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Title :

Steam Temperature Control of Hydro-Steam Distillation Process Using Self-Tuning Fuzzy Fractional-Order PI Controller

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Essential oil is the volatile extracts of botanical material and it is being used to promote health and human well-being because of its therapeutic effect. Essential oil is commercially extracted using distillation method which requires heat in order to break the oil glands during the process. Unfortunately, the oil quality obtained using this method is uncertain because chemical compounds in the oil are exposed to decomposition or transformation at high temperature. Hence, this research proposed a novel approach of closed-loop temperature control using a new self-tuning fuzzy fractional-order PI (FOPI) controller to realize low temperature essential oil extraction for a hydro-steam distillation process. The controller will regulate the steam temperature at a desired

level to protect the oil from excessive heat. FOPI control technique is still at its infancy but the efficiency of the controller had been acknowledged by many researchers globally. FOPI controller is a generalized form of PI controller whereby it provides more degree of freedom that can guarantee better performances relative to the integer-order PI with the same controller parameters. Unfortunately, this characteristic leads to a more complex tuning methodology. Self-tuning capability of fuzzy rules was found to facilitate this issue satisfactorily using only information about the output error and rate of the output error. The control performances were evaluated on a hydro-steam distillation process under set point change and load disturbance tests. The proposed controller was found to produce less overshoot and better steady-state response under both conditions compared to PI, FOPI, self-tuning fuzzy PI, and self-tuning PID pole-placement controllers. Essential oil quality assessment was also performed on citronella oil samples that were extracted at 85°C and 100°C. Some differences had been observed in the sample extracted at lower temperature which produced lower refractive index and lower composition in citronellal but higher composition in citronellol and geraniol based on Gas chromatography – Mass spectrometry (GC-MS) analysis. This results show that the improvement proposed in this research is feasible towards improving the quality of essential oil extracted using hydro-steam distillation process.