ABSTRACT

Characteristics of the reverse flow region of a bluff body are closely related to its geometrical shape. In particular, shape and size of the reverse flow region, location of center of primary vortex, front and rear stagnation points are dependent on the geometrical shape of the bluff body. Number of researchers has studied the aerodynamic characteristics of recirculation zone of two-dimensional bluff bodies like cylinder of circular, square, rectangular and triangular cross section. But limited work was carried out with three-dimensional bodies like cone of circular cross section as the bluff body. In the present investigations, cold flow experiments were conducted to study wake axis parameters of circular and elliptic cone with different base-jet configuration.

All the experiments have been carried out in a closed jet test section table top subsonic wind tunnel. The Cross section size of the test section is 240 mm X 180 mm with 660 mm length. The Base area and length of the cones were maintained constant as 1296 mm$^2$ and 110 mm respectively to maintain constant finesse ratio of 2.75. The test section blockage ratio of the test model in the wind tunnel experiments is 0.03. Elliptic and circular cone models are mounted symmetrically in the test section during all the experiments.

Experiments were conducted in three categories as follows: i) Static pressure measurement along the wake axis of the circular and elliptic cone at
6 m/s, 15 m/s and 25 m/s freestream velocity without any base-jet injection using Digital Sensor Array (DSA-Scanivalve). ii) Using Constant Temperature Hot-wire anemometer (CTA-DANTEC), velocity and its fluctuations were measured along the wake axis of the cones. Effect of base-jet Injection Ratio (IR =0.5, 0.75, 1.0, 1.25 and 1.5), base-jet Area Ratio (AR = 0.005, 0.01 and 0.015) and base-jet orifice shape (circular, square and hexagonal) on the mean velocity and fluctuation were studied at only 25m/s freestream velocity (Re=66000). iii) Flow visualization (shadowgraph) of incompressible base-jet injection (Helium) was carried out to study the base-jet penetration characteristics behind circular and elliptic cones at 15m/s freestream velocity.

Time averaged mean velocity measurements (without base-jet injection) along the wake axis show that the length of recirculation zone of an elliptic cone is 38% shorter than equivalent base area circular cone at 25 m/s freestream velocity. RMS value of velocity fluctuations ($u'$)$_{rms}$ along within the recirculation zone of an elliptic cone without base-jet injection was found to be 15% higher than that of circular cone. Reverse flow region of elliptic cone is shorter in length and turbulent in nature than that of an equivalent base area circular cone.

Comparison of penetration lengths of different base-jet shows the penetration length of base-jet injected from an elliptic cone was averagely 26% shorter than penetration length of a jet injected from circular cone. The velocity gradient of base-jet injected from an elliptic cone is normally 25% greater than velocity gradient of jet injected from a circular cone. An
empirical relation was also derived from the available experimental data between base-jet penetration length and base-jet momentum ratio.

There is no effect of base-jet shape on the penetration length at smaller jet size and jet injection velocity. At higher jet size, penetration of square and circular shape base-jet is approximately equal but longer than penetration of hexagonal shape jet. \((u')_{\text{rms}}\) in a square base-jet is larger than \((u')_{\text{rms}}\) of other jets due to the abrupt change in its circumference and creation of corner vortices. Hence a base-jet with square shape injected from elliptic cone may mix earlier and better with the recirculation fluid in a combustion system than a base-jet injected (circular, square and hexagon) from circular cone. Flow visualization study also reveals the same results as velocity measurement results regarding the penetration lengths of base jets.