

The Impact of Undisturbed Flow Speed on the Correlation of Aerodynamic Coefficients as a Function of the Angle of Attack for the Gyroplane Body

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Abstract : This paper discusses the results of aerodynamic investigation of the Tajfun gyroplane body designed by a Polish company, Aviation Artur Trendak. This gyroplane has been studied as a 1:8 scale model. Scaling objects for aerodynamic investigation is an inherent procedure in any kind of designing. If scaling, the criteria of similarity need to be satisfied. The basic criteria of similarity are geometric, kinematic and dynamic. Despite the results of aerodynamic research are often reduced to aerodynamic coefficients, one should pay attention to how values of coefficients behave if certain criteria are to be satisfied. To satisfy the dynamic criterion, for example, the Reynolds number should be focused on. This is the correlation of inertial to viscous forces. With the multiplied flow speed by the specific dimension as a numerator (with a constant kinematic viscosity coefficient), flow speed in a wind tunnel research should be increased as many times as an object is decreased. The aerodynamic coefficients specified in this research depend on the real forces that act on an object, its specific dimension, medium speed and variations in its density. Rapid prototyping with a 3D printer was applied to create the research object. The research was performed with a T-1 low-speed wind tunnel (its diameter of the measurement volume is 1.5 m) and a six-element aerodynamic internal scales, WDP1, at the Institute of Aviation in Warsaw. This T-1 wind tunnel is low-speed continuous operation with open space measurement. The research covered a number of the selected speeds of undisturbed flow, i.e. $V = 20, 30$ and 40 m/s, corresponding to the Reynolds numbers (as referred to 1 m) $Re = 1.31 \cdot 10^6, 1.96 \cdot 10^6, 2.62 \cdot 10^6$ for the angles of attack ranging $-15^\circ \leq \alpha \leq 20^\circ$. Our research resulted in basic aerodynamic characteristics and observing the impact of undisturbed flow speed on the correlation of aerodynamic coefficients as a function of the angle of attack of the gyroplane body. If the speed of undisturbed flow in the wind tunnel changes, the aerodynamic coefficients are significantly impacted. At speed from 20 m/s to 30 m/s, drag coefficient, C_x , changes by 2.4% up to 9.9%, whereas lift coefficient, C_z , changes by -25.5% up to 15.7% if the angle of attack of 0° excluded or by -25.5% up to 236.9% if the angle of attack of 0° included. Within the same speed range, the coefficient of a pitching moment, C_{m_y} , changes by -21.1% up to 7.3% if the angles of attack -15° and -10° excluded or by -142.8% up to 618.4% if the angle of attack -15° and -10° included. These discrepancies in the coefficients of aerodynamic forces definitely need to consider while designing the aircraft. For example, if load of certain aircraft surfaces is calculated, additional correction factors definitely need to be applied. This study allows us to estimate the discrepancies in the aerodynamic forces while scaling the aircraft. This work has been financed by the Polish Ministry of Science and Higher Education.

Keywords : aerodynamics, criteria of similarity, gyroplane, research tunnel

Conference Title : ICAMAME 2016 : International Conference on Aerospace, Mechanical, Automotive and Materials Engineering

Conference Location : San Francisco, United States

Conference Dates : September 26-27, 2016