CHAPTER 5

SUGGESTIONS FOR IMPROVEMENT

5. SUGGESTIONS FOR IMPROVEMENT

5.1 Overview

From the CFD results of the current solar dryer greenhouse design, it can be concluded that the condition whereby both side and roof openings were opened was more favourable for improvement because both the temperature and ventilation inside the solar dryer can be controlled by the side opening. In the condition in which only the roof opening was opened, the ventilation was poor because it purely depends on the temperature difference between the outside and inside air. In the current solar dryer design, the air flow from the outside to the inside or the ventilation can be induced either by thermal buoyancy or by wind. Ventilation caused by wind occurs when wind strikes the building and creates positive pressure on the windward side and negative pressure on the leeward side of the building. This pressure difference acts as a driving force and starts ventilation by allowing air to flow into the building through the windward opening and leave the building through the leeward opening. This system is referred to as wind-driven cross-ventilation. Wind-driven ventilation is solely dependent on wind direction and wind intensity. In the case of this study, from the measure wind speed data, it was found that the average wind speed in a day is only 0.5 ms^{-1} and from the air flow result the ventilation caused by the wind is very minimal.

On the other hand, buoyancy driven ventilation depends on the temperature difference between the inside and outside of the building as well as between different zones within the building. Bigger temperature difference will produce higher ventilation rate. From the result of the analysis, the temperature difference between inside and outside air can reach up to 20^{o}C when the side opening is close and only up to 12^{o}C when the side opening is open. However, since in most of the cases the higher temperature was only at the drying chamber area while the temperature at the chimney area is slightly lower, this causes only part of the air from the drying chamber to release to the environment through the roof opening on top of the chimney. This situation contribute to the problem faced by current design where the moisture from the dried crop is trapped inside the solar dryer and causing development of mould especially when the inside temperature is lower or the same with the outside temperature during the drying period.

The main objective of the improvement of the current solar dryer greenhouse is to reduce the above mentioned problem and increase its efficiency with a very minimum cost. Therefore in the improved design of the solar dryer greenhouse, the same type of material will be used and the size is almost the same as the current design. The improvement is focused to increase the ventilation rate by increasing the air flow from the drying chamber to the chimney area, so that the air saturated with water vapour from the crop can be released to the environment through the roof opening and replace with fresh air from environment through the side opening. At the same time the improved design should have the same or more temperature increase at the inside of the solar dryer. An important factor to be considered is when the ventilation rate increases as this will cause the temperature inside the drying chamber to be slightly lower because the cold air is replaces the hot air in faster rate. Therefore, the optimum design will have better ventilation and increase the temperature inside the solar dryer.

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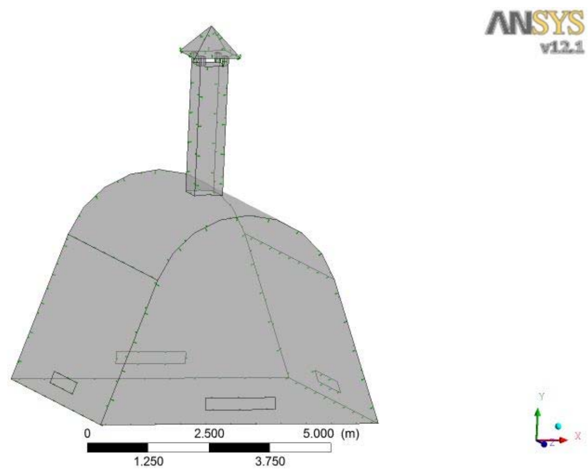
5.2 Proposed design

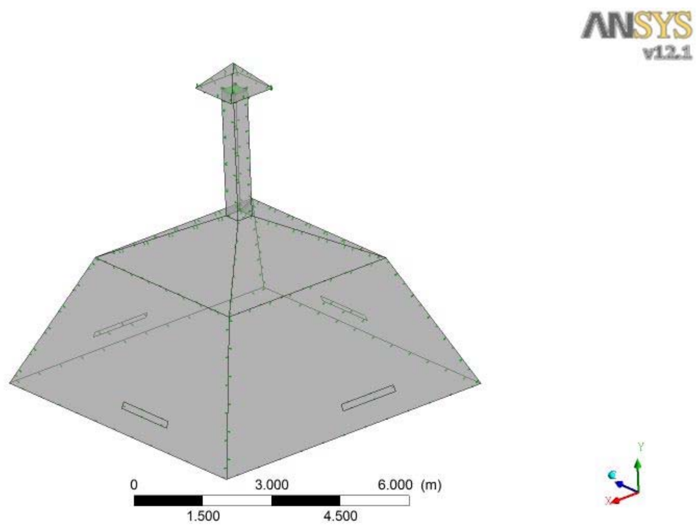
The improved design of the solar dryer was designed to ensure that more heat from the solar is trapped inside the greenhouse and this will further increase the temperature difference. Two new designs were considered for the improvement. The first was designed based on solar dryer design by Janjai et al. (2011), but the size is reduced to match the current solar dryer size and added with side opening, chimney and opening on top of the chimney. The second designed is similar to the current design, but each side wall of the drying chamber was designed slanted about 30^{o}. Therefore the base of the new design is bigger compared to the upper part of the drying chamber. The slanted wall is to ensure more sides are facing the solar directions and more heat can be absorbed. The height of the side opening is reduced from 0.5m to 0.25m to produce higher temperature inside the drying chamber and simultaneously allow ventilation from outside. For the chimney, the shape remains the same but the size is increased from 0.3m to 0.4m. This is to ensure that more air can flow easily towards the opening on the top of the chimney from the drying chamber. However larger chimney size is not possible because this may cause lower temperature difference between inside and outside air.

Both new designs use the same construction material and no additional mechanical ventilator is added to the system to ensure that the new design is still low cost and affordable. Figure 5.1 shows the design to be considered in the improvement study.

Simulation was carried out on both designs for condition 2 and the results for the temperature and air flow velocity are compared for selected point. Figure 5.2 shows the results of both design compared to the current design.

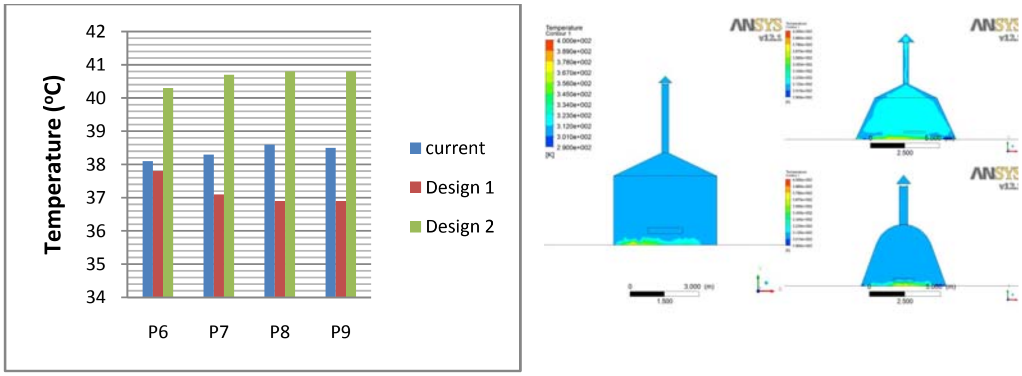


(a)



(b)

Figure 5.1: Designs considered in the improvement study (a) design 1 and (b) design 2



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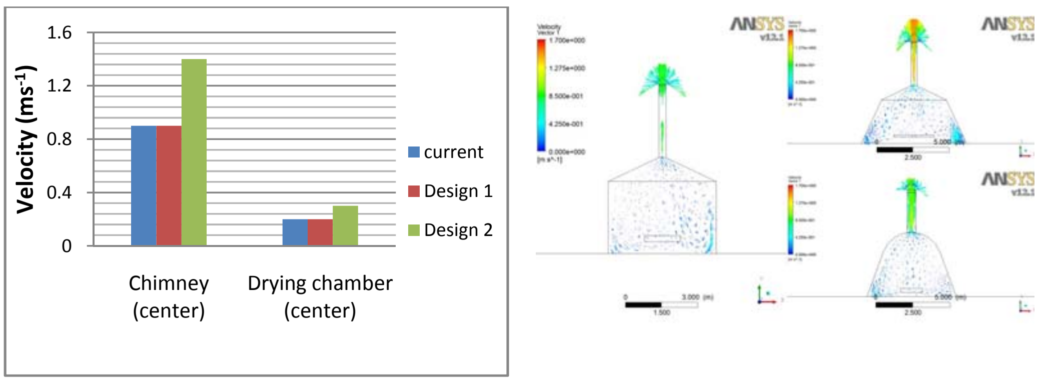


(b)

Figure 5.2: Results of current design, design 1 and design 2 for (a) temperature and (b) air flow velocity

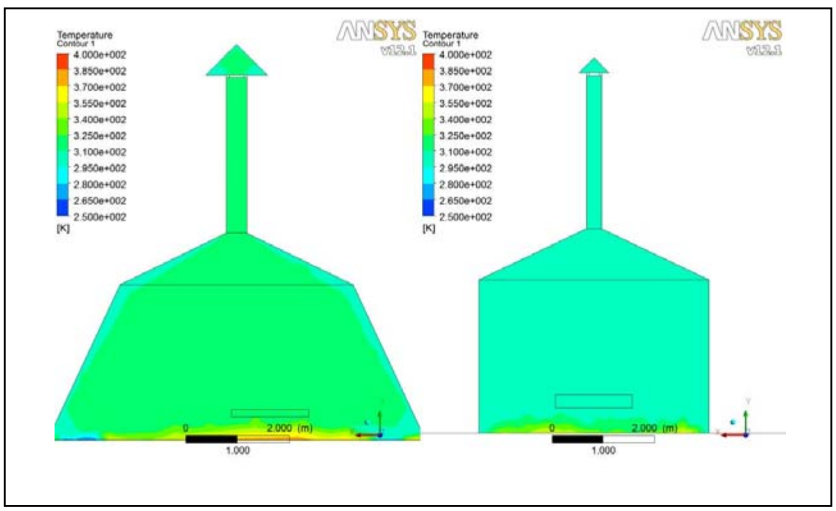
From the result is was found that design 2 is having higher temperature and higher air flow velocity compare to current design and design 1. Therefore design 2 is selected as the final improved design and further simulation is carried out to compare the selected design with current design.

5.3 Comparison of current and new design solar dryer greenhouse.

CFD analysis was carried out for the selected new design and the result of the CFD analysis of the new design was compare with the current design. Both designs were analyze based on weather on the 21st March 2011 with condition where both roof and side opening is open. The results were compared in terms of temperature and air flow velocity.

5.3.1 Temperature distribution.

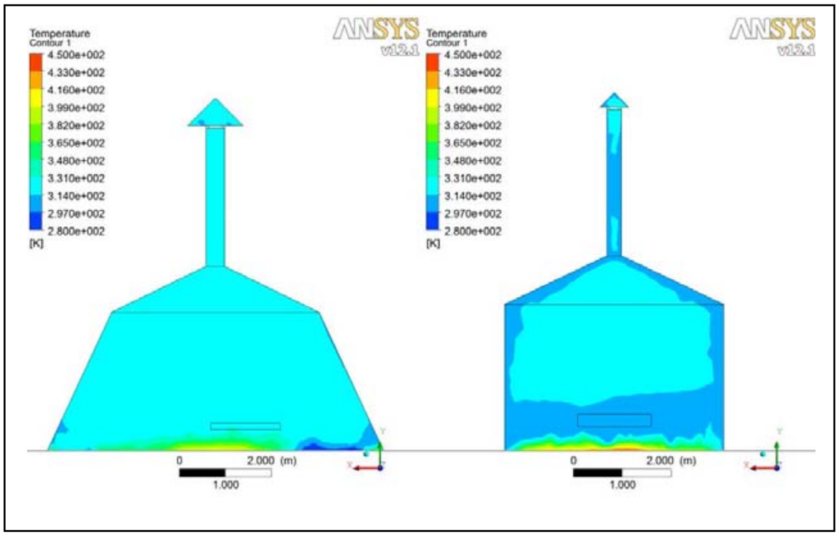
Figure 5.3 shows the comparison of current and new design of the solar dryer greenhouse for the temperature distribution for different time of the day. The same scale is used for both designs.



(a)

Figure 5.3: Temperature distribution for improved and current design solar dryer at

(a) 10.30 am, (b) 1.30 pm and (c) 4.30 pm



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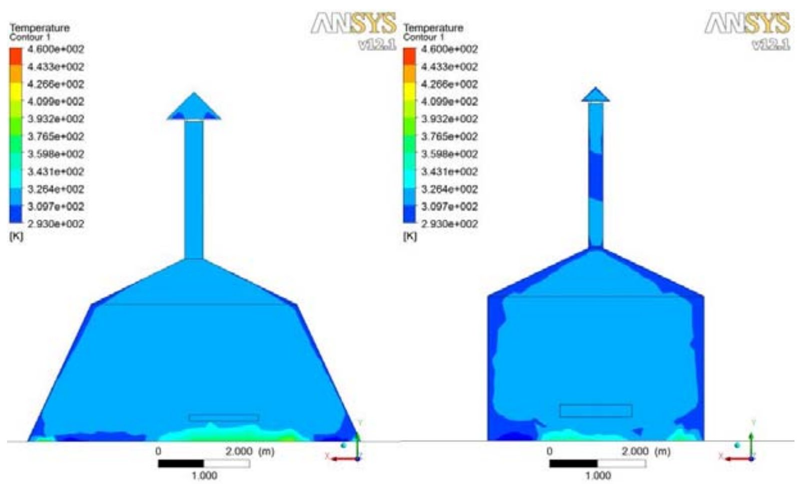
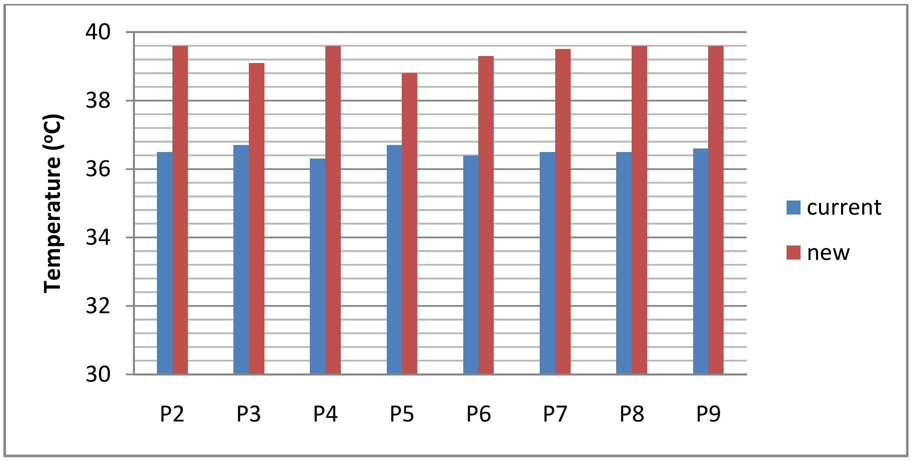


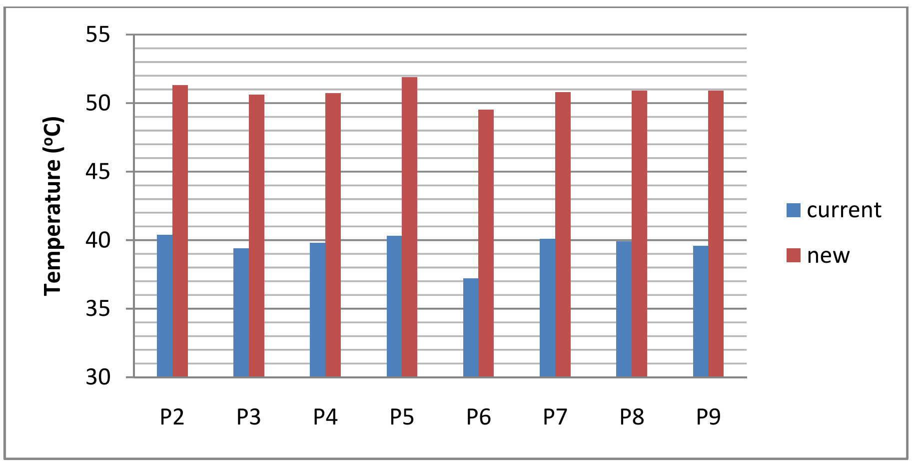
(c)

Figure 5.3: Continue.

From the result of both designs, the temperature inside the new design solar dryer greenhouse was higher compare to the current design. Figure 5.4 shows the temperature at each location for both designs. The temperature inside the new design was increased by 7.8% at 10.30 am, 28.4% at 1.30 pm and 5.0% at 4.30 pm. The temperature distributions at the drying chamber and the chimney are more even and equal in the new design compare to the current design. Therefore it contributes to easier air flow from inside the drying chamber to the environment.



(a)



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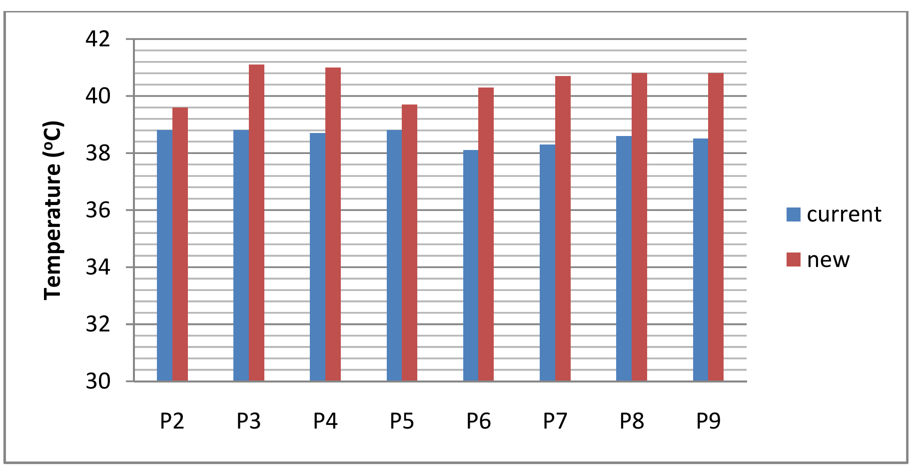
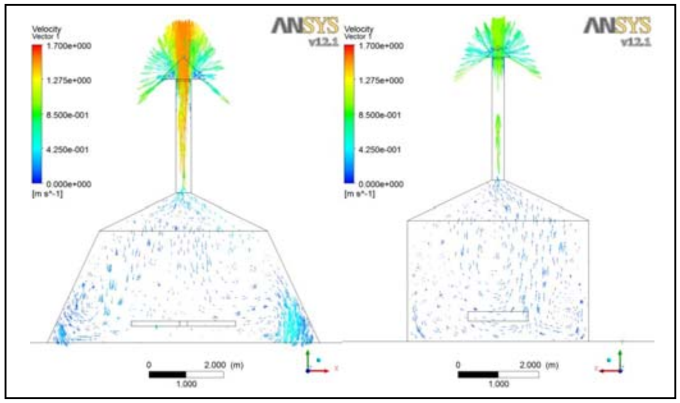


(c)

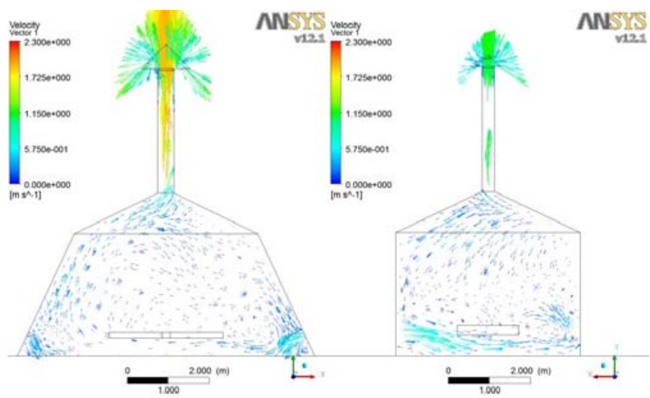
Figure 5.4: Temperature for each location at (a) 10.30 am, (b) 1.30 pm and (c) 4.30 pm

5.3.2 Air flow velocity.

Figure 5.5 shows the comparison of current and new design of the solar dryer greenhouse for the air flow velocity for different time of the day. The same scale is used for both designs.



(a)



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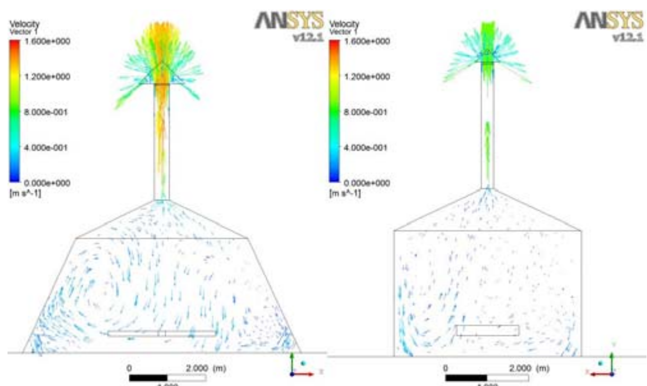

(c)

Figure 5.5: Air flow velocity distribution at (a) 10.30 am, (b) 1.30 pm and (c) 4.30 pm

From the airflow profile of the new and current design, the distributions and velocity of the airflow at the drying chamber area of both designs is almost the same. However for the new design the air velocity at the chimney was higher compared to the current design by 45.1% at 10.30 am, 64.7% at 1.30 pm and 53.9% at 4.30 pm. The increase in air velocity in the chimney shows that the ventilation of the new design is better compare to the current design. Figure 5.5 shows the air flow velocity for current and new design.

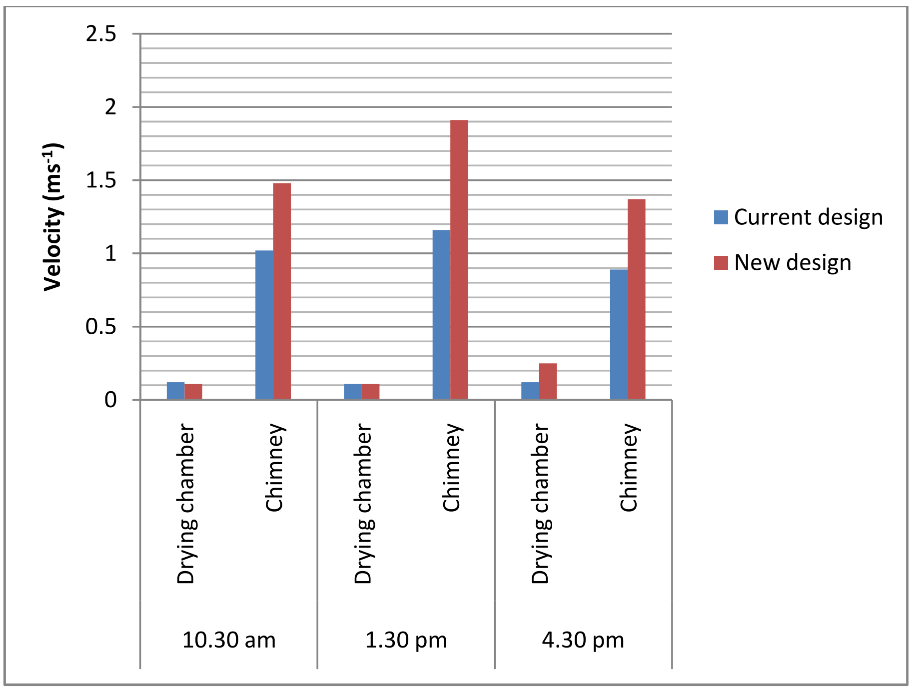

Figure 5.6: Air flow velocity at (a) 10.30 am, (b) 1.30 pm and (c) 4.30 pm