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RANDOM VORTEX METHOD FOR COMBUSTING FLOWS

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The random vortex method RVM of Chorin has been developed by the University of California - Berkeley to compute turbulent, reacting, recirculating flows, ref. 1. The RVM method models turbulence from first principles, tracking the vorticity and obtaining the interaction of vorticity with the bulk flow field. A computer program has been produced called MIMOC, Modeling the Interface Motion of Combustion, which can be used to calculate the reacting flow field behind a rearward facing step, ref. 2

Several comparisons between experimental data and calculations have been made, refs. 3-4. The RVM method computes qualitatively good results, but the quantitative agreement as yet is not completely satisfactory. Much of the difficulty may be caused by the treatment of boundary conditions and the techniques used for obtaining statistical averages of velocities and turbulence quantities. For the rearward facing step the computed reattachment length equals the experimental value as shown in figure 1. However the reverse velocity in the recirculation zone is over predicted by 300 percent, figure 2. In the calculations, a uniform entrance velocity was assumed with no boundary layer at the step lip. This high velocity may be overdriving the reverse flow region. The profile shown in figure 2 is the worst agreement obtained. Figure 3 shows that the time steps used to obtain the statistical average also is important. As the calculation continues, stationary values should be obtained for the mean values, but the averages must be taken over the time of several large scale vortex sheddings.

In house calculations are being conducted to look at the comparison between the turbulence quantities and the experimental values.

Recent calculations by Hsiao, ref. 4, show much better agreement between computations of the mean velocities and experimental data, figure 4. Hsiao has included the inlet passage within the calculation domain. The statistical quantities are not in good agreement, figure 5, but the averages were computed over only 20 time steps.

The results from the RVM method have been very encouraging and much can be learned through continued study of the calculation method.

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References

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2. Ghoniem, Ahmed F.; Marek, Cecil J.; and Oppenheim, Antoni K.: Modeling Interface Motion of Combustion (MIMOC). NASA TP 2132, August 1983.

3. Dai, Y.-W.; Ghoniem, A.F.; Sherman, F.S.; and Oppenheim, A.K.: Numerical modeling of Turbulent Flow in a Channel. NASA CR-168278, March 1983.

4. Hsiao, C.C.; Ghoniem, A.F.; Chorin, A.J.; and Oppenheim, A.K.: Numerical Simulation of a Turbulent Flame Stabilized Behind a Readward-Facing Step; submitted to the Twentieth Symposium (International) of Combustion, Aug. 12-17, 1984.

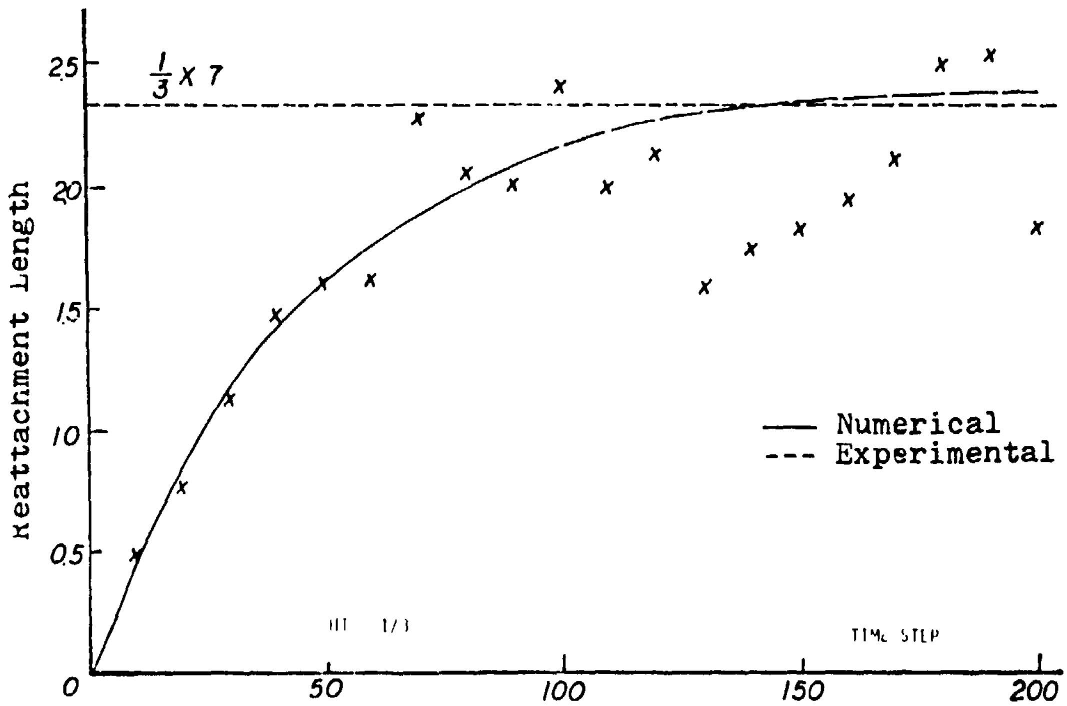

Figure 1. Comparison of reattachment length, from ref. 3.

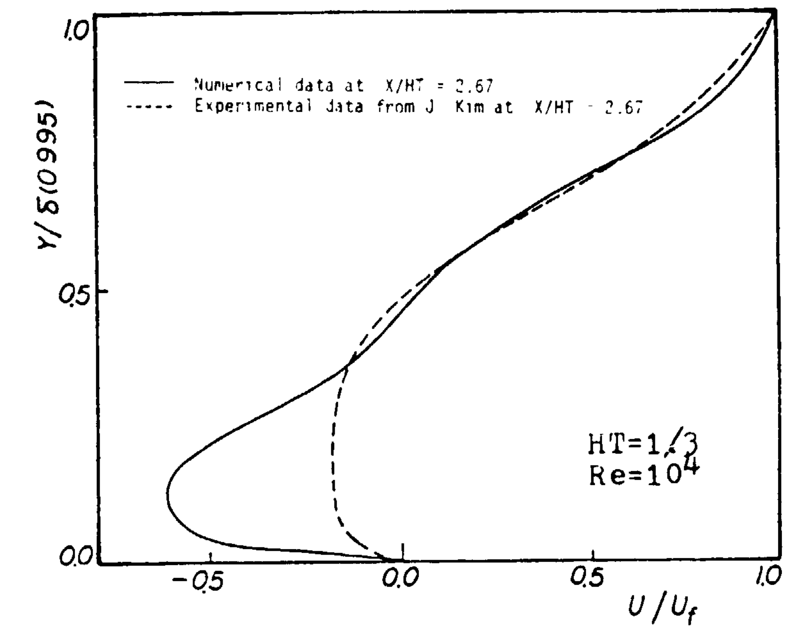

Figure 2. Comparison of mean velocity profile, between time steps 158 to 200, from ref. 3.

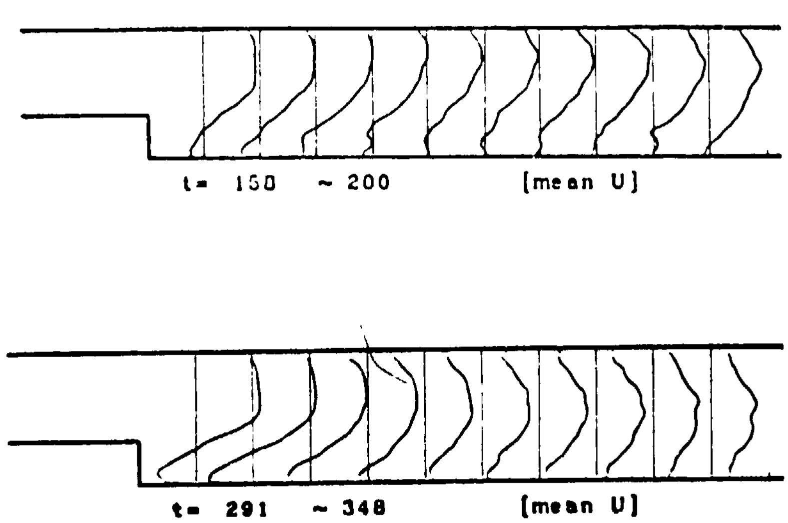

Figure 3 Comparison of mean velocity profile at HT = 1/3 and Re = 10^4 with different averaging time period., from ref. 3.

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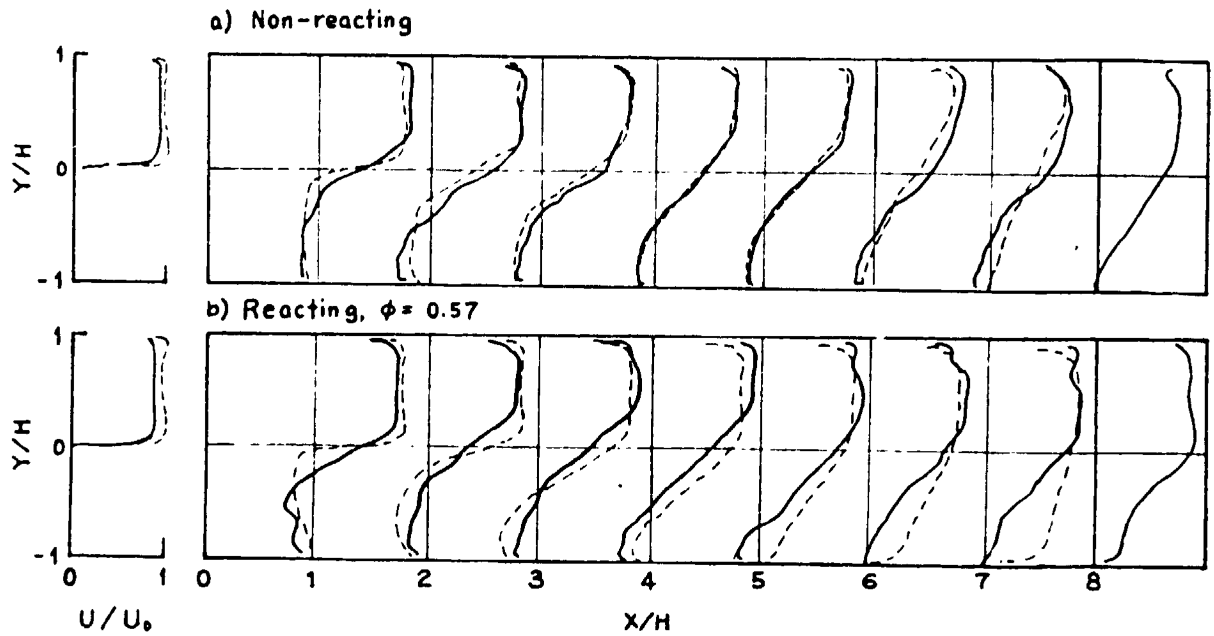

Figure 4. Average velocity profiles at Re=22,000, from ref. 4. Solid-Numerical: Dashed-Experimental.

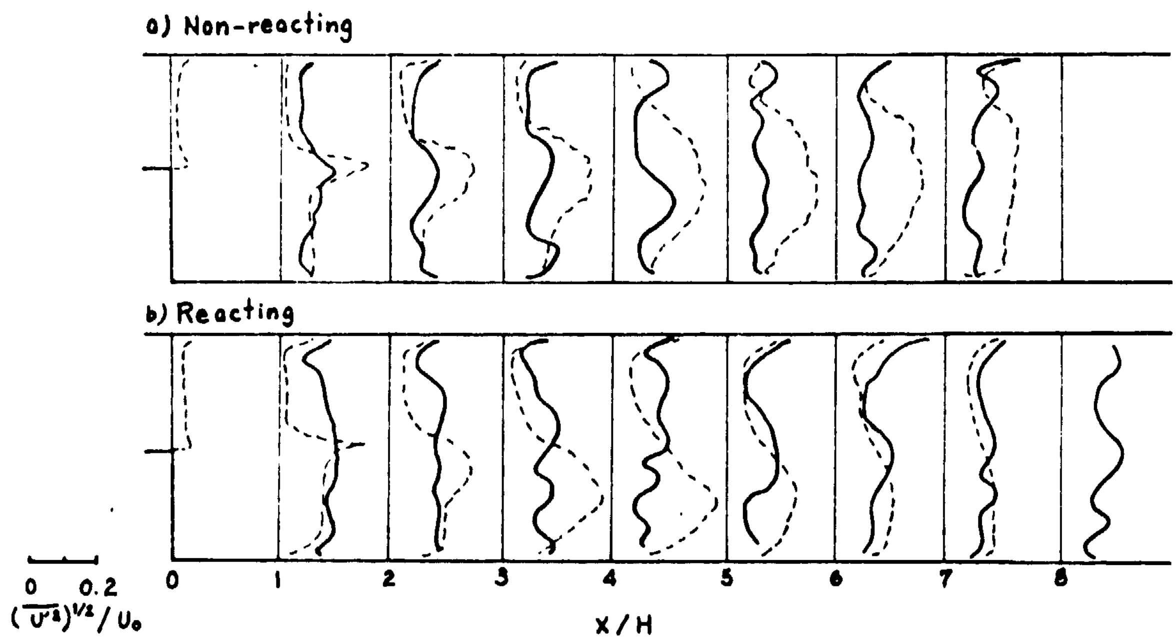

Figure 5. Streamwise turbulence intensity profiles, from ref. 4. Re=22,000; Solid-Numerical: Dashed-Experimental