EXPERIMENTAL STUDY OF HYDRODYNAMICS ON ARROWS

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INTRODUCTION: Athletes' technical skill must be matched with appropriate equipment if an archer is to be successful. A lot of key skills of archery are determined by the features of aerodynamics of a flying arrow. Therefore, the performance of bow and arrow and the understanding of them have a direct impact on archery skill and competition result. Water and wind tunnel testing of arrows to establish their hydrodynamic characteristics are needed if performance is to be optimized.

METHODS: The experiment was conducted at the Low Speed Research Institute of Chinese Aerodynamic Research and Development Center. 1. Water tunnel test: The length of the water tunnel in this test is 15.76 m and the cross section size of the working section is 0.4m×0.4m with its length of 1.5 m. JVC9300 and OLYPUS digital camera were used to record the process. Four arrows (DIVA20, DIVA19, E1912 and E1914) were used as models in the test. 2. Wind tunnel test: The test was carried out in a 1.4m×1.4m low speed wind tunnel with the working section 2.8m-long and the cross section size of the corner-cut square is 1.4m×1.4m. The model used is a built-up pattern. The aerodynamic force on the model is transformed into electrical signal, then magnified, A/D converted and input to a computer for real-time processing.

RESULTS AND DISCUSSION: 1. Comparing the water tunnel test results of the four arrowheads, it was observed that "E1912" was the most streamlined. It was also evident that the feathers made from spiral plastic pinna were superior to those characterized by straight and smooth pinna.2. In the wind tunnel test, the result is based on the body axis of the arrow with the reference point of the moment at the center of the gravity of the model. During the test, the flight speed and the arrowhead and arrow tail produced by different manufacturer had little impact on the lift coefficient Cy and the pitching moment m_z of the arrow, while the location of the arrow nest and the existence of arrow feather would had great influence on the model.

CONCLUSION: 1. Within the attack range tested($-6 \le \alpha \le 6°$), the arrowhead can keep the state of attached flow. 2. As for the four testing arrows, the arrow "E1912" has relatively good streamline. 3. The state of flow of the arrow with spiral plastic pinna is better than that of arrows with straight and smooth one. 4. When $\alpha = 0°$, the change of the flight speed of arrows has little impact on the lift coefficient Cy and the pitching moment m_z. 5. Within the experimental angle of attack ($0° \le \alpha \le 16°$), the lift coefficient Cy will become larger while the pitching moment m_z gets smaller with an increase in the angle of attack. The arrow has the vertical static stability. 6. Different arrowheads have little impact on the lift coefficient Cy and the pitching moment m_z. 7. The arrow feather is the primary producer of lift force Y and pitching moment Mz; the feather's rolling will have some impact on lift coefficient Cy. The arrow feather is the main parts to produce lift force Y and to give the arrow body relatively great static stability. 8. A preliminary exploration on the features of hydrodynamics of arrows was carried out in this study.
The aerodynamic data and information from the arrow model, collected in these experiments, lay the foundation for future research.

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