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A Numerical Investigation of Total Temperature Probes Measurement Performance

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Abstract : Measuring total temperature of air flow accurately is a very important requirement in the development phases of many industrial products, including gas turbines and rockets. Thermocouples are very practical devices to measure temperature in such cases, but in high speed and high temperature flows, the temperature of thermocouple junction may deviate considerably from real flow total temperature due to the effects of heat transfer mechanisms of convection, conduction, and radiation. To avoid errors in total temperature measurement, special probe designs which are experimentally characterized are used. In this study, a validation case which is an experimental characterization of a specific class of total temperature probes is selected from the literature to develop a numerical conjugate heat transfer analysis methodology to study the total temperature probe flow field and solid temperature distribution. Validated conjugate heat transfer methodology is used to investigate flow structures inside and around the probe and effects of probe design parameters like the ratio between inlet and outlet hole areas and prob tip geometry on measurement accuracy. Lastly, a thermal model is constructed to account for errors in total temperature measurement for a specific class of probes in different operating conditions. Outcomes of this work can guide experimentalists to design a very accurate total temperature probe and quantify the possible error for their specific case.

Keywords : conjugate heat transfer, recovery factor, thermocouples, total temperature probes
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