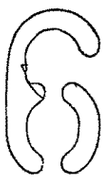

CHAPTER - 6

CONCLUSION

6.1 CONCLUDING REMARKS :

Present numerical study on free convection in rectangular enclosures, using constant strain traingle (CST) finite element method (FEM) produced interesting results, discussed at length in earlier articles. These results are summarised as under :

i) Free convection in horizontally oriented rectangular enclosures under adverse temperature gradients is aspect ratio dependent, in which three distinct convective flow regimes based on aspect ratio (AR) are identified e.g. low aspect ratio ($1 \leqslant AR \leqslant 5$) region, transitional aspect ratio ($5 \leqslant AR \leqslant 10$) region and high aspect ratio ($10 \leqslant AR \leqslant 300$) region.

ii) Two criticalities based on Rayleigh number are observed in high aspect ratio region. Heat transfer is essentially by conduction until Ra value exceeds first critical Rayleigh number Ra_{c1} , when first criticality occurs and cellular convection begins to appear. On further increasing Rayleigh number, cellular convection breaks into boundary layer convection, if Ra value exceeds second critical Rayleigh Number Ra_{c2} , when second criticality is supposed to occur.

iii) Both the critical Rayleigh numbers Ra_{c1} and Ra_{c2} are strongly dependent upon aspect ratio while heat transfer in cellular and boundary layer convection is also aspect ratio dependent.

iv) Increasing aspect ratio of an enclosure delays the onset of both the cellular convection and the boundary layer convection.

v) Preliminary study on horizontally oriented enclosures under favourable temperature gradients ($\phi = 180°$) shows a departure from classical conduction behaviour into aspect ratio dependent cellular convection at high Ra values for low aspect ratio enclosures.

vi) Present method fails to access the effect of enclosure orientation on heat transfer for $0° \leq \phi \leq 90°$, probably because of the two-dimensional approximation made in the present investigation, which may not be valid for inclined enclosures under adverse temperature gradients.

vii) Following correlations for high aspect ratio, horizontally oriented, rectangular enclosures, under adverse temperature gradients, are obtained from the present investigation :

$$Nu = 1 \qquad \text{for} \quad Ra \leq Ra_{c1}$$

$$Nu = 0.8463 \cdot Ra^{0.0675} \cdot AR^{-0.125} \qquad \text{for } Ra_{c1} \leq Ra \leq Ra_{c2}$$

$$Nu = 0.6760 \cdot Ra^{0.125} \cdot AR^{-0.25} \qquad \text{for } Ra \geq Ra_{c2}$$

$$Ra_{c1} = 10 \cdot AR^2$$

$$Ra_{c2} = 70 \cdot AR^2$$

6.2 FURTHER SCOPE :

Present investigation was made, essentially to study free convection from high aspect ratio, horizontally oriented, rectangular enclosures, under adverse temperature gradients. A constant strain triangle finite element method which uses variational formulation, was developed for the purpose. The study resulted in interesting observations, particularly with regard to effect of aspect ratio, as is evident from earlier articles. The study can be pursued further, either by modifying the method or by developing a new suitable method, for the following cases :

i) Low aspect ratio region covering aspect ratios from 1 to 5 and very low aspect ratio region covering aspect ratios less than 1, requires a special attention as these regions are scantly studied by earlier investigators, either analytically or experimentally.

ii) Exclusive experiments and flow visualisation study for high aspect ratio regions, to confirm the results of the present investigation, is of course, not out of place, for further study.

iii) Analytical study of inclined rectangular enclosures under adverse temperature gradients ($0° \leqslant \phi \leqslant 90°$) does not appear to be available in literature. This may be due to failure of two-dimensional approximation invariably made in all the numerical studies so far. This is an area of interest in solar collectors.

iv) Preliminary study made in the present investigation for inclined rectangular enclosures under favourable temperature gradients ($90° \leqslant \phi \leqslant 180°$) suggests the possibility of obtaining useful results if the study is extended further.

v) Effect of boundary condition on aspect ratio dependent heat transfer from inclined rectangular enclosures, is also an area of interest, not adequately studied so far.

vi) Real life applications of rectangular enclosures involve an enclosure with a partition like a doorway, window, corridor or an incomplete dividing wall and the fluid is supposed to be trapped inside the cavity due to the presence of such a vertical obstacle. This results in the sizeable portion of inactive trapped fluid, significantly changing free convection heat transfer in such a partitioned enclosure. Bajorek and Lloyd [104] in 1982 and Lin and Bejan [105] in 1983 studied the problem experimentally. There is a scope for analytical and experimental research in this field.

vii) Free convection in shallow waters with slopping bottoms heated by solar radiation and energy conservation in attics are the applications of free convection studies in triangular enclosures. Experiments in this field were performed by Poulikakos and Bejan [106] and corresponding numerical solutions are also made available by them [107] . This is also a field of recent interest in which there is a scope for further research.