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Title : MODELING AND CONTROL OF STEAM DISTILLATION IN ESSENTIAL OIL EXTRACTION SYSTEM USING FUZZY MODEL REFERENCE LEARNING CONTROL (FMRLC)

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Malaysia is one of developing countries endowed with abundant resources of raw materials which have to be exploited especially in terms of technological provision in order to sustain and enhance aromatic plants industries and utilization. The essential oil from plant materials contains fragile aromatic molecules that can easily be destroyed or modified by changes caused during the extraction process. Even a subtle difference in extraction process conditions can have a significant effect on oil quality. Temperature one of important parameters that mostly affect essential oil production. In the conventional steam distillation method, high temperatures and extended heat were exposed to botanical plants that can cause thermal degradation to the extracted oil. In this research, a pilot-scale steam distillation system with temperature monitoring and control module was proposed to maintain process temperature at desired response, to avoid waste of energy usage and inconsistency of oil production quality and quantity due to uncertainties. In this study, the range of controlled steam temperature was set between 80^{o}C to 90^{o}C with time constant of desired reference model at 220 seconds with no overshoot. The model of steam temperature has been derived using auto-regression exogenous (ARX) function. For controller module, a Fuzzy Model Reference Learning Controller (FMRLC) was designed and applied to regulate steam temperature based on desired model reference heating profiles. In the FMRLC, fuzzy controller and inverse fuzzy elements were constructed using 49 and 121 IF-THEN rules respectively. In the study, the controller parameters were tuned until the error analysis, RMSE and SSE values reached as low as possible. The study also investigates the robustness and tracking set-point capability of FMRLC compared with several control methods i.e. Model Reference Adaptive Controller (MRAC-Lyapunov and MRAC MIT-rule), Fuzzy-PID and PID. From the results, it was found that the proposed FMRLC provides the best performance compared to the other controllers. Moreover, the actuation effort of FMRLC was minimised as it achieved lowest SSC among other controllers. Lower SSC value reflects on lower energy usage of the actuator and the resultant of FMRLC controller output response may reduce wear on the heating element. Further assessment has been done on actual Kaffir lime peel to confirm the reliability of designed system on the quality and quantity of production oil. The evaluation of oil quality by GC and GCMS identification has shown that the extracted oil contained all major constituents' of Kaffir lime oil at 85^{o}C steam temperature and the variation of temperature conditions (i.e. from 80^{o}C to 90^{o}C) is evidently influenced the amount of essential oil production.