Rebuttal to the Foreign Reviewer

We would like to thank the reviewer for giving his valuable time to evaluate this thesis, and suggest the necessary changes so as to improve it. Again, the author thanks the reviewer for his appreciation in terms of the useful contribution and well lay out of this thesis.

Question #1: The choice of using overall entrainment ratio to validate the models (Fig. 2.8 & 2.10) may not be most appropriate. The entrainment ratio may be less sensitive to changes in models since it is an overall measure. Even with this global measure, Fig. 2.10 shows notable difference at lower Re and lower H_{nz}/D_{nz}. Comparison of local profiles such as velocity profiles would be better test for the models. Since the author have access to hot wire data, if they could take the data at several axial locations, and compare with their predictions, it would be more appropriate. While the author has compared with single jet velocity decay data (Sec 2.4) comparison with similar data for the IRS geometry would be more appropriate.

Answer: The air entrainment in Figs 2.8 and 2.10 (Page: 27 & 29) was calculated by measuring the local velocities at nine different radial locations on the IRS device outlet. Then these velocities were integrated numerically to measure the mass outflow rate. The mass flow rate at inlet is subtracted from the out flow rate to compute the mass suction into the IRS device.The local velocities were measured by a Veloci-meter which works on the hot-wire principle.

A new curve (i.e., Page 28, Fig. 2.8 (b)) for the velocity measurement at different radial location on the funnel out let has been incorporated in revised thesis as has been suggested by the reviewer.

At low Re, the air entrainment rate computed from the numerical model is little lesser than the experimental value. This is due to the fact that at low Re, the probes may not be getting sufficient air for the measurement.

In the present experimental set up, we are unable to measure the axial velocity decay ofa jet since our set up is not equipped with the velocity probes at different axial locations.

Question #2: On a similar vein, the differences noted in Table 2.1between the various turbulence models is not very informative since the entrainment ratio is a global parameter that may not show a lot of sensitivity to the choice of turbulence model. It may not be the best metric to use in judging the turbulence model.

Answer: Yes, we agree that this is not the best way to judge a turbulence model, however the use of several other turbulence models give the confidence when one gets similar results from all the models.

Question #3: The grid independence results on page 22 should be done by doubling the number of grid points instead of increasing it by aboutn 20% or so as is done in the thesis.

Answer: We have checked the grid indepedence test by doubling the grid points, and we found there is a little (0.05%) or no change in the mass suction rate. Since the computaional time is increased by taking more grid points and the results are insentitive to this change, the pervious grid independence test still valid for the study.

Question #4: In Fig. 2.13, while discussing the temperature effects, it would be helpful to bring in a discussion of buoyancy and its role in altering the flow field and the entrainment rates. It would be helpful to view this from the perspective of Grashof numbers.

Answer: It is seen that the effect of inertia force dominates the buoyancy force in the present mixed convetive flows as can be seen from Table 2.1 given in Page 36. It is well known that as $Gr/\mathrm{Re}^2 < 1$, the effect of the inertia force dominates the buoyancy force, although it is present.

Question #5: In Chapter 3 serveral correltions for positive and negative overlaps and isothermal and heated flow are presented. Again, for non-isothermal flows, I suspect buoyancy or Grahof number plays a role? Either this should be discussed, or the authors should demonstate that the flow is dominated by intertial forces and that the buoyancy foces play a little role or no role.

Answer: In the full scale IRS device, similar effects (i.e., dominance of the intertia force over the buoyancy force) have been seen. Threfore, we agree with the reviewer that the the flow is dominated by the inertia force and the buoyancy forces play little or no role.

Question #6: In Chapter 4, the effect of multiple nozzles as well as non-circular nozzles has been considered, and the entrainment rates calculated. There is work in the literature on entrainment rates from single non circular nozzles (see work reperoted by Gutmark or Grinstein for example), and it may be instructive to compare with these results.

Answer: The entrainment rate for sigle circular nozzle have been compared with our experimental resluts. It has been reported earlier that the numerical resluts for air entrainemt by non-circular nozzles matcehs well with the experimetal resluts. Thefore, we derived the confidence to use present numerical methods for computing the air entrainment for noncircular nozzles.