The Air Flow of Two-Dimensional Aaberg Slot Exhaust Hoods

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Introduction

Exhaust hoods are used in many industries to remove contaminant from a region close to the source(s) of the generation by the withdrawal of air and contaminant. In comparison with traditional exhaust hoods, the Aaberg exhaust system, with its additional jet, can significantly improve the capture efficiency of the hood. Since the 1980's experimental investigations and mathematical analyses on the Aaberg exhaust systems have been performed by Hogsted (1), Hyldgard (2), Pedersen and Nielsen (3) Fletcher and Saunders (4) and Hollis (5). Hunt and Ingham (6) have employed a combina-tion of analytical and numerical solutions of the governing mathematical equations. In this paper the numerical results of the air flow of an Aaberg exhaust system, schematically shown in Figure 1, are produced by using both a theoretical model, which is associated with the boundary integral technique, and the standard k-ε model, which is associated with the control volume technique.

Operational Parameters

The most common operational parameters are I, or G, which are defined by

$$I = \frac{m_j u_j}{m_i u_i} \qquad \text{and} \qquad G = \frac{C u_j (pb)^{1/2}}{m_i} = C\left(\frac{pI}{S}\right)^{1/2} \tag{1}$$

where m_j is the volume flux of the air which is injected with an initial average speed u_j and m_i is the volume flux of the exhausted air which has an average speed u_i.

When the back of the Aaberg system is vertical, i.e. $\alpha = \pi/2$, Figures 2(a)-(d) show that an increase in the value of the operating parameter I, or G, makes the dividing streamline move closer to the surface of the workbench and this leads to higher air velocities near to the surface of the workbench.

When $\alpha = \pi/4$, the effect of the strength of the jet on the streamlines is shown in Figure 3. Similar to the situation when $\alpha = \pi/2$, it is observed that the stronger is the jet then the dividing streamline moves closer to the surface of the workbench. This

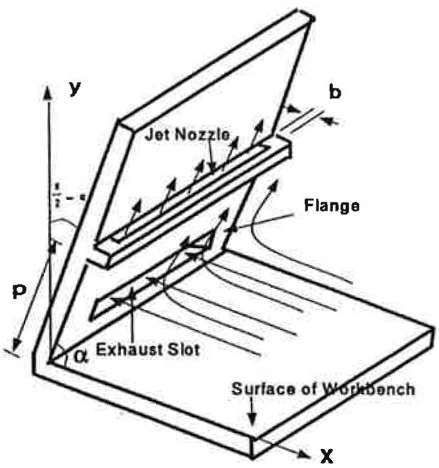

Figure 1. A schematic diagram of theAaberg slot exhaust hood.

leads to a larger increase in the air velocity near to the surface of the workbench compared with the case $\alpha = \pi/2$ and therefore further enhances the capture efficiency of the exhaust system.

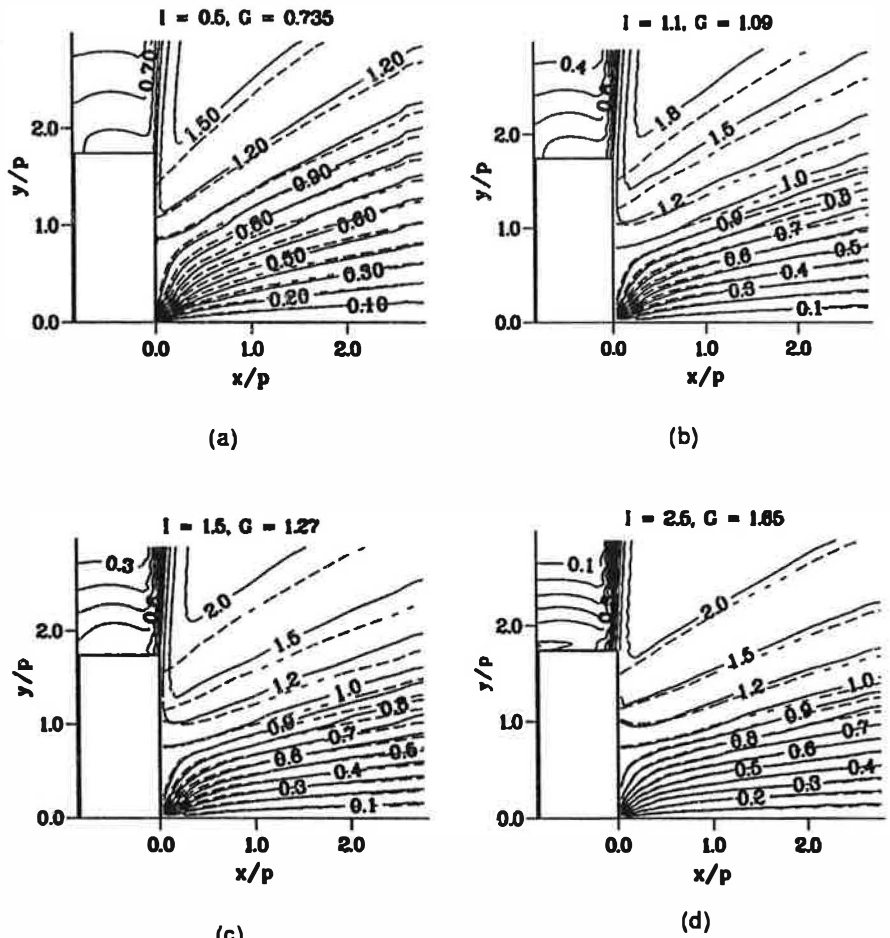

Figure 2. Streamlines when $I = 0.5$, 1.1, 1.5 and 2.5, $G = 0.735$, 1.09, 1.27 and 1.65, --------- k-ε model, - - - - potential model.

Figure 4 (a) shows that the ratio of the air speed on the surface of the workbench, $U(x,0)$, which is created by the Aaberg exhaust hood, to the air speed created by the exhaust flow alone, $u_s(x,0)$, when $\alpha = \pi/2$. This figure illustrates that an increase in the value of I leads to an increase in the air velocity near to the surface of the workbench. We also observe that this velocity ratio has a larger value at a large distance from the exhaust outlet and this indicates that the larger the distance from the exhaust outlet then the larger is the relative increase in the air velocity produced by the jet. Figure 4(b) shows that the ratio of the air speed on the surface of the workbench $U_\alpha(x,0)$, created by the Aaberg exhaust hood when $G = 1.0$, $\alpha = \pi/3$ and $\alpha = \pi/4$, to the air speed $u_{90}(x,0)$ when $G = 1.0$, $\alpha = \pi/2$. It is observed that approximately we have $U_\alpha(x,0) \approx \frac{\pi}{2\alpha} u_{90}(x,0)$.

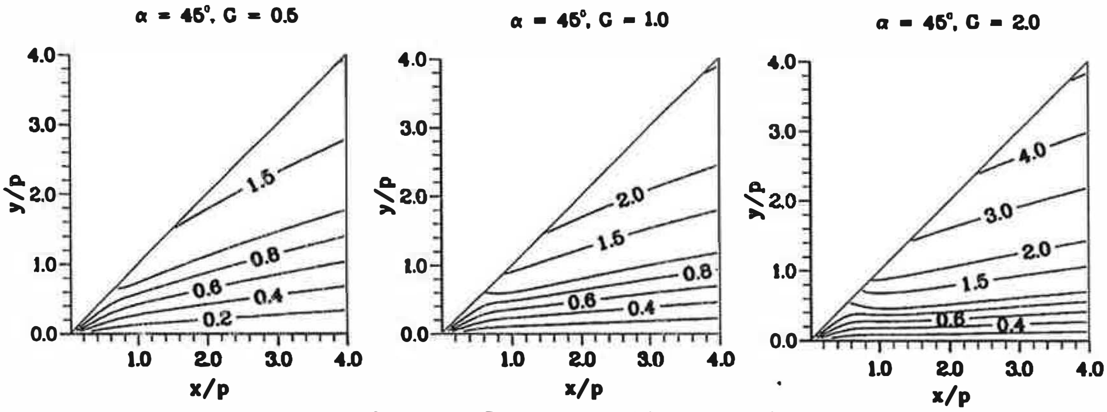

Figure 3. The streamlines of the air flow created by the Aaberg exhaust when $\alpha=\pi/4$ *and* G = *0.5, 1.0 and 2.0.*

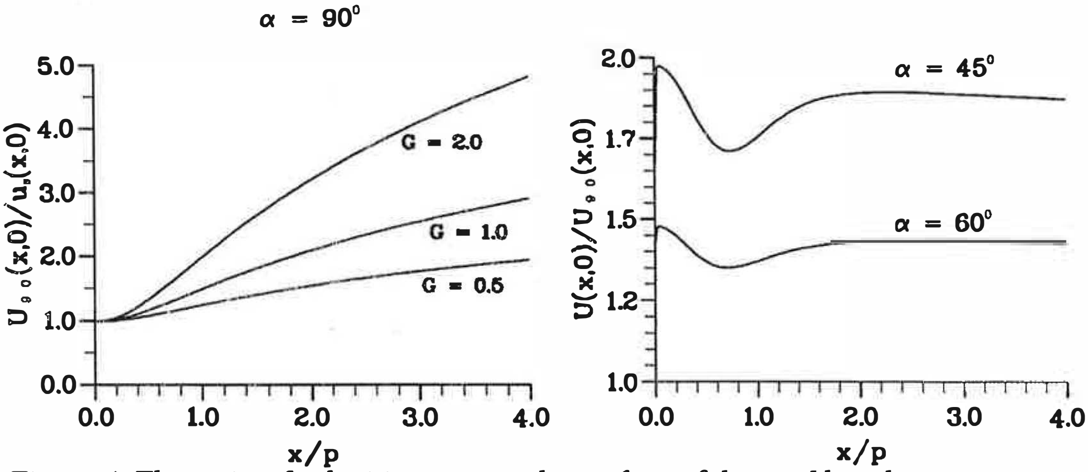

Figure 4. The ratio of velocities near to the surface of the workbench.

Conclusions

For the two-dimensional Aaberg slot exhaust hood the velocity near to surface of the workbench may be increased by increasing the values of the parameter I, or G, or decreasing the angle between the axis of the jet flow and the surface of the workbench.

Acknowledgments

The authors would like to thank the EPSRC for the financial support of this work.

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