Assessment of an Analytical Prediction Technique for the Shock Wave Attached to a Cone at an Angle of Attack

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Fast analytical or semi-empirical models are required for flight-vehicle design and increased understanding of the physics of high-speed flow-fields. Taylor and Maccoll (1933) proposed a method to predict the inviscid flow-field around a cone with attached shocks at zero angle of attack. The method requires numerical integration of two ordinary differential equations. Existence and closed-form solutions continue to elude investigators. A lesser-known approach developed by Savin (1951) allows for predictions with attached shocks at an angle of attack but is not representative of an exact solution of the inviscid equations of motion. The accuracy of Savin's approach generally increases relative to experiment for higher hypersonic similarity parameter, K. A system of four nonlinear algebraic equations is solved numerically with Savin's approach to obtain the surface of the attached shock wave. The entire flow-field is then reconstructed in meridian planes. We predict shock wave angles from Mach numbers 4 to 10, over half-cones angles of 5 to 15 deg., and angles of attack from 0 to 7 deg. These predictions are compared to the numerical results of Stone (1948) with Sims (NASA SP-3007, 1964). We find that the maximum absolute error of predicted wave angle is as low as 0.005 deg. and as high as 3.106 deg. Finally, we examine the underlying assumptions of these methods and present some conjecture on how to overcome them.

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