CONCLUSIONS

In this thesis, reactive distillation was studied to model and to simulate the biodiesel production from Jatropha oil. The biodiesel processing was based on and compared to the conventional process of Zhang *et al.* (2003). In addition, three steps of reversible transesterification reaction which are triglyceride to diglyceride, diglyceride to monoglyceride and monoglyceride to glycerin were added for improving the calculation result. The structure of unsupplied components –triglyceride, diglyceride, monoglyceride and fatty acid methyl ester- can be generated by GaussViewW or in the ASPEN PLUS. Because of less difficult and more accuracy of Gauss ViewW, this program was used to draw unsupplied components. These structures were then optimized by GAUSSIAN 03W and were used in the property estimation step. Set of simulations which were defining chemical components, property estimating, selecting a thermodynamic property, determining plant capacity, choosing proper operating units and setting up input conditions were performed by ASPEN PLUS 2004.1. The conventional process was firstly modified according to some misoperation of the purification sections. The dissoluble features of biodiesel and glycerin have been illustrated by three phase diagram which agreed to with Zhou's work (Zhou *et al.*, 2006). It was found that there were two phases between biodiesel and glycerin. It is easy to separate these two components by the gravitational unit instead of using the washing tower. Therefore, the gravitation unit was introduced to remove the glycerin from the biodiesel after the methanol recovery. With the same manner, the alkali removal by the gravitational unit can be used to separate water from biodiesel. The quality and quantity of biodiesel obtained from the proposed process were comparable to the Zhang's process and EN standard. However, the proposed process used only two gravitational units in the purification section while the conventional one needed two distillation columns, one reactor, and two separators.

In the conventional process, there were 4 sections which are transesterification, methanol recovery, glycerin removal and alkali removal. The process starting with mixed the methanol 130 kg/h with sodium hydroxide 10 kg/h to produce sodium methoxide which was heated to 60 °C and sent to that reactor. At the same time, 1,000 kg/h of refinery Jatropha oil was heated to 60 °C and sent to the reactor. In the reactor, the temperature was maintained to 60 °C. After that, the outflow from the reactor was sent to a distillation to

remove and recycle excess methanol. The bottom stream which contains biodiesel and glycerin were sent to the purification section. The higher density glycerin was separated from biodiesel by the gravitational unit. The biodiesel stream leaving from gravitational contained some catalyst. Water was introduced to dissolve catalyst in the biodiesel. The 900 kg/h of water was mixed with the biodiesel in the mixer. Afterwards, the mixture was sent to gravitational unit in order to separate biodiesel and the mixture of water and sodium hydroxide. The properties of biodiesel obtained from this proposed meets the specification of EN standard.

The reactive distillation system was slightly different to the conventional one. It consists of three 3 sections which were reactive distillation, glycerin removal and alkali removal. The process details were mostly the same except for the reactive distillation. Two reactant streams were heated to 60 °C before sent to stages 3 of the reactive distillation. The column contained 10 theoretical stages which reaction zone was set between stages 4 to stages 6. The operating conditions in column were one reflux ratio, 0.6 boilup ratio and 1 atm. The methanol was recycled from the distillate stream to reduce the fresh feed. The biodiesel and other components obtained from the bottom were sent to the purification sections, the glycerin and the alkali removal.

The biodiesel conversion and energy requirement of reactive distillation process are higher than conventional process about 1.14 % and 1.36 %, respectively. However, the reactive distillation can almost completely consume the reactant. While there are 0.008 % of triolein and 0.002 % of diolein still remained in the product of conventional process, these residues should be separated in the down stream otherwise it will degrade the quality. The recycled methanol was also investigated. In order to obtain the same biodisel conversion, the methanol requirement can decrease 81 % when recycle methanol. Moreover, the conditions of reactive distillation which were region of reaction, rectifying, stripping, reflux ratio, boilup ratio and column pressure were considered. The optimum columns specification were two stages of reaction zone, no rectifying stages, no stripping stages, 5 reflux ratio and 1 atm. Additionally, the controllability of process was studied by varing oil feed flow rate ± 2 % from the normal value. The specifications of biodiesel were still the same with EN standard both increase and decrease feed. The default control structure of process can reject the disturbances and keep the process to the desired steady state.