CHAPTER 7

Conclusions and Recommendations for the Future

7.1 Summary of discussion

From the experimental study, numerical study and smoke visualization of air flow over the dimple surface, the results can be discussed in each part as follows:

1) Flow structure above the dimple surface

For internal flow, Mahmood et al. (2001) describes the flow structure above the dimple surface by smoke visualization. Their results show vertical fluid as vortex pairs shedding from the dimples. Nevertheless, from the smoke visualization in this work since the smoke is advected downstream, the recirculation occurs inside the dimple and flow dispersion at the downstream rim is observed. Moreover, the vortex and secondary flow of this work were not observed.

2) The influence of dimple area

From the literature, some researchers studied the heat transfer performance of flow over the dimple surface and they neglected the added area of the dimple. Some researchers studied included the area of the dimple. In this work, the heat transfer coefficient in Chapter 2 to Chapter 4 included the area of the dimple. These results show that the spherical dimple surface has the maximum heat transfer coefficient is about 26% higher than the smooth surface, and ellipsoidal dimple surface has the maximum heat transfer coefficient is about 22% higher than the smooth surface. On the other hand, when the area of the dimple is not included in the calculation of heat transfer coefficient values, it found that the spherical dimple surface has the maximum heat transfer coefficient is about 36%

higher than the smooth surface, and ellipsoidal dimple surface has the maximum heat transfer coefficient is about 33% higher than the smooth surface.

3) Heat transfer enhancement of spherical dimple surface vs. ellipsoidal dimple surface

Wang et al. (2010) reports that the heat transfer enhancement of flow inside the ellipsoidal dimple tube is higher than the spherical dimple tube. Their investigation applied the dimples on the tube surface in only one arrangement. This work found that, when the dimples are set up on the surface in the appropriate arrangement, the spherical dimple surface has the maximum heat transfer enhancement, higher than that of the ellipsoidal dimple surface.

7.2 Summary of conclusion

The potential use of dimples on the surface, either spherical or ellipsoidal dimple has been investigated through experimental and numerical investigation in air flow over dimple surfaces and dimple-flat tube. The dimple geometry and dimple arrangement are investigated to identify the configuration at its best in order to optimize the heat transfer performance. The conclusions of this work are as follows:

1) The dimple shape which offers the optimized heat transfer performance is a spherical dimple. The dimple shape which offers the optimal effectiveness is an ellipsoidal dimple with a 45º angle of attack. The air side heat transfer performance of a spherical and ellipsoidal dimple surface is augmented by approximately 5-26%. The augmented heat transfer depends on the dimple arrangement.

2) For spherical dimple surface, the best configuration which offers the optimal heat transfer performance is the staggered arrangement of S_T/D=1.667, S_L/D=1. It has a maximum heat transfer coefficient which is about 26% higher than a smooth surface. For ellipsoidal dimple surfaces, the best configuration which offers the optimal heat transfer performance is the inline arrangement of S_L/D_{minor}=1.875, S_T/D_{minor}=1.875. It has the maximum heat transfer coefficient which is about 22% higher than the smooth surface.

3) The air-side heat transfer enhancement of flat tube and flat-dimple tube showed values of 1.5 and 1.63 times respectively, higher than a cylinder.

4) From the numerical simulation and smoke visualization, the recirculation flow occurs inside the dimple and flow dispersion is developed after the smoke exiting the downstream rim of dimple.

7.3 Recommendation for future work

1) Study the influence of dimple size to heat transfer enhancement.

2) Study the heat transfer enhancement of dimple flat tube bank in the case of several rows and smaller dimples.

3) Study the flow structure by other numerical schemes which have more accuracy than the k- ε turbulent model.