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粮食热风干燥含水率在线模型解析

Analytical study on on-line model of moisture in hot air drying process of grain

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中文摘要:

为了揭示粮食在深床动态干燥过程中的含水率变化规律，指导干燥工艺设计，实现干燥过程实时跟踪与调控，提高干燥品质，降低能耗。基于薄层干燥水分扩散模型、深层干燥质量守恒原理、态函数和不可逆热力学分析方法，建立并求解了粮食深床干燥基础方程，获得了顺流、逆流、横流和静置层干燥方式下粮食含水率和干燥速率分布解析式，解析出了粮食在顺流层内经历持续降速干燥的过程，逆流层内存在干燥速率的极值点，在通风温度、湿度、送风量相同的干燥条件下，逆流干燥速率明显高于顺流，表明了逆流干燥能量利用效果优于顺流；粮食在横流和静置层内的干燥特性相同，进风侧和出风侧的干燥速率相差很大，在层厚度0.5 m、粮食含水率20%以上时，出风侧的干燥速率几乎为0，干燥的均匀性较差。在5HP-3.5型循环式缓苏干燥机上的试验结果显示，深层干燥解析值与实测值间的最大偏差为0.69%，极差范围为?0.27%～0.69%，从粮食干燥的惯性特征推断，产生偏差的原因主要是仪器检测误差。解析方法对实现粮食深床干燥过程动态跟踪和调控，指导干燥设计，降低干燥能耗、提高干燥效率和干燥机产能等具有重要意义。

英文摘要:

Abstract: In order to reveal the change rule of grain moisture content in deep bed drying, guide the design of drying technology, and realize real-time tracking and regulating the drying process, as well as improve the drying quality and reduce the energy consumption. Based on the moisture diffusion model of thin bed drying process and the mass conservation equation of deep bed drying process, as well as the state function and irreversible thermodynamics analysis method, the basic function of deep bed grain drying was set up and solved, and the analytical formula of the distribution of grain moisture content and drying rate in the drying methods of concurrent flow and counter flow, cross flow and standing drying were obtained. The result showed that the drying rate experienced the continuously decreasing process inside the concurrent flow deep bed drying, and the maximum point occurred at the beginning of the drying, that said the moisture content decreased quickly, and the late changed extremely smooth in the hot air inlet position. In counter flow deep bed drying, the drying rate had an extreme value point, and the maximum drying rate did not necessarily in the position of hot air inlet and outlet of drying layer. Indeed, the drying rate of counter flow was significantly higher than concurrent flow drying under the same drying conditions of ventilating temperature, humidity and air volume. And in cross flow and standing drying, the drying rate in the position of hot air inlet and outlet had a big difference. When the layer thickness was 0.5 m, and the grain moisture content was more than 20%, the drying rate was nearly zero in the air outlet. This paper pointed out that the change process of grain drying was from initial state point(wet grain)to the final state point (dry grain), the uniformity of cross flow and standing drying was poor, and the counter flow drying technology was more energy-saving than concurrent flow. The experiment was studied in 5HP-3.5 type circulating and tempering dryer, and the results showed that the analytical values and measured values of paddy moisture content in dryer export presented high fitting degree after experiencing the drying and tempering every time. And the maximum deviation between analytical values and measured values was 0.69%, the range of drying process was 0.27%-0.69%. Grain drying was a typical larger inertia and nonlinear process, which pointed out the reason for deviation should be detection error caused by instrument, and confirmed the reliability of the analytical results. The given analytical method avoided the problem of the poor reliability of grain moisture on-line detection instrument and the thin bed superposition simulation error accumulation under the grain drying conditions of high temperature, high humidity and high dust. The analytical methods were of great significance for achieving dynamic tracking and regulating of the grain drying process, guiding drying design, as well as achieving high efficiency and energy saving, improving the drying efficiency and capacity of the dryer.