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A CONTRIBUTION TO DESIGNING EFFICIENT COOLING FANS FOR MODERN ENGINE COMPARTMENTS

[1]Tesch, Gregor[*], [1]Demuth, Rainer, [2]Adams, Nikolaus A.
[1]BMW Group, Germany, [2]Lehrstuhl für Aerodynamik, Technische Universität München

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ABSTRACT

Adjusting the cooling fan design to its environment in modern vehicle engine compartments can reduce both energy consumption and aerodynamic drag at high vehicle velocities. Since cooling fans generally operate over a wide mass flow range, dominated not only by the fan rotational speed but also by the vehicle speed, axial fans are the traditional approach to acceptable fan efficiency over the entire range. They show satisfactory efficiency at operating points with high pressure ratio and a more moderate decrease in efficiency than radial fans at high vehicle speed. However, in a modern engine compartment the flow field through the fan is significantly affected by surrounding parts, imposing strong radial velocity components and decreasing axial fan efficiency in most of the mass flow range.

This paper presents the results of a study of the influence of geometrical fan parameter variations on fan efficiency for installation in a typical environment. Characteristic fan data, such as pressure ratio and required power, are measured over mass flow on a test stand, on which the neighbourhood of engine components is modelled by a specific deflector. Using a similar setup, a variation of a series of geometrical parameters is conducted based on a reference fan, and the influence on fan efficiency in the vicinity of the deflector is analysed with CFD. The combination of favourable parameter changes on hub, shroud and blades clearly shows improvement of fan efficiency throughout the considered mass flow range. Following this study, a new approach for the design of an axial-radial cooling fan is presented, where the blades are geometrically adjusted to the imposed flow field, using pre-defined airfoil data. Similar to the parametrically optimized fan, the simulation results show significant improvement in comparison to the reference fan, providing considerable potential of power reduction and aerodynamic drag reduction at high vehicle velocities.