A New Empirical Capture Velocity Formulae for the Design and the Assessment of Local Exhaust Ventilation System

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Laboratory-based research data were used to examine the validity of existing formulae. The data collected during this study was obtained using more accurate velocity measuring instruments than that used earlier. The measurement concerned the point capture velocity in front of different geometrically shaped suction openings and the suction flow rates.

A comparison of the observed and the predicted capture velocities using the existing formulae revealed an unacceptably wide discrepancy. Evaluation of the results proved that the existing formulae are not valid for the estimation of the capture velocity. From the observed results a functional relationship emerged between the point capture velocity and a number of variables affecting the design of the suction system. The " nonlinear regression curve fitting statistics" were used to evaluate data. The existing empirical formulae were used as a fitting model.

It was found that the centre line capture velocity in front of round and rectangular suction openings for the same suction flow rate differ. A comparison of the theoretical potential flow rate with the experimentally obtained value proved them to be far apart.

All the previous researchers assumed a spherical surface as a potential flow field. In this, study, however, a half-oblate ellipsoid surface for the potential flow was tested. Therefore, both spherical and ellipsoidal surface areas were calculated. Using these areas, a numerical solution of the potential flow field was obtained. The experimentally obtained values were compared with theoretical values. It was found that the ellipsoidal potential surface gives a better prediction than the others. Whatever the size of the suction opening, the velocity fields thereby induced for any suction flow rate through geometrically similar suction openings are of similar shape. Moreover, the ratio of suction flow rate and mean air velocity thereby induced at some point in the suction affected area for similar suction openings / hoods, is the same at geometrically similar points. The general trend of the velocity gradient for similar suction openings is similar, but it is dependent on the shape of the connection piece. The velocity gradient in front of a round suction opening is higher than that in front of a rectangular suction opening. It was found that the asymptotes of velocity attenuation in front of a round suction opening, are narrower that those of a rectangular suction opening. This means that an increase in the suction flow rate will increase the centre-line point capture velocity at a point further in front of rectangular openings than in front of round suction openings.

It was also found that the capture velocity strongly depends on the hydraulic radius as a general factor for the shape of a suction opening.

The following formulae have been derived from the data on laboratory experiments:

1- For a round suction opening $v/V = (1.8(X/HR)^{-0.865}))/ (1+0.23(X/HR)^{-0.865})$
2- For a rectangular suction opening $v/V = (1.8(X/HR)^{-2.04}))/ (1+0.16(X/HR)^{-2.04})$
3- a general formula for flat flanged all shaped of main duct $v/V = (1.022(X/HR)^{-1.56}))/ (1+1.825(X/HR)^{-1.56})$

Where v= center line point suction velocity (m/s)
V= average suction velocity at the face of suction opening (m/s)
x= position of suction points along the centre line (m)
HR= ratio of area of suction opening to its circumference/perimeter

The above formulae can be used by Ventilation Engineers for designing captor hoods, whilst Maintenance Engineers and Occupational Hygienists can use them for assessing the performance of existing captor hoods.