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Design and Manufacture of Removable Nosecone Tips with Integrated Pitot Tubes for High Power Sounding Rocketry

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Abstract : Over the past decade, collegiate rocketry teams have emerged across the country with various goals: space, liquid-fueled flight, etc. A critical piece of the development of knowledge within a club is the use of so-called "sounding rockets," whose goal is to take in-flight measurements that inform future rocket design. Common measurements include acceleration from inertial measurement units (IMU's), and altitude from barometers. With a properly tuned filter, these measurements can be used to find velocity, but are susceptible to noise, offset, and filter settings. Instead, velocity can be measured more directly and more instantaneously using a pitot tube, which operates by measuring the stagnation pressure. At supersonic speeds, an additional thermodynamic property is necessary to constrain the upstream state. One possibility is the stagnation temperature, measured by a thermocouple in the pitot tube. The routing of the pitot tube from the nosecone tip down to a pressure transducer is complicated by the nosecone's structure. Commercial-off-the-shelf (COTS) nosecones come with a removable metal tip (without a pitot tube). This provides the opportunity to make custom tips with integrated measurement systems without making the nosecone from scratch. The main design constraint is how the nosecone tip is held down onto the nosecone, using the tension in a threaded rod anchored to a bulkhead below. Because the threaded rod connects into a threaded hole in the center of the nosecone tip, the pitot tube follows a winding path, and the pressure fitting is off-center. Two designs will be presented in the paper, one with a curved pitot tube and a coaxial design that eliminates the need for the winding path by routing pressure through a structural tube. Additionally, three manufacturing methods will be presented for these designs: bound powder filament metal 3D printing, stereo-lithography (SLA) 3D printing, and traditional machining. These will employ three different materials, copper, steel, and proprietary resin. These manufacturing methods and materials are relatively low cost, thus accessible to student researchers. These designs and materials cover multiple use cases, based on how fast the sounding rocket is expected to travel and how important heating effects are - to measure and to avoid melting. This paper will include drawings showing key features and an overview of the design changes necessitated by the manufacture. It will also include a look at the successful use of these nosecone tips and the data they have gathered to date.

Keywords : additive manufacturing, machining, pitot tube, sounding rocketry
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