

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The objective of this study is to perform feasibility study of numerical simulation of biodegradable flow behavior in injection molding process. The numerical simulation was generated and resolved by employing the CFD simulation program, ANSYS CFX. As mentioned, this numerical simulation was only concentrate on the mold filling stage of injection molding process which indicates that the phase change of molten plastic to the solidified plastic was not taken into account. Moreover, the different melt temperatures, 175 °C, 190 °C and 230 °C were applied in the numerical simulation since the melt temperature is the most critical injection molding parameter on mold filling stage. The effect of melt temperature and the predicted flow behavior of molten PLA in filling stage are summarized and discussed as exhibited below:

The simulation results firstly reveal that viscosity of plastic decrease with increasing in melt temperature and viscosity decreases with increasing shear rate simultaneously. From the relationship between temperature and viscosity-shear rate, the temperature dependence of viscosity is insignificant at high shear rates whereas the temperature is very significant to viscosity at low shear rates. This result also points that the Cross-WLF viscosity expression can be capable with this simulation.

Second, the flow front at temperature of 230 °C is clearly faster than 190 °C and 175 °C. This result in the filled up time at 230 °C is less than 190 °C and 175 °C which are 1.7, 2.6 and 3.0 seconds, respectively. Nonetheless, at the starting filling time, all of the flow characteristics are fairly similar to each other since the molten PLA was just pushed into the mold cavity and the cooling effect due to mold temperature can be ignored. Then, the cooling effect of mold wall becomes effective to molten plastic temperature which exhibited in the temperature profile of molten plastic. It showed that the coldest plastic layer is formed near the mold wall and the plastic is the hottest at core of mold cavity.

Next, all cases give the same trend of pressure distribution along the melt flow advancement during filling stage. The pressure decreases from the inlet position to the end of the mold cavity in according to the pressure loss in the system. However, the simulation results of pressure distribution were not enough to use for demonstrating the pressure variation in practical since the outlet pressure was not realistic.

Eventually, the simulation took the calculation time around 3 weeks for each case which may be too long for the sponsor to use as daily simulation process. As a consequence of the aforementioned conclusions, it may be summarized that this numerical simulation of PLA flow behavior on filling stage of injection molding might be used as the preliminary numerical simulation but it was not sufficient to employ as the prediction model in practical sense.

5.2 Recommendations

Owing to the limited timeframe of this thesis, the mesh independence study of the desired system, PLA-air, has not been considered in this work. Therefore, the mesh independence study should be carried out as well so as to assure that the numbers of elements and nodes are strong enough to resolve the governing equations and then give the satisfactory solutions.

Additionally, to perform the numerical simulation effectively, the convergence criteria of the simulation could be typically set as 10^{-5} or 10^{-4} based on the RMS residual type, because, these values may give more robust simulation results than the current convergence criteria of this study.

Next, there are several commercial computer aided engineering (CAE) software which use the same calculation procedure as ANSYS CFX but more specific to the injection molding simulation that provide deep insight into the plastic injection molding process and easy to use, for instance Moldex3D and MoldFlow, that can handle with the every stage in injection molding process, filling, cooling and ejection. These programs can be applied the injection molding parameters which may make the simulation more realistic and then gives the reliable simulation results.

Finally, in order to ensure that the simulation gives the satisfactory and reliable prediction of filling stage in polymer injection molding process of PLA, the simulation results should be validated with the experimental results. Because the validation can be clearly exhibited the difference in result between simulation model and actual process which can help to improve and make the simulation model more practical.