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Optimization of Cold Pressing Process Parameters of Chopped Corn Straws for Fuel

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Abstract: Pressed condensation is a key process before the reclamation of loose corn straws. In this study, the effects of stabilization time on the relaxation density and dimensional stability of corn straws were studied firstly, and then the stabilization time was determined to be 60 s by comprehensively considering the compression effect, energy consumption, efficiency and significance. On this basis, the effects of the water content (12%, 15%, 18%), ratio of pressure maintenance time to stabilization time (0, 0.5, 1), maximum compression stress (60.4, 120.8, 181.2 kPa) and feeding mass (2.5, 3, 3.5 kg) on the relaxation density, dimensional stability coefficient, and specific energy consumption of post-compression straw blocks were investigated by the Box–Behnken design. It was found that the water content, ratio of pressure maintenance time to stabilization time, maximum compression stress, and feeding mass all very significantly affected the relaxation density, dimensional stability coefficient and specific energy consumption. The interaction between water content and maximum compression stress significantly affected both relaxation density and specific energy consumption. The interaction between the ratio of pressure maintenance time to stabilization time and feeding mass significantly affected the dimensional stability coefficient. The factors and the indices were regressed by quadratic equations, with the coefficients of determination larger than 0.97 in all equations. The optimized process parameters were water content of 13.63%, pressure maintenance time of 22.8 s, strain maintenance time of 37.2 s, maximum compression stress of 109.58 kPa, and raw material feeding mass of 3.5 kg. Under these conditions, the relaxation density of cold-pressed straw blocks was 145.63 kg/m^3, the dimensional stability coefficient was 86.89%, and specific energy consumption was 245.78 J/kg. The errors between test results and predicted results were less than 2%. The low calorific value of cold-pressed chopped corn straw blocks was 12.8 MJ/kg. Through the situational analysis method based on the internal and external competition environments and competition conditions (SWOT analysis method), the cold-pressed chopped corn straw blocks consumed the lowest forming energy consumption than other forming methods and, thus, are feasible for heating by farmers. Our findings may provide a reference for corn straw bundling, cold-press forming processes and straw bale re-compressing.

Keywords: chopped corn straws; relaxation density; dimensional stability coefficient; specific energy consumption; optimization; fuel