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环模式成型机压缩水稻秆成型工艺参数优化

Optimization of technique parameters of annular mould briquetting machine for straw briquette compressing

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中文摘要:

为了确定环模式成型机压缩水稻秸秆最佳的成型工艺参数，该文以水稻秸秆为原料，利用9JYK-2000A型环模式成型机进行压缩成型，寻求工作参数对环模式成型机压缩水稻秸秆成型影响规律和优化工艺参数组合。采用四因素五水平二次回归正交旋转中心组合设计试验方法，以含水率、成型温度、模辊间隙和主轴转速为影响因子，以成型压块的松弛密度和抗破碎性为评价指标。利用Design-expert8.0.6的回归分析法及响应面分析法，建立并分析了4个因子对评价指标影响的数学模型。结果表明：当参数组合含水率为17.5%～27.1%、成型温度为81.9℃～88.1℃、磨辊间隙为2.49～3.78 mm、主轴转速为157.6～186.5 r/min条件下，成型压块的松弛密度大于1.0 g/cm3，成型压块的抗破碎性大于65%；各因素对松弛密度贡献率的主次关系为：主轴转速>磨辊间隙>含水率>成型温度，各因素对抗破碎性贡献率的主次关系为：含水率>主轴转速>磨辊间隙>成型温度。研究可为环模式成型机压缩水稻秸秆成型提供一定理论依据和技术支撑。

英文摘要:

Abstract: China is a large agricultural nation with abundant straw resources, and the crop straw is regarded as a kind of precious biology resource. Recently, the straw briquetting technology was found to be an effective way to solve the low comprehensive utilization of straw. The annular mould briquetting machine has become the mainstream equipment among lot of straw curing equipment, because of its lower energy consumption, wear resistance and high productivity, etc. However, the present biomass compression molding process research mainly concentrates on the experiments and theories of corn stalks, cotton stalks, wheat straw, and wood chips molding instead of rice straw molding, especially by using annular mould briquetting. A significant feature of molding briquette is the physical properties that directly determine the transportation, usage requirements, and the storage condition of compression moldings. Both the relaxed density and the durability are the indexes to measure the physical properties of molding briquette. This paper introduced the process of the straw's compressing by using a 9JYK-2000A type of annular mould. The rice straw was taken as material in the experiments and the influence of the key work parameters on straw's compressing was analyzed. Besides, the optimal parameter combination was obtained in the experiments. A central composite rotatable orthogonal experimental design of response surface methodology (RSM) was employed to find the optimum technical parameters. Relaxed density and crush resistance were selected as responses, and the material moisture content, operation temperatures, clearances between rolls and die, and screw rotary speed were selected as input variables with five levels respectively. A design-expert 8.0.6 regression analysis method and a response surface method were applied to analyze the regression equation of relaxed density and crush resistance. In addition, the mathematical model has been established to analyze the effect of four factors on test indexes. The experiments showed that the proposed model was agreeable with the practical condition, which could adequately reflect the relations among factors. Through the experimental analysis, the rules of influence and the contribution brought by the interaction among factors on relaxed density and crush resistance were discussed, and finally the optimized process parameters was obtained. The value of relaxed density and crush resistance was predicted by applying a regression equation. Moreover, the optimal parameters were chosen to verify the reliability of the experimental results. Results indicated that the calculating results were in agreement with the measured results, and the relative errors of relaxed density and crush resistance were respectively 0.263% and 1.678%. The regression model equations can be used to predict the annular mould briquetting machine compressing the rice straw molding process-molding briquette of relaxed density and crush resistance. The relaxed density and crush resistance had a peak value under the optimal combination of the factors. When the raw material had the moisture content of 17.5%-27.1%, operation temperature of 81.9℃-88.1℃, the gap of roll-die of 2.4-3.78 mm and the spindle speed of 157.6-186.5r/min, the relax density was over 1.0g/cm3 and the crush resistance was over 65%. The contributing rate of every factor on relax density was as follows: screw rotary speed > clearances between rolls and die >straw moisture content > operation temperature. And the contributing rate of every factor on crush resistance was as follows: moisture content > screw rotary speed > gap between rolls and die > operation temperature. The research findings provide a theoretical basis and technical support for straw briquette compressing with an annular mould briquetting machine.

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