UNIVERSITI TEKNOLOGI MARA

SELF-TUNING FUZZY PID CONTROL OF HYDRO-DIFFUSION ESSENTIAL OIL EXTRACTION SYSTEM

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ABSTRACT

Essential oils (EO) is a substance extracted from a botanical material and always in high demanded. Steam distillation is a widespread method to isolate the essential oil from aromatic plants. The steam distillation method is most preferable due to factors of operational cost, cleanliness, system cost, high productivity and maintenance cost. However, some disadvantages of this method is loss of some volatile compounds, which will be diluted with boiling water within the distillation tank. The issue of steam distillation has not been given sufficient treatment in literature. The hydro-diffusion system was implemented as a viable alternative to overcome these setback. In the extraction process, the temperature will influence the final product of the extraction. The extraction temperature gives large effect on the percentage yield and quality of the oils. Almost all compounds of essential oils are unstable at high temperature and should be regualted below the saturated temperture throughout the extraction process. In order to regulate the temperature, a suitable controller is required. Three controllers namely PID, HFPID and STFPID are proposed and integrated to hydro-diffusion system to control the steam temperature. All developed controllers are expected to improve system performance in both transient and steady state dynamics. The ARX structure has been used to represent the system dynamic and successfully implemented in the simulation studies. Real-time implementation of the simulated controllers have been carried out on the real extraction process. The performance of the proposed controllers were evaluated. All the controllers have shown their ability to track the set point change and curb the disturbance in real-time. However, the STFPID with 5 membership controller is the most preferable, and demonstrated better performance compared to the HFPID and PID controller. By applying the proper temperature control during extration process give better quality and preventing quality degradation of the essential oils.

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1.1 INTRODUCTION

Essential oils are the volatile aromatic compounds produced by an extraction process and always in high demand due to its vast application in human life [1-4]. Generally, the eessential oils are derived from one or more parts such as flowers, leaves, peels, bark, root, and seeds. The essential oils are highly demanded due to its special usage such as aromas and fragrances, cosmetics, insect repellents, medical activities, natural additive for food flavouring and pharmaceutical industries [1]. The quality of essential oil can be identified based on main compounds found in the substance via Gas Chromatography/Mass Spectrometry (GC/MS) analysis [5].

In the last three decades, there has been an increase in the number of publications for the extraction techniques. Steam distillation extraction process is a popular extraction method and suitable for most plant materials [6]. This method applies hot steam to extract the essential oil from the raw materials. The mixture of oil and steam will be condensed and separated at their liquid form. In the majority of cases the oil is less dense than water and so forms the top layer of the distillate and can be separated easily using proper method and instruments [7].

Almost all compounds of essential oils are unstable at high temperature. Numerous publications on this domain mentioned that the effect of temperature on the essential oil quality and yield [8, 9]. Continual exposure to excessive heat may degrade the quality of the essential oil as had been studied and reported in [10]. The results show that the significant correlation between temperature and the quality of the essential oil. It was obvious that the quality was decreased with increase in temperature. The study proposed that steam temperature needs to be regulated below saturated temperature throughout the extraction process [7]. But yet, only few publications were found so far that regulated the temperature during the extraction process and provided the qualitative data of the yield [11]. Most of the publications focused on the superheated steam temperature control. There is very little publication so far that discussed on the steam temperature regulation below 100 ^{o}C [12].