects by binding material together until a shape and size is achieved based on 3D model data. AM has been associated with potential benefits, including reductions in product weight, transportation and material losses, as well as improved functionality and the possibility of printing spare parts. However, it has also been linked to potential drawbacks, including increased energy use in production and a slow printing process.

In light of these potential effects and the expected development and diffusion of this new technology, it is important to assess the environmental and resource consequences of implementing AM. Researchers therefore conducted an LCA (a technique used to assess environmental impacts associated with all stages of a product's life cycle). In this case, the LCA quantified the environmental impacts of using Powder Bed Fusion (PBF) to manufacture the metal parts of an engine in a light distribution truck. PBF is an AM technology that uses a laser or electron beam to melt and fuse material powder together, and it is currently in an early stage of adoption in the automotive and aerospace industries. To account for future technological development, the LCA compared PBF in its present state and PBF in its potential future state (roughly one decade from now) to current conventional manufacturing. It is worth noting that potential future developments in conventional manufacturing were not considered.

The results show that, in its present state, PBF technology shows only moderate or negligible environmental improvements. However, there are potential environmental and resource benefits to AM. Notably, if PBF develops as predicted (higher machine utilisation rate; higher machine throughput; increased automation; and increased machine efficiency)1, reduced impacts in the use-phase will more than compensate for the increased production impacts. This is largely due to components being redesigned for reduced weight, which lowers fuel consumption and hence reduces the life-cycle environmental impact of the vehicle. In both PBF scenarios, 3D-printed components were assumed to be redesigned to weigh 25% less than components made using conventional manufacturing, based on an average from Volvo Group test prints.

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Can 3D printing reduce environmental impacts in the automotive industry? *(continued)*

However, the potential environmental and resource benefits of AM are based on several underlying assumptions. If the above impact reduction is to be achieved, a clean energy source is required, just as is needed for conventional manufacturing. Similarly, if the above impact reduction is to achieved, AM technology must be developed to allow for the printing of larger components and of lower-impact raw materials (e.g. low-alloy steel); in its present state, PBF technology has not overcome these material limitations, meaning less of the engine can be 3D printed and also that components are printed in stainless steel, which is more energy and carbon intensive.

The researchers suggest that there is a potential future role for AM as a means to reduce the life-cycle environmental impact of vehicles — but, for this reduction to be achieved, clean energy must be readily available and efforts must be made to further develop AM technologies. The researchers state that industries should also seek to exploit other benefits of AM, such as weight reduction and improved functionality, as well as its potential for printing spare parts for remanufacturing and repairing.

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1. The researchers cite Huang, R., Riddle, M.E., et al. (2017). Environmental and economic implications of distributed additive manufacturing: the case of injection mold tooling. Journal of Industrial Ecology. 21 (S1), S130eS143. https://doi.org/10.1111/jiec.12641; who in turn cite Gausemeier, J., Echterhoff, N., and Wall, M. (2014). Thinking ahead the future of additive manufacturing—Innovation roadmapping of required advancements. Paderborn, Germany: DMRC, University of Paderborn