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压缩状态下玉米秸秆粉粒体大变形有限元分析

Finite element analysis on large deformation of compressed cornstalk powder

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中文摘要:

为玉米秸秆模压托盘成型模具和相关设备的设计和工艺提供基础的力学数据，需要探明玉米秸秆粉粒体模压过程的成型规律，在分析模压成型原理的基础上，对玉米秸秆粉粒体压块进行了单轴压缩试验，探讨了模压过程中玉米秸秆粉粒体的弹塑性特征。采用有限变形理论，研究并推导了欧拉描述的轴对称有限元模型，编制了大变形有限元分析程序，计算得到了玉米秸秆粉粒体圆柱形试件在压缩率30%时的变形图、等效应变图，以及载荷位移曲线，探讨分析了玉米秸秆粉粒体压缩成型过程的成型特性，并与试验值和小变形计算结果进行了配对t检验和回归分析。结果表明：1）有限变形数值解与试验结果最接近。2）采用大变形有限元模型进行计算时，加载步长为0.01，小变形为0.0001；有限变形解和小变形增量解与试验曲线的决定系数分别为R2=0.9855和R2=0.9398，说明利用大变形进行计算，可以用较大的加载步长，而且得到的结果精度较高。该文研究结果对于深入研究玉米秸秆粉粒体的模压工艺，实现工艺和装备的优化设计提供了技术基础数据。

英文摘要:

Abstract: Molded tray that was manufactured by crop stalks is a new type of green packaging material. In order to provide a basic date for design and technology for molded t is necessary to understand the forming laws of cornstalk powder in the course of molded compression. Since previous research to study the principle of compression and forming cornstalk used rheology theory, it could not solve the problem of the plastic deformation in the compression process. In addition, the molding process of stalk powder is the probl of double nonlinear that contains material nonlinear behavior and geometric nonlinear behavior. To analyze the relationship between the deformation and load histories for cornsta powder, the uni-axial compression tests of cornstalk powder, which was with about 12% of moisture and 0.4-1.0 mm of granularity, were studied in this paper. The elastoplastic characteristics of cornstalk powder in molded compression process were investigated. Then the relationships between load and displacement were discovered after analyzing the results of the experiments. Moreover, the constitutive equation of cornstalk powder was established using the non-linear fitting method. Using plasticity theory, the Eulerian meth large deformation for the compression analysis of powder was introduced. Based on finite deformation theory, this paper studied a finite element model of axial symmetry for corns powder during compaction, and a FEM program was proposed. Three main formulae, including tangent modulus、tangent stiffness matrix、and unbalanced force, were discussed the model of the large deformation. The deformation principles were revealed during the forming process. Because of the friction between the corn stalk powder and the die wall, t distance of deformation curve nearby the axial line was obviously greater than the deformation curve nearby the die wall. The paper also obtained the equivalent strain and load-displacement curve. The maximum axial strain was located at the upper portion of the compaction block where there was contact with the die wall. The strain increased along with height of the die wall. The total load increased very quickly in the process of the plastic deformation, and the smaller deformation was needed to exert greater load. The relationshi between the numerical results and the experimental results was analyzed using paired t-test and regression analysis. Paired t-test gave that P-value (Bilateral) of the large strain wa greater than 0.05 and agreed well with the experimental results. This paper put forward the finite element model of large strain which can better describe the molding process of compression for cornstalk powder. The correlation coefficient between the results of the large strain and the experimental results was R2=0.9855, but the correlation coefficient bet the results of the small deformation and the experimental results was R2=0.9398. The study indicated that the large deformation method has a higher calculating precision. The larg deformation computation can adopt large step (0.01) and the step of the small deformation is 0.0001. The result showed that the computation efficiency is improved. The paper pro a reference for further study on the technology of cornstalk powder's molded compression, and the optimization design of techniques and equipment.