Natural Convective Heat Transfer Near the Critical State

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Revival of carbon dioxide as refrigerant in recent years has involved increased interest in heat transfer near the critical state. In general, experimental results for this region differ significantly from those far from it because some fluid properties which are important for heat transfer – as e.g. specific enthalpy – vary much more near the critical state than in greater distance, if compared at a given isobaric driving temperature difference. On the other hand, forced convection is mainly used in this range in practice. Butt his kind of heat transfer is not very convenient to show the influence of fluid properties varying within the superheated boundary layer near the heating wall, since in downstream direction, also the bulk fluid state varies along the heat transfer area. Therefore, the configuration of a pool of fluid (thermostatted at constant temperature) and a horizontal tube (with outer diameter not too small) are apt much more for this purpose. In addition, forced convection will always be accompanied by free convection, if density varies as drastically with temperature as in the critical region. Measurements for natural convective heat transfer from an electrically heated copper tube with 25mm O.D. to refrigerant R125 ($CHF_2.CF_3$) which is suitable for our test loop, are discussed for fluid states very close to the critical point and in greater distance, and for a great variation of heat flux. In particular, attention will be given to differences in circumferential variation of the wall superheat near the critical state and far from it, and the data will also be compared to film boiling at a pressure slightly below critical. In an additional comparison with former experimental data for three meanwhile outdated refrigerants, it is finally shown that the principle of corresponding ctates in its simplest form is perfectly suited to directly transfer the results to carbon dioxide.