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Design of Nano-Reinforced Carbon Fiber Reinforced Plastic Wheel for Lightweight Vehicles with Integrated Electrical Hub Motor

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Abstract : The increasing attention is given to the issues of environmental pollution and climate change is exponentially stimulating the development of electrically propelled vehicles powered by renewable energy, in particular, the solar one. Given the small amount of solar energy that can be stored and subsequently transformed into propulsive energy, it is necessary to develop vehicles with high mechanical, electrical and aerodynamic efficiencies along with reduced masses. The reduction of the masses is of fundamental relevance especially for the unsprung masses, that is the assembly of those elements that do not undergo a variation of their distance from the ground (wheel, suspension system, hub, upright, braking system). Therefore, the reduction of unsprung masses is fundamental in decreasing the rolling inertia and improving the drivability, comfort, and performance of the vehicle. This principle applies even more in solar propelled vehicles, equipped with an electric motor that is connected directly to the wheel hub. In this solution, the electric motor is integrated inside the wheel. Since the electric motor is part of the unsprung masses, the development of compact and lightweight solutions is of fundamental importance. The purpose of this research is the design development and optimization of a CFRP 16 wheel hub motor for solar propulsion vehicles that can carry up to four people. In addition to trying to maximize aspects of primary importance such as mass, strength, and stiffness, other innovative constructive aspects were explored. One of the main objectives has been to achieve a high geometric packing in order to ensure a reduced lateral dimension, without reducing the power exerted by the electric motor. In the final solution, it was possible to realize a wheel hub motor assembly completely comprised inside the rim width, for a total lateral overall dimension of less than 100 mm. This result was achieved by developing an innovative connection system between the wheel and the rotor with a double purpose: centering and transmission of the driving torque. This solution with appropriate interlocking noses allows the transfer of high torques and at the same time guarantees both the centering and the necessary stiffness of the transmission system. Moreover, to avoid delamination in critical areas, evaluated by means of FEM analysis using 3D Hashin damage criteria, electrospun nanofibrous mats have been interleaved between CFRP critical layers. In order to reduce rolling resistance, the rim has been designed to withstand high inflation pressure. Laboratory tests have been performed on the rim using the Digital Image Correlation technique (DIC). The wheel has been tested for fatigue bending according to E/ECE/324 R124e.

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