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Press Hardening as a Sustainable Solution for Lightweight Chassis Construction in Heavy-Duty Vehicles From a LCA Perspective

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Abstract

Currently, weight reduction in vehicles is a crucial concern for mitigating air pollution and also to achieve net zero emissions vehicles by 2035. Press hardening offers a huge lightweight potential, for thick sheet applications, as those used to construct heavy-duty vehicles. The use of press hardened steels can give up to 40% weight reduction in chassis components, in comparison with current solutions. Aimed to boost the application of such solution in heavy-duty vehicles, the present work addresses the environmental benefits of using press hardening from an environmental perspective. Two cases were compared, the current solution, based on cold forming, and the proposed press hardening approach. In both cases, the study follows a cradle-to-grave life cycle assessment approach, including raw material extraction, component manufacturing, vehicle use, and end-of-life. To ensure a high level of precision in the analysis, extensive primary data from the manufacturing stage and a comprehensive use of the vehicle were utilized, encompassing three different powertrain options for HDV of vehicles in a European context: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV). In terms of the manufacturing stage, the production of the press hardened component had the most significant impact due to the substantial energy needed during its processing (furnace). Nevertheless, this stage's overall effect on the entire Life Cycle Assessment (LCA) was relatively minor because the advantages of weight reduction during the vehicle use stage made a substantially larger contribution. Significantly, HEV had the most pronounced impact, largely due to their consumption of fossil fuels. Conversely, BEV, when considering an average European electric mix, exhibited a more favorable environmental profile. This work showcases the environmental significance of lightweighting through press hardening in chassis part of heavy-duty electric vehicles.

1 Introduction

The transport sector, a significant contributor to adverse environmental impacts [1], is key to EU's ambitious climate goals outlined in directives like the Green Deal. In the EU, transportation currently constitutes a substantial portion of greenhouse gas (GHG) emissions, necessitating urgent action [1]. The Green Deal outlines a roadmap for making a sustainable EU economy aiming for net zero emissions by 2035 and carbon neutrality by 2050[2], requiring emissions reductions across sectors, including road transport. Among the key strategies within the EU's framework is vehicles weight reduction to enhance fuel efficiency and cut emissions, aligning with the EU principles of circular economy and sustainable resource management[3]. Efforts, mainly through advanced high strength steels (AHSS), and press hardened steels have cut passenger's cars weight by up to 30%. However, heavy-duty vehicles (HDV), which currently account for about 25% of GHG emissions from road transport[4] have received less attention in lightweighting. As passenger car travel decreases, HDV emissions are projected to exceed those from cars and motorcycles.

Recent truck developments include AHSS and press hardening steels, but still most of the chassis' components are manufactured by microalloyed high strength steels. Steels are the perfect material family candidate to achieve high weight reduction in HDV while improving part durability at affordable cost and environmental impact in a short time frame. Press hardening of Boron steels is widely used in the automotive industry to obtain very high strength components with complex shapes. The technology is mature in Europe so the well-established innovations in the automotive industry can be transferred to HDV components to attain relevant weight reductions and directly contribute to the EU's commitment to reducing the carbon footprint of the transport sector. As the EU pushes for the adoption of alternative materials and innovative manufacturing processes, the exploration of new solutions becomes imperative to meet regulatory requirements and environmental targets. In this sense,