An Automated Control System for Fluidized Bed Drying

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Orthodox-Rotorvane teas, currently producing in tea factories in Sri Lanka, comprise smaller size particles than that was produced two decades ago. Fluidized Bed Dryers (FBD) are preferred and widely used for drying Orthodox-Rotorvane type of teas. Most of the time, manual operation of this dryer is difficult to maintain it in a steady state. At present, achieving proper fluidization with required co-existence of continuous phase and bubble phase and obtaining moisture content in dried-tea within the acceptable limit of 2.5 – 3.0 % are difficult. Also, smaller tea particles are carried away by the exiting air stream leading to higher blowout.

An automated control system based on a Programmable Logic Controller was developed to facilitate steady operation of FBD and ensure drying tea with moisture content within the acceptable limit. A mathematical model correlating tea-bed temperatures and moisture content of tea at the dryer discharge end was developed and incorporated into the control system to adjust automatically the feeding rate of tea. The control system was incorporated with an additional measure to alter retention time of tea as well in the dryer. A software program was established using ladder programming language to feed input data in order to gradual controlling of feeding rate of tea and regulate retention time using the control system.

Further, control system provides additional advantages such as maintaining rated output of the dryer, drying tea with required blackness and tea character leading to increased prices of main grades and improved working environment.

An Automated Control System for Electrical Energy Saving in Trough Withering

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Energy utilization and product quality improvement are industry issues connected to Cost of Production and price realization where intervention of R&D and new innovations are needed. Therefore, a control system was developed for optimizing the electrical energy consumption in trough withering while preserving the required quality of withered tea leaves. The electrical energy saving was achieved by controlling the speed of the fan through a variable speed drive (VSD) and controlling the hot and ambient air delivering into the trough. The fan speed was determined based on the theoretical mass flow rate requirement of air, calculated by the mathematical model developed for withering, while calculating the thermodynamic properties of withering air and the moisture content of tea leaves in real time. A single board computer, Raspberry pi 3 model B was used as the controller to run the mathematical model. Software programme was developed to control the VSD with a view to control the mass flow rate of air delivered and temperature of air.

The experiments were conducted with and without control system in order to evaluate the electrical energy consumption of the fan and the quality parameters of tea during withering process. The results showed that specific energy consumption of withering in the range of 0.17 to 0.18 kWh.kg $^{-1}$ of made tea with the control system while 0.27 to 0.35 kWh.kg^{-1} of made tea without control system. By introducing the control system, a saving of 39% of electrical energy was achieved as compared to the withering process without control system. Further, it confirmed that leaf withering using the control system preserved the quality of withered leaf than that of without control system.

Automatic Control System for Existing Humidifiers in Tea Factories

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Black tea manufacturing process involves withering, rolling and roll breaking, fermentation, drying and Grading. During the fermentation process, certain important chemical reactions are occurred in tea which results in formation of Theflavins and Thearubigins and contributes to character of tea. Control of humidity in the rolling room area is therefore very important to prevent moisture loss from rolled leaf and dhool and to facilitate controlling the rate of chemical reactions. At present, manually controlled humidifiers are installed in most of the tea factories to perform the above task. Hygrometers are also placed to monitor relative humidity (RH) in the room.

It was observed that the humidifiers are not regulated properly in most of the time in tea factories due to various reasons such as the delay in operation of the humidifier, over size of water droplets & excessive use of water. Incorrect reading of the hygrometer due to poor maintenance was also an issue. This leads to surface drying of rolled leaf and dhool or condensation of water on the rolled leaf and dhool. The improper operation of humidifier leads to vary the level of Theflavin and Thearubigin in tea and it finally affects the quality of made tea and teas price.

In this study, an automatic control system was developed with a digital display to monitor real-time hygrometric difference, temperature & RH in the rolling room and control electronically water supply of existing humidifier. The system was field tested and found to facilitate to maintain the required dry and wet bulb temperature difference in the given environment. The system was low cost and can be attached to any existing humidifier in tea factories while reading dry and wet bulb temperature difference, room temperature and RH value on a digital display.