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管道输送过程中典型粮食粉尘火焰燃爆特性

摘要

粮食粉尘在管道输送时易爆炸，严重威胁人员和生产安全，探究其火焰燃爆特性意义重大。本研究以 13.85μm 玉米淀粉为材料，结合实验与模拟，分析单侧障碍物、管道倾角等因素对玉米淀粉粉尘火焰传播特性的影响。研究发现，单侧障碍物会使火焰形态不规则，火焰传播速度先增后缓，温度峰值变化趋势与之相同，堵塞率越高影响越显著；弯曲管道障碍物条件下，火焰向上传播占优，弯曲角度增加会使火焰形态更复杂，90° 弯曲时火焰速度和湍流动能变化明显，粉尘云浓度越高出口扰动越剧烈，MFSV 和 AFSV 先升后降，弯曲角度增加二者呈上升趋势。单侧障碍物和弯管障碍物会增加湍流动能，对火焰传播影响重大。本研究为预防粉尘爆炸、优化工业设计和制定安全标准提供了理论和数据支持，企业可据此优化设备、控制粉尘浓度和加强通风来降低事故风险。

关键词

单侧障碍物；管道弯曲角度；火焰传播速度

Abstract

Grain dust is prone to explosion during pipeline transportation, posing a serious threat to personnel and production safety. Exploring its flame explosion characteristics is of great significance. This study uses 13.85 μ m corn starch as the material, and combines experiments and simulations to analyze the effects of factors such as single-sided obstacles and pipeline inclination on the flame propagation characteristics of corn starch dust. Research has found that single-sided obstacles can cause irregular flame shapes, with flame propagation speed increasing first and then slowing down. The trend of temperature peak changes is the same, and the higher the blockage rate, the more significant the impact; Under the condition of curved pipeline obstacles, flame propagation is dominant, and increasing the bending angle will make the flame shape more complex. When bending at 90 °, the flame velocity and turbulent kinetic energy change significantly. The higher the dust cloud concentration, the more intense the outlet disturbance. MFSV and AFSV first increase and then decrease, and both show an upward trend with increasing bending angle. Unilateral obstacles and curved obstacles can increase turbulent kinetic energy and have a significant impact on flame propagation. This study provides theoretical and data support for preventing dust explosions, optimizing industrial design, and developing safety standards. Enterprises can use this to optimize equipment, control dust concentration, and strengthen ventilation to reduce accident risks.

Keywords

Unilateral obstacle; Pipe bending angle; flame propagation speed

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